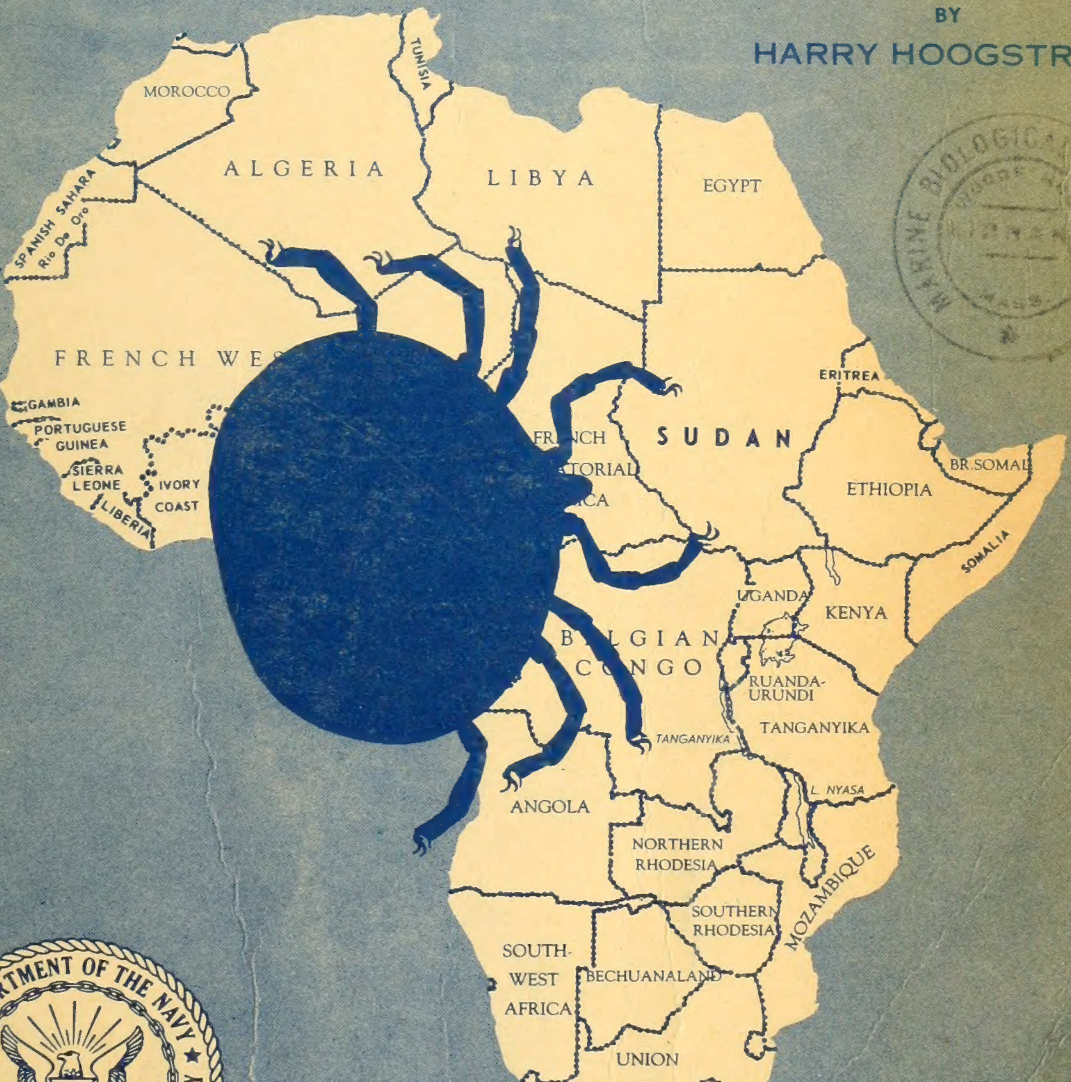
AFRICAN IXODOIDEA

VOLUME I

TICKS OF THE SUDAN

BY

HARRY HOOGSTRAAL



DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY

MARINE BIOLOGICAL LABORATORY
LIBRARY
WOODS HOLE, MASS.

595.42
H76.

AFRICAN IXODOIDEA

I. TICKS OF THE SUDAN

(WITH SPECIAL REFERENCE TO EQUATORIA PROVINCE AND WITH PRELIMINARY REVIEWS OF THE GENERA BOOPHILUS, MARGAROPUS, AND HYALOMMA)

MBL/WHOI
0 0301 0016788 8

Harry Hoogstraal

Head, Department of Medical Zoology

U. S. Naval Medical Research Unit No. 3

Cairo, Egypt

Glenn Hoffman

Research Report NM 005 050.29.07

Date of Publication, 1956

With 372 Figures on 103 Plates

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

TO

COLONEL

WILLARD VAN ORSDEL KING, PH.D.

A VETERAN MEDICAL ENTOMOLOGIST AND

PIONEER WORKER ON TICK VECTORS OF

ROCKY MOUNTAIN SPOTTED FEVER.

FROM WHOM I HAVE LEARNED MUCH OF

THE METHODS OF SCIENTIFIC INQUIRY.

TABLE OF CONTENTS

76911

Page

---

* Non-Sudanese species.

**Non-Sudanese "biological form" of H. detritum.

Page

MAPS AND ILLUSTRATIONS

A R G A S I D A E

ARGAS

ORNITHODOROS MOUBATA

*Non–Sudanese species.

---

* Non-Sudanese species.

**The ♀ of H. schulzei is illustrated in PLATE

NOTE

Throughout this report, "the Sudan" refers to the Condominium, dissolved on 1 January 1956, known since 1898 as the Anglo-Egyptian Sudan. It should not be confused with the "French Soudan" of French West Africa and French Equatorial Africa.

ABBREVIATIONS

BMNH or BM(NH): British Museum (Natural History) collections.
CNHM: Chicago Natural History Museum collections.
HH: Hary Hoogstraal.
MCZ: Museum of Comparative Zoology (Harvard University collections).
NAMRU3: United States Naval Medical Research Unit Number Three (Cairo).
SGC: Sudan Government collections (Wad Medani).
SVS: Sudan Veterinary Service material (Hoogstraal collection).
L: Larvae.
N: Nymphs.
det.: Identification determined by.
legit = collected by.
ms.: unpublished manuscript.

FOREWORD

Mosquitoes have generally been credited as the worst pests of man and animals, but ticks, in spite of their lack of wings, could truly be considered to run them a close second both as pests and as vectors of an even wider variety of diseases of man and animals. Because of the varied habits of different species of ticks, of first importance to an understanding of the problems they create is an accurate knowledge of their taxonomy and biology.

Among the continents, Africa in particular is burdened with more than its share of species. This first in a series of volumes, with emphasis on the Sudanese tick fauna, will provide the basic systematic and biological information that can safely be said to bear in a major way on the entire continent. Many of these species occur far beyond the region under discussion.

It will be evident to the specialized reader that the author not only has a scholarly command of the pertinent literature based on exhaustive library work and liaison with competent authorities, but an unusual field experience of personal collecting in Africa and elsewhere in the world. More than this, he has been able to straighten out a number of knotty problems, particularly in the genera Argas, Ornithodoros, Haemaphysalis, and Hyalomma, which contain important disease carrying species, through study of his own and of various museums' extensive collections. This expansion of our knowledge of African ticks will be a major contribution, and provide authoritative reference work for years to come. For example, here for the first time is brought together the extensive literature on Ornithodoros moubata, the relapsing fever tick, notorious since Livingstone's vividly described, evil encounters with it in the Congo.

Most of the important species of African ticks are found in the Sudan. The few that are not, plus such aspects as relationships to disease, will be treated in companion volumes to follow so that the future student of any phase of the entire continental tick fauna will undubitably resort to these elegant contributions as his major reference.

The United States Navy is to be congratulated for its foresightness in supporting this timely and continuing work through its Naval Medical Research Unit Number Three in Cairo, Egypt.

CORNELIUS B. PHILIP

I

INTRODUCTION

OBJECT AND SCOPE OF THIS AND RELATED PROJECTS

The primary objective of Volume I of this series of studies is to present our research on Sudanese ticks, including a critical survey of published worldwide information concerning each species. This has been attempted with reference to: (a) distribution in the Sudan and elsewhere, (b) hosts, (c) biology, and (d) identification. The secondary objective is to provide a suitable background for subsequent volumes presently in preparation. These studies will include all economically important tick species of Africa and all diseases and injuries associated with them.

The present report is intended to serve the tyro and specialist alike, and should provide a sound source of information for those who compile textbooks and review literature. Special attention is invited to the introductory paragraphs in section IV, pages 43 to 47, in which presentation methods and handling of data are elucidated, and to the fact that mention of disease relations herein are merely cross-referencing for subsequent volumes.

It should be stressed that most tick species of known or potential medical or veterinary importance of the Ethiopian Faunal Region (see Figure 1) are found in the Sudan and are treated in the present report. Those few species that do not occur in the Sudan will be treated in a forthcoming volume, entitled "The Economically Important Ticks of Africa." Therefore, pertinent facts concerning all known species of medical and veterinary importance of continental Africa will be included in these two reports. Also included in the forthcoming volume will be maps of the distribution of each species in the Sudan, as well as in other African regions and elsewhere in the world. Subsequent volumes will be entitled: "Human Tick-Borne Diseases and Injuries in the Ethiopian Faunal Region" and "The Biological Relationships of African Ticks and Veterinary Diseases." Since a year or more will probably elapse between the publication of each volume, additional material concerning species previously treated will be presented in each new section in an effort to bring the pertinent information up-to-date.

The primary purpose of the report on veterinary diseases, mentioned above, is to present the biological relationships of ticks to these diseases in order to provide a better working knowledge for basic research in human diseases. It is also intended that this section will be of use to veterinarians in the area concerned.

Possibly one of the greatest general criticisms of contemporary literature on African ticks is that the reader obtains the impression that specialists' knowledge is usually more or less complete with respect to identification, biology, hosts, and distribution. When first considering the study of African ticks, I was told by several scientists that these parasites were so well known and so easily identified that there would be little to do that could not be accomplished in short order! Quite the contrary proved to be true; and it was soon realized how much specialized and practical information on African ticks is lacking. The best expectation for this undertaking is that the numerous indications for existing queries, problems, and *lacunae* in our information on African ticks will stimulate readers to seek out additional data. It is also hoped that this work will provide a useful body of information for authors of textbooks and teaching manuals. Towards these ends, every effort has been made to present and review data as correctly as possible. Should errors occur, it will be appreciated if readers call them to my attention for inclusion in *errata* in subsequent volumes.

HISTORY OF THIS PROJECT

This project commenced in 1948 with a small tick collection made mostly in Equatoria Province of the Sudan, and also in other parts of East Africa and Madagascar. I was, at that time, a member of the Naval Medical Science Group accompanying the University of California African Expedition. Subsequently, between October 1949 and April 1950, when assigned by NAMRU-3 to Torit, in Equatoria Province, for study of elephant shrew malaria (Hoogstraal, Huff, and Lawless 1950, Hoogstraal 1950,1951,1953A, 1955A), a larger tick collection was accumulated. This was assembled, however, chiefly as an avocational pursuit.

Upon the return of our party to Cairo in 1950, study of these collections commenced. During the course of the literature review necessary for this work, it became apparent that much data was so scattered as to be of little use, that a certain amount of earlier inaccuracy or vagueness was frequently uncritically quoted and reported, and that our specimen material contributed no little amount of new information on African ticks. Interestingly enough, though much new data were obtained, only two completely undescribed species and a few previously erroneously recognized species were included in the collection. This would indicate that the skeleton of knowledge of East African ticks is rather complete but that the covering body of supporting data is still much in need of development.

In the light of these observations, it was decided to add a literature survey to the Sudan tick report and to commence the review of African tick-borne diseases. This latter report is an outgrowth of attempts to find details of African tick-borne diseases in current textbooks on medical entomology. Suffice it to say that the study of these textbooks was most disappointing with respect to accuracy, weight of controversial information, and evaluation of important factors in relation to each disease.

In order to make the already-available tick collection more broadly representative of the overall composition of the local tick fauna, a collecting trip in the Sudan was undertaken during December 1951 and January 1952. The Sudan Government collections at Wad Medani were also studied, and additional information on tick distribution in the Sudan was incorporated into the present report. At the same time, the Sudan Veterinary Service requested its staff in various Provinces to collect and send specimens for determination. These latter collections added valuable data on distribution of ticks infesting domestic animals, which are often also those most important in relation to human diseases. Subsequently, other collections were also identified for the Sudan National Museum and for Gordon College, Khartoum, and their data recorded.

During the course of these studies, a number of taxonomic problems, background questions, and literature-evaluation uncertainties have arisen. Opinions of specialists in various parts of the world have been widely solicited in order to settle these matters so far as possible.

The magnificent tick collection in the British Museum (Natural History) was studied during the summers of 1951 and 1952 and early in 1955 further to investigate taxonomic problems and to extract pertinent unpublished data (Hoogstraal 1954C). African collections have also been identified for the Chicago Natural History Museum, Museum of Comparative Zoölogy at Harvard University, and several other institutions. During the summer of 1952, visits were made to the following institutions for the purpose of checking and acquiring information: Museum of Comparative Zoölogy, United States National Museum, and Rocky Mountain Laboratory at Hamilton, Montana.

Another visit to Equatoria, Bahr El Ghazal, Blue Nile, and Khartoum Provinces was made in November and December of 1952 to search for Ornithodoros ticks and to collect living ticks and human blood sera for comparative virus and rickettsial investigations. In February of 1953, I visited the Sudan Veterinary Service's "Jur Narrows game eviction project" in the Galual-Nyang forest area of Bahr El Ghazal Province and obtained a number of valuable records from this area.

During the winter of 1954-1955, I was fortunate to be able to visit a number of institutions for final studies and conferences in connection with the preparation of this report. Chief among these were: The Rocky Mountain Laboratory; Camp Dietrick, Maryland; Animal Parasite Laboratory of the United States Department of Agriculture at Beltsville; Zoology Department of the University of Maryland; United States National Museum; Bureau of Medicine and Surgery of the Navy Department at Washington, D.C.; British Museum (Natural History); London School of Hygiene and Tropical Medicine; King's College of the University of London; and Tring Museum.

At various times throughout this period of study I have been privileged by the United States Navy to visit other areas for obtaining comparative materials for this study. In addition to extensive searching in Egypt, including Sinai and the Sudan frontier, trips for this purpose have been undertaken in Kenya, Uganda, Tanganyika, Belgian Congo, Eritrea, French Somaliland, Yemen, and Turkey. A U.S. Navy-Smithsonian Institution collaborative project is at present underway in Libya.

A brief preliminary report of this work has been published (Hoogstraal 1954B) and three new species found in the Sudan during this survey have been described (Hoogstraal 1955B,1956A,).

II

ACKNOWLEDGEMENTS

I am happy to express appreciation to Captain C. B. Galloway (MC) USN, Director of U.S. Naval Medical Research Unit No. 3, and to his predecessors, Captain A. R. Higgins (MC) USN, and Rear Admiral J. J. Sapero (MC) USN (Ret.) for their constant encouragement in the preparation of this report.

For much assistance I am also indebted to my first mentor in the study of ticks, Dr. J. Bequaert of the Museum of Comparative Zoölogy, Harvard University.

The helpful hand of Dr. Gertrud Theiler of Onderstepoort, Transvaal, appears on many pages of this report. In many otherwise unmentioned ways she has been so cooperative that it is difficult to express appreciation in sufficiently glowing terms. Dr. Theiler has identified all the immature specimens listed in this report and has checked many adult specimens of difficult or questionable species. Many of the discussions of species in this report reflect conclusions Dr. Theiler has drawn from years of study and her generous permission to utilize unpublished results of this experience.

Special attention should also be called to the wholehearted cooperation of Mr. Glen M. Kohls of the Rocky Mountain Laboratory who since the beginning of this work has spent many hours in reviewing this manuscript and offering valuable comments. During two periods of study at his laboratory, Mr. Kohls provided me with every assistance.

To Mr. David J. Lewis, formerly of Wad Medani, Sudan, I am indebted for his graciousness in putting the Sudan Government collections at my disposal and providing me with facilities for study while visiting there. Dr. R. Kirk, formerly Director, Stack Medical Research Laboratories, Khartoum, Dr. J. F. E. Bloss, formerly Assistant Director, Sudan Medical Service, and numerous other persons in the Sudan have been most generous in providing assistance of various kinds for work in that country. I am especially grateful to Mr. J. T. R. Evans, formerly Director, Sudan

Veterinary Service, who canvassed his field officers for specimens for distributional records and who invited us to study parasitological aspects of the Jur Narrows Game-Eviction Project; to Mr. John Owen, formerly District Commissioner, Torit, for many courtesies and a number of worthwhile specimens; to Mr. H. B. Luxmoore, formerly Equatoria Veterinary Inspector, who was especially helpful in providing ticks from livestock and facilities for obtaining additional such specimens; to Mr. T. W. Chorley, formerly Tsetse Control and Reclamation Officer, Sudan Veterinary Service, our cooperative and indefatigable host on the trip to Jur Narrows; to Mr. E. T. M. Reid and others of Mr. Chorley's staff (page 808) for special efforts to collect ticks and data; and to Bimbashi Hillory Hook, formerly of the Sudan Defense Force, for a number of fine specimens from a variety of big game.

Special acknowledgement is made to my assistants, Chief Hospital Corpsman Deaner K. Lawless, USN, and Mr. Richard Alison, for help in collecting specimens in 1948.

While studying collections at British Museum (Natural History) I was the recipient of many kindness and courtesies from Mr. E. Browning and Dr. G. Owen Evans, for which hearty thanks are expressed. The privilege of being permitted to identify literally thousands of unnamed African ticks in British Museum (Natural History) collections has provided excellent background material for many phases of this report.

In the course of this work, it has been our privilege to have outstanding parasitologists and specialists review parts of the manuscript and offer comments and suggestions. In addition to Dr. G. Theiler, Miss J. B. Walker, Mr. Glen M. Kohls, and Dr. C. B. Philip, it is a pleasure to note the cooperation of Dr. P. C. C. Garnham of the London School of Hygiene and Tropical Medicine; Dr. G. E. Davis and Dr. W. Burgdorfer of the Rocky Mountain Laboratory (on *Ornithodoros moubata*); Dr. L. Delpy of Paris (on *Hyalomma*, in early stages of manuscript); and Dr. D. R. Arthur of the University of London (on *Ixodes*). Dr. A. C. Chandler of Rice Institute and Commander T. K. Ruebush, Office of Naval Research, kindly reviewed extensive parts of this report during its preparation.

Commander S. W. Handford of the NAMRU-3 staff, Miss J. B. Walker of the East African Veterinary Research Organization, and Mr. George Curtis Moore, Second Secretary of the American Embassy at Cairo, kindly provided their excellent services as editors. The thankless task of checking the bibliography was kindly undertaken by Dr. Edith W. Ware during a research tour sponsored by Dr. Henry Field, Coconut Grove, Florida.

Information on systematic names and other matters pertaining to hosts of ticks has been secured from prominent specialists: Dr. A. L. Rand, Chicago Natural History Museum, on birds; Mr. C. C. Sanborn of the same institution on bats; Dr. H. W. Setzer, United States National Museum, on other mammals; and Mr. A. Loveridge, Museum of Comparative Zoology, on reptiles. Dr. C.W. Sabrosky, United States National Museum, has kindly answered questions on several nomenclatorial problems that arose during the course of this work.

To Mr. R. Strekalovsky of Cairo University, appreciation must be expressed for the care with which he has prepared the illustrations in this report. It is also a pleasure to acknowledge the services of Miss Marcelle Boshi and Mrs. Mary Youakim of Naval Medical Research Unit Number Three for their careful typing of the manuscript in its numerous preliminary forms, as well as in final form.

Although most illustrations used in this work were prepared especially for it, a few have been copied from previous publications with the permission of the authors or editors concerned. These are acknowledged in the title of each figure so obtained.

In the introductory section of the Bibliography, those persons who have been of special assistance in securing literature for these studies are mentioned.

Figure 1

PLATE I

I. WEST AFRICAN SUBREGION

A.- Guinean Forest Province

1. Upper Guinea Forest District
2. Lower Guinea Forest District

B.- Guinean Savanna Province

3. Upper Guinea Savanna District
4. Ubangi-Uelle Savanna District
5. Southern Congo Savanna District
6. Uganda-Unyoro Savanna District

II. EAST AND SOUTH AFRICAN SUBREGION

C.- Humid Montane District

7. Cameroons Montane District
8. Eastern Montane District

D.- Sudanese Province

9. Sudanese Arid District
10. Sudanese Savanna District

E.- Northeast African Province

11. Abyssinian Highland District
12. Somali Arid District

F.- Eastern and Southern Province

13. East African Highland District
14. Rhodesian Highland District
15. East African Lowland District
16. Southeast Veld District
17. Southwest Arid District

Figure 1

SUBDIVISIONS OF THE ETHIOPIAN FAUNAL REGION

As suggested by the range of many species and races of birds. These prove rather satisfactory for mammals and some other terrestrial animals.

From Chapin (1932), with the author's permission.

PLATE 1

Figure 2

POLITICAL DIVISIONS OF AFRICA AND ADJACENT AREAS

PLATE II

Figure 3
THE SUDAN. PROVINCES AND PRINCIPAL COLLECTING
SITES OF TICKS REPORTED HEREIN

(For additional Equatoria Province collecting localities
see Figures 321 and 322)

PLATE III

III

LISTS OF TICKS REPORTED FROM THE SUDAN

SPECIES AND SUBSPECIES RECORDS BY PROVINCE

FAMILY ARGASIDAE

SPECIES	PROVINCE RECORDS								
	EQUATORIA	BAHR EL GHAZAL	UPPER NILE	BLUE NILE	KORDOFAN	DARFUR	KASSALA	KHARTOUM	NORTHERN
ARGAS									
A. boueti	**	0	0	0	0	0	0	0	0
A. brumpti	+	0	0	X	X	0	X	0	0
A. confusus	**	0	0	0	0	0	0	**	**
A. persicus	X	X	X	X	X	X	X	X	X
A. reflexus	**	0	0	0	0	0	0	0	0
A. vespertilionis	+	0	0	0	0	0	0	X	X
(A. sp.)	**	0	0	0	0	0	0	0	0
ORNITHODOROS									
O. moubata	X	+	0	0	0	0	0	0	0
O. savignyi	0	0	0	X	X	X	X	X	X

** first record from Sudan, except for preliminary report (Hoogstraal 1954B) on same material.

* first definite locality record from Sudan.

f first record under this name from Sudan.

+ first record from Province.

X previously published and new records.

? record questionable.

FAMILY IXODIDAE

SPECIES	PROVINCE RECORDS								
	EQUATORIA	BAHR EL GHAZAL	UPPER NILE	BLUE NILE	KORDOFAN	DARFUR	KASSALA	KHARTOUM	NORTHERN
A M B L Y O M M A									
A. cohaerens	**	0	0	0	0	0	0	0	0
A. lepidum	X	X	X	X	X	X	X	0	0
A. marmoreum	*	0	0	0	0	0	0	0	0
A. nuttalli	*	0	0	0	f	0	0	0	0
A. pomposum	**	0	0	0	0	0	0	0	0
A. rhinocerotis	f	0	f	0	0	0	0	0	0
A. tholloni	X	0	0	0	0	0	0	0	0
A. variegatum	X	X	X	+	X	+	0	0	0
A P O N O M M A									
A. exornatum	X	0	+	+	+	0	+	?	0
A. latum	f	+	f	0	0	0	0	0	0
B O O P H I L U S									
B. annulatus	**	**	**	0	**	0	0	0	0
B. decoloratus	X	X	X	X	X	+	+	0	0

FAMILY IXODIDAE

	PROVINCE RECORDS								
SPECIES	EQUATORIA	BAHR EL GHAZAL	UPPER NILE	BLUE NILE	KORDOFAN	DARFUR	KASSALA	KHARTOUM	NORTHERN
D E R M A C E N T O R									
D. c. circumguttatus	**	0	0	0	0	0	0	0	0
D. rhinocerinus	f	0	0	0	0	0	0	0	0
H A E M A P H Y S A L I S									
H. aciculifer	X	+	0	0	0	0	0	0	0
H. bequaerti	**	0	0	0	0	0	0	0	0
H. hoodi hoodi	**	**	0	0	0	0	0	0	0
H. houyi	f+	f+	f+	f	0	0	0	0	0
H. leachii leachii	X	X	X	X	X	+	+	+	+
H. leachii muhsami	**	**	0	**	0	0	0	**	0
H. parmata	**	0	0	0	0	0	0	0	0

FAMILY IXODIDAE

SPECIES	PROVINCE RECORDS EQUATORIA	BAHR EL GHAZAL	UPPER NILE	BLUE NILE	KORDOFAN	DARFUR	KASSALA	KHARTOUM	NORTHERN
HYALOMMA									
H. excavatum	0	0	0	0	**	**	**	**	**
H. detritum	0	0	0	0	**	**	**	**	**
H. dromedarii	0	0	0	0	**	**	**	**	**
H. impeltatum	0	0	0	0	**	**	**	**	**
H. impressum	0	0	0	0	**	**	**	**	**
H. marginatum	0	0	0	0	**	**	**	**	**
H. rufipes	**	**	**	**	**	**	**	**	**
H. truncatum	**	**	**	**	**	**	0	0	0
IXODES									
I. cavipalpus	**	0	0	0	0	0	0	0	0
I. nairobiensis	**	**	0	0	0	0	0	0	0
I. rasus ?subspecies	**	0	0	0	0	0	0	0	0
I. schillingsi	**	0	0	0	0	0	0	0	0
I. simplex simplex	**	0	0	0	0	0	0	0	0
I. vespertilionis	**	0	0	0	0	0	0	0	0

FAMILY IXODIDAE

	PROVINCE RECORDS								
SPECIES	EQUATORIA	BAHR EL GHAZAL	UPPER NILE	BLUE NILE	KORDOFAN	DARFUR	KASSALA	KHARTOUM	NORTHERN
M A R G A R O P U S									
M. reidi	0	**	0	0	0	0	0	0	0
R H I P I C E P H A L U S									
R. appendiculatus	**	0	0	0	0	0	0	0	0
R. arnoldi	**	0	0	0	0	0	0	0	0
R. bequaerti	**	0	0	0	0	0	0	0	0
R. compositus	+	0	0	0	0	0	0	X?	0
R. cuspidatus	0	**	0	0	0	0	0	0	0
R. distinctus	**	0	0	0	0	0	0	0	0
R. evertsi evertsi	X	X	X	X	X	X	X	X	X
R. kochi	**	0	0	0	0	0	0	0	0
R. longicoxatus	0	**	0	0	0	0	0	0	0
R. longus	**	0	0	0	0	0	0	0	0
R. mühlensi	**	0	0	0	0	0	0	0	0

FAMILY IXODIDAE

	PROVINCE RECORDS								
SPECIES	EQUATORIA	BAHR EL GHAZAL	UPPER NILE	BLUE NILE	KORDOFAN	DARFUR	KASSALA	KHARTOUM	NORTHERN
R H I P I C E P H A L U S (Cont.)									
R. pravus	**	0	0	0	0	0	0	0	0
R. sanguineus sanguineus	X	X	X	X	X	X	X	X	X
R. simpsoni	**	0	0	0	0	0	0	0	0
R. simus simus	X	X	X	X	X	+	X	0	X
R. simus senegalensis	**	**	0	0	0	0	0	0	0
R. sulcatus	0	**	0	0	0	0	0	0	0
R. supertritus	**	0	**	0	0	0	0	0	0
R. tricuspis	0	**	0	0	0	0	0	0	0
(R. sp.)	**	0	0	0	0	0	0	0	0

NOTE: Records from Zoological Gardens and from animals in transit to foreign markets are not included.

APPENDIX

I X O D E S									
I. alluaudi	**	0	0	0	0	0	0	0	0

SPECIES ATTRIBUTED IN ERROR TO THE SUDAN

ORNITHODOROS MEGNINI (Duges) (now Otobius megnini). Balfour (1906) stated: "Mrs. Broun .... recognized the spinose nymph of the ear tick, Ornithodorus Megnini from the Sudan".

There is little doubt that this was an erroneous identification. O. megnini, listed for the Sudan (King 1911), was considered an error by King (1926). Nevertheless, the possibility that this species may be introduced into the Sudan should be considered. A tick infesting the ears of cattle, it has been introduced into South Africa (Bedford 1925,1932B) from America. It has also established itself in Nyasaland (Wilson 1950B), Northern Rhodesia (Morris 1933), Southern Rhodesia (Jack 1942), southern Belgian Congo (Schoenaers 1950, 1951A), and on Madagascar (Bück 1948B, Hoogstraal 1953E).

AMBLYOMMA HEBRAEUM Koch, 1844. Listed for the Sudan (King 1911) but later deleted (King 1926).

This species does not occur in the Sudan. BM(NH) files contain records of A. hebraeum from the Sudan (H. H. King legit, 1911), but corresponding specimens cannot be located in the collection. A specimen tube in the same institution contains material of both A. variegatum and A. hebraeum and a label (in Hirst's handwriting) identifying them as such. Another almost illegible label in the vial reads "Taufikia, Sudan, 1909, H. H. King". There is a remote chance that the A. hebraeum specimens were removed from imported cattle but it is more likely that these are South African specimens that were somehow mixed with Sudan specimens. Museum records show that the specimens were presented by members of the Committee for Entomological Research.

A note by Nuttall in his collection logbook states that the A. variegatum-hebraeum of King (1911) is A. lepidum.

APONOMMA LAEVE Neumann, 1899. Listed from the Sudan by King (1911 and 1926). This is a non-African species name (Theiler 1954B). The species in the Sudan is actually A. latum (Koch, 1844).

BOOPHILUS AUSTRALIS (Fuller, 1899). Listed from the Sudan by Balfour (1911H) and King (1911). This name, a synonym of B. microplus (Canestrini, 1888), which is not known from the Sudan, probably refers to misidentified material of B. decoloratus. It is less likely that it refers to B. annulatus.

HAEMAPHYSALIS CALCARATA Neumann, 1902, was reported from Roseires, Blue Nile Province, by Neumann (1910A). From his description and figure it is evident that this material represents H. houyi Nuttall and Warburton, 1915 (Hoogstraal 1955D). King (1926) did not list H. calcarata in his reports on Sudan ticks, and, although he collected specimens of H. houyi, they had been identified as H. leachii.

HAEMAPHYSALIS ERINACEI Pavesi, 1884, which was reported from the Sudan (Hoogstraal 1954B) was later (1955C) deleted. This record was due to an early erroneous identification.

HYALOMMA AEGYPTIUM (Linnaeus, 1758). All Sudan Hyalomma ticks previously have been lumped under this name by King (1911,1926), O'Farrell (1913A,B), and others. This species does not occur in the Sudan.

RHIPICEPHALUS BURSA Canestrini and Fanzago, 1877. The report by Weber (1943), from 8700 feet elevation in the Imatong Mountains of Equatoria Province, is based on material (kindly loaned by Dr. J. Bequaert) that Dr. Theiler and I have found to be R. kochi.

RHIPICEPHALUS CAPENSIS Koch, 1844. I have been unable to find evidence to support Zumpt's (1942B) statement that this tick occurs in the Sudan.

PREVIOUSLY REPORTED NAMES USED IN ERROR, CHANGED, OR SYNONYMIZED.

This is not a list of synonyms of names now used; these may be found in taxonomic papers cited throughout this report. It is rather a list of names that have appeared in earlier papers on Sudan ticks or for which the Sudan has been listed as the source, but that subsequently have been changed or synonymized under names appearing in the present report.

ARGAS MINIATUS Koch, 1844, mentioned by Balfour (1906) from Khartoum, is a synonym of *Argas persicus* (Oken, 1818).

AMBLYOMMA PETERSI Karsch, 1878, is believed by Schulze (1932A) to be synonymous with *A. rhinocerotis* (de Geer, 1778). King (1926) and almost all other previous authors have applied the name *petersi* to this species. Schulze's findings are tentatively accepted in the present work, though specialists are not in complete agreement.

AMBLYOMMA WERNERI WERNERI Schulze, 1932A, said to originate from Kordofan, is synonymized under *A. nuttalli* Dönitz, 1909.

DERMACENTOR RHINOCEROTIS (de Geer, 1778), was used by previous authors, including King (1911,1926), probably in error for *Dermacentor rhinocerinus* Denny, 1843. The species *rhinocerotis* described by de Geer is actually an *Amblyomma* according to Schulze (1932A), whose decision is tentatively accepted here, though specialists are not in complete agreement.

HAEMAPHYSALIS sp. nov. Hoogstraal (1954B). Later described as *H. bequaerti* Hoogstraal, 1956(A).

HYALOMMA BRUMPTI Delpy, 1946. Listed by Hoogstraal (1954B) but herein changed to *H. impeltatum* Schulze and Schlottke, 1930, on the basis of information resulting from examination of type material.

RHIPICEPHALUS FALCATUS Neumann, 1908, is a synonym of R. longus Neumann, 1907 (Zumpt 1942B,1950A). R. falcatus was listed by King (1926) from the Sudan. Specimens in Sudan Government collections identified as this species by King refer actually to R. longus, R. supertritus, R. simus senegalensis, and R. sanguineus sanguineus. R. falcatus was originally rather vaguely described for the complex group in which it falls, and frequently the name has been used indiscriminately.

RHIPICEPHALUS LUNULATUS Neumann, 1907. This name was used (Hoogstraal 1954B) on the basis of Santos Dias' (1950D,1952C) assertion that this is a valid species, distinct from R. tricuspis Dönitz, 1906. Dr. G. Theiler, however, has studied this question so thoroughly (1955 correspondence) and confirmed her earlier findings (1947) so convincingly that R. lunulatus is herein used in synonymy under R. tricuspis.

RHIPICEPHALUS MACROPIS Schulze, 1936(C) is a synonym of R. sanguineus sanguineus Latreille, 1806, according to Zumpt (1950A). The original specimens of R. macropis came from dogs in Port Sudan (Sudan) and Aden (Arabia).

RHIPICEPHALUS PUNCTATISSIMUS Gerstäcker, 1873, is a synonym of R. sanguineus sanguineus Latreille, 1806, according to Zumpt (1950A). R. punctatissimus was listed by King (1908, 1911) from the Sudan. Santos Dias (1952H,1953A,B) considers this to be a subspecies of R. sanguineus, and to be the same as R. sulcatus, but he has not examined type material or reared series.

(?) RHIPICEPHALUS SHIPLEYI Neumann, 1902. Type locality: "Soudan" possibly meaning Anglo-Egyptian Sudan (or "French Soudan", i.e. French Equatorial Africa). Zumpt (1943A,1950A) has synonymized R. shipleyi under R. s. simus Koch, 1844.

RHIPICEPHALUS SULCATUS Neumann, 1908. The material on which King's (1926) report of this species in the Sudan was based has proven upon comparison with Dr. Theiler's reared series of R. sulcatus and large numbers of other specimens to be heavily punctate individuals of R. s. sanguineus. R. sulcatus is known, however, by a few more recent specimens from the Sudan.

NAMES HEREIN CHANGED, SYNONYMIZED, OR PROPOSED.

*AMBLYOMMA WERNERI WERNERI Schulze, 1932(A) is synonymized under A. nuttalli Dönitz, 1909.

*APONOMMA HALLI Tendeiro, 1950, is synonymized under A. exornatum (Koch, 1844).

BOOPHILUS CONGOIENSIS Minning, 1934, is synonymized under B. annulatus (Koch, 1844).

HAEMAPHYSALIS LEACHII HUMEROSOIDES, a subspecies tentatively suggested by Theiler (1943B), is an elongate form of H. leachii leachii, so far as now demonstrable.

HAEMAPHYSALIS MUHSAMI Santos Dias, 1954(E), is a subspecies of H. leachii.

**"HYALOMMA SCUPENSE" Schulze, 1919, appears from Soviet works to have distinct biological characteristics and minor morphological characteristics intergrading with H. detritum; it is therefore indicated as a "form" of yet unknown taxonomic status.

HYALOMMA IMPELTATUM Schulze and Schlottke, 1930, is considered to have priority over H. brumpti Delpy, 1946. H. erythraeum Tonelli-Rondelli, 1932, is also considered to be a synonym of H. impeltatum.

HYALOMMA MARGINATUM Koch, 1844, is said by Pomerantzev (1950) to be a synonym of H. plumbeum (Panzer, 1795). This matter should be investigated by independent workers.

---

*The fact that these names have been modified or are considered synonyms has been mentioned in the preliminary publication on Sudan ticks (Hoogstraal 1954B), but the reasons for these changes are presented only in the present report.

**Non-Sudanese species.

HYALOMMA LEWISI Schulze, 1936, is a synonym of H. truncatum, not of H. excavatum as stated by Delpy (1949B).

**HYALOMMA AEGYPTIUM PUNCTATA Schulze, 1919, is considered as a synonym of H. aegyptium.

**HYALOMMA ALBIPARMATUM Schulze and Schlottke, 1930, is raised from the status of a synonym of H. marginatum (= H. savignyi) (Delpy 1949B) and of H. truncatum (Feldman-Muhsam 1954) to full species rank; H. impressum brunneiparmatum S. and S., 1930, is considered as a synonym of H. albiparmatum, not of H. truncatum as stated by Feldman-Muhsam (1954).

**HYALOMMA HUSSAINI Sharif, 1928, is treated as a valid species (not a synonym of H. excavatum - cf. Delpy, 1949B) and most probably the proper type species of the subgenus Hyalommina, the previously designated type species of which (H. rhipicephaloides Neumann, 1901) is no more than a misformed H. excavatum.

**HYALOMMA TURANICUM Pomerantzev, 1946, is raised to full species rank and considered to be the same as H. rufipes glabrum Delpy, 1949.

HYALOMMINA (Subgenus): See H. hussaini above.

MARGAROPUS REIDI SP. NOV. is described from males, females, and nymphs.

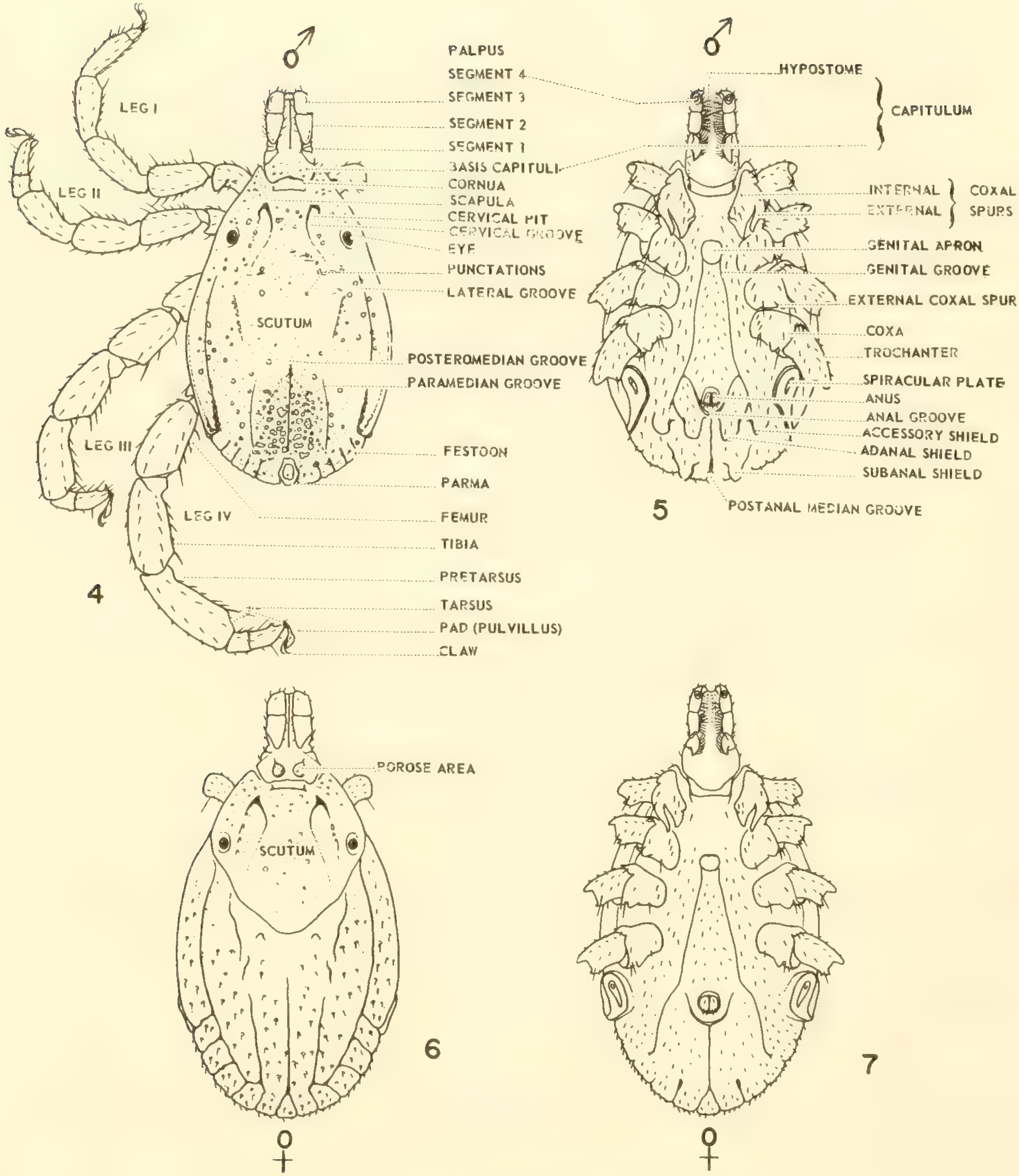
*RHIPICEPHALUS CUSPIDATUS Neumann, 1906, is shown to be actually different from the tick described and illustrated under this name by Zumpt (1950A) in his review of this genus.

RHIPICEPHALUS PSEUDOLONGUS Santos Dias, 1953(D) is a synonym of R. longus Neumann, 1907.

---

*The fact that these names have been modified or are considered synonyms has been mentioned in the preliminary publication on Sudan ticks (Hoogstraal 1954B), but the reasons for these changes are presented only in the present report.

**Non-Sudanese species.



Figures 4 and 5, ♂, dorsal and ventral views
Figures 6 and 7, ♀, dorsal and ventral views

KEY MORPHOLOGICAL CHARACTERS
HYPOTHETICAL ♂ and ♀ ticks, FAMILY IXODIDAE

(Characters used in keys in this report, except for self-explanatory terms, such as "caudal appendage" of certain Boophilus males. Additional characters used in fuller descriptions of individual species are explained where they first occur).

PLATE IV

KEY TO FAMILIES AND GENERA OF ADULTS*

MALES AND FEMALES

A. Dorsum covered by leathery integument lacking scutum. Mouthparts ventral. Eyes absent, or present in lateral folds. Spiracular plates small, anterior of coxa IV. ("Soft ticks")....................................FAMILY ARGASIDAE
Figures 8 to 63

Body periphery flattened and usually structurally different from dorsum; lateral suture usually present**. (From birds, bats, or their resting places; only A. brumpti from mammals or lizards)...ARGAS
Figures 13 to 38

Body periphery undifferentiated; lateral suture absent. (Thick, leathery ticks from houses, corrals, burrows, or retreats)............................ORNITHODOROS
Figures 8 to 12, 39 to 63

B. Dorsum completely covered by scutum (♂♂) or anteriorly covered by scutum (♀♀). Mouthparts anterior. Eyes absent, or present near lateral margin of scutum. Spiracular plates large, posterior of coxa IV. ("Hard ticks")......FAMILY IXODIDAE
Figures 4 to 7, 64 to 316

---

*Characters in this key do not necessarily apply to species within the same genera from areas outside of the Sudan. Two other genera, Otobius (Argasidae) and Rhipicentor (Ixodidae), occur in the Ethiopian Faunal Region outside of the Sudan and are not listed in this key. A few other genera occur in other faunal regions. Another family, Nuttalliellidae, is known only from Southwest Africa.

**The peripheral differentiation of A. boueti and A. confusus is only slight and these species lack a lateral suture.

1. Anal groove distinct, extending anteriorly around anus. Scutum without eyes, festoons, or ornamentation. ♂♂ with seven shields adhering to and almost entirely covering ventral surface. (Rare in the Sudan)....................................IXODES
Figures 212 to 235

Anal groove distinct or indistinct but never extending anteriorly around anus. ♂♂ with fewer (2 to 6) or no ventral shields, these partially non-adherent and only circumanal..............................2

2. Without eyes. (Basis capituli rectangular dorsally)..3

With eyes..4

3. Palpi narrow, elongate; segment 2 at least twice as long as wide. (Reptile parasites)..................................APONOMMA
Figures 96 to 103

Palpi conical, short; segment 2 about twice as wide as long. (Mammal or bird parasites)............................HAEMAPHYSALIS
Figures 128 to 157

4. Palpi as wide as or wider than long......................5

Palpi longer than wide (Common, usually large ticks)......................................8

5. Large ticks with colored ornamentation. Basis capituli rectangular dorsally. (Rare in Sudan, parasites of elephant and rhinoceros)............................DERMACENTOR
Figures 120 to 127

Small or moderated-sized, unornamented, common ticks. Basis capituli usually hexagonal dorsally...................................6

6. Anal grooves faint or obsolete. Festoons absent. Spiracular plates round or oval. ♂♂ very small............................7

Anal grooves distinct. Festoons present. Spiracular plates with a tail-like protrusion. ♂♂ moderate size...............................RHIPICEPHALUS
Figures 240 to 316

7. Palpi ridged dorsally and laterally. ♂♂ with normal legs. (Common chiefly on domestic cattle and equines).....................................BOOPHILUS
Figures 104 to 119

Palpi not ridged and somewhat more elongate. ♂♂ with massive, beady leg segments. (Rare in Sudan, known only from giraffes)..............................MARGAROPUS
Figures 236 to 239

8. Scutum without colored ornamentation. ♂♂ with adanal and subanal shields. Palpal segment 2 at least twice as long as segment 3. Festoons irregular, partially coalesced.....................HYALOMMA
Figures 158 to 211

Scutum with colored ornamentation*. ♂♂ without adanal or subanal shields. Palpal segment 2 less than twice as long as segment 3. Festoons regular, not coalesced.................................AMBLYOMMA
Figures 64 to 95

---

*Ornamentation is often not extensive in the elephant tick, A. tholloni. Ornamentation may be more or less faded in poorly preserved specimens.

KEY TO DEVELOPMENTAL STAGES

With scutum.................................... Family Ixodidae

Without scutum................................. Family Argasidae

Family Argasidae

1. Six legs... Larvae

   Eight legs.. 2

2. Genital aperture undeveloped; in large nymphs may be indicated by a small, otherwise undifferentiated depression............................ Nymphs

   Genital aperture clearly developed as a differentiated area...................... Adults

Family Ixodidae

1. Six legs... Larvae

   Eight legs.. 2

2. Genital aperture undeveloped. Scutum of ♀ type but basis capituli lacking porose areas..................................... Nymphs

   Genital aperture developed. Scutum of ♂ or ♀ type and basis capituli of ♀ with two porose areas (Figure 6)................ Adults

IV

SPECIES RECORDS

MANNER OF DATA PRESENTATION

EQUATORIA PROVINCE RECORDS

On the following pages all available EQUATORIA PROVINCE RECORDS for each species are listed according to numbers of specimens of each stage and sex, locality within the Province, host, and month of collection. The mammalian hosts are described by Setzer (1956B) in his "Mammals of the Anglo-Egyptian Sudan". Domestic animals and wild birds or reptiles are listed following wild mammals. Where human beings have served as hosts, the records precede those from animals. Different collections from one kind of host are listed geographically from east to west.

If two or more collections have been made from a single kind of host in the same locality during one month, the data have been collated on one line and the number of collections noted in parentheses immediately following the month. The "number of collections" are statistically unreliable since they may refer to one day's collection or to a collection from one herd of domestic animals. However, every collection from a single wild animal host is considered as a single collection.

It will be noted that most specimens were taken during the dry season, November to April. This has no significance except to indicate that much of my tick collecting in Equatoria Province was accomplished during this season. Most Sudan material presented by other persons has also been gathered during this period when travel is easier and most officials have returned from home leave.

The great bulk of records in the Equatoria Province section are from my collection and are not otherwise noted. Any data from other sources are indicated by initials in parentheses following the month of collection: (SVS) for Sudan Veterinary Service, (SGC) for Sudan Government Collections, (BMNH) for British Museum (Natural History), or (CNHM) for Chicago Natural History Museum collections. Since King's (1926) review, only two literature references for ticks from definite localities in Equatoria Province have been published and these have been noted, following the month of collection, in the usual literature reference manner.

Most Equatoria Province collecting localities may be located in Figure 317. Common names of hosts may be found in Chapter V. The situation of a few of King's early collecting localities cannot now be definitely ascertained, but they are all close to the present Uganda border.

Reasons for special reference to Equatoria Province are several. My Sudan collection is largely from this Province, and it is from here that most of the new data presented in this report have been obtained. Also, Equatoria Province represents the northern limits of a number of truly tropical African species. Of these, a few undoubtedly range into Bahr El Ghazal and Upper Nile Provinces, though they are not yet recorded from these areas.

Ticks now known from the Sudan number 62 identifiable species plus two additional subspecies. Of this total of 64 identifiable forms, 52 occur in Equatoria Province. Twenty-five are presently recorded only from Equatoria Province and five are known only from Bahr El Ghazal Province. Two uncertain forms are also listed.

DISTRIBUTION IN THE SUDAN

Under DISTRIBUTION IN SUDAN all known collecting localities have been listed for each species by Province, with the exception of course, of Equatoria Province, which is separately considered. Besides my own collections, the chief source of this information has been the collections of the Sudan Government, for which H. H. King, R. Cottam, W. Ruttledge, D. J. Lewis, and a few other persons have been largely responsible.

Specimens submitted to me for identification by the Sudan Veterinary Service have been important for data on species parasitizing domestic animals. British Museum (Natural History) collections have contributed additional information for areas outside of Equatoria Province. Almost no other Sudan data have appeared in literature, except for a few papers by King, one or two by Ruttledge, and brief notes by Balfour and a few other persons.

DISTRIBUTION

Under the heading, DISTRIBUTION, all available pertinent literature records for each political territory of Africa have been listed. I have attempted to select critically each reference for accuracy of species identification and to include only references based on actually known specimens in relation to distribution, disease, control, biology, availability for taxonomic study, etc. Authoritative taxonomists' lists have been included especially where localities are involved and where questions of species identity in any territory exist. Also noted are references by experimental workers who have indicated the source of their material; biological variations within populations presently considered as identical species may subsequently prove to be of the utmost importance in evaluating results of laboratory experiments.

While I personally am concerned with these data in the interests of geomedical knowledge, it is intended that these lists should be a useful guide to interested persons in the territories concerned. Otherwise, this listing is chiefly for advanced, specialized students with some knowledge of the literature, who should be able, by consulting the reference titles in the bibliography, to locate subjects of interest. After serious consideration, it is felt that further breakdown of these references into subject groups would be too unwieldy and cumbersome.

Maps showing tick distribution in Africa will be presented in subsequent volumes of this work.

Every attempt has been made to provide as complete a list of useful references as possible. Probably, all really important works have been seen and noted but if any has been missed it will be much appreciated if readers will call my attention to it.

HOSTS

The object of the HOSTS section has been to indicate the chief references to kinds of animals on which each species feed in each life stage and to give a brief statement concerning the preferred host or hosts. The references following each host do not necessarily include all reports in which the animal has been mentioned. Further pertinent host surveys may be included in the section entitled BIOLOGY, of which the host list should, of course, be considered an integral part. The common name of non-Sudanese hosts may be found in Allen's (1939) checklist of African mammals. After serious consideration of several suggestions that the scientific name of each kind of host be provided, it has been decided to do so only where the common name might frequently be confused, as for the "wild dog" or "hunting dog", *Lycaon pictus*.

BIOLOGY

All available references, including data on BIOLOGY of species discussed herein, have been summarized in more or less detail, depending on the weight of their importance. It is hoped that this section will be especially useful in indicating further research problems.

DISEASE RELATIONS

DISEASE RELATIONS with which each species has been incriminated are usually merely listed by common name and etiologic agent. *This section is intended only as a cross reference to subject chapters in the subsequent volume on disease relations.* Unpublished results of work undertaken in the virology and bacteriology laboratories of NAMRU3 on Sudan ticks are also included in this section.

REMARKS

Miscellaneous REMARKS are included here. This section preceeds that on identification if most of the notes are taxonomic or else follows that on biology if mostly other subjects are involved.

IDENTIFICATION

Diagnostic criteria in addition to key characters are provided for IDENTIFICATION by the average reader. Where Sudan material or special studies modify previously accepted diagnostic features or are of other importance, greater detail is provided. Otherwise, no attempt has been made to present a full description of each species since this falls in the province of more complete, overall taxonomic studies. For serious studies, specimens rather than written descriptions are almost invariably required.

A word of explanation is due concerning the absence of species diagnosis for immature stages of ticks treated in this report. Often, when collections are made from hosts of smaller size, the only ticks on them are immature and the difficulty or impossibility of identifying them is most discouraging. Larvae and nymphs of about half the Sudan tick species have been described, but those of even fewer species can be distinguished from all others with any degree of confidence. The inclusion of what we do know would be of little practical value, except to a very few most highly specialized students. Anyone favorably situated in this area with resources for rearing progeny from known, isolated female ticks can make valuable contributions in this respect. At the present time, Dr. Theiler and I are gathering data on this subject which will be published as soon as we have sufficient information to make a utilitarian report.

In morphological terminology, I have followed almost entirely the usage of Cooley (1946) and Cooley and Kohls (1944), except that I have substituted the word "segment" for "article" as used by these authors. Where Kohls has recently modified some designations, I have followed his lead. Cooley and Kohls' terms have not been extensive enough for adequate description of Rhipicephalus species, and I have been forced to add to them. Unfortunately, some terminology used by British, American, and other workers differs or conflicts. An International Committee needs be called to decide a standard set of morphological terms for the gross description of ticks. The problem is reasonably simple and could easily be settled. Consideration should also be given to standardizing insofar as possible the morphological terms used for mites and ticks. Reference to terms appearing in this report is provided in various text figures.

FAMILY ARGASIDAE

INTRODUCTION

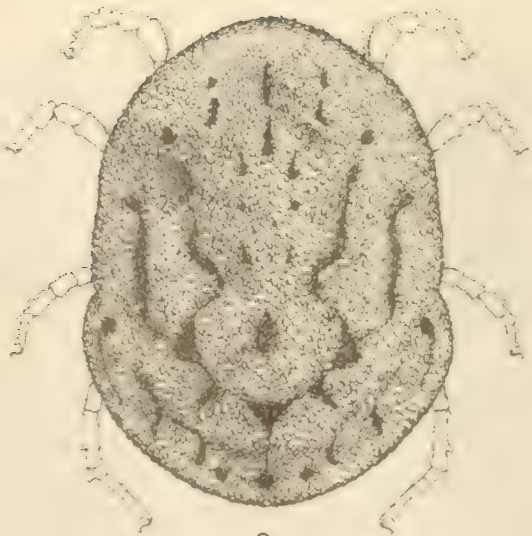
Argasid ticks (Family Argasidae) are called *haim* (هيم) in Sudani Arabic. They are leathery or "soft" ticks that secrete themselves in soil or in crevices, come out to feed for a short while, and then retreat to their hiding place. Two of the several argasid genera, *Argas* and *Ornithodoros*, are common in Africa. The term argasid should not be construed to refer to the genus *Argas* alone. The sole African representative of a third argasid genus, *Otobius*, an ear tick, has been introduced from America into South Africa, Madagascar, and parts of Central and East Africa, but is not known to occur in the Sudan. A variety of argasids occur throughout most of the tropics and subtropics of the world. Fewer species live in temperate areas and very few inhabit arctic climes. Two species presently are distributed widely as a result of human transportation of domestic fowls.

Argasid eggs, deposited at intervals in small batches and totalling only a few hundred, are laid in niches where females seek shelter. Chances that hatching larvae will find a favourable host nearby are reasonably good. Larvae of the two *Ornithodoros* species in the Sudan are nonmotile and do not feed; this feature of their life cycle is unique in the genus. Larvae of *Argas* feed on birds or bats, or less commonly on other animals, and remain on the host for several days to several weeks. Nymphs and adults of both genera feed for only a few minutes to a few hours at most, in marked contrast to the longer attachment time of most nymphal and adult ticks of the family Ixodidae. There are at least two and sometimes as many as six or more nymphal instars. Argasid adults take several blood meals, each of which is usually followed by a rest for digestion and, in the female, for oviposition. The genus *Otobius*, mentioned above, has more highly specialized feeding habits.

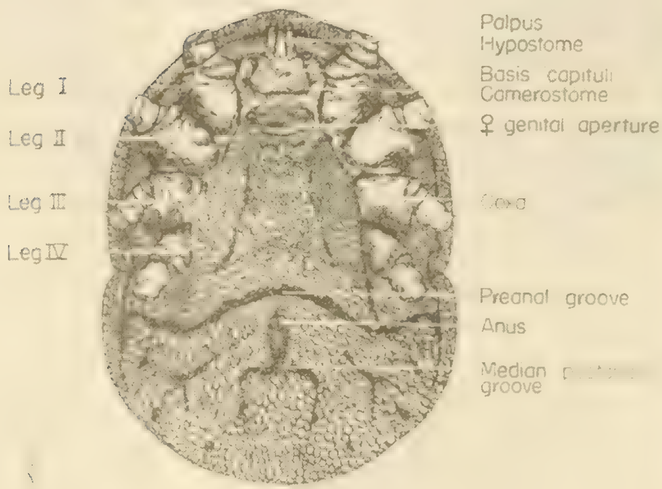
Argasid ticks are of considerable economic and medical importance in many parts of the world. However, at the present time they are apparently of less importance in the Sudan than in many other parts of Africa. As transportation facilities improve and urban areas become larger and more settled, it is to be expected that *Ornithodoros moubata* will become more widely established in human habitations of southern Sudan.

It should be noted that argasid ticks in general are xerophilic animals. Many students of their life cycle have failed to recognize this important fact. Although in localities of extremely low relative humidity argasids may seek a somewhat more humid microhabitat, these niches are seldom those with a significantly high relative humidity. The few species extending into the humid tropics choose dry niches in dry habitats and do not thrive away from these retreats. Within this range, individual species have varying degrees of tolerance.

Examination of bird nests, caves, bat roosts, animal lairs, burrows, rodent nests, hyrax dens, and big game resting and rolling areas in the Sudan will undoubtedly reveal unrecorded or possibly even undescribed argasid species. Although of considerable medical importance and zoological interest, these ticks are not frequently collected because specialized efforts and techniques are necessary to obtain them. Sifting of soil or sand in animal burrows, caves, or dens is often most fruitful. Examination of rock interstices and searching under stones is also important in some situations. Investigation of bird nests, especially those of larger birds, should yield much interesting data. There is little doubt that at least one *Argas* parasite of birds, and *Ornithodoros erraticus* remain to be found in the Sudan, in addition to *O. delanoëi* and some member of the *O. tholozani* group.



8



9

Figures 8 and 9, ♀, slightly engorged, dorsal and ventral views

KEY MORPHOLOGICAL CHARACTERS, FAMILY ARGASIDAE

Ornithodoros savignyi (Egyptian specimen)

PLATE V

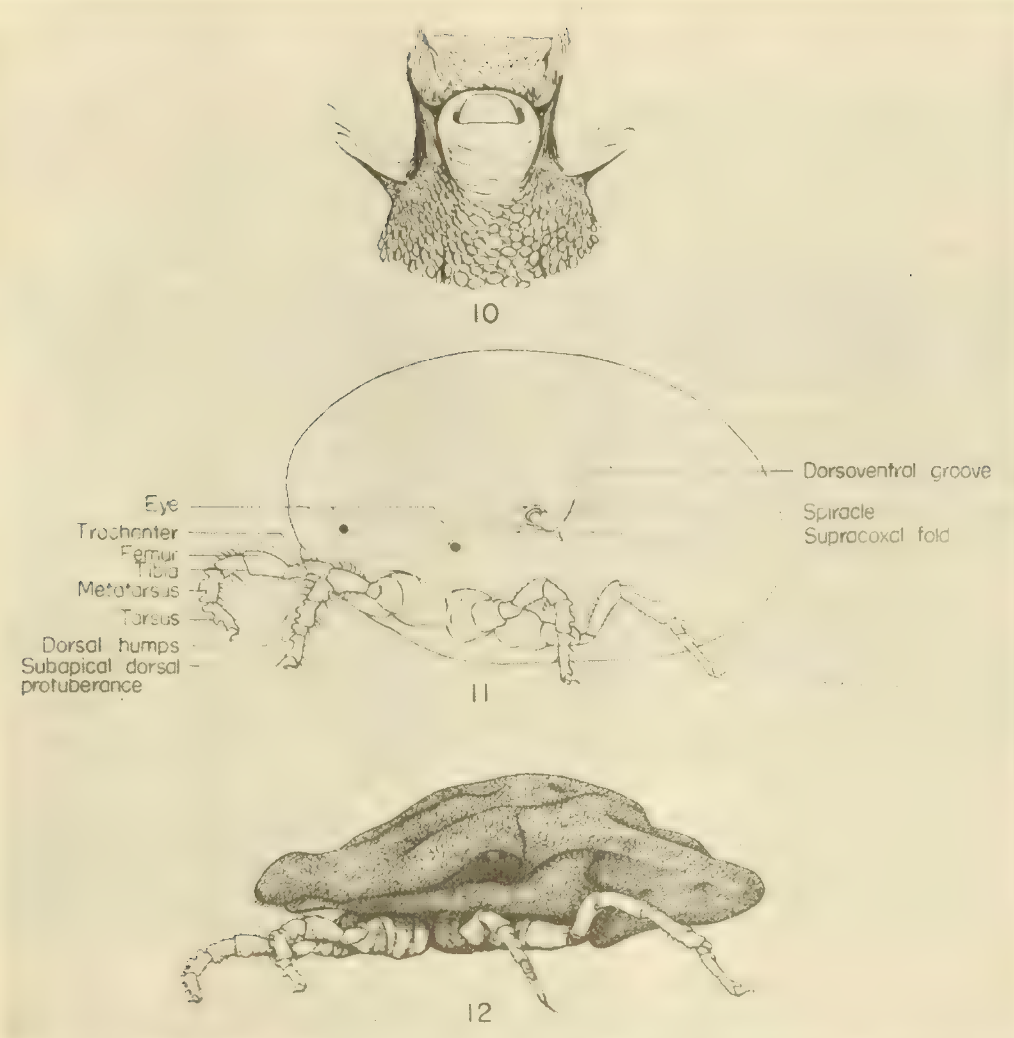


Figure 10, ♂, genital area
Figure 11, ♀, greatly engorged, lateral view (sketch)
Figure 12, ♀, slightly engorged, lateral view

KEY MORPHOLOGICAL CHARACTERS, FAMILY ARGASIDAE

Ornithodoros savignyi (Egyptian specimens)

PLATE VI

ARGAS

INTRODUCTION

Six Argas species occur in the Sudan. Four or possibly five other rare kinds have been recorded elsewhere in Africa. All the Sudan species may bite man, and, except possibly for the bat parasites, all may cause more or less painful sequelae. Insofar as our present knowledge goes, Argas ticks are rarely known to transmit human disease. Birds and bats are the chief hosts of most Argas species. The more widely spread species that parasitize domestic fowls are often serious pests and important vectors of avian diseases. The bat-infesting species also range rather widely and may possibly disseminate pathogenic organisms among their hosts.

Larval Argas ticks, in contrast to the two well-known African argasids, Ornithodoros moubata and O. savignyi, are all active, suck blood, and often may be observed feeding on their hosts. Argas nymphs and adults, like those of Ornithodoros, are usually found only by careful searching in niches and concealed resting places in the immediate habitat of their favorite host.

Ticks of the genus Argas, unless recently engorged, are usually flatter in profile than Ornithodoros, and can in most instances be easily distinguished from them by the presence of some morphological differentiation of the peripheral integument of the body.

Argas ticks are still surprisingly poorly known in most parts of the world and considerably larger collections, more data on their life history, and more exact collecting data are necessary before the biology and systematics of this genus can be finally settled.

The other species of Argas known to occur in Africa, some of which undoubtedly will be found in the Sudan, are the following:

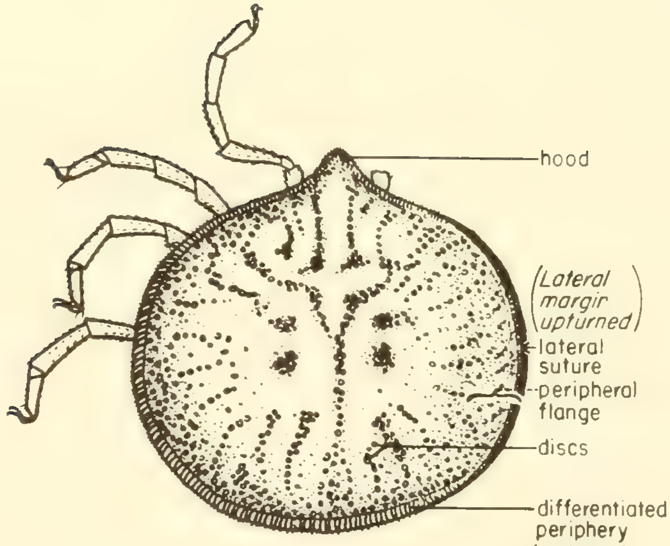
A. aequalis (Neumann, 1901) from Tanganyika. The host is unknown and apparently only the original collection is known. Originally described in the genus Ornithodoros but subsequently referred to Argas (Neumann 1908B).

A. hermanni (Audouin, 1827) from Egypt. Neumann (1896) noted material from Ethiopia and Hoogstraal (1952A) from bird nests in Egypt. We are still studying material referable to this species in view of its possibly unsatisfactory taxonomic criteria and species status.

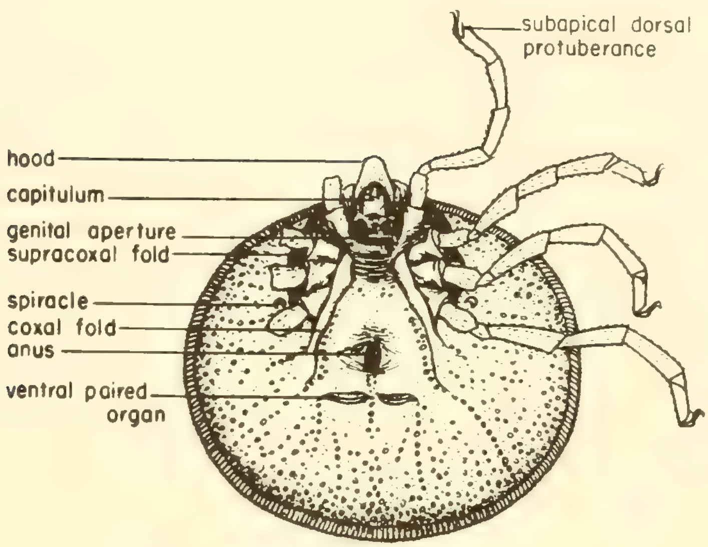
A. striatus Bedford (1932A,1934) from weaver bird nests, Cape Province, South Africa. This species is said to be closely related to *A. aequalis*, but both are in need of comparative biological and morphological studies.

A. transgariepinus (White, 1846) from South Africa. *A. kochi* (Neumann, 1901) from Basutoland possibly is a synonym. Berlese (1913) reported specimens biting a child and walking on the wall of a bank in Italy. Hoogstraal (1952A) described biology in Egyptian bat caves. Hoogstraal (1954C) noted presence in Spain. A report on a study of the life cycle, biology, and morphology of each stage will be presented in a forthcoming paper.

Subgeneric classifications are not included for other groups in this work because their status is still moot. The issue has been forced in the genus *Argas* by the necessity for deciding whether to refer to some species generically as *Carios*, *Ogadenus*, or *Argas*. Studies on this subject are presently under way and will be reported more fully elsewhere.



13



14

Figures 13 and 14, ♀, Hypothetical Argas species

KEY MORPHOLOGICAL CHARACTERS, GENUS ARGAS

PLATE XII

KEY TO SUDAN SPECIES OF *ARGAS*

MALES AND FEMALES

1. Pair of transverse, slitlike organs situated just posterior of anus. Body outline generally subcircular or wider than long. (Bat parasites)....................................2

   Ventral paired organs lacking. Body outline oblong, considerably longer than wide. (Not bat parasites)....................................4

2. Legs as long as or longer than body. Hood present. Peripheral differentiation of integument and lateral suture lacking..*A. BOUETI*
   Figures 23,24,33,34

   Legs shorter than body....................................3

3. Body outline considerably wider than long. Hood present. Peripheral differentiation of integument and lateral suture lacking....................................*A. CONFUSUS*
   Figures 25,26,35,36

   Body outline generally subcircular or circular, never as wide as *A. confusus*. Hood absent. Peripheral integument striated and lateral suture present.........*A. VESPERTILIONIS*
   Figures 21,22,37,38

4. Dorsum with large, depressed polygonal areas. Size large (15 mm. to 22 mm. long). (Adults parasitic on mammals).............*A. BRUMPTI*
   Figures 19,20,31,32

   Dorsum finely wrinkled. Size moderate (10 mm. long, usually less). (Fowl parasites)....................................5

5. Dorsal and ventral periphery of distinct quadrangular "cells". Postpalpal hairs present. (Chicken parasite, common in Sudan)..A. PERSICUS
Figures 15,16,27,28

Dorsal and ventral periphery finely wrinkled. Postpalpal hairs absent. (Pigeon parasite, very rare in Sudan).............A. REFLEXUS
Figures 17,18,29,30

Figures 15 and 16, *Argas persicus*
Figures 17 and 18, *Argas reflexus*
Figures 19 and 20, *Argas brumpti*
Figures 21 and 22, *Argas vespertilionis*
Figures 23 and 24, *Argas boueti*
Figures 25 and 26, *Argas confusus*

DORSAL PERIPHERAL DIFFERENTIATION (odd numbered figures) AND LATERAL INTEGUMENT (even numbered figures) OF *ARGAS* SPECIES.

Note especially the presence of a lateral suture in Figures 16,18,20 and 22 and its absence in Figures 24 and 26.

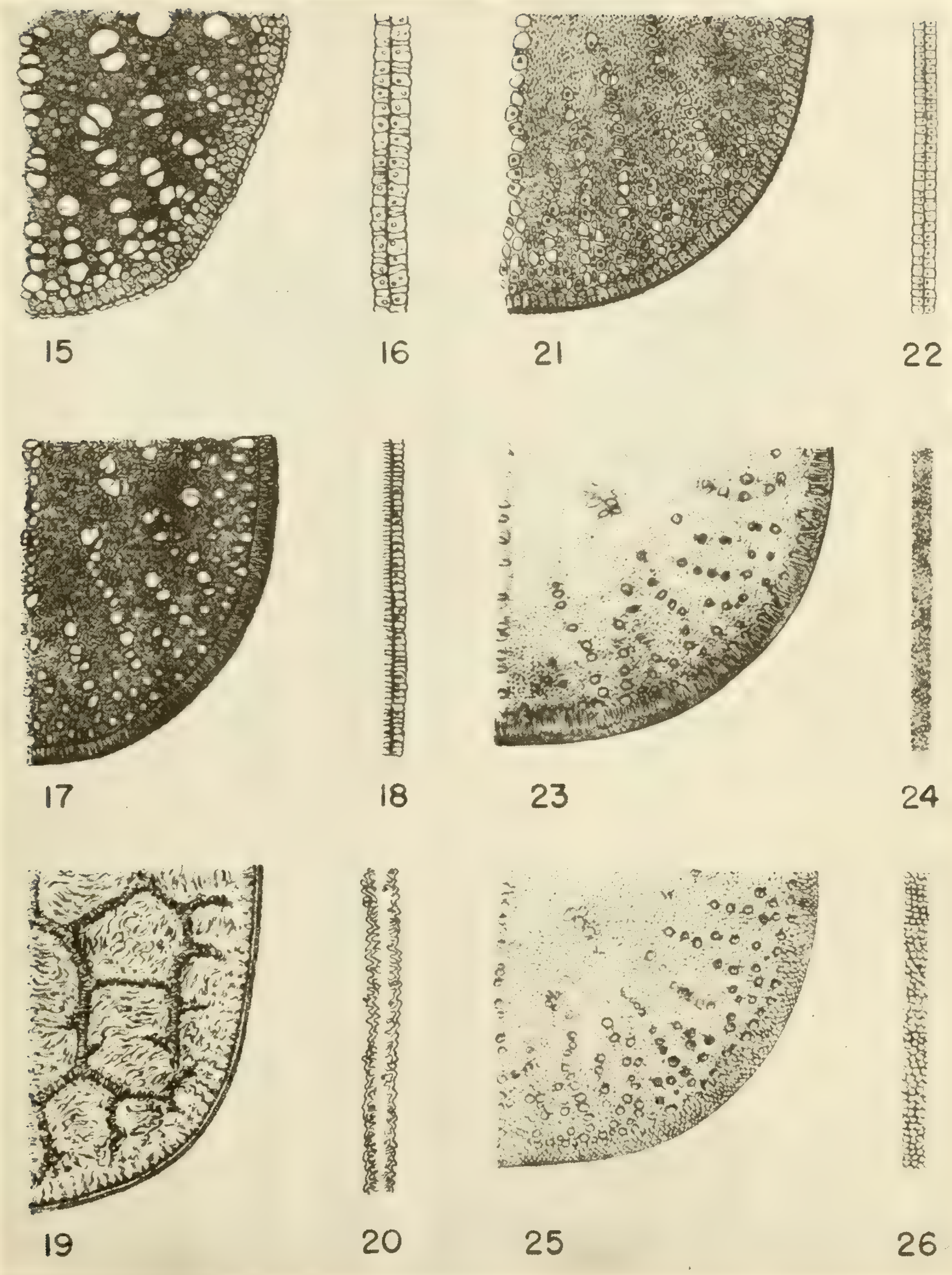
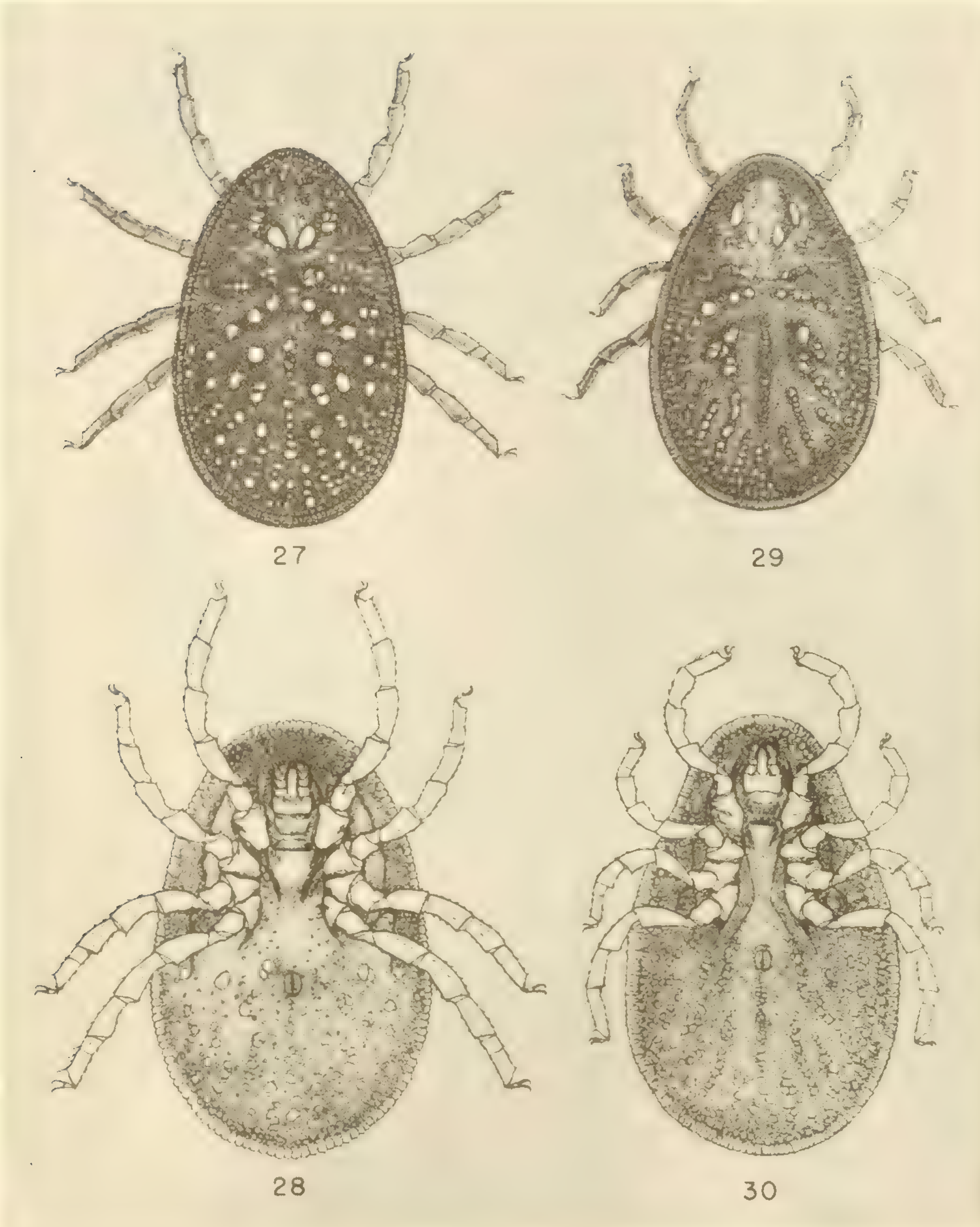


PLATE VIII
(Legend on opposite page)



Figures 27 and 28, Argas persicus, ♀, dorsal and ventral views
Figures 29 and 30, Argas reflexus, ♀, dorsal and ventral views

ARGAS (ARGAS) PERSICUS and ARGAS (ARGAS) REFLEXUS

Egyptian Specimens

PLATE IX

ARGAS (ARGAS) PERSICUS (Oken, 1818).

(Figures 15,16,27 and 28)

THE POULTRY ARGAS OR FOWL TICK*.

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
1				Kapoeta	domestic chicken	Jul (SGC)
19				Torit	domestic chickens	Dec
684	96			Imurok	domestic chickens	Jan
48	2			Juba	domestic chickens	Dec
	17	11	9	Torit	poultry house	Dec
	12	4	2	Juba	poultry house	Aug

DISTRIBUTION IN THE SUDAN

"Throughout the Sudan" (King 1926). In addition to the above-listed Equatoria Province records, two localities have been published in the literature and I have seen specimens from the following places:

Upper Nile: Malakal (HH).

Bahr El Ghazal: Wau (SVS; HH).

Blue Nile: Kosti, Wad el Nail near Singa, Wad Medani (all SGC). "Blue Nile Districts" (Archibald 1923).

Kassala: Suakin (SGC).

Kordofan: Delami (SGC).

Darfur: Fasher (SVS).

Khartoum: Khartoum (SGC, SVS, Gordon College collection, HH). Omdurman (HH). See also Balfour (1906,1907,1908B,1909,1910,1911A, B,C,D,E,G,1912) for spirochete studies on *A. persicus* from Khartoum.

Northern: Dongola (Neumann 1901). Wadi Halfa, Abu Hamed, Atbara, Ed Damer (HH).

---

*In South Africa, called "The Fowl Tampan" (Theiler 1952A,B).

DISTRIBUTION

A. persicus is now established in most parts of the world between 40°N. and 40°S. as a result of transportation of poultry. In Siberia, this tick occurs even farther north than 55°N. (Olenev 1926,1927). In Argentina, 38°S. is its southern limit (Roveda 1940). As an example of the fowl tick's long range spread, it is said to have been introduced into New Zealand from America. Its initial appearance in many parts of the world is believed to have been during early Persian conquests though the species did not necessarily originate in Persia (Robinson and Davidson 1913A).

Once introduced, the fowl tick often spreads quickly and widely, as it has done in Argentina where it became a common pest within sixteen years after first reported (Lahille and Joan 1931, Roveda 1940, Lucas 1940). In the United States, after having first been collected in 1872 in southwestern Texas, its dispersion has been "gradual and orderly" (Parman 1926). In other areas it occurs only sporadically. For instance, in Madagascar, A. persicus is said to be restricted to the western coastal lowlands and absent from the central uplands (Bück 1935,1948A,C). In Mauritius it is not common or widely spread and seldom appears in large numbers (Moutia and Mamet 1947).

The following records are for Africa, Arabia, and outlying islands only.

NORTH AFRICA: EGYPT (Savignyi 1826. Audouin 1827. Taschenberg 1874. Neumann 1901,1911. Nuttall et al 1908. Hirst 1914. Mason 1916. Carpano 1929A,B,1935. El Dardiry 1945. Said 1948. Fahmy 1952. Hoogstraal 1952A. Floyd and Hoogstraal 1956. Hurlbut 1956. Taylor, Work, Hurlbut, and Rizk 1956). LIBYA (Zanon 1919. Franchini 1926,1929E. Tonelli-Rondelli 1932A,D. Gaspare 1933. Stella 1938C). TUNISIA (Galli-Valerio 1909A,1911B,1914. Comte and Bouquet 1909. Blaizot 1910. Neumann 1911. Langeron 1912, 1921). ALGERIA (Neumann 1901,1911. Brumpt and Foley 1908. Edm. Sergent and Foley 1910,1922,1939. Hindle 1912. Robinson and Davidson 1913A. Donatien 1925. Catanei and Parrot 1926. Foley 1929. Clastrier 1936). MOROCCO (Delanoë 1923. Delanoë and Lelaurin 1923).

WEST AFRICA: NIGERIA (Absence of A. persicus: Macfie and Johnston 1914. Presence of this tick: Mettam 1943). GOLD COAST

(Stewart 1933,1934). FRENCH WEST AFRICA (Bouet 1909. Brumpt 1909B. Rousselot 1951,1953B). [LIBERIA: Absence of A. persicus, Bequaert (1930).] PORTUGESE GUINEA (Tendeiro 1951C,1952A,C,D, 1953,1954).

CENTRAL AFRICA: CAMEROONS (Mohn 1909. Rageau 1953B). BELGIAN CONGO and RUANDA-URUNDI (Ghesquiere 1919,1921A,B,1922,1928. Schwetz 1927A,B. Bequaert 1930A,B,1931. Gillain 1935. Schoenaers 1951A). No records seen from French Equatorial Africa.

EAST AFRICA: SUDAN (Neumann 1901. As A. miniatus: Balfour 1906. Balfour 1906,1907,1908B,1909,1910,1911A,B,C,D,E,G,1912. Nuttall et al 1908. King 1908,1911,1921,1926. Archibald 1923. Tonelli-Rondelli 1930A. de Beaurepaire Aragao 1936. Kirk 1938B. Hoogstraal 1954B).

ETHIOPIA (Neumann 1911). ERITREA (Franchini 1929E. Niro 1935. Stella 1938A,1939A,1940. Ferro-Luzzi 1948). BRITISH SOMALILAND (Drake-Brockman 1913B,1920. Stella 1940). ITALIAN SOMALILAND (Brumpt 1909A. Paoli 1916. Franchini 1925,1929E. Niro 1935. Stella 1938A,1939A,1940).

KENYA (Anderson 1942A,B. Lewis 1931C,1939A. Piercy 1948. Wiley 1953). UGANDA (Mettam 1932 stated that A. persicus was then not yet reported, but Wilson 1950C lists it as present). [TANGANYIKA: ?No records.]

SOUTHERN AFRICA: ANGOLA (Howard 1908. Absence in San Salvador: Gamble 1914. Sousa Dias 1950. Bacelar 1950. Santos Dias 1950C). MOZAMBIQUE (Howard 1908,1909C,1910. Theiler 1943B. Santos Dias 1953B,1954H).

"RHODESIA" (Robinson and Davidson 1913A). [NORTHERN RHODESIA: ?No records.] SOUTHERN RHODESIA (Little 1919,1920. Jack 1921, 1928,1937,1938,1942. Cooper 1944). NYASALAND (De Meza 1918A. Wilson 1950B).

SOUTHWEST AFRICA (Tromsdorff 1914. Sigwart 1915. Warburton 1921. Mitscherlich 1941. Schulze 1941). BECHUANALAND (As "tampans": "J.G." 1943). UNION OF SOUTH AFRICA (Lounsbury 1895,1899B, C,1900A,B,C,1903B,1904D. Dönitz 1907C,1910B. Howard 1908,1909C, 1910. Nuttall et al 1908. Bourlay 1909. Jowett 1910. Neumann

1911. Robinson and Davidson 1913A. Bedford 1920,1926,1927,1932B, 1934. Du Plessis 1932. Robinson and Coles 1932. Bedford and Coles 1933. Bedford and Graf 1934,1939. Mönnig and Coles 1934, 1936,1939,1940. Coles 1933,1945. Cooley 1934. des Ligneris 1939. Mitscherlich 1941. R. du Toit 1942B,C,1947A,B. Gericke and Coles 1950. Annecke and Quinn 1952).

OUTLYING ISLANDS: MAURITIUS (As A. mauritianus: Guerin-Meneville 1829-1843. Neumann 1911. De Charmoy 1914,1915,1925. Moutia and Mamet 1947). MADAGASCAR (Recorded by Bück 1935,1948A, C,1949. Millot 1948 states that A. persicus does not occur on Madagascar but Bück seems to have definite evidence that it does. Hoogstraal 1953E). REUNION (Gillard 1947,1949). SEYCHELLES (Millot 1948). [ZANZIBAR: ?No records.]

ARABIA: YEMEN (Hoogstraal, ms.).

HOSTS

A. persicus in all stages is chiefly a parasite of chickens. Ducks, geese, turkeys, and infrequently pigeons, are attacked. This parasite often becomes so numerous in fowl houses that the birds die from exsanguination. Canaries are sometimes attacked, and in South Africa young ostrichs have been killed from the volume of blood lost to these ticks.

Wild birds may be infested if they construct large, numerous, or fairly permanent nests in the vicinity of human activities. The question of infestation of other wild birds and of mammals is a most uncertain one. Although the fowl argas does parasitize man on occasion, the frequency and fierceness of these attacks have been fancifully exaggerated and enhanced to the point that it might even seem advisable to exterminate Africa's chickens rather than subject mankind on this continent to the scourge of his fowls' argasid parasite.

Wild bird hosts

Rookeries of the buff-backed heron, Bubulcus ibis ibis, in parks in and near Cairo (Hoogstraal 1952A) and heron rookeries in South Africa are heavily infested (Theiler, correspondence). In the Nile Barrage Park near Cairo, literally tens of thousands of fowl ticks in all stages can be found in crevices and under bark of any large fig tree in which herons roost and nest.

In Pakistan, Abdussalam and Sarwar (1953) found frequent parasitism of vultures and common herons in sixteen kinds of trees in which these birds nest. Other birds and palm squirrels also perch in these trees, but only a young kite was found infested. (Whether smaller birds and squirrels were examined for ticks is not clear from the report). On trees with relatively smooth bark and few cracks, ticks extended down the trunk almost to the ground, but on those with cracked bark they concentrated chiefly in the upper branches near the perches of their hosts. (In the Cairo area, rough-barked trees harbor tremendous tick populations from near the roots to the crown). The incidence of ticks in trees harboring vultures and herons was much higher than it was in nearby chicken houses.

Specimens have occasionally been reported from isolated nests of wild birds and on ground birds such as quail. Howard (1908) recorded the secretary bird and Bedford (1934) the guinea fowl as wild hosts. Theiler (unpublished) informs me of the following South African records: wattled crane, hadada ibis, and pelican. King (1926) reported the guinea fowl, buff-backed heron, and crow as wild hosts of the larval stage in the Sudan. Specimens from guinea fowl at Khartoum (SGC) probably came from zoological garden hosts.

Identification of larvae from wild birds that construct isolated nests and that do not live close to human habitations should be regarded with suspicion if these larvae have not been identified by a contemporary expert in argasids. Larvae of related species closely resemble those of <u>A. persicus</u>. Wild bird parasites are so poorly known that the presence of argasid larvae on them should be a hint to consider rare or poorly known tick species before concluding definitely that those found are <u>A. persicus</u>. The mouthparts of larvae pulled from birds are usually broken unless extreme caution is exercised and the body characters are frequently obscured by engorgement so that it is difficult to identify the material.

Wild Mammal Hosts

Apparently the only authentic report for the fowl tick from a wild mammal is a note of three adults from a Texas jack rabbit shot in 1906 (Hooker, Bishopp, and Wood 1912).

Domestic Mammal Hosts

Howell, Stiles, and Moe (1943) believe that *A. persicus* may feed on cattle more commonly than is generally suspected but reasons for this assumption are not presented. This tick has been vaguely reported from Persian animals (Aluimov 1935) and, on the basis of a museum specimen label, from cattle in the Congo (Schwetz 1927B). Hoffman (1930), apparently from personal information, stated that in Mexico *A. persicus* may bite animals and man in the absence of fowls. In the United Provinces of India, Sen (1938) listed this species "off dog". Varicus workers have reported that they were unable to induce the fowl argas to feed on laboratory or domestic animals, or, if some blood was taken, the meal was only a partial one.

Human Hosts

Authentic records of *A. persicus* attacking man in almost all instances stress the infrequency of such experiences. Reports in certain textbooks of medical entomology that the fowl tick is an important pest of man or even "a veritable scourge .... in the Sudan and South Africa" (!) are without the slightest foundation (see below).

In the Sudan, King (1926) reported, *A. persicus* rarely bites man. Several nymphs and adults in Sudan Government collections are labelled "from Yemenese man, Suakin, 7-3-09, O. Atkey". The inference is that the specimens were taken on the person. The numerous Kosti specimens already mentioned in Sudan records arouse suspicion that this species have been a pest in houses there at one time. My own inquiries in many parts of the Sudan and from reading a considerable number of travel, medical, and natural history reports of the Sudan have failed to reveal any indication that *A. persicus* is known as a human pest anywhere in the Sudan.

In South Africa, Bedford (1934) wrote, *A. persicus* seldom attacks man. Lounsbury (1900C, 1903B) recorded a severe bite on a person in Graaff-Reinert, and stated that he had heard of two other persons who were bitten, but, especially in the former paper, he minimized the importance of *A. persicus* as a pest of people, as did Behr (1899) for California. Howard (1909C), however, heard of a South African cart that had been stored in an old infested chicken house; "no one was able to ride in it afterwards". In Southern Rhodesia, *A. persicus* is pre-eminently a fowl parasite (Jack 1921).

Drake-Brockman (1913B,1920) stated that this tick is found in or near huts in British Somaliland but that it does not bite man there. From the United Provinces of India, Sen (1938) noted A. persicus "on bed (presumably can infest man)". "This species was reported from Quetta (India) where it was stated to infest houses and to bite human beings" (Warburton 1907). As stated above, Hoffman (1930), remarked that in Mexico A. persicus may bite man and animals in the absence of fowls, but details were not provided. In Korea, Kobayashi (1925) "examined certain specimens of Argas persicus .... said to have stung men".

Old Iranian (Persian) reports that A. persicus is such a pest of human beings that whole villages have had to be moved, so widely quoted from Nuttall et al (1908) who reviewed the earlier literature, hardly bear contemporary repetition. The evidence in all cases is circumstantial and based on hearsay. That these fables should have gained the stature of serious fact in most books of medical entomology is a reflection on methods of textbook fact-finding. One writer has even gone so far as to throw in for good measure a large part of the African continent as a scourged area. Since 1890 there has been hardly a single published eyewitness or corroborated report of Argas persicus biting human beings that has not referred merely to isolated instances. Though some bites have been described as painful, only one or two have been shown to cause other sequelae.

Twentieth century Iran has not provided evidence to corroborate the early apparent misrepresentations concerning the fowl tick. Carre (1909), in reporting on the frequency of larval attacks on chickens in Teheran did not mention that man is attacked. Harold (1922) expressed the belief that Ornithodoros lahorensis Neumann is actually responsible for painful bites attributed to A. persicus in Iran [cf. also Harold (1920)]. Dr. Baltazard, Director of the Pasteur Institute in Teheran, an outstanding student of argasid ticks and of their disease relations, informs me that he knows of no troubles from A. persicus in Iran so far as human beings are concerned. Delpy (1947B) observed large numbers of A. persicus and O. lahorensis in and around peasant houses and stables near Persepolis in Iran but he did not mention bites of either species. Delpy and Kaweh (1937), however, record an actual observation in Iran of a laboratory person who, when washing his hands, noted a large nymphal fowl tick biting him. The bite was painless but the victim succumbed to a bout of anthrax, demonstrated to have been transmitted by the attack.

In Palestine, Nicholson (1919) and Dunlop (1920) attributed human relapsing fever to bites of A. persicus. Their reports were based entirely on circumstantial evidence [cf. also Balfour (1920A,B), Woodcock (1920), MacKenzie (1920), etc.]. Experimental evidence negates this probability.

Members of my staff and I on several occasions have questioned people who spend much time in heavily infested parks and houses in and near Cairo without finding anyone who acknowledged being bitten.

Apparently reliable accounts of A. persicus infesting human huts in which chickens are also kept, and not infrequently biting persons, are those of Sergent and Foley (1910,1922,1939) from Algeria. Natives there refer to fleas and to the fowl argasid by the same name, Although the ticks are frequently associated with cases of human relapsing fever, they were proven by these observers to have a negative role in the transmission of spirochetes causing the disease.

There are a few scattered, apparently authentic reports of A. persicus biting man outside of Africa. One such, a vivid description enhanced by illustrations of the tick and of dark weals where the human victim was bitten, has been reported from Romania by Ciurea and Stephanescou (1929). The attacks occurred inexplicably in the upper stories of a new concrete apartment house and no chickens or pigeons were known to have been associated with the buildings.

With regard to the lively account of attacks by "A. persicus" on indigent persons in Chile (Porter 1928), see A. reflexus, p. 77.

Reptile and Amphibian Hosts

Although A. persicus always shows a predilection for avian blood, it will feed on toads if the skin of these animals is warmed, according to Galli-Valerio (1911B). The blood is probably toxic for the ticks die afterwards.

The record of A. persicus from a tortoise in Iran (Michael 1899) is most probably based on misidentification or incorrect or incomplete specimen labelling.

Infestation of Human Habitations (Africa)

African records of *A. persicus* in huts of indigenous people (inferred presence of chickens in some huts) are: Annecke and Quinn (1952) for South Africa, Drake-Brockman (1913) for Somaliland, Sergent and Foley (1919,1922,1939) for Algeria, and Sudan records above. Lounsbury (1903B) stated that the fowl tick seldom occurs in South African houses unless chickens are kept close by.

BIOLOGY

Life Cycle

Among the many references to some phase or other in the life cycle of *A. persicus*, some of the more important are: Lounsbury (1903B) for South Africa, Nuttall *et al* (1908) for laboratory observations, Olenev (1928A) for the Saratov area of Russia, Roveda (1940,1950) for Argentina, Bodenheimer (1934) on temperature and humidity tolerance, and Zuelzer (1920A,B,1921) on feeding, excretion, and life cycle. Hooker, Bishopp, and Wood (1912) contributed a detailed study of the life cycle in southern United States and reviewed earlier literature. These authors also provided data on growth and size of the fowl tick.

The life cycle in general under favorable conditions requires about four months.

Larvae attach usually to the base of the host's wing. They feed there for five to ten days before dropping from the host and seeking shelter. Nymphs and adults become satiated in from five minutes to two hours and then seek a sheltered place in the building, yard, or tree in which they secrete themselves. Feeding is usually done at night, sometimes in subdued light, seldom if ever in strong light.

Coxal fluid is emitted within a few minutes after engorgement is complete and often while the tick is stationary or moving about the host, but only infrequently while the mouthparts are still inserted in the host's skin.

Digestion is extremely slow and fowl blood may be identified by the precipitin test for at least 23 months after ingestion (Gozony, Hindle, and Ross 1914).

The following notes are chiefly from Hooker, Bishópp, and Wood (1912). Many more details may be found in their report.

Usually females oviposit after each meal, which may number up to six or seven in a lifetime. Under exceptional conditions, a female may require two blood meals before laying eggs. The greatest number of eggs deposited after the first few blood meals increases progressively from 195 to 646, but decreases after subsequent feedings to as few as 47 eggs following the seventh or last feeding. The average number of eggs laid after each engorgement was: first, 131; second, 159; third, 133; fourth, 110; fifth, 97; sixth, 95; seventh, 47. Eggs are laid in the adult tick's retreat.

Oviposition generally commences four to ten days after feeding, in summer sometimes as early as the third day. In winter or in the absence of males, egg laying may be delayed for weeks or months. Oviposition of moderately large batches continues over a six to ten day period but only three days are required for depositing a small number of eggs. In nature it appears that the fowl argas seldom engorges and oviposits more than five times, unless females commence feeding early in the spring.

Incubation of eggs extends over an eight to eleven day period in warm summer weather, but in cooler climates or seasons this period is extended to three weeks or even longer.

As stated above, larvae generally feed for from five to ten days, but they may complete engorgement in three or four days, and Rohr (1909) recorded two days. There is some indication that quiet, setting hens allow the greatest number of larvae to thrive, and that different breeds of hosts exert no influence on larval development. In NAMRU-3 laboratories, Dr. Herbert S. Hurlbut (unpublished) is finding that only a moderate number of larvae kills chickens used in his experiments, apparently not doing so by transmission of pathogenic organisms or by exsanguination. Nymphs and adults resulting from these larvae have no observable deleterious effect on their hosts. Reasons for this exceptional larval toxicity have not yet been ascertained.

Larvae survive unfed for over five months in cool weather, but in Texas during midsummer they succumb in about two months. At 30°C. and 70% R.H., unfed Egyptian larvae survive for up to thirty days (H. S. Hurlbut, personal communication).

Larvae molt to nymphs in warm summer weather about four days following completion of feeding.

Nymphs usually feed twice, in a matter of half an hour (sometimes two hours) and molt a week or two (sometimes longer) afterwards. Some nymphs undergo a third molt before reaching adulthood; this phenomenon cannot be correlated with sex, food supply, or climatic conditions. Unfed second instar nymphs survive up to a year but first instar nymphs are known to live for only up to nine months.

Female feeding has been discussed above. Copulation is similar to that described for O. moubata (page 134).

Adults may live as long as three years without food (Laboulbene 1881) but this appears to be exceptional. Unfed adults generally succumb more rapidly than engorged adults, which normally appear to live from five to thirteen months, but which may on occasion survive longer.

Besides being a particularly intriguing study for some workers, the ability of the fowl tick to withstand starvation for long periods no doubt accounts in part for its wide distribution and large numbers. Observations made by Newman (1924) on longevity without food were summarized as follows: Test 1: An isolated female lived two years and three months, (2) it produced fertile eggs four months after isolation, and (3) larvae lived for three months. Test 2: (1) Males died four months after isolation, (2) first female died after two years and four months, (3) two females lived three years, (4) three females lived four years, and (5) the maximum time a female lived was four years and five months. Removal of fowls from a house or yard is in itself of little use in ridding the premises of ticks.

Larval survival without food for 228 days at 22°C. to 26°C. and 90% to 100% relative humidity was reported by Roveda (1940). At temperatures of 37°C. to 38°C. and at relative humidities of 85% to 100% larval survival was reduced to an average of 50 days.

Ecology

All stages congregate on walls, in crevices, or between boards of poultry houses. Around Cairo we find literally tens of thousands under loose bark, in crevices, and on the trunks of trees in city-park heron rookeries. Trees in which chickens roost are frequently reported as hiding places for *A. persicus*. Other habitats have been discussed under HOSTS above.

The ability of eggs, larvae, nymphs and adults to withstand a wide range of temperature and humidity conditions has been studied by Bodenheimer (1934). Fifty-nine observations of nymphs and adults in temperature gradients ranging from 2°C. to 47.7°C. failed to exhibit a significant response to changing temperature stimuli. While the vital optimum of the egg stage is 20°C. and 80% relative humidity, the tolerance to fluctuating climatic factors is remarkably great. Even at 20% relative humidity, mortality is only slightly greater than at optimum conditions of environmental moisture. The thermal constant for the egg stage is 316 day-degrees. At temperatures of from 33°C. to 18°C., eggs hatch in from 10.5 days to 33.3 days (from highest to lowest temperature). Temperatures of 15°C. and below inhibit egg hatching. At high temperature (33°C.), a relative humidity of at least 60% is necessary for hatching. At moderate temperature (18°C. to 27°C.), there is little difference in numbers of larvae hatching from eggs maintained at various percentages of relative humidity ranging from twenty to a hundred.

The ability of *A. persicus* to withstand desiccation and high temperatures has been studied by Lees (1947) in his excellent research on transpiration and epicuticle structure in ticks.

In Argentina, the optimum temperature for egg hatching is said to be between 22°C. and 38°C. with relative humidity from 90% to 100%. Mortality increased from 4.85% under the above conditions to 22.45% at 37°C. and 80% to 95% relative humidity. [Roveda (1940)]

It appears, from these observations as well as from the comparatively great adaptability of this species as demonstrated by its wide geographical range, that *Argas persicus* is less restricted by higher humidity factors than are many other argasids.

In cold climates such as Saratov, Russia, development occurs only at temperatures over 20°C. Exposure to high humidity (presumably at cold temperatures) kills the ticks (Olenev 1926,1928A).

The presence or absence of A. persicus in coastal areas frequently is referred to in literature. Lounsbury (1903B) stated that A. persicus is everywhere common in South Africa, including coastal towns and areas. Howard (1908) reported that in South Africa this tick is common except near the coast and that the same distributional pattern had been reported from Australia. Records from a number of other localities indicate that the fowl tick does indeed inhabit coastal areas. For instance, Theodor (1932) reports this species especially common along the Mediterranean coast and in Jordan Sea areas of Palestine. In Egypt, we find it commonly in coastal villages and cities. We have also found cast nymphal skins at Djibouti, the seaport of French Somaliland. It occurs at Port Sudan on the Red Sea coast of Sudan (Sudan Government Collection record) and at Hodeida on the opposite coast in Yemen (Hoogstraal, ms.). In Reunion, Gillard (1949) reported the fowl tick particularly common on the coast, and in Madagascar it occurs chiefly in coastal areas (Bück 1935,1948A,C).

Concerning altitudinal range, A. persicus is frequently reported as common in lowlands and rare or absent in highlands. In mountains of the Sinai Peninsula of Egypt we find numerous specimens at elevations up to 6000 feet.

Lewis (1939A) stated that in Kenya A. persicus is present only in European areas. This is certainly not true for the Sudan, where chicken flocks of many remote, indigenous tribes have been known to be infested for half a century. More recently, Wiley (1953) indicated that the fowl tick is increasing its range in Kenya.

An apparent negative geotropism displayed by unfed larvae reared from adults collected from trees serving as a heron rookery has been observed by Dr. H. S. Hurlbut at NAMRU-3, Cairo. At the same time, larvae from adults collected from chicken houses appeared to show a positive geotropism. The F_1 larvae of adults from heron rookeries were inclined to prefer herons rather than chickens as hosts and the reverse appeared true for larvae from adults from chicken houses. Informal as these observations are, they suggest an interesting research problem.

DISEASE RELATIONS

MAN: Reported sequelae of the fowl argas' bite range from itching to death. Actually, there are no trustworthy accounts of severe illness resulting from a fowl argas bite. Anthrax (Bacillus anthracis), however, has been transmitted to man by the bite of this tick in the laboratory on one known occasion. Specimens have been experimentally infected with plague (Pasteurella pestis) and with yellow fever virus. A. persicus has been reported in textbooks and discussion papers to transmit human relapsing fever (Borrelia spp.) but there does not appear to be a shred of conclusive evidence to support this claim. Experimental studies to date negate this possibility. The little work done on A. persicus in relation to typhus has gone only far enough to show that the etiologic agent (Rickettsia prowazekii) survives in the tick for ten days. The fowl tick is susceptible to parenteral infection with West Nile virus but does not transmit the virus.

FOWLS: The fowl argas is frequently so numerous that birds are killed by exsanguination. Spirochetosis [Borrelia anserina (= B. gallinarum)] of chickens, ducks, geese, turkeys and canaries is a serious disease transmitted by A. persicus nearly everywhere that it is found, but not everywhere. Fowl piroplasmosis (Aegyptianella pullorum) is also transmitted by the fowl argas, which also has been suggested to be a vector of Grahamella gallinarum. A condition called fowl paralysis by some students and tick paralysis by others, due possibly to a toxin from the tick, sometimes occurs after bites. Chicken cholera or fowl plague (Pasteurella avicida) may cause the death of birds that eat infected ticks. Virus induced fowl tumors are not transmitted by bites of the fowl argas. See next paragraph.

WILD BIRDS: Populations of this tick from Egyptian rookeries of the buff-backed heron or cattle egret have been found infected with Salmonella typhimurium, but others from chicken yards were negative for Salmonella spp.

CATTLE: Successful experimental transmission of anaplasmosis (Anaplasma marginale) by A. persicus has been reported.

MISCELLANEOUS: It has been claimed that West African specimens have been found infected with Q fever (Coxiella burnetii). In Egypt, the fowl argas is infected with one or more viruses distinct from West Nile but otherwise unidentified.

REMARKS

An excellent and detailed study of the internal and external morphology of A. persicus has been presented by Robinson and Davidson (1913A,B,1914), and by Patton and Cragg (1913). An earlier work is that of Heller (1858). Rohr (1909) reported on life cycle and biological studies in Brazil, and included a few photomicrographs of internal organs. Regeneration of broken appendages has been reported by Hindle and Cunliffe (1914) and by Nuttall (1920B). Sensory perceptions have been studied by Hindle and Merriman (1912). The coxal cymatium of A. persicus has been discussed by Schulze (1936A), who also (1941) described and illustrated the haller's organ. Micks (1951) gives an account of a convenient rearing technique and life cycle observations and Sapre (1943) described his method for laboratory rearing. Immunity of chickens to bites of the fowl argas has been studied by Trager (1940). Anticoagulin in the salivary glands and gut has been reported by Nuttall and Strickland (1909) and by Cornwall and Patton (1914). The salivary glands have been described and illustrated by Heller (1858) and Elmassian (1910).

Larvae of clothes moths, Tineola biselliella, have been observed attacking living larvae of A. persicus in laboratory colonies (Volimer 1931).

According to Zuelzer (1921), A. persicus and A. reflexus mate and produce fertile offspring. We have been unable to duplicate these results in our Cairo laboratories.

Observations on the bacteriostatic factors in blood-engorged ticks, including A. persicus (Anigstein, Whitney, and Micks 1950A, B), prompted further studies showing that bacterial growth inhibition in vitro is comparable with the phenomenon induced by antibiotics (Whitney, Anigstein, and Micks 1950) and that a blood hydrolysate called sanguinin is responsible (Micks, Whitney, and Anigstein 1951). This subject is reviewed under O. moubata (page 178).

Symbiots of A. persicus have been described in some detail by Cowdry (1925C, 1926A, 1927) and by Jaschke (1933).

The subgenus Argas is tentatively defined as follows:

"Parasites chiefly of fowls. Morphological characters entirely of genus Argas. Sutural line (i.e. lateral groove) encircling body. With a flattened body flange morphologically differentiated dorsally and ventrally by a row of quadrate cells or by fine striations or wrinkles; body shape elongate. Integument finely wrinkled; discs conspicuous, radially distributed; lacking ventral "paired organ". Hood lacking; mouthparts posterior of anterior body margin by a distance about equalling their own length. Legs moderate; tarsal humps lacking".

A. reflexus was designated as the type species of the genus Argas by Latreille (1802) and is so considered by Cooley and Kohls (1944) and by Pospelova-Shtrom (1946) [Nuttall et al (1908) preferred to use A. persicus]. A. reflexus would, therefore, also be the type species of the subgenus Argas.

The size of each stage and of each sex, engorged and unengorged, has been reported by Hooker, Bishopp, and Wood (1912) and by Campana-Rouget (1954).

IDENTIFICATION

A. persicus is easily recognized by characters listed above for the subgenus Argas, with the restriction that its dorsal and ventral periphery is marked by a row of quadrate "cells" (fine striations in A. reflexus).

The male is seldom over 5.0 mm. long and has a semicircular genital aperture. The female measures from 4.0 mm. to 11.0 mm. long and has a narrow, transverse genital aperture.

Nymphs are similar to adults except that they lack a genital aperture although advanced instars may have a shallow depression in its place.

Larvae are nicely illustrated in various editions of Brumpt's Precis.

ARGAS (ARGAS) REFLEXUS (Fabricius, 1794).

(Figures 17,18,29 and 30)

THE PIGEON ARGAS

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	2	1	1	Juba	domestic pigeon cote	Nov
	1			Juba	domestic pigeon cote	Jan

These specimens were collected in 1949 and 1950 but subsequently we have been unable to find the pigeon argas in Juba or elsewhere in the Sudan. These few may have been remnants of stragglers or of a small number of introduced individuals. If it is a normal inhabitant of the Sudan, the pigeon argas is sporadic and rare here. No other specimens are known from the Ethiopian Faunal Region, except those reported by Rousselot (1951,1953B) from French West Africa and one, possibly this species, from Kenya (Heisch 1954B).

DISTRIBUTION

Argas reflexus appears to be a Near or Middle Eastern tick that has spread northward through Europe and Southwestern Russia and eastward to India and elsewhere in Asia (the status of related species or subspecies in Asia requires further study). It may have been accidentally introduced into a few localities in the Ethiopian Faunal Region north of the Equator and to parts of the Americas. If so, transportation of infested domestic pigeons undoubtedly has been responsible for this range.

NORTH AFRICA: EGYPT (El Dardiry 1935. Hoogstraal 1952A. Taylor, Work, Hurlbut, and Rizk 1956). ALGERIA (Nuttall et al 1908. Neumann 1911. Presence not subsequently verified). [Unknown in Tunisia (Colas-Belcour 1929B).]

WEST AFRICA: FRENCH WEST AFRICA (Rousselot 1951,1953B from Bamako, Soudan).

EAST AFRICA: SUDAN (Hoogstraal 1952A,1954B).

[?KENYA: Heisch's (1954B) specimen may represent a closely related species.]

NEAR EAST: *A. reflexus* has been reported from Palestine (Theodor 1932), Turkey (Vogel 1927, Kurtpinar 1954) and Iran (Delpy 1947B). Its occurrence in intervening areas is to be expected.

FAR EAST: According to Sharif (1938), this tick, as variety *indicus* Warburton, is an important pigeon parasite all over India.

EUROPE: In Europe, *A. reflexus* is generally distributed and extends at least as far north as Denmark (Christiansen 1934). It occurs also in the British Isles. The Russian range of this tick is said to be confined to the Caucasus, Crimea, and areas bordering southern Europe (Pavlovsky 1948), but Olenev (1929A,B,C,1931A,B,C) also includes Middle Asia and western Siberia. Oswald (1939) did not find the pigeon tick in Yugoslavia.

[AMERICAS: Cooley and Kohls (1944) list western United States and Columbia as collecting localities for ticks that they call *A. reflexus* but that show morphological differences of yet unknown importance as species indicators.]

HOSTS

Domestic pigeons are the chief host of *A. reflexus* and are mentioned by all authors. Man is frequently attacked, especially in the vicinity of long unoccupied pigeon cotes. Chickens, horses, and (in America, see above) wild birds such as the condor, swallow, and screech owl (Cooley and Kohls 1944) have been listed as hosts. In the laboratory, any usually available mammal may serve as host.

The literature contains numerous reports of *A. reflexus* biting man and the painful sequelae of these attacks. Although the pigeon argas is mostly strictly associated with pigeons, the exigencies of its domestic existence drive it to attack persons, possibly more frequently than does *A. persicus*.

Early literature concerning the pigeon argas as a parasite of man has been reviewed by Nuttall *et al* (1908). More recently, Kemper (1934) attributed four cases in Germany to the effects of warm weather. Kemper and Reichmuth (1941) reviewed the literature and reported over twenty attacks in Germany. They believe it possible that this tick might not be able to complete its life cycle on human blood.

It is now evident that Porter's (1928) spirited account of "*A. persicus*" in Calama, Antofagasta Province, Chile, must be referred to *A. reflexus* (or to the American variant; see DISTRIBUTION above), as indicated in the following paragraph. Bites of these ticks were sufficiently numerous and painful for attention to be devoted to the matter in the daily press of the region. Specimens furnished parasitologists as the cause of this "grave molestation" were identified as *A. persicus*. Concerning Porter's report, Kohls (correspondence) has provided the following note for inclusion here.

> "Early in 1950, I received from Dr. Amador Neghme R., Chief Department of Parasitology of the Public Health Service, Chile, four adults and a nymph (said to be) *Argas persicus*, collected in the Province of Antofagasta at the town of Calama. This seems to be the only Chilean place where this tick occurs, and is found in human houses and in dovecotes. In reply to his letter, I said, "Study of this material indicates that the ticks are not *Argas persicus* but *Argas reflexus*, ... The only South American specimens of *reflexus* that I have seen previously were collected in chicken coops at Bogota, Colombia..... The Calama specimens appear to agree in all particulars with *reflexus* of the Old World and from Bogota except for the presence of a few quadrangular plates interspersed with the striae on the flattened margins. This difference could well be due to variation and for this reason I would like to have more specimens from Calama for study". In response to this I received eleven adults from Calama and twenty adults and fifteen nymphs from Chuquicamata, a town about twenty miles away. The source was not mentioned in either case, but all the specimens proved to be the same as those sent previously. In brief, these specimens from Chile that I have seen are not *Argas persicus* but are probably local variants of *A. reflexus*".

The subject of *A. reflexus* as a human parasite will be treated more fully in a subsequent volume of this work.

BIOLOGY

The pigeon tick may remain unfed in or near pigeon houses for many months, or even for several years (Nuttall et al 1908. Mayer and Madel 1950). Feeding is much like that of A. persicus, which attacks poultry, and is accomplished at night. Domestic chickens are apparently considerably less liable to attack by A. reflexus than are pigeons. Hiding places of these ticks are easily found in the cracks and crevices of pigeon cotes. The life cycle appears to be much like that of A. persicus. Restrictive and optimum biological and climatic factors have not yet been reported in literature. Females feed prior to oviposition, but according to Schulze (1943B), males require only a single blood meal annually.

During the larval stage there is no urinary or fecal excretion (Enigk and Grittner 1952). Nymphs and adults immediately after feeding discharge a mixture of urine and feces, followed by further excretion the following day. The simultaneous deposition of urine and feces causes the rapid formation of a "guanocrystal" in the viscous mass, thus frequently leaving a white center of urine surrounded by a dark fecal ring on the surfaces on which the substance has been deposited. (Note: Compare this type of excretion with that of Ornithodoros moubata). Adults deposit only urine for some two weeks after feeding, then at long intervals a mixture of feces and urine. Four weeks after feeding, females begin oviposition, during which time no excretion is seen. Coxal fluid is seldom voided during feeding, but usually begins only following complete engorgement (Zuelzer 1920B, and our own observations).

DISEASE RELATIONS

MAN: Human beings who venture near occupied or long abandoned pigeon houses are readily attacked, and the ticks may invade nearby human habitations after pigeons have left their usual resting places. Pain or irritation may be felt for years after the pigeon argas has bitten. This species is incapable of transmitting spirochetes of African tick-borne relapsing fever (Borrelia duttonii).

PIGEONS: Squabs are especially susceptible to bites of this tick and adults too may suffer to the point of death by exsanguination when their houses are heavily infested. The pigeon argas is of negligible importance in the transmission of Salmonella bacteria among pigeons but does transmit fowl spirochetosis, B. anserina (= B. gallinarum). It is said to be probably capable of transmitting fowl piroplasmosis (Aegyptianella pullorum).

MISCELLANEOUS: In Egypt, the pigeon argas is infected with one or more viruses distinct from West Nile but otherwise unidentified.

REMARKS

Egypt is the only territory on continental Africa where the pigeon tick is known to be of some economic importance. The review of this species for the present work has not been as intensive as for most other species.

The temperature preferences of unfed and engorged pigeon argas have been described by Herter (1942).

The anatomy has been described by Pagenstecher (1862).

According to Zuelzer (1921), *A. persicus* and *A. reflexus* mate and produce fertile offspring. We have unsuccessfully attempted to duplicate this phenomenon in our Cairo laboratories.

With reference to remarks on coxal fluid by Remy (1921,1922B), see *O. moubata* section, page 173. See also Lavoipierre and Riek (1955).

Senevet (1920A) discussed the relationship of the size of the pads of the first pair of legs in larvae in relation to overall body size.

Schulze (1943B) figured the midgut, as *A. columbarum*, to illustrate his observation that in the argasids, and particularly in this species and in bat-parasitizing species, there is little basal branching of the diverticula but considerable distal branching.

Schulze (1941) also noted and illustrated the haller's organ of each stage of the pigeon argas. K. W. Neumann (1942), a student of Schulze, discussed the morphology and function of the dorsal plate of the larva, also under the name *A. columbarum*.

There is some chance that the name *A. reflexus* refers to a European parasite of wild birds and the correct name of the pigeon parasite should be *A. columbae* (Hermann, 1804) (cf. DuBuysson 1924).

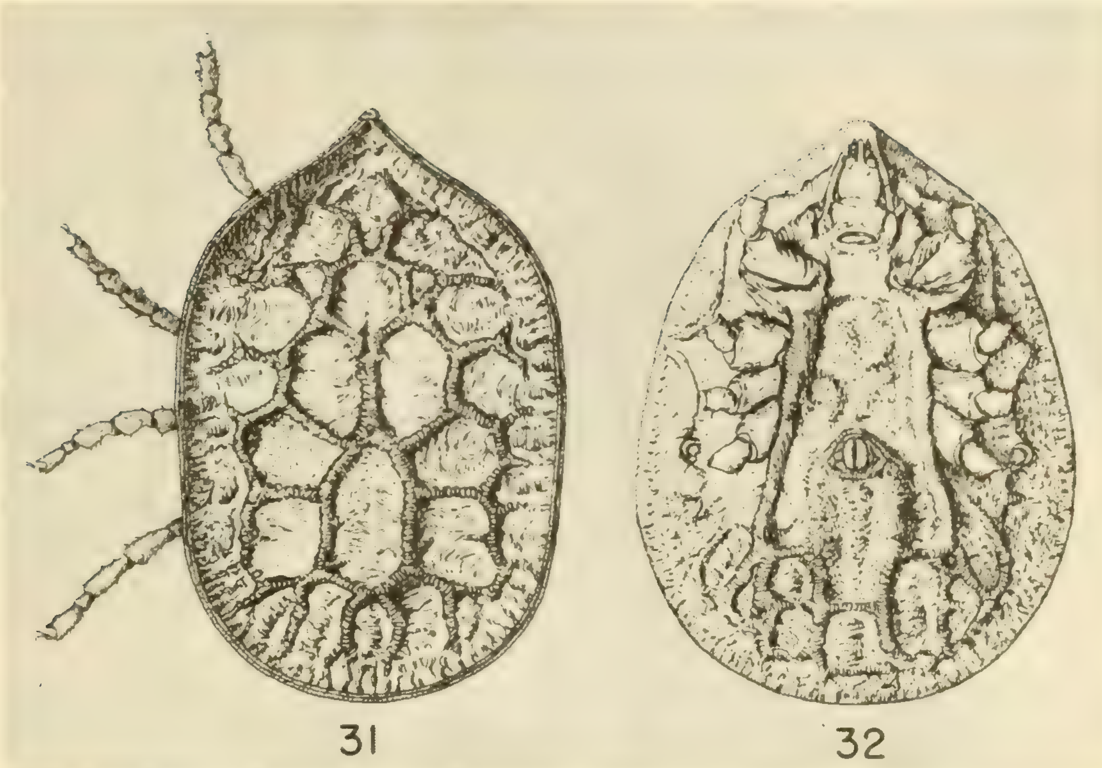
Schulze (1943B), referring to this species as Argas columbarum Shaw, 1793, a name usually considered as a nomen nudum, cited as his authority an apparently unpublished thesis on biology of the pigeon argas by one K. H. Müller (1939, Berlin), whose report I have not seen.

Note, under remarks for A. persicus, the characters of the subgenus Argas and that A. reflexus is considered to be the type species of the genus and of the subgenus (page 74).

A tick of questionable systematic status, A. hermanni (Audouin, 1827) is closely related to or identical with A. reflexus. When commencing the study of this group (Hoogstraal 1952A) it appeared that the two were valid species but subsequent investigation has left me with some doubts. Further observations are at present under way.

IDENTIFICATION

Remarks under identification of A. persicus apply. Note that the dorsal and ventral body periphery of A. reflexus is composed of irregular striations.



Figures 31 and 32, ♀, dorsal and ventral views

ARGAS (OGADENUS) BRUMPTI

Sudan specimen

PLATE X

ARGAS (OGADENUS) BRUMPTI Neumann, 1907(B).

(Figures 19,20,31 and 32)

BRUMPT'S ARGAS

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
12				Imurok	Heterohyrax brucei hoogstraali	Feb
		1		Imurok	Heterohyrax brucei hoogstraali (in den)	Feb
1				Imatong	Heterohyrax brucei hoogstraali	Feb
1				Nimule	Acomys hystrella	Apr

DISTRIBUTION IN THE SUDAN

Blue Nile: Gebelein (El Jebelein) (King 1911,1915), "Blue Nile districts" (Archibald 1923).

Kassala: Erkowit (King 1926).

Kordofan: Nuba Mountains (Ruttledge 1930).

Sudan Government collections contain King's Gebelein collections, numerous laboratory reared progeny, and Ruttledge's specimens from Delami in the Nuba Mountains.

Note the Egyptian records below, most of which are from the Southeastern Desert near the Sudan frontier in that part of Egypt administered by the Sudan Government.

DISTRIBUTION

Argas brumpti is a tick of drier East African areas that has spread into South and Southwest Africa, into that part of south-eastern Egypt that is included in the Ethiopian Faunal Region, and some distance into the Western Desert of Egypt (Palearctic Faunal Region). The distribution has been mapped by Hoogstraal and Kaiser (1956).

NORTH AFRICA: EGYPT (Hoogstraal 1952A. Garnham 1954,1955. Hoogstraal and Kaiser 1956. Davis and Mavros 1956B. Schmidt and Marx 1956).

EAST AFRICA: SUDAN (King 1911,1915,1926. Archibald 1923. Ruttledge 1930. Hoogstraal 1952A,1954B. Hoogstraal and Kaiser 1956).

ETHIOPIA (as Somaliland) (Neumann 1907B,1911,1922. Nuttall *et al* 1908. Stella 1938A,1939A,1940).

KENYA (Neave 1912. Cunliffe 1914B. Anderson 1924A. Warburton 1933. Walton 1950B. Garnham 1954,1955. Heisch 1954F). UGANDA (Hoogstraal and Kaiser 1956).

SOUTHERN AFRICA: OVAMBOLAND, SOUTHWEST AFRICA (Theiler, unpublished). UNION OF SOUTH AFRICA and BECHUANALAND (Bedford 1936).

HOSTS

Available records indicate that in nature larvae feed on lizards and on a number of mammals inhabiting dry caves, lairs, and rock ledges. Nymphs and adults also attack lizards and almost any mammal that happens to stop near their retreat. Certain birds are acceptable as larval hosts in the laboratory but birds have not yet been found infested in nature. Larvae have been reared on guinea pigs and nymphs and adults on white mice.

Larvae

Animals on which larval *A. brumpti* have actually been found in nature are the following:

Lizards: *Agama colonorum* in the Sudan (Ruttledge 1930). *Uromastix ocellatus* and *Agama a. spinosa* in Southeastern Egypt (Hoogstraal and Kaiser 1956. Schmidt and Marx 1956). *Gerrhosaurus validus* in Transvaal (Bedford 1936). The gecko *Tarentola a. annularis* in the Western Desert and in the Southeastern desert of Upper Egypt.

Rock hyraxes: *Heterohyrax brucei hoogstraali* (Equatoria Province record above), *Procavia* sp. in Egypt (Hoogstraal 1952B), and *Procavia capensis burtoni* in Southeastern Egypt (Hoogstraal and Kaiser 1956).

Rodents: Spiny mice, Acomys hystrella (Equatoria Province record above) and Acomys cahirinus dimidiatus in Southeastern Egypt (Hoogstraal and Kaiser 1956).

Nymphs and Adults

Specimens from the Kitui District of Kenya (Heisch 1954F) were determined by precipitin tests to have fed on porcupines and not on hyraxes, rats, or gerbils. Lizards and baboons were suspected as possible hosts. Subsequently, Garnham (1954) working in the same area found blood corpuscles of lizards in recently fed ticks and noted that undigested corpuscles could be identified in the ticks at least a month after feeding. Garnham fed captive nymphs and adults on geckos and agamid lizards.

Inasmuch as nymphs and adults feed rapidly, they are seldom found when the vertebrate host is examined. It may be assumed, however, that these stages probably feed on most of the larval hosts noted above.

Walton (1950B) reported that Brumpt's argas attacks hyraxes and people who take refuge near hyrax dens in Kenya. Theiler's five female specimens from Ovamboland are from a mierkat, Cynictis penicillata cinderella. Africans of the Yatta Plains say that this tick (kitunu) feeds on human beings, elephants, buffalo, elands, and giraffes, and that specimens may be found in dust where big game animals roll (Cunliffe 1914B). I have seen three adult specimens from a lion's lair near Pusa, Kenya (BMNH collections). In Ethiopia, Brumpt found A. brumpti near porcupine burrows, and reported its bite on himself (Nuttall et al 1908. Brumpt's Precis). King's (1915) Sudan records are from sparsely vegetated areas containing caves and crevices in which many kinds of animals rest. Uganda hosts are the African porcupine and the rock hyrax, Procavia capensis meneliki (Hoogstraal and Kaiser 1956).

Experimental Hosts

King (1926) reared larvae on the bare skin of the head of guinea fowl. Larvae failed to engorge on man, dogs, cats, goats, pigeons, doves, sparrows, or bats, though some attached to sparrows and pigeons. Nymphs and adults fed on rabbits and man. Ruttledge (1930) found no larvae on guinea fowl in the Nuba Mountains and believed that lizards are the favorite larval host there.

Davis and Mavros (1956B) successfully reared larvae on guinea pigs and nymphs and adults on white mice.

That the various stages of Brumpt's argas feed to an extreme degree of repletion on white mice and guinea pigs has been noted in Dr. G. E. Davis' and in our laboratories. This phenomenon is exceptional in the genus *Argas*.

BIOLOGY

Life Cycle

Ruttledge (1930) found larvae on lizards only in March, at the end of the dry season. Larvae taken in Egypt were attached to hosts in the winter and spring months of February, March, and April; but it should be noted that these are the only months during which we have extensively explored Upper Egypt, to which area *A. brumpti* is probably restricted here.

At Khartoum, eggs were laid in the laboratory in March, April, and October; some of these hatched about a month later (King 1915). Females brood over their eggs until larvae emerge (confirmed by Davis and Mavros 1956), as has been observed for many argasid species (Hoogstraal 1952B). Hosts on which King fed immature stages have been listed above.

Cunliffe (1914B) reported egg laying from a single female as follows: 53 eggs between 99 and 106 days after emergence, 66 eggs between 118 and 125 days, 21 eggs between 152 and 156 days, and 18 eggs between 161 and 166 days; total 158 eggs. The female had fed on a fowl on the 12th, 17th, and 143rd day and had been fertilized on the 13th, 17th, 142nd, 158th, and 168th day. Larvae hatched from two egg batches 24 to 27 days after the eggs had been laid but refused to attach to a fowl and died. King (1915) observed that larvae do not feed readily until they are about ten days old.

Subsequently, eggs were laid in the laboratory in batches of about seventy eggs, about a month apart, after each feeding, through the cooler months of the year in Khartoum (King 1926). One male fertilized at least three females. Four nymphal stages were observed. A certain mature female collected in July, 1918 was still alive in December, 1926.

Recently, Davis and Mavros (1956B) have been most successful in rearing larvae on guinea pigs and nymphs and adults on white mice. Between feedings, ticks were held at 30°C. in a humidified cabinet. The life cycle under these conditions required from four to eight months. Larvae fed from six to fifteen days, mostly for eleven to thirteen days, and molted to nymphs ten to twelve days later. This lot all reached the adult stage after three nymphal molts, as follows: first to second instar, fourteen to twenty days; second to third instar, seventeen to 32 days; third instar to adults, 21 to 37 days. One third nymphal instar specimen fed twice before molting to an adult male. This individual required 140 days postlarval feeding to reach adulthood while the most rapid time for this interval, also for a male, was ninety days.

In an additional lot, six males and fourteen females required three nymphal instars and two females underwent a fourth nymphal molt. Three pairs fed twice in the last nymphal instar. The last nymphal instar lasted from 26 to 65 days, but most required only 26 to 33 days. Females fed for eight to 21 minutes and mated for ten to 27 minutes. Oviposition commenced eight to 58 days after feeding and larvae hatched after eight to 24 days. The number of eggs per batch ranged from 24 to 96, and while generally smaller batches showed a higher rate of fertility than larger batches this was by no means consistant. For instance, in one batch of 24 eggs 22 larvae hatched, one batch of 72 was entirely fertile, a batch of 62 was about fifty percent fertile, and the batch of 96 eggs hatched 81 larvae. The least fertile female oviposited a second time without a second feeding or mating. The most fertile female fed a second time and then oviposited though without having mated since the first feeding three months previously.

Further observations showed that while larvae take a small amount of blood within an hour of attaching to the host, the bulk of the blood is ingested shortly before completing feeding. Molting ticks free themselves from the exuvia within a few minutes after the skin splits. Mating and feeding takes place readily in daylight. Feeding adults stand perpendicularly, bracing themselves against the tube; when partially distended they fall over on their dorsum to complete engorgement.

Ecology

A. brumpti lives in areas of low rainfall (Ovamboland, Kalahari, Nuba Mountains, Egypt) or in dry niches within areas of comparatively high rainfall (Kenya, southern Sudan, Transvaal). It rests in caves, lairs, or dens, where it feeds on either permanent mammal residents or on visiting mammals or lizards, or it may hide under rocks from whence it emerges to feed on passing lizards or mammals.

The original Ethiopian specimens were found in dust under rock ledges in a dry streambed visited by porcupines (Nuttall *et al* 1908. Brumpt's Precis). It was said that these adults wandered about at night but not during the day. King (1915) found specimens in caves and crevices where they were living among debris of soil and rotting leaves and twigs. One of Bedford's (1936) individuals was hiding under a stone. In Southeastern Egypt we have found from one to 23 nymphs and adults together a millimeter or two below the surface of fine, dry sand in small caves and in holes in rocky hillsides. These areas range from barren desert bordering wadis with a little vegetation to arid parkland at the base of mountains facing the Red Sea.

In the lowlying country north of Kitui, Kenya, Heisch (1954F) observed immobile specimens on fine, brown earth under large boulders on a peneplane of red, sandy soil covered by thornbush. Dr. Heisch has informed me (conversation) that the loose soil below these rocks is probably too sparse for burrowing by the ticks. He and Dr. Garnham, who accompanied him on a collecting trip to this area, have also told me that the ticks rest in rock crevices or between rock layers where there is little or no accumulation of soil. It is of interest to learn from information furnished Cunliffe (1914B) for other parts of East Africa that Brumpt's argas burrows in the dust of termite mounds where large game animals roll.

Biologically, therefore, in its feeding and resting habits, *A. brumpti* appears to show tendencies towards certain intermediate characters between typical *Argas* ticks and typical *Ornithodoros* ticks. *Argas* ticks in all stages are considered typically as fairly host-specific parasites of birds or of bats and as ticks that normally hide in crevices but do not burrow in sand or soil. *Ornithodoros* ticks, on the other hand, usually parasitize mammals, although exceptions are known, and unless the soil is too hard, they normally burrow below the surface or at least hide in cracks in soil. It is, therefore, of interest that larval *A. brumpti* feed, apparently more or less indiscriminately, on reptiles, birds, and mammals, and that nymphs and adults attack either lizards or mammals. A further interesting observation, from both Dr. G. E. Davis' and our laboratories, is that the various stages of this tick feed fully on white mice, whereas most other *Argas* species feed only partially on mice. When resting, *A. brumpti* apparently prefers to burrow in soil or sand, but if this is not possible it hides among surface debris or between or under rocks.

King (1926) mentioned the possibility that Brumpt's argas might infest human dwellings although actual records had not been obtained. Archibald (1923) reported Brumpt's argas among a collection from in and around human dwellings, but he did not specify exactly in which situation specimens were taken. Archibald's records and specimens cannot now be located. Walton (1950B) states that in Kenya this species does not occur in human huts.

DISEASE RELATIONS

MAN: Bites of *A. brumpti* may be quite painful to human beings and cause itching lasting for years. Kenya natives claim that this tick causes pain and sickness when it bites man.

LIZARDS: In Kenya and in Egypt, *A. brumpti* and lizards have been found infested with a hemogregarine, *Hepatozoon argantis* Garnham, 1954.

HYRAXES: This tick should be considered as a potential vector of the piroplasm *Echinozoon hoogstraali* Garnham, 1951, a parasite of *Heterohyrax brucei hoogstraali*.

REMARKS

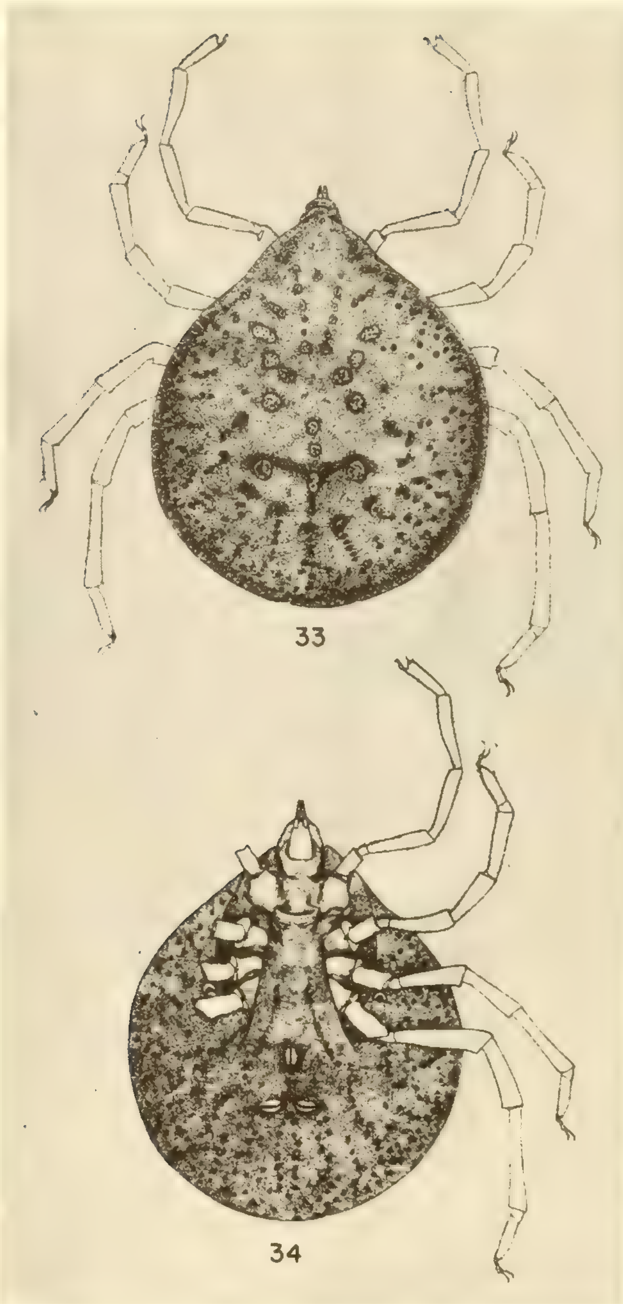
The diagnostic characters listed below comprise the criteria for Pospelova-Shtrom's (1946) genus *Ogadenus*, herein considered as a subgenus of *Argas*. Warburton's (1933) views on the generic position of *A. brumpti* will be reviewed in subsequent studies of the genus.

Schulze (1936G) compared the body outline of *A. brumpti* with that of certain fossil trilobites that it happens to resemble.

IDENTIFICATION

Neumann's original adult specimens from Ethiopia measured from 15 mm. to 20 mm. long and from 10 mm. to 13 mm. wide. The size range among available Sudan and Egyptian females is from 10 mm. to 12 mm. long and from 7 mm. to 8 mm. wide. The dorsal integument is marked most distinctively by large, symmetrical polygonal depressed areas bounded by rugose ridges; laterally the dorsal integument is evenly striated. A continuous, clear, and distinct sutural line divides the dorsal and ventral surfaces. Discs, which are small and inapparent, lie in clumps or lines in the integumental depressions, and short hairs are scattered anteriorly and posteriorly on the periphery of the body. The outline of the body is subquadrangular with parallel lateral margins, a bluntly rounded posterior margin, and a pointed projection of the anterior margin over the mouthparts. Tarsus I has two dorsal humps and the other tarsi each have a prominent subapical dorsal protuberance. Males have a narrow, rounded genital aperture; females have a transversally elongate, narrow genital orifice.

The nymph closely resembles the adult, except for size and absence of genital aperture. The larva has been described by Cunliffe (1914B) and by Hoogstraal and Kaiser (1956).



Figures 33 and 34, ♀, dorsal and ventral views

ARGAS (CHIROPTERARGAS) BOUETI
Egyptian specimen

PLATE XI

ARGAS (CHIROPTERARGAS) BOUETI Roubaud and Colas-Belcour, 1933.

(Figures 23,24,33, and 34)

THE LONG-LEGGED BAT-ARGAS.

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
4	1			Sunat	Taphozous perforatus haedinus	Feb
7				Torit	Rhinolophus lobatus	Jan

These are the only records of this species from the Sudan.

DISTRIBUTION

Argas boueti is known from scattered localities in Africa as far south as Transvaal and is also present in the Near East. A tick apparently of drier areas, which has been widely spread by its chiropteran hosts, the long-legged bat-argas is obviously more frequent than present meagre records indicate (Hoogstraal 1955B). Whether North Africa, the Near East, or the Ethiopian Faunal Region is its origin is difficult to determine from evidence at hand.

NORTH AFRICA: EGYPT (Hoogstraal 1952A,1954A,1955B).

WEST AFRICA: FRENCH WEST AFRICA (Roubaud and Colas-Belcour 1933. Hoogstraal 1955B).

CENTRAL AFRICA: FRENCH EQUATORIAL AFRICA (Hoogstraal 1955B).

EAST AFRICA: SUDAN (Hoogstraal 1952A,1954B,1955B).

KENYA (Heisch 1951B. Hoogstraal 1955B).

SOUTHERN AFRICA: ANGOLA (Hoogstraal 1955B). UNION OF SOUTH AFRICA (Hoogstraal 1955B. Subsequently, Dr. Zumpt has sent me additional specimens from Tzaneen, Transvaal).

NEAR EAST: Palestine (Hoogstraal 1954A,1955B).

HOSTS

Bats

Asellia (= Hipposiderus) tridens and Taphozous perforatus (Roubaud and Colas-Belcour 1933). Taphozous p. perforatus, T. (Liponycteris) nudiventris, Rhiponoma hardwickei cystops, and Otonycteris h. hemprichi are most heavily infested in Egypt. Less frequent hosts here are Rhinopoma microphyllum, Asellia t. tridens, Rhinolophus clivosus brachygnathus, R. mehelyi, Roussetus a. aegypticus, Nycteris t. thebaica, Tadarida a. aegyptiaca, T. teniotis ruppelli, Pipistrellus k. kuhli and Plecotus auritus christei (Hoogstraal 1952A,1955B). Megaderma cor (Heisch 1951B). Rhinolophus lobatus (Sudan record above). Eptesicus tenuipinnis (Hoogstraal 1955B).

Otonycteris h. hemprichi, a bat which roosts in small caves, crevices and niches, usually singly or with very few other of the same species, is most heavily infested in Egypt. Rhinopoma h. cystops, one of the most common cave-inhabiting bats near Cairo, is frequently heavily infested and probably represents the most important host in this area owing to its great abundance. All stages appear to feed on the same kinds of bats.

Man

Nymphs and adults have bitten us in caves on a few occasions. They readily do so when allowed to in the laboratory (Hoogstraal 1952A,1954A,1955B).

BIOLOGY

Life Cycle

Rearing of A. boueti has been accomplished in our laboratories at temperatures of from 80°F. to 90°F. with relative humidity ranging from 40% to 50%. Exceptionally large females may lay single egg batches of almost two hundred eggs over a two or three day period. An average size female deposits from 35 to 40 eggs in a single batch usually on a vertical surface. Afterwards, she stands motionless over or next to the eggs for fifteen to 22 days until the larvae hatch. (Earlier, at unrecorded high summer room temperatures, we obtained hatching in eleven to fourteen days). Larvae attach to a host after twelve to fifteen days (earliest host offered), and feed from eight to 42 days, but mostly from sixteen to 25 days. Afterwards, larvae may require from four to thirteen days before molting to first instar nymphs, but they usually do so after four to seven days.

Nymphs molt two or, uncommonly, three times before reaching adulthood. In our laboratory, those nymphs that reach adulthood after two molts have never fed in the nymphal stage, even though bats were frequently offered. When a third instar nymph, which has not molted to an adult, feeds it does so for half an hour to an hour from seven to 26 days after the previous molt and becomes an adult from twenty to 32 days after feeding. The duration of each nymphal instar is seven to seventeen days for the first instar, with eleven to fourteen days the most common. The duration of the second instar is longer, from sixteen to 43 days, with 22 to 29 days average. The duration of the third stage, when it occurs, is erratic and lasts from 27 to 58 days. No significant data on sexual differentiation from the unusual third nymphs have been obtained.

Adults feed for thirty to 35 minutes beginning some five days after molting. Further studies on the life cycle of progeny are under way.

A biting tick remains motionless during feeding. It often stands the full length of its anterior legs away from the point of insertion of mouthparts that are extended by a pendulous tube from the basis capituli. Once the hypostome is inserted, the host's hand or arm (or the bat) may be moved freely till the tick is satiated without causing it to remove its mouthparts. When blood is rapidly engorged a large drop of clear coxal fluid appears beneath the body, but none is emitted during slow feeding. Repletion from the human hand or arm requires from 25 to 35 minutes but full engorgement from the membrane of a bat's wing may require three or four hours. Individuals that feed slowly become very lethargic and one may remove them, even though fully fed, after seven to 24 hours with the mouthparts still inserted in the wing membrane. Itching at the site of the bite on man may persist for several weeks.

When disturbed the long-legged bat-argas is much more active and moves with greater speed that either A. confusus or A. vespertilionis. The long anterior legs wave up and down while walking and tap objects antenna-fashion. This tapping is especially active just before the mouthparts are inserted. During feeding the anterior legs may or may not touch the host skin but they seldom function as a support for the tick. These ticks will feed in light or in darkness but prefer darkness.

Ecology

The original authors of A. boueti described this species from material collected about 1910 in hollow trees inhabited by the two species of bats listed above. In the generally arid Northern Province of Kenya, Heisch found adults on walls of an underground concrete shelter and larvae on Megaderma cor in the same structure. Those South African specimens with collecting data are from houses.

In Egypt we commonly find the long-legged bat-argas thriving under the most severe desert conditions. It is less common in more humid buildings inhabited by bats in Cairo. A. boueti is the most numerous bat-parasitizing argasid in Egypt and the same ecological observations noted for Egypt under A. vespertilionis apply to this species.

The frequency with which these long-legged ticks fall from rough surfaces in the laboratory is surprising in view of their usual habitat on walls and on ceilings of caves and chambers. A number of specimens exhibit a body tremor that causes them to flip over on their dorsal surface with every few steps. Righting movements require considerable effort.

DISEASE RELATIONS

MAN. Attacks on our laboratory personnel have caused mild itching persisting for several weeks in warm weather.

BATS. We have been unable to find spirochetes in Egyptian material. Collections of local specimens injected into laboratory animals have resulted in negative findings for viruses and rickettsiae. Other material from the Cairo area has not yielded Shigella organisms. The hosts from which the type series was collected in French West Africa showed a trypanosome infection but research to ascertain the relationship of ticks and trypanosomes was not undertaken.

REMARKS

For a discussion of long-legged parasites of bats, see REMARKS under Ixodes vespertilionis.

A. boueti populations consist of two size groups, the larger about 6.8 mm. long and 6.9 mm. wide and the smaller about 5.0 mm. long and 4.5 mm. wide (Hoogstraal 1955B, figure 125). The significance of these "races" is at present being studied.

The subgenus Chiropterargas Hoogstraal, 1955(B), of which A. boueti is the type species, contains one other species, A. confusus. This subgenus is defined as follows:

"Parasites of which bats are hosts of predilection. Morphological characters intermediate between those of typical Argas and typical Ornithodoros; with a general Argas facies but lacking a sutural line; with a flattened body flange but lacking "cells" and with exceedingly slight integumental differentiation at periphery; body shape circular to transversely elliptical. Integument with fine, close granular projections; discs mostly small, conspicuous, radially distributed, ventral "paired organ" present. Definite hood over mouthparts; mouthparts about level with anterior body margin. Legs of variable length, arising from anterior half of body; tarsal humps lacking."

IDENTIFICATION

The remarks above include the outstanding characters for identifying this species and A. confusus.

The male of A. boueti is somewhat smaller than the female and has a semicircular genital aperture while the female has a narrow, transversely elongate genital aperture bounded by two rugose lips. In both sexes, the body outline is subcircular to pearshaped (definitely wider than long in A. confusus), leg IV extends far beyond posterior margin of body (only slightly beyond in A. confusus), basis capituli and palpal segments comparatively narrow and elongate (globose in A. confusus), minute integumental protuberances are mostly flat (mostly tapered in A. confusus), etc. The dental formula of both species is 1/1, the apex of the hypostome is slightly indented, and a corona is lacking.

The larva and nymph have been described by Roubaud and Colas-Belcour (1933) and in more detail by Hoogstraal (1955B).

35

36

Figures 35 and 36, ♀, dorsal and ventral views

<u>ARGAS</u> (<u>CHIROPTERARGAS</u>) <u>CONFUSUS</u>
Egyptian specimen

PLATE XII

ARGAS (CHIROPTERARGAS) CONFUSUS Hoogstraal, 1955(B).

(Figures 25,26,35, and 36)

THE WIDE BAT-ARGAS

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
2				Torit	Chaerephon major	Dec	
1				Torit	*Eptesicus pusillus	-	(SVS)
1				Latome	*Pachyotus sp.	Mar	(SVS)
3				Sunat	Taphozous perforatus haedinus	Feb	

DISTRIBUTION IN THE SUDAN

As A. vespertilionis (in part): Khartoum and Northern Provinces (King 1911,1926).

The following lots are in Sudan Government collections:

Khartoum: Khartoum. Larvae from unidentified bat.

Northern: Dongola. Larvae from unidentified bat.

DISTRIBUTION

A. confusus is recorded from scattered localities from Egypt to the Cape of South Africa. Additional collecting will undoubtedly reveal its occurrence elsewhere on the continent. This species is thus far not known outside of Africa.

NORTH AFRICA: EGYPT (Hoogstraal 1955B).

EAST AFRICA: SUDAN (In part as A. vespertilionis: King 1911, 1926. As A. vespertilionis group: Hoogstraal 1954B. As A. confusus: Hoogstraal 1955B).

KENYA (Hoogstraal 1955B).

---

*Host name on label; identity not checked by authority in host group.

SOUTHERN AFRICA: SOUTHERN RHODESIA, BASUTOLAND, and BECHUANALAND (Hoogstraal 1955B). UNION OF SOUTH AFRICA [For details concerning *A. confusus* reported as *A. vespertilionis* by Nuttall *et al* (1908), Howard (1908), and Bedford (1934), and for more recent records, see Hoogstraal (1955B). Subsequently, Dr. Zumpt has sent additional specimens from Bloemfontein, Orange Free State, and from Lady Frere, Cape Province.]

HOSTS

At the present time we have definite evidence of larval *A. confusus* from only a few species of insectivorous bats; *Chaerephon major* and *Taphozous perforatus haedinus* (Equatoria records above); questionably (host field determinations not checked by a specialist) from *Eptesicus pusillus* and *Pachyotus* sp. (Equatoria records above); and from *Eptesicus capensis*, *Pachyotus* sp., *Miniopterus natalensis arenarius*, *Taphozous p. perforatus*, *T.* (*L.*) *nudiventris*, *Otonycteris h. hemprichi*, *Nycteris t. thebaica*, and *Tadarida a. aegyptiaca* (Hoogstraal 1955B). Nymphs and adults found in bat-infested caves and buildings probably feed on the same species of hosts as do larvae.

The record of *A. confusus* (= *A. vespertilionis*) attacking penguins in Queenstown, Cape Colony (Nuttall *et al* 1908) must be regarded as questionable (Hoogstraal 1955B).

BIOLOGY

Life Cycle

A. confusus has been reared in our laboratory at temperatures between 80°F. and 90°F. and at relative humidities between 40% and 50%. A single egg batch consists of from forty to seventy eggs with fifty to sixty the most common quantity. Eggs hatch from 21 to 25 days after being laid. Larvae have commenced feeding five to 26 days after hatching. The duration of larval feeding varies from five to fifty days but most larvae drop from the host in two or three weeks. Afterwards, larvae remain quiet for seven to twelve days before the nymphal molt.

Four nymphal instars are invariable in our numerous observations. Nymphs, like adults, feed for from 25 to fifty minutes. The first nymphal instar, however, never feeds; it molts to the second instar usually in ten to thirteen days (range eight to 21 days). One to three weeks later the second instar nymph feeds and molts to the third instar some two weeks later (range eight to 23 days). The third instar nymph takes food between three and 35 days afterwards and molts three or four weeks later (range fifteen to 59 days). The fourth instar nymph feeds between five and 36 days afterwards and molts to the adult stage three or four weeks later (range seventeen to forty days).

Note that although there are many morphological similarities between *A. confusus* and *A. boueti*, the biology of the nymphal stage of each is distinct.

In this species, the observed period between nymphal molting and feeding is quite variable. Some accept food within five to seven days although two to three weeks, or longer, is more common for this and for other bat-parasitizing argasids. Also noteworthy is (1) the average two week postfeeding period of second instar nymphs in contrast to the three or four week average postfeeding period of the two subsequent instars, and (2) the nonfeeding first instar.

Adults placed together shortly after molting have been observed to mate only after feeding which may occur from eight to sixteen days after molting. The feeding period varies from forty minutes to two hours. No egg batches have been deposited before three and a half to four months after molting. Further studies on the F_1 generation are in progress.

Ecology

We have collected, with considerable and strenuous effort, several hundred specimens of *A. confusus* in Egypt. This species, together with *A. transgariepinus*, is the most secretive of bat infesting argasids. It wedges itself deeply into the narrowest crevices of caves and of hillside crannies in which bats rest. It is never found easily or in groups of more than two to a maximum of twelve specimens. We know of only a single exceedingly small population in Cairo, where bats roost in buildings that are more humid than desert caves. In the environs of Cairo, *A.*

confusus is scattered throughout desert and desert-edge retreats, all arid, such as antiquities structures, caves, and hillside crannies.

Records from northern Sudan and from the Protectorates of South Africa indicate a more or less similar tolerance of aridity, but those from various regions of South Africa, Torit, and the crater of Mt. Menengai in Kenya indicate also that certain populations exist in markedly humid environments where they tolerate lower temperatures and higher relative humidity than they do in Egypt.

DISEASE RELATIONS

BATS: A small number of specimens thus far studied in NAMRU-3 laboratories have been negative for blood protozoa, spirochetes, viruses and rickettsiae, and *Shigella* organisms.

REMARKS

Further studies on the habits and ecology of this species are presently under way and will be reported when completed. For a definition of the subgenus *Chiropterargas* and for criteria to distinguish this species from *A. boueti*, see page 95.

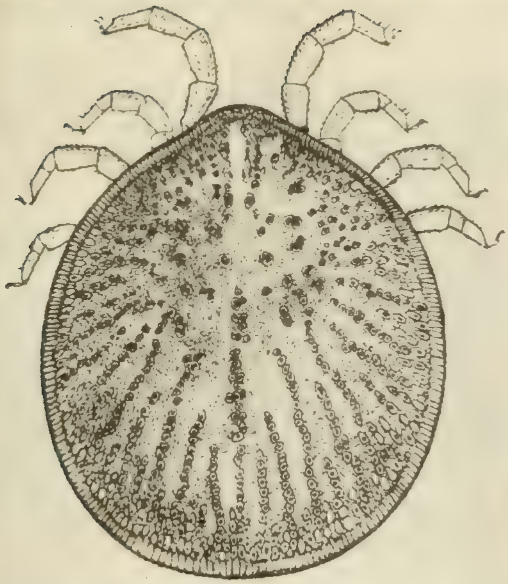
IDENTIFICATION

A. confusus adults have an extremely wide body outline, and, in common with *A. boueti*, are characterized by the absence of a sutural line dividing dorsal and ventral surfaces, and by the presence of a conspicuous hood over the mouthparts. In *A. confusus* the dorsal integumental protuberances are fine, shiny-tipped, tapering points which on the lateral margin are more closely spaced and more regular. The posterior discs are arranged radially; the legs are shorter than the body length; and the hypostome has only a single pair of denticle files. The tarsi have no dorsal protuberances. A pair of grooved organs of unknown function is present just posterior of the anus on the ventral surface.

Except when greatly engorged, the peripheral flange of the body remains partly unfilled. In partially engorged individuals this flange is flat, and in dry specimens it may be turned up like a rim. The body color is reddish yellow with a central, darker area of varying extent.

Males measure from 5.9 mm. to 6.4 mm. long, and from 7.4 mm. to 7.8 mm. wide (average 6.1 mm. long and 7.5 mm. wide). The genital aperture forms a wide arc. Females are larger, and measure up to 8.0 mm. long and 9.5 mm. wide. The female genital aperture is a transverse groove with thick, rugose lips.

The nymph and larva have been described by Hoogstraal (1955B). The larva and first instar nymph are quite similar to those of *A. boueti* but the successive instars of each resemble the associated adults.



37

38

Figures 37 and 38, ♂, dorsal and ventral views

ARGAS (CARIOS) VESPERTILIONIS
Egyptian specimen

PLATE VIII

ARGAS (CARIOS) VESPERTILIONIS (Latreille, 1802).

(Figures 21,22,37, and 38)

THE ROUND BAT-ARGAS

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
2				Lokwi	Rousettus aegyptiacus	June (CNHM)
4				Katire	*Mimetellus ?moloneyi	Sep
9				Sunat	Taphozous perforatus haedinus	Feb

DISTRIBUTION IN THE SUDAN

Northern: One larva from an undetermined species of bat at Dongola, 12 April 1917, Bedford *legit*; Sudan Government collections.

Khartoum: Several larvae from an undetermined species of bat(s?) at Khartoum, 20 September 1914, R. Cottam *legit*; in Sudan Government collections, one retained in Hoogstraal collection.

DISTRIBUTION

The *Argas vespertilionis* group, consisting of *A. vespertilionis* (Latreille, 1802) in Europe and Africa, *A. pusillus* Kohls, 1950, on Palwan Island in the Philippines, and of numerous closely related forms of yet uncertain species status, ranges throughout the continents and island groups of the world, except in the Americas. It is possible that certain African populations presently identified as *A. vespertilionis* will prove to be separate, closely related species. A fuller study of this group is under way.

African Records Only

Eventually, the round bat-argas most likely will be found in many more territories of Africa.

---

*Field identification of host; specimen not seen by a specialist in bat taxonomy.

NORTH AFRICA: EGYPT (As A. fischeri: Audouin 1826, Savigny 1827, and Lavoipierre and Riek 1955. Hoogstraal 1952A). TUNISIA (Colas-Belcour 1933B).

WEST AFRICA: FRENCH WEST AFRICA: Although reported as A. vespertilionis by Marchoux and Couvy (1912A,B,1913A,B), there is some likelihood that some or all of these specimens may have been those subsequently used as the types of A. boueti. Rousselot (1953B). GOLD COAST (Simpson 1914).

CENTRAL AFRICA: BELGIAN CONGO (Schoenaers 1951A).

EAST AFRICA: SUDAN (King 1911,1926; in part. Hoogstraal 1954B).

KENYA (HH collecting in crater of Mt. Menengai).

SOUTHERN AFRICA: ANGOLA (Larvae from Dundo, Lunda, northeastern Angola, CNHM). MOZAMBIQUE ("Brumpt's Precis"). SOUTHERN RHODESIA (Jack 1932. Bedford 1934).

UNION OF SOUTH AFRICA: South African adults described and illustrated by Nuttall et al (1908) as A. vespertilionis represent A. confusus. Howard (1908), Dönitz (1910B), Bedford (1932B,1934), also confused these two species as probably also did Cooley (1934); cf. Hoogstraal (1955B, p. 586) for details. Dr. G. Theiler has sent a female and nymph of A. vespertilionis from Pretoria and Grahamstown. These were among larger numbers of A. confusus and A. boueti. No specimens of A. vespertilionis were included with material of A. confusus and A. boueti from collections of the South African Institute for Medical Research, recently sent for identification by Dr. F. Zumpt. These observations lead one to suspect that A. vespertilionis may be less common in South Africa than A. confusus.

OTHER AREAS: Available material referable to this group is from England, Netherlands, Sweden, Spain, Germany, Korea, China, Philippines, and Ceylon. The group is also known to occur in southern India, Cambodia, Australia, France, Italy, and Russia. Differences between African and European specimens and those from Australia and Asian areas are very slight indeed.

HOSTS (Africa)

Bats

Almost any bat, whether it lives in large colonies or in small groups, may be parasitized by *A. vespertilionis*. All stages probably infest the same kinds of hosts.

Three species of chiropteran hosts are thus far known from the Sudan (records above). The Angolan larva is from *Pipistrellus nanus*. In Egypt, we find larvae chiefly on *Otonycteris h. hemprichi*, *Rhinopoma hardwickei cystops* and *R. microphyllum*, *Taphozous p. perforatus* and *T. nudiventris*, *Nycteris t. thebaica*, *Tadarida a. aegyptiaca* and *T. teniotis ruppelli*. They are less numerous on *Rhinolophus clivosus brachygnatus*, *R. mehelyi*, *Asellia t. triedens*, *Plecotus auritus christiei*, *Pipistrellus k. kuhli*, and *Rousettus a. aegyptiacus*. [Egyptian bats reviewed by Sanborn and Hoogstraal (1955)].

Man

Nymphs and adults on several occasions have attacked us in caves and we easily induce it to bite ourselves in the laboratory (Hoogstraal 1952A,1955B).

BIOLOGY

Life Cycle

In our laboratory, Mr. Sobhy Gaber successfully rears specimens of *A. vespertilionis* at 80°F. to 90°F. and 40% R.H. to 50% R.H. Egg batches consist of thirty to fifty eggs, one-fifth or one-sixth of which usually do not hatch. Larvae emerge from sixteen to twenty days after the eggs are laid and some will feed as quickly as four days afterwards. The duration of larval feeding varies from fourteen to 31 days, but is usually seventeen to nineteen days. Five to ten days later larvae molt to nymphs, which are capable of feeding three or four days after this and after subsequent molts. Usually two feedings are indulged by nymphs, followed by a molt eight or nine days after the first meal and twelve to fourteen days after the second meal. Nymphs become replete in from twenty to fifty minutes, usually in thirty to forty minutes. Males may emerge from the first nymphal molt, but usually nymphs molt twice before becoming adults. Males and females may feed within seven days after molting. Duration of adult feeding is thirty or forty minutes. No female has oviposited within six months after the nymphal-adult molt, even though she has been with a male continuously and both have had two to six blood meals. The first egg batch follows a blood meal by about a week. The first oviposition appears to trigger a physiological release mechanism for, in several instances, three months afterwards females have deposited a fertile egg batch with or without a meal. We are at present attempting to ascertain whether the long interval between molting and oviposition is peculiar to these laboratory observations or whether it is a usual feature in our local populations.

A. vespertilionis is more lethargic than A. boueti. Adults, if undisturbed while imbibing from a vein in the wing membrane of a bat, may remain attached for as long as five hours after engorgement is apparently completed. The feeding tick remains motionless with all legs down but, when fully distended without release of mouthparts from the host skin, it usually raises the fore legs to an antennalike position. During engorgement the beak is disengaged from the host skin only after considerable disturbance.

Large blood clots form at the site of the bite, both on the bat's body and in the wing membrane. This phenomenon, on bats, is in marked contrast to that observed by Lavoipierre and Riek (1955), using ticks from our collections, and laboratory rodents. The greater avidity with which these ticks attack bats probably accounts for the more conspicuous sequelae in these animals.

Larvae may be found anywhere on the body or wing membranes, but most commonly at the edge of the hairy parts, seldom on the head, feet, tail, or trailing edge of the wings.

Ecology

European and African populations of this tick, which thus far cannot be morphologically differentiated, withstand a wide range of temperature and humidity conditions. Host flight habits account for the wide distribution of A. vespertilionis, but we are not aware that host migration is a factor in mixing populations from widely differing ecological situations.

European and South African populations exist under temperate climatic conditions with pronounced seasonal changes and with moderate to heavy rainfall. Those of Egypt and of northern Sudan normally tolerate the most extreme arid niches in which any arthropod is known to survive. Their engorged larvae, however, are found usually among moist dung or in dung between crevices of bats' retreats. Just where females commonly oviposit in nature and where unengorged larvae rest before seeking a host has not yet been satisfactorily determined

Throughout Europe and Africa interstices in the walls of bat-infested caves and buildings are the most common habitats of A. vespertilionis. They may also be found in tree holes and in other situations frequented by certain bats. In Cairo a specimen, recalling Robert Burns' wee louse, has been taken from a worshipper during church service by an observant but distracted friend sitting behind. In Iraq, Patton (1920) reported the same or a closely related species in Bedouin tents in which bats presumably rested by day.

Egyptian specimens hide alone or clustered in large or small groups usually well concealed between shale or in crevices of walls. Some individuals are observed wandering openly on the walls. Unconcealed individuals are noted much more frequently in those caves or niches that only erratically harbor a few bats than in large caves where many bats usually roost. Possibly our entry into caves infrequently visited by any animals induces these ticks to investigate the possibility of a meal.

Small numbers of the round bat-argas frequently are found in niches in the most unexpected cliffsides where a few old pellets of dung indicate that hermit bats such as Otonycteris h. hemprichi occasionally spend the day. These ticks lead a most uncertain existence and often wait months on end for a host, as revealed by their compressed bodies and by the age and scarcity of hosts' dung in these places.

In Egypt, *A. vespertilionis* occurs with the more common *A. boueti* and with the less common *A. confusus* and *A. transgariepinus*. *A. vespertilionis* and the other two species are rare, however, in the comparatively humid situations in Cairo favored by the fruit-bat parasite, *Ornithodoros salahi*.

DISEASE RELATIONS

MAN: Mild itching resulting from a bite may persist for several weeks.

BATS: Large blood clots form at the site of the bite, both on the host's body and on the wing membrane.

It has been stated that this tick is a vector of a spirochete of bats but reports of conclusive supporting evidence have thus far not been located.

In the Cairo area blood of a few of these ticks has been found to contain a most interesting organism resembling, according to Dr. P. C. C. Garnham (correspondence): "the sporozoites of a Haemoproteid; they are not unlike the sporozoites of *Leucocytozoon* ..... described ..... from the abdominal cavity of *Simulium* flies." Unfortunately, it has thus far been impossible to undertake further study of this phenomenon.

Egyptian specimens examined in NAMRU-3 laboratories have been negative for spirochetes, viruses, rickettsiae, and *Shigella* organisms.

REMARKS

The taxonomy and biology of bat-infesting *Argas* ticks is presently being studied and the first report, on *A. boueti* and *A. confusus* has been presented (Hoogstraal 1955B). The second section will deal with the confounded status of *Argas* (*Carios*) *vespertilionis*. Some workers have considered *Carios* as a full genus, indiscriminately including in it features of a variety of species based on vague and ambiguous remarks in the literature.

The presence of the ventral paired organ related the subgenus *Carios* to the subgenus *Chiropterargas* and separates *Carios* from the subgenus *Argas* and from other subgenera. The presence of a lateral suture and of peripherally differentiated integument, and the absence of an appendagelike hood clearly separates the subgenus *Carios* from the subgenus *Chiropterargas*.

The name *vespertilionis* was assigned by Latreille in 1802, not in 1796 as stated by most authors. The reference to this name as of 1796 (Hoogstraal 1955B) derives from an editorial change.

Schulze (1943B) noted that the immature stages of species of this group ("*A. pipistrellae*") have especially highly developed terminal branching of midgut diverticula but little basal branching.

IDENTIFICATION

Males and *females* are alike except that males average somewhat smaller in size and their genital aperture is semicircular in outline, rather than narrowly ovoid, and is not bounded by thickened rugose lips as in females.

In both sexes and in nymphs, a definite lateral suture encircles the body, a dorsal and ventral row of rectangular "cells" marks the body periphery, no appendagelike hood is present over the mouthparts, but ventral paired organs are present just posterior of the anus.

The body outline is generally circular or subcircular, but may be somewhat longer or wider in some specimens. Few individuals reach six millimeters in length or breadth. The integument is smooth, marked by a fine network of small, irregular cells among which regular, subparallel rows of larger discs radiate.

Legs arise from the anterior half of the body and are shorter than the body; coxae are contiguous; and tarsi are tapered and lack dorsal humps.

Mouthparts are situated close to the anterior margin of the body. The hypostome formula is 2/2 to 2.5/2.5, the apex is notched and bears a corona of three or four rows of small denticles in four to six files.

The larval and nymphal illustrations and descriptions of *A. vespertilionis* by Neumann (1896) are quite good, though they shall have to be expanded for present day purposes. These have been employed subsequently by the same author, Nuttall *et al* (1908), Bedford (1934), and others.

ARGAS SP.

(Not illustrated)

A single damaged larva, mounted on a slide, sent by Mr. E. T. M. Reid of the Sudan Veterinary Service, represents an unknown species of tick. Although many of the characters of this specimen are obliterated, enough are preserved to indicate distinct differences from *A. vespertilionis*, to which it is probably more or less closely allied, and from all other described species. This larva was collected from a *Pachyotus* bat at Latome, Equatoria Province, on 18 March 1951 by Mr. J. Owen.

ORNITHODOROS*

INTRODUCTION

Both important African species of Ornithodoros, O. moubata and O. savignyi, occur in certain areas of the Sudan, where they are known as haim (هيم). From two to five other species indubitably exist in the Sudan but have not yet been found there. Approximately fifty species comprise the genus throughout the world. O. moubata is the most important tick vector of relapsing fever in Africa and its bite is often painful. O. savignyi has been suspected to be a relapsing fever vector, although incriminating evidence in nature is negative or unconvincing.

Ornithodoros ticks are thick, leathery, and podlike. They may be more or less difficult to find but pain when they bite signifies their presence. In contrast to Argas ticks, which usually parasitize birds and bats, most Ornithodoros ticks parasitize mammals, including bats, and only exceptionally attack birds, reptiles and amphibians.

The two species under consideration represent a somewhat more advanced stage in evolution of parasitism than do Argas and other Ornithodoros species in that their larvae remain in the large, leathery egg until ready to make the larval-nymphal molt. The safety of the tough egg capsule affords delicate larvae considerable protection from the elements. O. moubata and O. savignyi are unusual in this respect; larvae of most other Ornithodoros species are active and feed from animal hosts. Shortly after hatching larvae molt to nymphs that soon set out to find a host. Nymphs and adults feed rapidly, in a matter of a few minutes to an hour or two, and are seldom transported while feeding on the host. They are, therefore, usually found only in their resting places. Ornithodoros

---

*Some writers replace the os ending used here by us. The original name used by Koch (1844) was spelled with an os ending, and this is generally though not universally conceded to conform to the rules of nomenclature and of philology. This question has been reviewed by Najera (1951).

ticks are able to withstand long periods of starvation and are very resistant to aridity. The two species discussed in the following pages have been widely spread along man's trade routes.

Subgenera of *Ornithodoros* are scarcely better established than those of *Argas*. *O. moubata* and *O. savignyi* are closely related species with only one other kindred kind, *O. eremicus* Cooley and Kohls, 1941, of Utah, western North America. Some workers would include only these three species in the genus *Ornithodoros* and all others in several different genera. This position seems an unnatural approach and a useless complexity. For present purposes, *O. moubata* and *O. savignyi* are treated as in the subgenus *Ornithodoros*, the only one presently known to be represented in the Sudan.

In addition to these two tampans, it is certain that several other species of *Ornithodoros* occur in the Sudan and await discovery. Among these should be *O. foleyi*, *O. delanoëi* subsp., and possibly some member of the *O. tholozani* group. When more intensive search is undertaken in the Sudan it will probably be found that *O. erraticus* is localized but widely distributed here. *O. erraticus* is broadly characterized by small size (maximum length 7.5 mm., usual length 3.0 to 5.0 mm.), oval shape, closely crowded, hemispherical granulations interspersed by large discs, and absence of tarsal armature and of cheeks surrounding the mouthparts. Specimens will probably be found in small mammal burrows.

The following are the other known *Ornithodoros* species that occur in Africa, with selected references concerning them:

O. arenicolous Hoogstraal, 1953(C); description of all stages; biology; from rodent, hedgehog, and *Varanus* lizard burrows in Egyptian deserts. Absence of spirochetes (Davis and Hoogstraal 1954).

O. capensis Neumann, 1901; described from penguin-inhabited islands off Cape Province. Found on Cargados Carajos Island in Indian Ocean (Neumann 1907E). Challenger Expedition specimens from St. Paul's Rocks (Nuttall *et al* 1908). Present on islands off Southwest Africa (Tromsdorff 1914). Biology of hosts and description of habitat, St. Croix Island off Cape Province (Hewitt 1920). Other South African records (Bedford 1934).

Records from western Australia (Taylor and Murray 1946). Present on marine birds, Guam (Kohls 1953). Specimen from leg of soldier on island in Lake Nyasa (Hoogstraal 1954C).

O. coniceps (Canestrini, 1890); described from Venice, Italy. Specimens, from near Aral Sea, in St. Petersburg Museum (Birula 1895); these quoted by Yakimov and Kohl-Yakimov (1911) and Yakimov (1917,1922). Present in France (Guitel 1918, Theodor 1932, Roman and Nalin 1948). As O. talaje from Fezzan, Morocco; introduced with pigeons; severe sequelae in human victims (Martial and Senevet 1921). From bats and pigeons, life cycle, Tunis (Colas-Belcour 1929D). Description of all stages, Palestine (Theodor 1932). Biology, Palestine (Bodenheimer 1934). Present in Spain (Gil Collado 1947,1948A,B). Present in Morocco (Blanc and Maurice 1950). Present in Nablus area of Jordan; parasite of chickens and persons; infected with spirochetes (Badudieri 1954,1955). Transmits fowl spirochetes ("Brumpt's Precis"). Life cycle (Davis and Mavros 1956C).

O. delanoëi delanoëi Roubaud and Colas-Belcour, 1931; described from porcupine burrow, Morocco. Biology (Roubaud and Colas-Belcour 1936). Life cycle and larval feeding (Colas-Belcour 1941). Non-transmission of spirochetes (Colas-Belcour and Vervent 1949). Present in Egypt (Hoogstraal 1953C). Absence of spirochetes (Davis and Hoogstraal 1954). Life cycle (Davis and Mavros 1956A). Biological observations and distribution in Egypt; descriptions of immature stages (Hoogstraal 1955E).

O. delanoëi acinus Whittick, 1938; described from cave in British Somaliland. Haemoglobin (Wigglesworth 1943). Biology (Robinson 1946). Coxal organs ("glands") (Lees 1946B). Transpiration from cuticle (Lees 1948). Egg waxing organ (Lees and Beament 1948). Weight of tick and of its cuticle, fed and unfed (Lees 1952). Larval and nymphal measurements, and the increase in size following each molt and male measurements have been noted by Campana-Rouget (1954).

O. erraticus Lucas, 1849; described from Algeria and now known in Iran, Turkey, and throughout much of the European and African Mediterranean area as well as in French West Africa, Kenya, and Uganda. This tick chiefly inhabits rodent burrows, sometimes lairs and dens of other animals, and pigsties. It also may parasitize man, reptiles, toads, and birds. The very extensive literature on O. erraticus will be reviewed in Volume II of this work.

O. foleyi Parrot, 1928; single female described from the Algerian Sahara. Description repeated by Foley (1929). A synonym of O. foleyi is O. franchinii Tonelli-Rondelli, 1930(B) from Libya; cf. Roubaud and Colas-Belcour (1931). As O. lahorensis, O. lahorensis group, or O. franchinii from Libya by Franchini (1927,1928B,1932A,B,1933A,D,1934A,1935A,1937) and Franchini and Taddia (1930); in these reports, the general remarks and those concerning fever in man as a result of bites do not appear to be based on sound evidence; the "biological differences" (1934A) are pointless. Morphology and generic discussion (Warburton 1933); cf. remarks herein under Argas brumpti (page 88). Presence in Southeastern Egypt (Hoogstraal and Kaiser 1956). Life cycle (Davis and Mavros 1956D).

O. graingeri Heisch and Guggisberg, 1953(A); all stages described from coral cave near sea, Mombasa. Life history (Heisch and Harvey 1953). Infected with spirochetes (Heisch 1953). Parasitizing bats (Garnham and Heisch 1953). Parasitizing porcupines and man (Heisch 1954A). Note: The actual date of publication of this species is 8 January 1953 although the volume number is that of 1952.

O. normandi Larrousse, 1923; all stages described, life cycle, from rodent burrows in Tunisia. Morphologic characters and biology (Colas-Belcour 1928). Egg laying and hatching (Colas-Belcour 1929A). Spirochete studies by Nicolle, Anderson, and Colas-Belcour (1927A,B,1928A,B,C,D,1930).

[O. pavimentosus Neumann, 1901; reported from Southwest Africa. Synonymized under O. savignyi by Theiler and Hoogstraal (1955).]

O. *peringueyi* Bedford and Hewitt, 1925; scanty descriptions and illustrations of male, female, and nymph from South Africa. Cliff swallow as host (Bedford 1929A,1932A). Failure to transmit *Aegyptianella pullorum* (Bedford and Coles 1933). All stages redescribed and reillustrated (Bedford 1934).

O. *salahi* Hoogstraal, 1953(B); a parasite of fruit bats in the Nile Valley and Wadi Natroun (Western Desert) of Egypt; also known from Palestine; all stages described; life history. Absence of spirochetes (Davis and Hoogstraal 1954).

O. *tholozani tholozani* Laboulbene and Megnin, 1882(A); first described from Iran. An important Asiatic vector of spirochetes of relapsing fever; the *tholozani* group consists of several subspecies and related species; reviewed by Desportes and Campana (1946). Rare in western Egypt and eastern Libya (Coghill, Lawrence, and Ballentine 1947; Hoogstraal 1953C) but accused of transmitting spirochetes causing disease in troops. Now known from several restricted, but large, spirochete-infected populations in Egypt (Davis and Hoogstraal 1956) and from Jordan (Babudieri 1954,1955).

O. *zumpti* Heisch and Guggisberg, 1953(B); female and nymph described from burrow of rodent (*Rhabdomys pumilio*) in Cape Province, South Africa. Onderstepoort collection material recently sent by Dr. Theiler for identification includes males, females, and nymphs from the nests of *Aethomys* and ?*Tatera* in Cape Province.

[O. *lahorensis* Neumann, 1908, an Asiatic-Near Eastern species, said by Franchini (1929B,1932B,1935) and Garibaldi (1935) to occur in Libya; most probably does not extend its range into North Africa.]

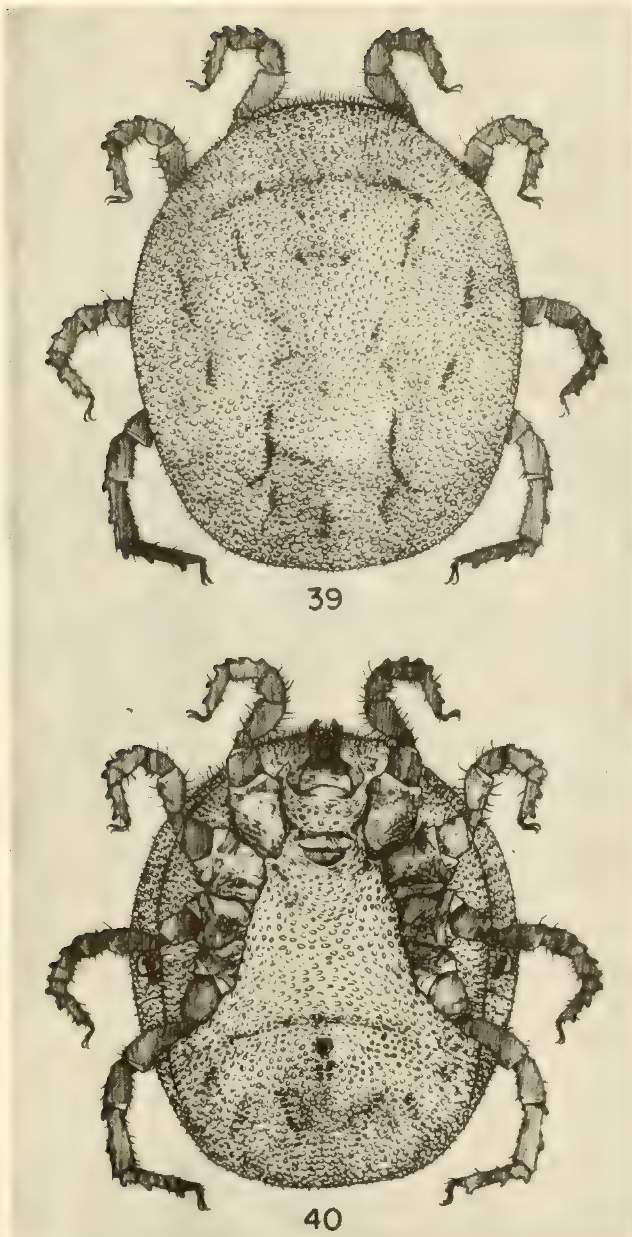
O. sp. nov.; an undescribed species closely related to O. *foleyi* has recently been found in porcupine burrows near Pretoria in the Union of South Africa (Theiler, correspondence).

KEY TO SUDAN SPECIES OF *ORNITHODOROS*

MALES AND FEMALES

With two pairs of eyes in lateral fold.
(Northern and Central Sudan)........................*O. SAVIGNYI*
Figures 8 to 12

Without eyes. (Southern Sudan)........................*O. MOUBATA*
Figures 39 to 62



Figures 39 and 40, ♀, dorsal and ventral views

ORNITHODOROS MOUBATA
(Laboratory reared)

PLATE XIV

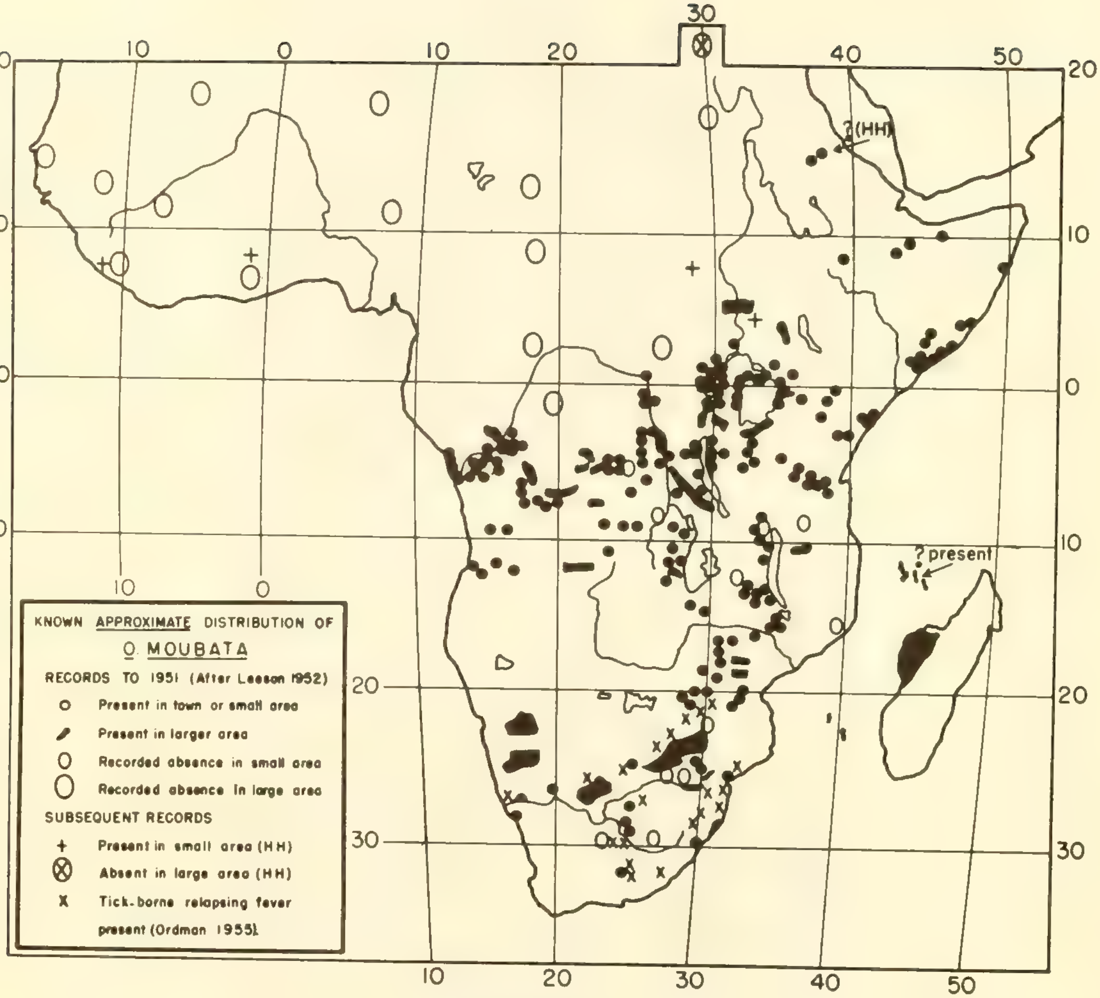


Figure 41

KNOWN DISTRIBUTION OF
ORNITHODOROS MOUBATA

PLATE XV

ORNITHODOROS (ORNITHODOROS) MOUBATA (Murray, 1877).

(Figures 39 to 62)

THE EYELESS TAMPAN*

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	2	1		Liria	African hut	Nov
	3	1	1	Wani Mika	?	Nov

Without locality data (King 1911,1926. Maurice 1932. Kirk 1939). Maurice (1932) stated that in connection with the 1925 relapsing fever outbreak, O. moubata had been found in "four Equatoria Province rest houses north of Minule".

The only eyeless tampans in Sudan Government collections are a few specimens from Wani Mika, collected by J. Dervish, 3 November 1925.

The three specimens collected from a hut at Liria in November of 1949 are the only ones that I have been able to find in the Sudan. A search of this and other Liria huts during January of 1952 failed to reveal additional material. During the same trip, preserved specimens were extensively exhibited to residents of many villages on the Juba-Torit-Tarangore track, and at Katire, Gilo, Yei, and Kajo Kaji. Although some persons who saw them professed to know the whereabouts of similar "dood", no tampans could be found.

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: From warthog burrows on Guar-Galual road near Guar, Gogrial Subdistrict, Tonj District, April, 1953, collected by E. T. M. Reid and P. Blasdale. Three burrows examined yielded one nymph in the first, two males and nine nymphs in the second, and two males and thirteen nymphs in the third. Mr. Thomas W. Chorley and the collectors are to be congratulated for

*In South Africa, called "The Hut Tampan" (Theiler 1952A,B).

these fine records of O. moubata. Guar is situated at approximately 8°50'N. and 28°30'E. The specimens were collected during the dry season; but for several months of the year this "Nile sponge" area is a vast flooded plain. It would be interesting to know the activity of the ticks at that time.

No evidence of O. moubata has been discovered from buildings in Bahr El Ghazal Province, but search in these places has not been extensive enough to draw conclusions from this negative data.

DISTRIBUTION

O. moubata is widely distributed locally throughout East and northern South Africa, and extends into the drier part of Central Africa. A few specimens indicate its presence in West Africa. In South Africa and elsewhere, human activities have carried the eyeless tampan far from its former habitats. Assuming, for lack of evidence to the contrary, that burrow-inhabiting populations and hut-inhabiting populations are identical species, it would appear that the distributional picture of the former populations, when it becomes better known, will be true indication of the primitive range of O. moubata.

Early collecting records were summarized by Neumann (1901) and by Merriman (1911). Some early records are under O. savignyi caecus Neumann, 1901, a synonym of O. moubata, and for a time O. moubata and O. savignyi were confused by Neumann and other writers. More recently, Leeson (1952) published a distribution map and (1953) additional notes that have been brought up to date herein (Figure 41).

The mapped distribution of tick-borne, human relapsing fever in the world (American Geographical Society 1955) contains numerous errors in the area devoted to the Ethiopian Faunal Region, where O. moubata is the only known vector, except rarely the human louse. A large section of the Sudan is shaded to indicate the presence of both tick-borne and louse-borne spirochetes - which would infer the widespread range of O. moubata in the Sudan. This is contrary to the available data, presented above. The same indications for the Yemen are based on uncritical repetition of earlier errors in literature, even though subsequent references disclaim earlier assertions - a frequent evil of uncritical fact-gathering from literature. Few outlines on the African map bear close relation to available facts.

WEST AFRICA: Not recorded by Simpson (1912A,B) from the northern or southern parts of Nigeria. Absent from northern Nigeria (McCullough 1925). No evidence to associate relapsing fever in northern Nigeria with O. moubata (Caffrey 1926).

Not known from Liberia (Bequaert 1930A).

Absent from thirteen French West Africa villages on the Niger (Kerrest, Gambier, and Bouroun 1922A,B). Recorded "south of Lake Chad" (Neumann 1901) but not found in Chad localities by Le Gac (1931); O. savignyi has been found in this general area (Alcock 1915) and Neumann may have misidentified his material. Apparently absent in French West Africa (Gouzien 1923). Absent around Dakar (Mathis 1928A,B. Mathis and Durieux 1932A,B. Mathis, Durieux, and Advier 1933,1934).

GOLD COAST: Appears to be absent according to Selwyn-Clarke, Le Fanu, and Ingram (1923) and Ingram (1924); nevertheless a single nymph from Ashanti has been seen (Hoogstraal 1954C). SIERRA LEONE: Specimens seen by Hoogstraal (1954C).

It is difficult to reconcile the GOLD COAST and SIERRA LEONE records from British Museum (Natural History) collections with previous distributional concepts of O. moubata, which have held that this species is absent from West Africa. Yet there is little reason to believe that the specimen labels are incorrect. A renewed search in these areas is indicated; otherwise one hesitates to draw conclusions from these unexpected records (Hoogstraal 1954C).

CENTRAL AFRICA: FRENCH EQUATORIAL AFRICA (Blanchard 1913, 1914. Le Boeuf and Gambier 1918A,B. Rodhain 1919A. Guillet 1924. Blanchard and Laigret 1924. de Buen 1926. Rousselot 1951,1953B).

BELGIAN CONGO and RUANDA-URUNDI (Livingston 1874, vol. 2, pp. 33 and 115. Neumann 1901,1911. Ross and Milne 1904. Dutton and Todd 1905A,B. Newstead 1905A,B,C,1906A,B. Massey 1908. Rodhain, Pons, van den Branden, and Bequaert 1913. Roubaud and Van Saceghem 1916. Van Hoof 1917,1924. De Ruddere 1917. Rodhain 1919A,B,1920, 1922A,B,C. Todd 1919. Bequaert 1919,1930A,B,1931. van den Branden and Van Hoof 1922. Ghesquiere 1922. Van Saceghem 1923. van den Branden 1924. Olivier 1924. Seydel 1925. Schwetz 1927A,B,1932, 1933A,1942,1943. Van Hoof and Duke 1928. Flamand 1928. Schouteden 1928. Dubois 1931,1949A,B. Trolli 1931. Seraglia 1932. Pierquin 1950. Jadin and Giroud 1950,1951. Giroud and Jadin 1950,1954,1955. Jadin 1951A,B. Himpe and Pierquin 1951. Pierquin and Niemegeers 1953. Jadin and Panier 1953. Davis and Burgdorfer 1954. Theiler and Robinson 1954. Burgdorfer and Davis 1954. Babudieri 1955*).

[NOTE: Rageau (1953B) suggests the strong possibility of the tampan's presence in Cameroons. He states, on epidemiological grounds, that relapsing fever there is presumed to be tick-borne and that the most likely areas in which the tick may occur have not been well studied.]

EAST AFRICA: SUDAN (Balfour 1906; tampan then not yet seen in the Sudan. King 1911,1926. Maurice 1932. Kirk 1939. Hoogstraal 1954C. See DISEASE RELATIONS and introductory paragraphs of DISTRIBUTION section).

ETHIOPIA (Brumpt 1908A. Bergsma 1928,1929. Giordano 1936. Absence of tampans at 2,200 meters altitude: Scaffidi 1937. Bruns 1937. Franchini 1937. Mennonna and Modugno 1937. Manson-Bahr 1941,1942. Bertazzi 1952). ERITREA (Franchini 1929D,E. Niro 1935. Stella 1938A,1939A,1940). [FRENCH SOMALILAND (No known records).] BRITISH SOMALILAND (Brumpt 1901. Drake-Brockman 1913,1915A,B,1920, identity in part confused with O. savignyi. Donaldson 1926. Clark 1937, remarks questionable. Stella 1938A, 1940. Cullinan 1946. Anderson 1947. Heisch 1950A. Heisch and Furlong 1954. Davis and Burgdorfer 1954). ITALIAN SOMALILAND (Brumpt 1901,1908A. Paoli 1916. Rodino 1922. Reitani and Parisi 1923. Franchini 1925,1929C,E,1937. Bartolucci 1933. Mattei 1933. Niro 1935. Massa 1936A. Moise 1938,1950. Stella 1938A, 1939A,1940. Lipparoni 1951,1954. Falcone 1952. Giordano 1953).

---

*Professor Babudieri (1955) states that he utilized the Itete strain procured from the Congo by Professor Geigy. This strain was collected by Geigy and Mooser (1955) in Tanganyika.

KENYA (As O. savignyi: Karsch 1878. Ross 1912. Neave 1912. Todd 1913. Anderson 1924A,B. Garnham 1926,1947. Mackie 1927. "Kenya 1928". Lewis 1931A,C,1939A. Hynd 1945. Quin and Perkins 1946. Jepson 1947. Absence of Ornithodoros ticks: Garnham, Davies, Heisch, and Timms 1947. Heisch and Grainger 1950. Heisch 1950A,B,1954C,E. Walton 1950A,1953. Teesdale 1952. Bell 1953. Heisch and Furlong 1954. Geigy and Mooser 1955).

UGANDA (Christy 1903A,B,1904. Pocock 1903. Johnston 1903. Sambon 1903. Ross and Milne 1904. Cook 1904. Ross 1906,1912. Hirst 1909,1917. Bruce et al 1911. Ross 1912. Neave 1912. Todd 1913. Neumann 1922. Mettam 1932. Hargraves 1935. Hopkins and Chorley 1940. Chorley 1943).

TANGANYIKA (Neumann 1901. Sambon 1903. Christy 1904. Ross and Milne 1904. Dutton and Todd 1905A,B. Koch 1905,1906. Werner 1906. Möllers 1907. Todd 1913. Morstatt 1913,1914. Manson and Thornton 1919. (?Lester 1928). Loveridge 1928. Bequaert 1930A. Knuth 1938. Hawking 1941. Schulze 1941. Knowles and Terry 1950. Phipps 1950. Geigy 1951. Geigy and Burgdorfer 1951. Walton 1953. Davis and Burgdorfer 1954. Mooser and Weyer 1954. Smith 1955. Geigy and Mooser 1955. Babudieri 1955: see footnote under Belgian Congo).

SOUTHERN AFRICA: ANGOLA (Livingstone 1857, pp. 382-383. Murray 1877. As O. savignyi: Neumann 1896. Neumann 1901. Pocock 1903. Calman 1905. Wellman 1905A,B,C,1906A,B,C,D,1907A,B. Dutton and Todd 1905A,B. Nuttall et al 1908. Gamble 1914. Rodhain 1919A. De Almeida and Rebelo 1928. Sousa Dias 1950. Santos Dias 1950C. Theiler and Robinson 1954). MOZAMBIQUE (Livingstone 1857, pp. 383, 628,629. Dowson 1895. Pocock 1903. Johnston 1903. Howard 1908, 1911. Amaral Leal and Sant'Anna 1909. Absent from Alto Molocue: McFarlane 1916. Neumann 1922. Marques 1943,1944. Santos Dias 1952H,1953B,1954H,K).

NORTHERN RHODESIA (Neave 1911,1912. Wallace 1913. Lloyd 1913, 1915. Holmes 1953. Hoogstraal 1954C). SOUTHERN RHODESIA (Jack 1921,1928,1931,1937,1938,1942. Leeson 1952). NYASALAND (Old 1909. Neave 1912. De Meza 1918A. Lamborn 1924,1927,1939. Wilson 1943, 1950B. Hardman 1951).

BECHUANALAND (Specimens from Ngamiland in Theiler collection). SOUTHWEST AFRICA (Neumann 1901. Trommsdorff 1914. Sigwart 1915. Mitscherlich 1941. Hoogstraal 1954C).

UNION OF SOUTH AFRICA (Lounsbury 1900C, in part confused with O. savignyi. Pocock 1903. Dönitz 1906,1907A,C,1910B. Greenway 1907. Howard 1907,1908. Cowdry 1925C,1926A,1927. Curson 1928. Bedford 1920,1926,1932B,1934,1936. Cooley 1934. Bedford and Graf 1934,1939. Cluver 1939,1947. Ordman 1939,1941,1943,1944A, B,1955. De Meillon 1940. Mitscherlich 1941. Collen 1943. Polakow 1944. R. du Toit 1942B,C,1947A,B. Thorp, De Meillon and Hardy 1948. Mönnig 1949 statements refer largely to O. savignyi. Annecke and Quin 1952. Annecke 1952. Davis and Burgdorfer 1954).

ISLAND GROUPS: MADAGASCAR (Lamoureux 1913A,B. Suldey 1916. Poisson 1927. Poisson and Decary 1930. Buck 1935,1948A,C,1949. Le Gall 1943. Millot 1948. Neel, Payet, and Gonnet 1949. Decary 1950. Colas-Belcour, Neel, and Vervent 1952. Hoogstraal 1953E). Although O. moubata has not been reported from the COMORES group, Neel, Payet, and Gonnet (1949) state that relapsing fever of the apparent type borne by O. moubata exists at Dzaoudzi.

Records from Zanzibar (Brumpt 1901,1908A) probably should be disregarded. They may refer to "East Africa" in general. According to Dr. S. D. Robertson, Pathologist, Medical Department, in personal correspondence, O. moubata does not occur in Zanzibar. It has been stated to be absent there (Aders 1913) and was not listed by Aders (1917B) in his report of insects injurious to man and stock in Zanzibar. Odd individuals of the tick may be imported in dhows from Tanganyika but these do not appear to become established on the island (Leeson 1953).

[NORTH AFRICA AND ARABIA: Records from Libya are difficult to accept. Franchini (1932A,B,1933A,B,C,D,1934B,1935A) listed Tripolitania as the source of specimens. He was probably dealing with O. savignyi, but Garibaldi (1935) accepted these reports. Zavattari (1932,1933,1934) stated that O. moubata is absent in Libya. Though Franchini (loc. cit.) and Gaspare (1933,1934) asserted differently, their remarks are so confused as to negate their argument unless fresh specimens can be procured. One of NAMRU-3's well trained assistants has been unable to find O. moubata in the Libyan localities from which it was reported.

Records from Egypt (Neumann 1896,1901,1911), without question erroneous, are probably based on mistaken identity of *O. savignyi*, or possibly on mixed locality labels (Hoogstraal 1954A). Halawani (1946) stated that although *O. moubata* was supposed to be common in Egypt, he could not find specimens in houses. Yakoub (1945) also noted its absence here.

According to Petrie (1939), the eyeless tampan is widespread in the Yemen (Arabia) (copied by American Geographical Society 1954,1955). From experience in the Yemen (Hoogstraal 1952C and ms., Girolami 1952, Mount 1953) it is questionable whether it is present there at all, to say nothing of being widely distributed.]

HOSTS

Introduction

Man is frequently attacked and is probably the chief host of *O. moubata*. Warthogs and a few other wild animals that inhabit large burrows, and domestic pigs appear to be the only other fairly common hosts of this tick. Incidentally, it should be noted that frequent textbook assertions that larvae feed are incorrect (see Life Cycle below).

Most laboratory animals including chickens serve as experimental hosts. Different "strains" may have different laboratory feeding habits, "burrow-haunting" populations being more difficult to induce to feed in the laboratory than those from domestic habitations (Heisch 1954C).

Human Hosts

The major portion of the literature concerning the eyeless tampan refers to its parasitism of human beings. Indication of this may be found in the section on Ecology below; specialized features of this problem will be considered in the forthcoming volume on tick-borne diseases.

Domestic Mammal Hosts

From the prevalence of records of attacks on domestic pigs in South Africa (Bedford 1936), Nyasaland (Wilson 1943,1950B), Belgian Congo (Roubaud 1916, Roubaud and Van Saceghem 1916, Schwetz 1927A), Southern Rhodesia (Jack 1921,1931,1942), and Angola (Wellman 1906D,1907A,B), it appears that this animal often is an important host. In Southern Rhodesia, O. moubata sometimes increases prodigiously in pigsties (Jack 1921,1931,1942). In the Zambi area of Belgian Congo, O. moubata was abundant in pigsties and in huts of pig keepers, but relapsing fever was absent, and the tick was unknown in local huts where no pigs were kept (Roubaud and Van Saceghem 1916). In Angola, Wellman (1906D,1907A) found "as many in pigsties as in any other situation". In Nyasaland, Wilson (1943) stated, O. moubata is suspected of causing mortality in pigs. Jadin (1951A) found specimens from pigsties in Ruanda-Urundi infected with the causative organisms of food poisoning, Salmonella enteritidis; these ticks were able to transmit the bacteria to experimental animals, by biting, over a year later.

O. moubata has been said to cause much trouble in Southwest Africa by feeding on sheep in resting places and pastures (Mönnig 1949), but Theiler states (correspondence) that the ticks actually involved in this situation are quite likely O. savignyi.

Domestic animal corrals are frequently cited in review papers as important habitats of the eyeless tampan. I can find little conclusive substantiation for this assertion, except for domestic pigs. Wellman (1906D,1907A) was possibly the first person from the field to state that O. moubata bites all domestic animals, but he did not mention that he had made personal observations. Careful search of corrals and comparison of incidence in these and in human habitations should make an interesting and simple research project in infested areas. One would expect that if domestic animals are attacked, it is chiefly in circumstances in which they are housed more or less like human beings in the same area.

(See also Ecology below).

Domestic Fowl Hosts

Domestic fowls in human habitations usually are considered to be important in maintaining the nymphal stage, but there is some controversy on this point (Knowles and Terry 1950, Phipps 1950). Rodhain (1919A) found avian blood in specimens from a vacant house in the Congo inhabited by chickens. Geigy and Mooser (1955) failed to find evidence of spirochetes in domestic fowls from tampan infested dwellings in Tanganyika, a suggestion that these ticks do not feed on fowls or do not transmit these organisms to fowls, or else that Borrelia duttonii does not survive in fowls in nature.

Along with A. persicus, Mitscherlich (1941) discussed the ravages of O. moubata in chicken houses in the Union of South Africa and in Southwest Africa (= Deutsch Südwest Afrika). It is not, however, clearly stated that this writer actually saw eyeless tampans in these situations. His remarks give the impression of being based on the assumption that O. moubata is an important parasite of domestic chickens.

(See also Ecology below).

Wild Mammal Hosts

See also "Wild" Habitats under Ecology below.

A wild relative of the domestic pig, the warthog, Phacohoerus aethiopicus subspp., is a normal host of O. moubata under conditions not influenced by man. An African boy in Northern Rhodesia has been observed emerging from a warthog burrow with about thirty nymphs biting him (Lloyd 1915). During a survey of the plains south of Lake Edward in the Belgian Congo, Schwetz (1933A) discovered that O. moubata was abundant in warthog burrows but rare in native huts. Chorley (1943) found over forty specimens crawling on a warthog shot in Uganda. He stated (personal conversation) that all these specimens were nymphs. Heisch and Grainger (1950) found numerous specimens in widely scattered warthog burrows in Kenya and presented a theory on the relationship of wild and domestic populations, discussed below in the section on "Wild" Habitats, under Ecology. A single specimen from a Northern Rhodesian warthog and a large lot of nymphs from a Nyasaland warthog burrow have been reported from material in the Nuttall collection (Hoogstraal 1954C). Warthogs are also hosts in the Sudan, as noted above and reported earlier (Hoogstraal 1954B). These mammals also have been noted as hosts in Mozambique (Santos Dias 1952H, 1953B).

In certain areas of Tanganyika, infestation of warthogs and other large mammals is well known in some quarters (Walton 1953). Walton described a warthog burrow in which 41 hungry later-stage nymphs and adults were found; stomach blood smears from these gave a positive reaction to pig antisera. O. moubata was also discovered in three other warthog and porcupine burrows in foothills of the Usambara Mountains. Literally hundreds of nymphs and adults emerged from the floor and ceiling to attack Walton and a friend when they entered some of these burrows. Subsequently, specimens were found in six other burrows and in two hollow baobab trees that were used from time to time as retreats by various kinds of animals. Smaller burrows in the Usambara Mountains area, presumably belonging to the giant forest rat, Cricetomys sp., were uninfested.

More recently in Tanganyika, Geigy and Mooser (1955) examined 55 burrows of warthogs, originally dug by antbears (Orycteropus afer), and found eyeless tampans in eighteen of them. More than 1,200 tick specimens were collected from these retreats and an additional one was taken on the body of a freshly shot warthog. They also found the burrows of other kinds of mammals infested in Kenya.

In connection with Sudan specimens from warthog burrows (Hoogstraal 1954B) (see also DISTRIBUTION IN SUDAN above), it is of interest to note that these are from the "Nile sponge" region that becomes a vast lake during the rains. Just what the ticks do during these floods should be worthy of investigation.

Walton's (1953) records for porcupine (Hystrix sp.) burrows are noted above. Heisch (1954E) noted nymphs and adults in porcupine burrows in Kenya and found that they had fed on porcupine blood. Geigy and Mooser (1955), also working in Kenya, did not find ticks in a porcupine burrow that they examined but a nearby hyena shelter was heavily infested.

In South Africa (Theiler, unpublished), specimens of O. moubata have recently been taken from burrows of aardvarks or antbears, Orycteropus afer, near Stockpoort in the Potgietersrust area. Search for ticks in the retreats of these large, almost hairless animals will undoubtedly provide further interesting data. As noted elsewhere, other workers have found eyeless tampans in burrows originally dug by antbears but later occupied by warthogs.

Loveridge (1928) ambiguously associated O. moubata with giraffes in Tanganyika, and Santos Dias (1952H, 1953B, 1954K) mentioned small numbers of nymphal and adult specimens from lion, Lichtenstein's hartebeest, waterbuck, and scaley anteater. Further data for these exceptional records are desirable.

Heisch (1950A) obtained negative results when he attempted to induce O. moubata in Kenya to bite house rats, Rattus rattus, placed in huts for experimental purposes. Wild rodents from tick-infested Tanganyika dwellings gave no evidence of spirochetes when tested in the laboratory (Geigy and Mooser 1955).

van den Branden and Van Hoof (1922) fed laboratory specimens on the fruit bat, Eidolon helvum.

No other wild mammals have been reported actually to have been observed as hosts of O. moubata in nature. The fact that the burrow-inhabiting warthog and the domestic pig each serve as a host of this tick is of special interest. Heisch and Grainger (1950) have concluded that before O. moubata became "domesticated" it inhabited large burrows of wild animals.

Roubaud (1916) conjectured that some of the several external parasites of warthog and man alike may be attracted to these hosts because of their hairless skin. This interesting theory is probably not now tenable for O. moubata in the light of present knowledge.

In review, it appears that large burrows of wild animals, among which those of the warthog are the most common, are the favorite and quite possibly the original habitat of O. moubata. It should be borne in mind, however, that those populations of this tick inhabiting wild animal burrows may possibly represent a different physiological or biological race, or a distinct subspecies. It would be of value to determine the domesticability of "wild" populations.

Recently, Heisch (1954C) has noted that ticks from burrows are more difficult to feed on laboratory animals than are those from domestic habitations. Geigy and Mooser (1955) observe that bush ticks are more blue gray in color, move more quickly, attach to the host and suck blood more quickly, and are hardier in captivity than specimens from domestic populations of O. moubata.

Contrary to Heisch's experience, they state that wild specimens "adapt themselves to feeding on mice and guineapigs easier than house ticks".

Wild Reptile Hosts

Bedford (1934) listed several collections from South African tortoises. Theiler (unpublished) has records of nymphs and adults from four species of South African tortoises, Testudo oculifera, T. verreauxii, T. schönlandi, and Homopus femoralis from Kimberley and Wodehouse Districts and from Namaqualand. Theiler considers tortoises to be exceptional hosts.

Rodhain (1920,1922B,C) found that blood of lizards, geckos, and snakes is easily digested by O. moubata. Although nymphs that had fed on snakes died in larger numbers than those that had fed on mammals, survivors reached the same size as mammal-fed individuals. Chameleon blood is initially very toxic, and digestion is slow and difficult. Though many ticks die after feeding on chameleons, a few do become adapted to it. Individuals that had fed exclusively on chameleons for sixteen months subsequently fed on mice when allowed to do so. Van Hoof (1924) reported similar findings. As already stated, tortoises sometimes are infested in South Africa, but no other collections from cold-blooded vertebrates in nature have been reported.

BIOLOGY

Life Cycle

Life history details have been studied and reported by Dutton and Todd (1905A), Newstead (1905A,B,C,1906A,B) and Wellman (1906C, D,1907A). These were reviewed by Nuttall et al (1908). Subsequent observations were reported by Cunliffe (1921), Jobling (1925), and Pierquin and Niemegeers (1953)*. Other contributions on specialized phases are noted below. Some discrepancies in observations exist, but the broad outlines of the life cycle are well established. Critical and restrictive factors are poorly known and no observations on the life cycle under natural conditions have been undertaken. The natural history of O. moubata is gradually being elu-

---

*The dates of publication of these reports will not be repeated in the life cycle section.

cidated, but each new observation suggests how many other details are yet to be known.

A summary of the life cycle is as follows: Copulation is effected by transfer of a male spermatophore to the female, after which the female indulges in a rapid blood meal and subsequently deposits a small batch of unusually large eggs in or on the soil. After the larva emerges it remains nonmotile and nonfeeding till the nymphal stage some hours or days later. The active nymph, after a short rest, feeds on an available host for about half an hour, then retreats to the soil or a crevice to digest its meal. Subsequently, the nymph molts, usually four or five times, with a similar pattern of resting, feeding, and resting between each ecdysis. Sexually mature adults emerge from the last molt and normally mate shortly afterwards. The female feeds two days later and several days afterwards deposits a batch of eggs. Adult hiding and feeding habits are like those of nymphs. Seven feedings and egg batches appear to be maximum in one female's lifetime. A minimum of about two and a half months is necessary to complete the life cycle, which normally is probably considerably more extended than this. Apparently these ticks do not voluntarily wander far in search of food and considerable numbers may develop in a single building or large animal burrow.

The mating behavior of *O. moubata* was described by Nuttall and Merriman (1911) but the account of mechanism of insemination has been augmented by Robinson (1942B). The development of the sperm has been described by Samson (1909).

In the male the spermatids travel down the vas deferens either in a continuous stream or are aggregated in rounded pellets, each containing a few hundred male elements. As stated by Robinson and Davidson (1914) (for *Argas persicus*), it is probable that the male accessory glands secrete the spermatophore case into which these elements pass.

[According to Robinson, the spermatophore is not chitinous. It completely dissolves in strong KOH solution at 150°C., and becomes red in Millon's reagent; therefore it is probably largely protein.]

In order to mate, the male crawls beneath the female and clings to her so that the two ventral surfaces are in apposition. After dilation and stimulation of the female orifice by insertion and movement of male mouthparts, a spermatophore issuing from the male genital aperture is grasped by the male's mouthparts and transferred to the female genital aperture. [Coxal fluid is emitted by the male during the course of these activities according to Nuttall and Merriman, but Dr. G. E. Davis and Dr. W. Burgdorfer state (conversation) that they have not observed this. It is possible that coxal fluid may or may not be emitted at this time, due either to copiousness of supply or to degree of excitement.]

The spermatophore is bulb shaped (Figure 42) as it issues. After the male applies it to the female aperture, contraction and evagination force out the long neck with the capsules (Figure 43) that are inserted into the aperture. Most of the spermatids are forced into the capsules but the bulb remains outside the female aperture and drops off sooner or later. As many as ten bulbs have been seen *in situ*. The neck dries and twists, making an effective seal at the capsule closure. After five days at 30°C., the now mature sperms escape into the uterus by rupture of the capsule wall. [For further details, see Robinson (1942B).]

As stated below, the initial fertilization usually occurs shortly following molting to the adult stage, and females first feed about two days afterwards. They may feed before mating, presumably chiefly when males are not readily available. However, according to Jobling, the period of time between fertilization and feeding has no effect upon the period between feeding and oviposition.

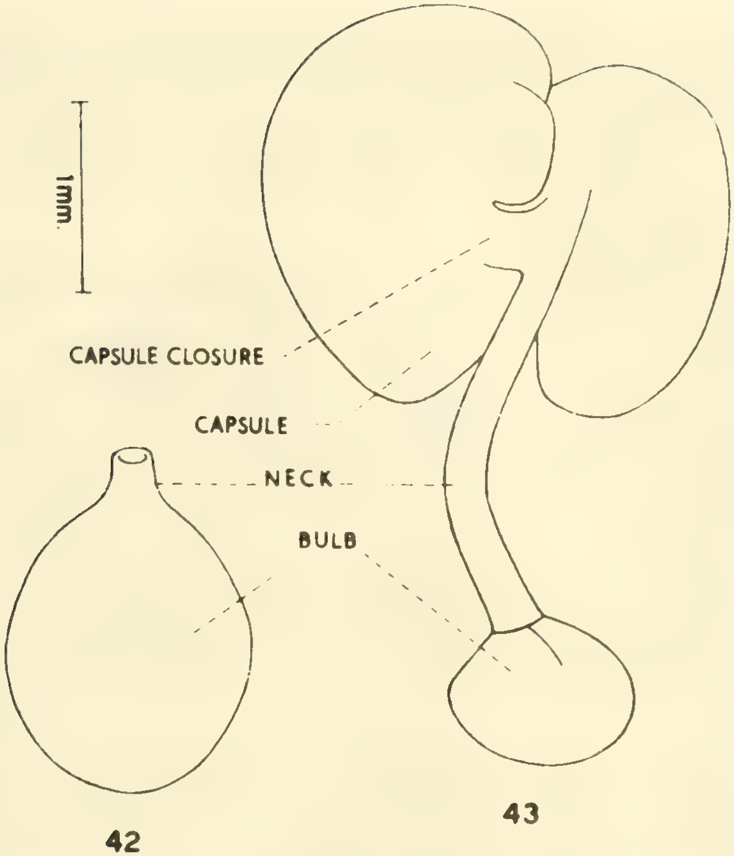


Figure 42. Invaginated, bulb-shaped spermatophore as it issues from male genital aperture.
Figure 43. Evaginated spermatophore, with neck and capsules, after having been applied to female uterus.

ORNITHODOROS MOUBATA SPERMATOPHORE

[After Robinson (1942)]

PLATE XVI

Generally, oviposition only follows a blood meal. For various reasons the interval between feeding and egg laying varies from five to 25 days, although (in tubes in jars with slightly moist cotton, maintained at 29.5°C. to 30°C.) the average is six to nine days (Jobling, and others). [Specialists will be interested in Wigglesworth's (1943) brief account of the fate of haemoglobin in ovipositing females.]

As each egg is emitted from the female genital aperture it normally comes in contact with a peculiar glandular organ, gene's organ, that lies dorsally at the base of the capitulum. Gene's organ, which is everted only during oviposition, envelops each egg and provides it with a waxy, waterproof coating. Should this organ fail to evert or if any eggs are missed, these shrivel and fail to hatch, even in a humid atmosphere. The waxy coating is soft and viscuous (melting point 50°C. to 54°C., in contrast to cuticular wax, which is hard and crystalline with a melting point of 65°C.). The critical temperature of O. moubata eggs well covered by this wax is 45°C. Lees and Beament (1948) have made a detailed study of gene's organ and its secretion, temperature and water loss of eggs, morphology of the female genital tract, structure and chemistry of the egg shell, and permeability of the egg shell.

Eggs are deposited in masses on the soil or in hollows burrowed out by the female. It has been stated that the masses are agglutinated. Actually, individual eggs have a somewhat adhesive coating. When a container in which they are kept is jostled they roll about like globules of mercury. This is true also for eggs of numerous other argasids that have been observed.

After oviposition, the female "broods" over the eggs for some days (Wellman), a phenomenon of unknown function common among argasids. Jobling observed that this "brooding" sometimes continues till the nymphal molt, after which the female may walk about for a time with several nymphs clinging to her.

Dutton and Todd recorded individual batches of ten to twenty eggs, with the greatest total of several batches from a single female numbering 139 eggs. Möllers (1907) observed a single batch of eighty eggs. Wellman mentioned a lifetime total of 88 eggs and Newstead reported a total of 94 eggs. Records obtained under optimum laboratory conditions have been higher than those secured by these early field and laboratory workers. Cunliffe observed a female that produced a lifetime total of 535 eggs of which over ninety percent were fertile. In Jobling's tests, one female deposited several batches totalling 1,217 eggs and eight other females laid totals of from almost 700 to over 1000 each. Dr. G. E. Davis and Dr. W. Burgdorfer report (conversation) that the largest number of eggs they have observed in a single oviposition has been 233 and 327, respectively. Most eggs are laid at night and sometimes more than one day is necessary before a full batch is deposited.

Six or seven batches, gradually diminishing in numbers, appear to be usual in one female's lifetime. The amount of the previous blood meal influences the number of eggs subsequently produced. Jobling noted that the fertility of later batches decreases.

In a laboratory study of O. moubata fertility, Robinson (1942C) found that three egg batches may be laid after one mating but that egg fertility is considerably increased if mating occurs before each oviposition. Fertility decreases when the interval between mating and oviposition is extended. Oviposition occurs almost without exception only after a blood meal. Eggs show no alteration in fertility when maintained between 22°C. and 32°C., but at 34°C. no larvae emerge. [As already stated, Lees and Beament (1948) have stated that 45°C. is the critical temperature for normal eggs.] Robinson recommenced a temperature of 30°C. and a relative humidity of 50% in the breeding chamber for safe and speedy production. He found that a female might deposit a few eggs without a blood meal and that large females produce more than do small ones. The range in number of eggs per female per batch in these experiments varied from fifty to 250, with an average of 170. Many females died shortly after their first blood meal; others after depositing their first egg batch.

According to Robinson, females lay over twice as many eggs when sand rather than a flat surface such as filter paper is provided for this purpose, but Dr. G. E. Davis and Dr. W. Burgdorfer report (conversation) that in their experience the opposite is true.

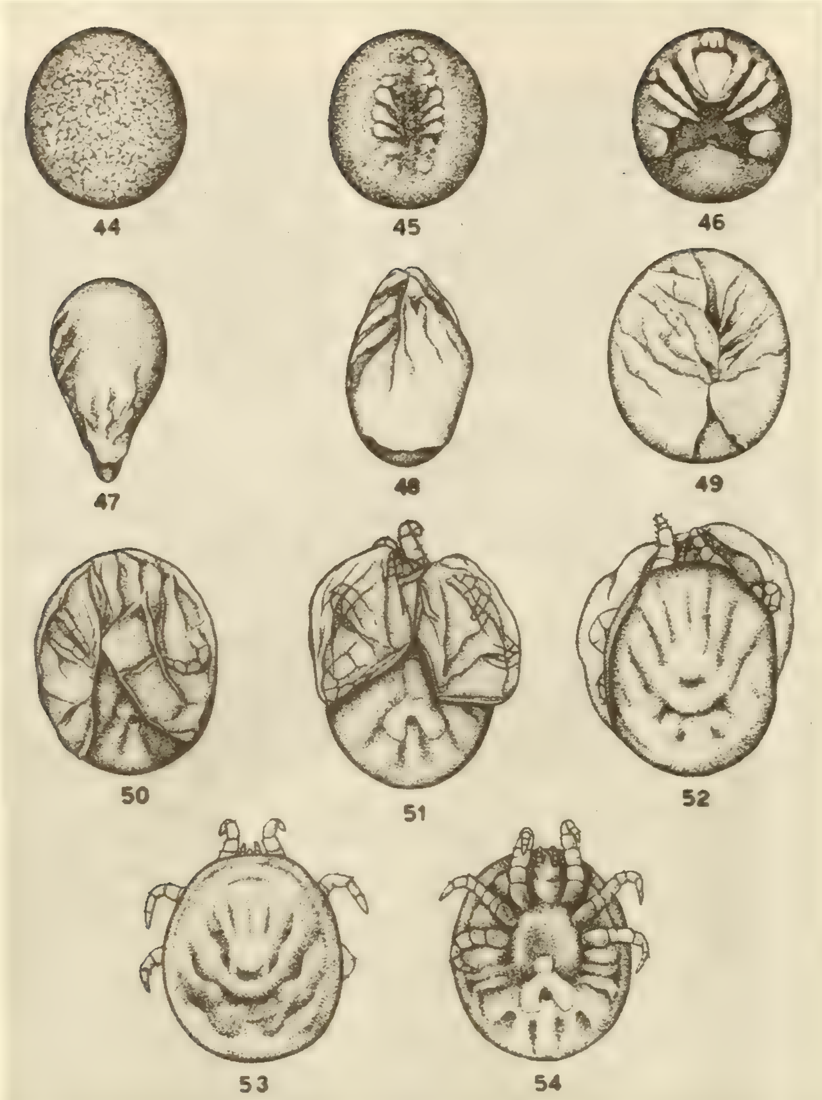


Figure 44, Egg just deposited
Figure 45, Embryo, fourth day
Figure 46, Embryo, sixth–seventh day
Figure 47, Hatching egg, lateral view
Figure 48, The same, alternate contraction and expansion
Figure 49, Rupture of egg shell
Figure 50, Larva hatching
Figure 51, Larva with shell, ventral view
Figure 52, The same, dorsal view
Figure 53, Larva, without shell, dorsal view
Figure 54, The same, ventral view

ORNITHODOROS MOUBATA EGG AND LARVA
[After Jobling (1925)]
PLATE XVII

The egg of O. moubata is among the largest known from ticks.

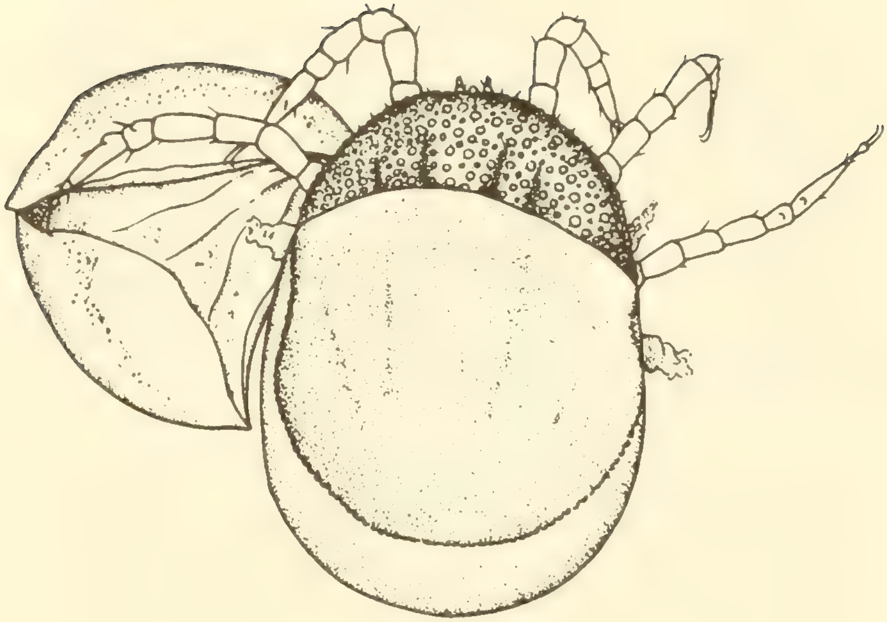
A newly laid egg (Figure 44) is slightly ovoid, glistening golden yellow, and measures approximately 0.9 x 0.8 mm. Later it becomes reddish brown. Eggs from older females are light to dark brown in color. An irregular, faint, whitish, polygonal reticulation and interrupted radiating streaks may be seen through the cuticle. The internal larva becomes discernable four days after the egg is deposited and occupies the whole egg by the sixth or seventh day (Figures 45 and 46). [An alkaline haematin product originating from haemoglobin in the maternal blood meal has been demonstrated in eggs (Wigglesworth 1943).]

Eight days after the egg has been laid (temperature 30°C.), the larva emerges by alternate contractions of the anterior and posterior ends of the body (Figures 47 and 48) that rupture the shell (Figure 49) and expose the larval dorsal surface. The shell may be completely detached in this manner, but usually remains on the ventral surface covering the mouthparts and legs (Figures 50 to 54). [Jobling]

When movements necessary for emergence are completed, the larva becomes quiescent till the nymphal molt. That larvae are nonmotile after hatching and do not feed has been conclusively established for over a century, though several recent textbooks on medical entomology report differently. All observers have noted the quiescent stage between hatching and molting, and have differed only in the time required for a larva to molt to a nymph. Davis (1947) found that this molt occurred only a few hours after emergence from the egg. Robinson (1942) and Jobling stated that larvae molt four days after emerging from the egg (minimum, three days; maximum, five days). The various early observers reported periods of from three to 23 days from hatching till the nymphal molt.

[The sacculated gut of a newly hatched larva is filled with a reddish brown fluid (Wigglesworth 1943). The inference is that this is an alkaline haematin resulting from the ingestion of haemoglobin by the mother tick.]

Before molting, the larva pales in color; its legs and mouthparts shrink. Its skin becomes detached from that of the internal



55

Figure 55. Nymph emerging from larval skin.

<u>ORNITHODOROS</u> <u>MOUBATA</u> LARVAL-NYMPHAL MOLT
[After Jobling (1925)]

PLATE XVIII

nymph; surface grooves disappear and the contour becomes more convex. The internal nymphal outline and limbs are now visible. The two fore pairs of legs move to cause pressure on the larval skin resulting in a transverse rupture from which the anterior part of the body and the anterior legs emerge (Figure 55). After all legs are free, the larval skin is abandoned. [Jobling]

The nymphal stage, in contrast to the quiescent larval stage, is very active. Cunliffe observed four to eight nymphal instars before adulthood. He noted that most males appear at the fifth molt, most females at the fifth or sixth molt. Jobling (1925) and Pierquin and Niemegeers, however, observed no more than five molts and found the majority of male emergence at the fourth molt and the majority of female emergence at the fifth molt. Dr. G. E. Davis' unpublished records show that in his laboratory most females reach the adult stage at the fourth molt.* Discrepancies in findings among various careful observers of this subject suggest an interesting field for research. [See also the section on symbiotes and growth-promoting substances, page 177.]

The interval between successive nymphal molts depends on the time of the preceding blood meal not on the time of the last molt. This is agreed by all workers. First instar nymphs require a longer period before they are capable of feeding (three to twelve

---

*It should be noted that while argasids have several nymphal instars, ixodids molt directly to adults from the nymphal stage. Ixodids remain on the host for several days in each stage and accommodate the huge volume of ingested blood by slow cuticular growth (whether this is true for all ixodids, as for instance males of several Madagascan haemaphysalids, should be investigated; cf. Hoogstraal 1953E). Argasids, on the other hand, feed much more rapidly and accommodate the volume of fluid ingested by stretching the skin. Lees (1952) believes that this feature necessitates the several nymphal instars of argasids. The rapid feeding of argasids on animals that are usually resting reduces the danger of their transportation under inclement conditions and to unfavorable environments; they normally remain in handy feeding range in the host's house, burrow, den, or lair. Lees cites the several blood meals that a female argasid may take to nourish several egg batches as an adaptation to maintain her fecundity. Female ixodids, which take only a single, extended meal as adults, oviposit only once over a period of several days. It is well known that ixodids deposit huge numbers of eggs but argasid eggs are relatively few in number. This discrepancy, however, is overcome by the more favorable environment for obtaining a host in which argasid larvae and nymphs usually find themselves. Survival of argasid populations does not depend on large numbers of eggs but it does in ixodids.

days, mean five days; at 30°C.) than do later instars that feed on an average of two days (minimum one day, maximum five days) after molting (Jobling). Dr. G. E. Davis reports (conversation) that nymphs kept at normal room temperature require eight days before molting to the second nymphal instar and longer for successive instars.

Jobling noted that first instar nymphs feed on an average of 25 minutes (minimum thirteen and maximum 87 minutes). Second and third instars average about four minutes less (minimum eleven and maximum 54 minutes), while fourth instar feeding is the longest (average 26, minimum 17, maximum 53 minutes). Jobling believes that the longer final nymphal feeding may possibly be necessary due to the requirements for metamorphosis to the sexually mature adult stage, which demands more nourishment than simple nymphal instar-to-instar development. These figures are in essential agreement with those of other students of the life cycle, mentioned in preceding paragraphs.

Shortly before feeding is completed, a clear fluid begins to emerge from the coxal organs of all nymphal stages (as it also does from both adult sexes during feedings) and continues to issue until after feeding is completed and the tick has left its host. (See REMARKS below).

Nymphs are more resistant to adverse temperature and humidity factors than egg and larval stages, during which there is a much higher mortality than among nymphs. This is also agreed by all workers.

The ratio of males to females is practically equal (Jobling).

Males emerge from the last nymphal molt with a strong sexual urge and may fertilize several females before feeding. The average male feeding time is sixteen minutes (maximum 42, minimum nine). After feeding they are less active and less eager for females and bury themselves in soil. Three or four days later they again become active and seek females. [Jobling]

Females can be fertilized immediately after molting and several males may engage a single female before she seeks a blood meal. A female feeds for an average of 35 minutes (minimum 21, maximum 92).

This feeding period is longer than those of nymphs and twice as long as that of the male. Females commence feeding about two days after molting. [Jobling]

Frequently repeated remarks by workers of the 1905 to 1907 period that O. moubata may molt after reaching adulthood unquestionably were based on erroneous identification of advanced nymphal stages as adults.

The minimum time necessary for O. moubata to complete its life cycle is 62 days for males and 73 days for females, but in practice in the laboratory there seems to be some advantage to lengthening the periods of rest after molting and before feeding (Pierquin and Niemegeers). The life cycle can be enormously lengthened by delaying feeding and mating; and, for laboratory rearing, nymphs can be produced to meet any desired schedule, within certain limits, by selective timing.

The longevity of O. moubata has excited much interest since it may be an important factor in allowing new populations to develop from a few imported specimens in areas where hosts are scarce. Hirst (1917) maintained unfed specimens alive for fourteen months and Mayer (1918) kept others alive as long as five years. Cunliffe (1921) recorded female longevity averaging 715 days under ideal conditions of temperature and humidity with food available, and 441 days when food was unavailable. Nymphs (reported as larvae) have been kept alive without food for over 710 days in the Nairobi medical laboratories ("Kenya 1928"). These figures are representative of numerous other records. The practical importance of the long life of this species needs to be determined inasmuch as the fertility of long unfed females is much less than that of individuals that are permitted to feed at will. It has also been shown that female fertility decreases sharply five or six months following the nymphal-adult molt. No reports have been encountered that indicate a difference between male and female life expectancy.

Parthenogenesis of O. moubata may have been observed by Cunliffe, although he hesitated to be assured that the female had not been fertilized when unobserved. Parthenogenesis definitely has been established by Davis (1951), who reared 38 of 48 individuals hatched from unfertilized females. Oviposition in unfertilized females was much delayed and the interval between hatching and molting of their progeny much prolonged. All progeny were females, but when these were mated with normal males both sexes were represented in the subsequent generation.

According to Cunliffe, O. moubata and O. savignyi may copulate but the resulting eggs are unfertile. This is contradicted by recent, unpublished findings of Dr. G. E. Davis who writes (correspondence) as follows: "I have found that the interbreeding of these two species not only results in progeny but in fertile progeny when the products of the first interbreeding are allowed to interbreed among themselves".

The foregoing is a reasonably complete though brief summary of what is known about the life cycle of O. moubata. Before leaving this subject, attention should be called to the additional temperature and humidity studies discussed under Environmental adaptability below for these factors exert considerable influence on the life cycle.

Ecology

Environment and Domestic Habitats

The ecology and distribution of O. moubata, as summarized in the paragraphs below, has always been considered in the light of domestic populations. The significance of the increasingly more numerous reports of the eyeless tampan in large animal burrows from the Sudan to South Africa awaits to be determined. Should it eventually be found that these two populations are a single biological entity that has happened by chance to occupy one or the other habitat, the conclusions of early workers, who believed that man has been wholly responsible for carrying this tick outward from its primitive range in the East African lowlands, will have to be modified.

The arid environment preferred by domestic populations of O. moubata restricts their presence to dry, permanent huts and structures where people gather. In its probable original area, the Somali Arid District and possibly the East African Lowland

District, this tampan appears to be more uniformly distributed than elsewhere. These details, however, await confirmation.

Outward from the Somali District the eyeless tampan normally inhabits dry structures in savannah areas, especially those with sandy or sandy clay soils with light woods. Riparian forests through grasslands, dense forests, and areas of heavy rainfall are usually free of the tick, although exceptional human culture patterns sometimes allow important foci to develop in dry habitats in these situations. Such details have been described most vividly by workers in the Belgian Congo (Bequaert 1919,1930A; Rodhain 1919A,B,1922A,C; Ghesquiere 1922; Schwetz 1932,1933A,1942, 1943; and others).

O. moubata appears to have spread gradually outward from somewhat dry areas of East Africa along main paths of human travel. Old Arabic slave routes are considered to have been largely responsible for its initial distribution by man (Dutton and Todd 1905A; Bequaert 1919,1930A). Although especially common along important old and new travel arteries, the tampan is often markedly absent a few miles distant. Exceptions do occur. For instance, Koch (1905) reported O. moubata from the Rubafu Mountains and elsewhere in villages away from trade routes in Tanganyika. More and more exceptions should occur as travel becomes easier and quicker, tribal customs disintegrate, and labor demands call numerous individuals, with possibly tick-infested personal effects, far from their usual range of activities.

O. moubata is said to be frequently concealed in sleeping mats, spare clothing, or baskets and thus may be transferred easily from one area to another. South African authorities blame the tampan's increasing spread in the Union on migratory laborers from Nyasaland and Portugese territories. In the Belgian Congo it has been found in potato baskets sent to distant markets (Ghesquiere 1922) and is frequently introduced in goods sent from the lowlands to villages at high elevations (Schouteden 1928). This tampan is common in fish baskets of vendors bicycling from Lake Nyasa and Lake Shirwa to villages in other parts of Nyasaland (Hardman 1951). Christy (1903A,B) collected specimens in salt bags being transported between Lake Albert and Tete.

Where soil consistency permits, the eyeless tampan usually burrows to a depth of approximately an inch; but in soil cracks it burrows deeper. On the ground surface it may rest under any object that offers shelter. If soil is too wet or too hard for burrowing the tick is induced to crawl up walls and seek concealment behind hanging objects, in cracks or in ceilings. The tampan's presence is often indicated by spots or streaks from its excretory products left on walls.

In Kenya, O. moubata ranges from sea level to an elevation of 8000 feet (Lewis 1939A) or of 9000 (Heisch 1950A). In Ethiopia, Manson-Bahr (1941) stated it is absent above 6000 feet elevation and Scaffidi (1937) reported that it is not present above 7150 feet.

This tampan survives in the Transvaal Highveld in spite of "bitterly cold winters" there (De Meillon 1940, Ordman 1941). Theiler reports (correspondence) that winter day-temperatures in the Transvaal highlands are "high enough" and that residents bring fires into their huts at night.

In certain Congo areas, Flamand (1928) found O. moubata thriving at about 10,000 feet elevation. Schouteden (1928) replied that these populations are the result of repeated introductions in goods from the lowlands. While tampans survive at these altitudes, they do not reproduce there.

Incidental to a disease transmission study, Van Oye (1943) reported that O. moubata dies in less than 24 hours at temperatures of 0°C. to 5°C. (41°F.). However, Burgdorfer reports (conversation) that he has maintained tampans at 3°C. for at least ten days without death of the specimens. Feng and Chung (1938) maintained these ticks alive for months at 5°C. to 8°C. It is obvious that the critical temperature range for the survival of O. moubata requires further study.

The absence of O. moubata from certain volcanic areas in the Congo was thought by Van Saceghem (1923) to be owing to an unfavorable chemical action produced by contact of lava with oxygen of the air. Dr. J. Bequaert reports (conversation) that these areas are all at high elevation and that he believes altitude to be the important limiting factor in these volcanic areas.

Wallace (1913) noted that in Northern Rhodesia O. moubata abounded in hilly country and on the Mpika plateau, but was absent in the hot Luangwa Valley. The combinations of temperature and relative humidity factors that restrict O. moubata in nature are still poorly known.

Dutton and Todd (1905A,B) and Bequaert (1919) mentioned an exception to the general rule that O. moubata does not occur in deeply forested, humid areas. The explanation was that infestations in the Upper Ituri Forest are in wooded areas where arabisized Negro inhabitants have cut over extensive forests and constructed villages of dry, permanent buildings. In these, ticks brought along the Arab trade route have been able to survive in spite of inclement conditions outside.

Another notable exception to the usual finding that O. moubata is absent from high rainfall areas is cited by Walton (1950A). In Meru District, Kenya, even under unfavorable high rainfall and humidity conditions, large populations of this tick survive in some huts. The predisposing factor is that the local tribes sleep on dry, raised mud beds. Hosts are readily accessible to ticks and fires near beds keep an area of ground dry enough to meet the tampan's requirements. Agricultural implements in these huts provide additional shelters behind and under which the ticks also hide. Contrary to usual advice to remove domestic animals from human habitations, Walton believes that under Meru District conditions animals provide enough extra humidity and pound floors hard enough to reduce tick populations. Under more usual conditions, however, this suggestion would probably not be an effective one. In some Meru District huts, where sticky soil has a humidity of about 90%, it is difficult for ticks to burrow and few specimens are found. Whether this investigator searched for ticks climbing walls or pillars in these huts is not stated.

At Kisumu, Heisch (1950A) found that the size of tampan populations in huts is uninfluenced by seasonal variation in rainfall.

Knowles and Terry (1950) collected hundreds of nymphal tampans on fowls kept in human habitations in Tanganyika, but Phipps (1950) asserted that chickens are seldom infested there. Careful research into the highly practical problem of relationship of chickens to tampan infestation is indicated. Rodhain (1919A) reported finding avian blood in specimens taken from an empty outhouse inhabited by chickens. It has been suggested that periodic forays by chickens into infested huts may partially reduce the tick population in these places.

Aside from usual indigenous dwellings, the eyeless tampan is frequently encountered where people congregate. In Uganda, rest camps often have been burned because of heavy infestation (Bruce et al 1911); jails and semipermanent buildings used by itinerant Africans are frequently infested (Hopkins and Chorley 1940). In Kenya, O. moubata is "alarmingly abundant" in labor camps (Jepson 1947) and military barracks are specially constructed to resist infestation (Hynd 1945). The tampan is a coffeehouse inhabitant in British Somaliland (Anderson 1947). In a Somaliland focus of relapsing fever, all patients were found to be members of a political party the headquarters building of which was infested with O. moubata and had escaped insecticiding when other structures were dusted (Lipparoni 1951). In South Africa, it is an important pest in "lesser mine" labor camps but in larger mines, such as those at Johannesburg where sanitary measures are practiced, the tick is absent (Ordman 1941,1943).

In contrast, the closely-related eyed tampan, O. savignyi, usually lives away from habitations, under trees, in village squares, near wells, in stockades, or in shaded spots along trails where men and animals rest.

There are but few reported observations of O. moubata living under outdoor conditions approaching those favored by O. savignyi. In 1916, Belgian colonial troops operating in Urundi, while tenting under a row of mango trees that had bordered buildings destroyed some six years earlier, recovered several specimens from the soil around the roots of these trees. The assumption was that these ticks had survived since the destruction of the nearby buildings some years earlier (Rodhain 1919B).

Ordman (1941) listed two cases of the eyeless tampan in South Africa living "in and under trees", but further conclusive evidence is not presented.

In various editions of Brumpt's "Precis," *O. moubata* is considered as an outdoor as well as an indoor species. There is, however, no published evidence to support the supposition that this species normally lives away from human structures, except in large animal burrows and in pigsties. Rare exceptions, such as ticks remaining in the area after a building is destroyed, or dropping from a bedding roll during transit, must be expected. Further search may, of course, show that the tampan has a broader range of habitats than present evidence indicates.

"Wild" Habitats

A gradually increasing body of information indicates the not uncommon occurrence of *O. moubata* in large animal burrows throughout tropical and southern Africa (see HOSTS above). The relationship of these populations to those of human habitations awaits determination. The environment of infested burrows has been only briefly described and it is not known whether wild populations have the same temperature and humidity requirements as domestic populations.

In Tanganyika burrows, Walton (1953) observed tampans clinging to the roof close to the entrance as though waiting for some animal to squeeze past. Ticks were found among the hair of the back of warthogs shot in the early morning. In the burrows, temperature was 75°F. and relative humidity of the soil 77%. Other infested Tanganyika burrows examined by Geigy and Mooser (1955) with thermohygrometers showed that the microclimate of these holes corresponded closely to that observed by them in infested native huts (details not stated).

Discovery of numerous specimens in large burrows in several widely scattered parts of Kenya has led Heisch and Grainger (1950) to speculate on the relationships between wild and domestic populations of eyeless tampans. The ticks were obviously breeding in these burrows that originally had been dug by antbears and later were inhabited by porcupines or warthogs. Other specimens were found in large burrows on a long-isolated Lake Naivasha island seldom visited by man. Heisch and Grainger conjecture that large burrows were the original or primitive home of the eyeless tampan and that it later became adapted to human habitations. The several reports of *O. moubata* from burrow-inhabiting warthogs, porcupines.

and antbears, already mentioned in the section on HOSTS, bolster this theory. Further indirect support is gained from the prevalence of the warthog's relative, the domestic pig, as a host. The tampan of human habitations may have evolved from populations formerly parasitizing burrowing, wild pigs, and they may still retain some predilection for pigs. As already noted, it is also possible that "wild" and "domestic" populations represent separate biological or physiological or even unrecognized morphological entities.

Predators and Enemies

Chickens, rats, and mice are said to feed on the eyeless tampan, and ants carry off eggs and nymphs. An Angolan Reduviid bug, Phonergates bicolor Stal. sucks the blood of both man and O. moubata [Wellman (1906B,D,1907B). Austen (1906,1907) reported on the nomenclature of this bug. The actual specimens involved may still be seen in British Museum (Natural History) collections]. Ant lions (Neuroptera, Myrmelionidae) have been observed feeding on nymphs (Ghesquiere 1922). In the laboratory, larvae of clothes moths, Tineola bisselliella, are said to feed on eggs and on living larvae of O. moubata (Vollmer 1931).

What was once described as a fungus disease beginning as an opaque white spot at one edge of the body and spreading out to stupify and destroy the tick (Wellman 1906A,D,1907B) is now believed by experienced workers to be a normal phenomenon of aging in engorged ticks. Christophers (1906) suggested that this "fungus" is actually a white rectal secretion of aged ticks. Burgdorfer (conversation) is of the opinion that this "white fungus" is nothing more than crystallized fluid in the malpighian tubules. Often this crystallization produces a complete, hard blockage. The lumen of such tubules fills with white crystals so that normal activity can no longer occur and soon the tick dies. (See Internal Anatomy below).

Numerous factors affecting the ecology of the eyeless tampan are discussed below.

REMARKS

Environmental Adaptability

The xeric environment in which O. moubata is capable of survival is best explained by two physiological studies by Lees (1946A, 1947). In his research on water balance in ticks, Lees (1946A) found that among the species studied, O. moubata shows the greatest ability in limiting evaporation from its own body. In this species, the critical temperature at which water loss increases through the superficial waxy epicuticular layer is also high (Lees 1947). This resistance to desiccation at temperatures within its biological range may be correlated broadly with the argasids' choice of dry, dusty ecological niches.

Lees summarized his 1946A studies, in which Ixodes ricinus was the principal species for research and O. moubata was one of eight other species used for comparative purposes, as follows:

> "The unfed tick gains water from humid air or from water in contact with the cuticle, and loses water by evaporation. Whilst attached to the host the tick is gaining water from the ingested blood and losing water in the excrement. The engorged tick usually lacks the ability to take up water from humid air.
>
> "The exchange of water takes place mainly through the cuticle. Regulation of the water balance is therefore brought about by the activity of the epidermal cells.
>
> "The cuticle comprises two principal layers, the epicuticle and endocuticle. The epicuticle is overlaid by a lipoid possessing important waterproofing properties. The pore canals, which traverse the endocuticle, are occupied by cytoplasm, and may in consequence play an important role in the active transfer of water through the cuticle; they do not penetrate the epicuticle.
>
> "Water loss from the unfed tick is not closely related to saturation deficiency, particularly at high

humidities. This departure is due to a physiological cause, namely, to the ability to secrete water. The effects of this activity are such that a state of equilibrium is attained at a relative humidity of about 92%; at lower relative humidities it takes up water. The retention of water at humidities below the point of equilibrium is due not only to the physical properties of the epicuticle but also to this secretory activity, for water loss increases when the tick is temporarily asphyxiated, poisoned with cyanide, or injured through excessive desiccation. Near the point of equilibrium the loss or gain of water over a wide range of temperature is determined by the relative humidity.

"'The uptake of water from humid air occurs when the tick is in a desiccated condition but ceases as the normal water content is restored. After previous exposure to saturated air the adapted tick at first loses water at relative humidities above the point of equilibrium, but later comes to retain water completely.

"'Both unfed and engorged ticks possess the ability to prevent or to limit temporarily the entry of water in contact with the cuticle.

"'The engorging female, originally weighing about 2 mg., ingests about 600 mg. of blood. About 300 mg. or two-thirds of the contained water are usually eliminated before the end of engorgement. Evaporation from the cuticle may account for a considerable fraction of this, for the temperature to which the attached tick is exposed (about 37°C.) is, in Ixodes ricinus, above that temperature at which a marked increase in the permeability of the epicuticular lipoid takes place.

"'The nine species of ticks examined differ considerably in their powers of limiting evaporation. This may reflect specific differences in the nature of the epicuticular lipoid. The order of their resistance is as follows: Ornithodoros moubata; Dermacentor andersoni; D. reticulatus; Rhipicephalus sanguineus; Amblyomma cajennense and A. maculatum; Ixodes canisuga; I. hexagonus; I. ricinus. In dry air, water loss through the cuticle is ten to fifteen times more rapid in Ixodes ricinus than in Dermacentor andersoni. The more resistant species also take up water through the cuticle after desiccation; indeed, the rate of uptake over a unit area of cuticle is approximately the same in all species of Ixodidae. Uptake thus appears to be limited by the ability of the epidermal cells to secrete water."

As already stated, Lees has shown that O. moubata is more resistant to desiccation than most ixodid ticks. Nymphs exposed to dry (0% R.H.) air at 25°C. survived for 35 days and lost only from one to three percent of their original weight daily. This survival period is strikingly longer than that of several ixodid tick species used in the experiments. After a period of desiccation (five days at 0% R.H.), O. moubata regains most of its original body weight when placed in 95% R.H. for five days. Water is taken up through the spiracles, for no increase occurred when these openings were blocked. Loss of water occurs through the cuticle and spiracles (see Spiracular Morphology and Function below).

In order to carry Lees' work one step further, Browning (1954B) conducted a study on the exchanges of water between the atmosphere and O. moubata. Unfed nymphs were able to abstract water from moist air (95% R.H.) and to restrict their rate of water loss in dry air. This ability was lost (a) in atmospheres containing 30% to 45% CO_2; (b) in atmospheres containing more than 90% N_2; (c) immediately after the tick fed; and (d) gradually after the tick has been starved for some five months. It was shown that the action of high (30% to 45%) concentrations of CO_2 is mainly upon the activity of the epidermal cells, possibly mediated through the central nervous system. The concentration required to cause opening of the spiracles is only about five percent. These findings are of considerable interest in relation to Lees' (1947) basic work.

By way of introduction to his 1947 study, Lees stated:

"In considering the mechanisms involved in the exchange of water through the cuticle the assumption was made that, in addition to active secretion, the passage of water, and particularly its retention, is also influenced by the presence of lipoid material in the cuticle. Ticks show great diversity in their powers of resisting desiccation, and this was thought to be accounted for by the specific nature of the waterproofing lipoid. Nevertheless, no direct evidence of such a component was advanced in this paper (i.e., Lees 1946A).

"Ramsay (1935B), and more recently Wigglesworth (1945) and Beament (1945), have shown that the impermeability of insects is entirely due to a thin, discrete layer of wax or oil in the outermost part of the epicuticle. Any agents such as abrasive dusts, wax solvents, or detergents, which interrupt the continuity of this layer, at the same time greatly increase transpiration. Water loss through the wax layer is also enormously increased if the temperature is raised above a certain critical value. ...... methods devised by Wigglesworth for demonstrating the properties of the waterproofing layers in insects have been applied to a number of species of ticks. ...... observations on the structure and deposition of the epicuticle, and on the functions of the dermal glands (are provided). The outermost layer of the tick cuticle visible in ordinary sections has hitherto been referred to as the "tectostracum" (Ruser 1933) ...... (but) the similarity of this layer with the insect epicuticle is so marked that the abandonment of this term seems fully justified."

The results and conclusions of this work, Lees summarized as follows:

"1. Ticks owe their impermeability primarily to a superficial layer of wax in the epicuticle. After exposure to increasing temperatures, water loss increases abruptly at a certain critical temperature. The critical temperature varies widely in different species, in Ixodidae ranging from 32°C. (Ixodes ricinus) to 45°C. [Hyalomma marginatum (= savignyi)]; and in Argasidae from 63°C.

(*Ornithodoros moubata*) to 75°C. (*O. savignyi*). Species having higher critical temperatures are more resistant to desiccation at temperatures within the biological range. A broad correlation is possible between these powers of resistance and the natural choice of habitat. Argasidae infest dry, dusty situations whereas Ixodidae occupy a much wider variety of ecological niches.

"2. If the tick cuticle is rubbed with abrasive dust, evaporation is enormously increased. Living ticks partially restore their impermeability in moist air by secreting wax from the pore canals on to the surface of the damaged cuticle.

"3. Unfed ticks are able to take up water rapidly through the wax layer when exposed to high humidities. Water uptake, which is dependent on the secretory activities of the epidermal cells, is completely inhibited by the abrasion of only part of the total cuticle surface - a fact which suggests that the cells are functionally interconnected. Resistance to desiccation at low humidities is achieved by a dual mechanism: active secretion and the physical retention of water by the wax layer.

"4. In Argasidae the epicuticle consists of four layers: the cuticulin, polyphenol, wax, and outer cement layers. Only the three inner layers are present in Ixodidae. Since the wax layer is freely exposed in the latter group, chloroform and detergents have a marked action in increasing transpiration, particularly in those species with low critical temperatures. In Argasidae the cement layer is very resistant to extraction but is broken down by boiling chloroform.

"5. The cuticulin, polyphenol, and wax layers are all secreted by the epidermal cells. The waterproofing layer, which is deposited on the completed polyphenol layer, is secreted by the molting tick relatively early in development and may be nearly complete by the time molting fluid is abundant. In *O. moubata* the cement is poured out by the dermal glands shortly after emergence. In Ixodidae the dermal glands undergo a complex cycle of growth and degeneration, but their products appear to add nothing of functional significance to the substance of the cuticle."

Lees' important contributions indicate why O. moubata is capable of surviving in the dry niches in which domestic populations occur. However, we still lack data on the actual relative humidity of these niches in nature. We know only that the tampan can withstand these conditions in laboratory investigations. And it should be stressed that we still know nothing about preferences and critical levels of temperature and humidity among burrow-haunting populations. The Bahr El Ghazal collections, from warthog burrows in the "Nile sponge area", especially excites curiosity in this respect.

Laboratory studies on the optimum temperature and humidity conditions under which O. moubata survives have resulted in widely differing data and conclusions. The reports in question are those of Cunliffe (1921) and Brett (1939) together with those of Robinson (1942C) and others already reviewed in the section on the life cycle of O. moubata.

Cunliffe found that a saturated atmosphere has no inhibitory influence on molting but is decidedly unfavorable for vitality (only one specimen passed the third nymphal stage under these conditions). Even under "medium conditions of humidity", mortality is high, but under "dry conditions", 66% of the nymphs complete metamorphosis and the rate of development is increased. High temperature increases the number of eggs laid but decreases fertility, longevity, and time required for metamorphosis.

Brett, on the other hand, found that (at 25°C.) higher relative humidity (up to 80%) was more favorable for survival of eggs, larvae, and first instar nymphs (the only stages and instars tested) though a proportion of all eggs were able to develop at any "low humidity normally met with in nature". He also found that the first nymphal instar is much more resistant to desiccation than larval and egg stages. The apparent inconsistency between Brett's findings and the known fact that domesticated populations of O. moubata are chiefly inhabitants of drier areas

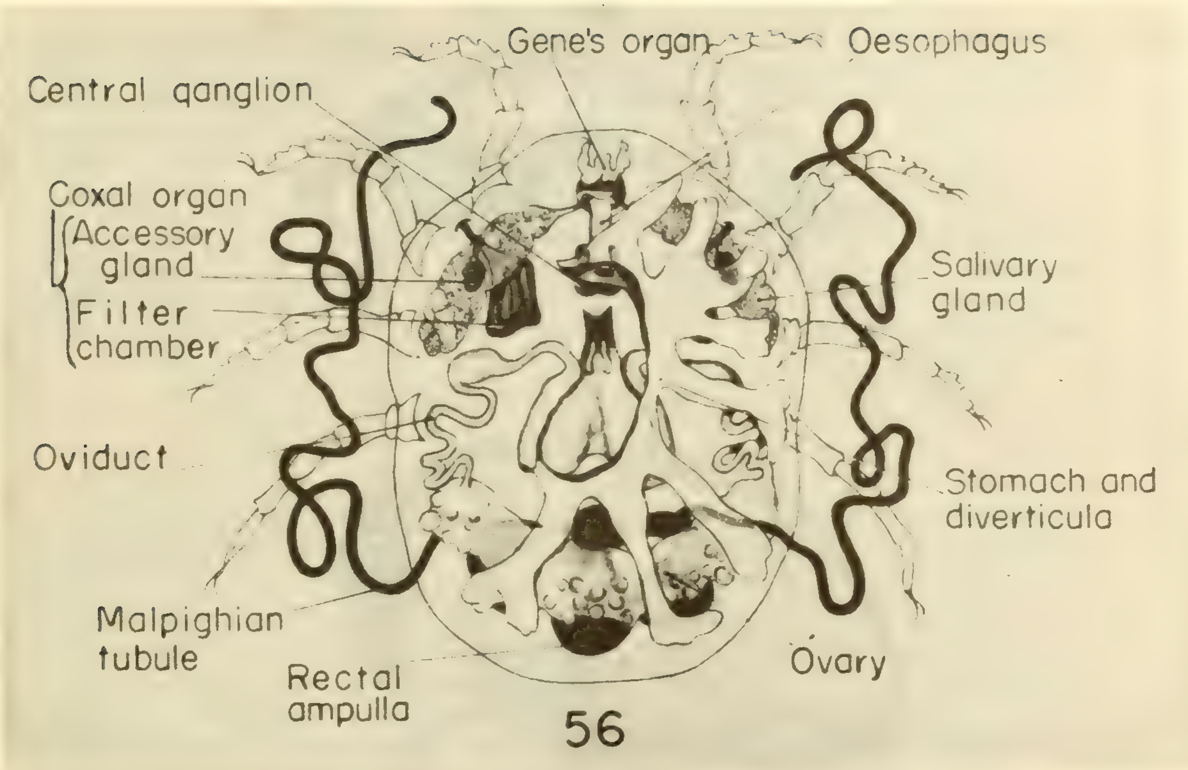
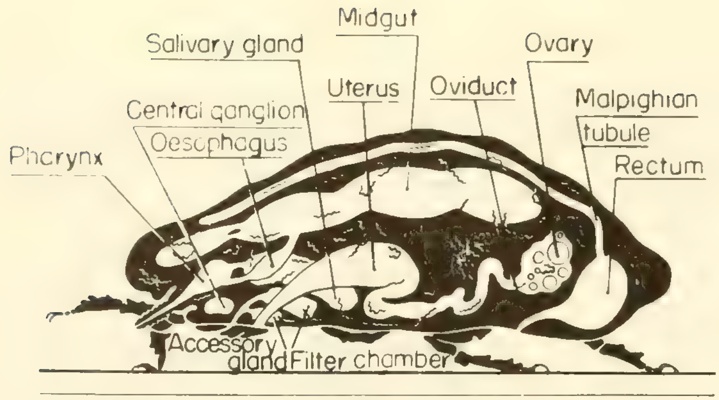
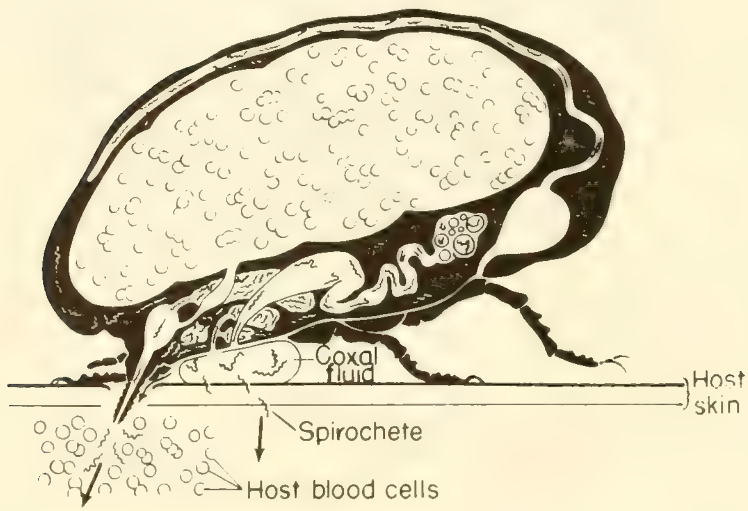


Figure 56
♀ ORNITHODOROS MOUBATA INTERNAL ORGANS
[After Burgdorfer (1951), with permission of the editor of ACTA TROPICA]

PLATE XIX



57



58

Figures 57 and 58, ♀, Unengorged and Engorging

Spirochetes of African tick-borne relapsing fever, Borrelia duttonii, are illustrated, as short wavy lines, in the positions they occupy in the tick's body. Note their escape routes from the tick's body and into the host's body while the tick is feeding.

ORNITHODOROS MOUBATA DIAGRAMMATIC SAGITTAL VIEW

[After Burgdorfer (1951), with permission of the editor of ACTA TROPICA]

PLATE XX

is explained on the basis of Williams' (1923,1924A,B) and Buxton's (1932,1933) exposition of the comparatively high humidity in sand, cracks of walls, and soil in areas that are otherwise dry. Brett's discussion and the comparison of his findings with those of Cunliffe and of other workers, especially those of Robinson (1942C) discussed on p. 137, which corroborate those of Brett, should be studied for their practical importance by anyone concerned with O. moubata. Since only careful and thorough research in the field as well as in the laboratory can conclusively settle the matter, a more complete discussion of this question is hardly in order here.

Structure and Function

Introduction

No thorough studies of the internal anatomy and histology of O. moubata have been undertaken. What has been done on certain aspects of these subjects is reviewed in the following paragraphs. On the whole, workers have been content to accept Christophers' (1906) careful though still somewhat general description of the internal anatomy of O. savignyi as also applicable to O. moubata. Recently, Burgdorfer (1951) has provided a short account of the internal anatomy of O. moubata and some of his excellent illustrations are reproduced (Figures 56 to 58). However, O. moubata deserves more specialized attention than it has thus far been accorded. These two species differ in habits, habitats, distribution, and receptivity to pathogenic organisms. It may be expected, therefore, that under their leathery shells, which also differ, significant anatomical and physiological differences remain to be demonstrated.

Internal Anatomy

The general features of the internal anatomy of these two species are similar and Christophers' (loc. cit.) description of a dissection of O. savignyi, as presented below, applies equally well to O. moubata (with known differences noted):

> "Over the whole dorsum lies a fine membranous expansion of tracheae and trabeculae of the fat body. Lying in this, in the median line, is the delicate tubular heart. Posteriorly, at about the junction of

the middle with the posterior third of the body, this is considerably dilated. Stripping off the expansion, the main mass of the viscera, consisting largely of the large dark red blood sacs of the alimentary canal, are exposed. By carefully unravelling these, the arrangement of long diverticula, described later, can be made out. Lying upon the diverticula in the posterior portion of the body is the ovary, studded with developing ova. Upon either side of the ovary are the coiled oviducts, and in the middle line is the large conspicuous bilobed spermatheca (uterus). In almost every region of the body a portion of the thin coiled malpighian tubules will be found. Behind the spermatheca is an opaque white organ, having very thin saccular walls and filled with characteristic white secretion from the malpighian tubules. This is the rectum (rectal ampulla), which in ticks serves as an excretory bladder. By displacing the diverticula from the extreme anterior portion of the body a bilobed glandular organ, the cephalic gland (gene's organ) is displayed. Further back, the bulbous ends of the cheliceres with radiating muscular fibres are seen. Around them will be noticed the ringlike chitinous fold at the base of the rostrum. By displacing to one side the whole of the anterior and lateral diverticula, a member of further structures are apparent. Passing in from the stigmatic (spiracular) openings is a leash of tracheal branches, of which the large anterior ventral trachea is the most conspicuous. Lying upon the origin of the first and second legs is the large racemose gland which functions as the salivary gland in ticks. Lifting this gland by its posterior extremity, which lies on the anterior ventral trachea, and tracing it forward, the short salivary duct will be apparent entering the ringlike fold of chitin, already mentioned, immediately beneath the cheliceres. Lying partly under the salivary gland, and partly internal to this structure is (the large, saccular coxal organ) conspicuous from the number of tracheae which supply it.

"By careful examination, the delicate, colorless esophagus can be made out entering the lower surface of the large median blood sac of the alimentary canal, whilst lying behind the spermatheca is the fine hairlike termination of the sac in the rectum. To the rectum can be traced the attached end of the two extremely long malpighian tubules. To display the esophagus in its passage from the pumping organ to the alimentary sac it is necessary to tear away the dense mass of muscle from which it will be seen to emerge. By seizing the muscular mass boldly in the forceps, the unattached entosternum surrounded with muscle will come away, exposing the central ganglion, perforated by the esophagus. By seizing the bulbous ends of the cheliceres they may be drawn from their sheaths. Lying beneath them is the horizontal entosclerite of the head. Beneath this, again, is a dense mass of muscle within which lies the chitinous pumping pharynx.

"In the male, in the position of the ovary in the female, there is a delicate tube abundantly supplied with trachea. On either side this is continuous with a coiled duct much resembling the oviduct in the female. In the middle line, much in the position of the spermatheca in the female, is a curious lobular organ, the white gland ......" (that) is probably concerned in the elaboration of spermatophores.

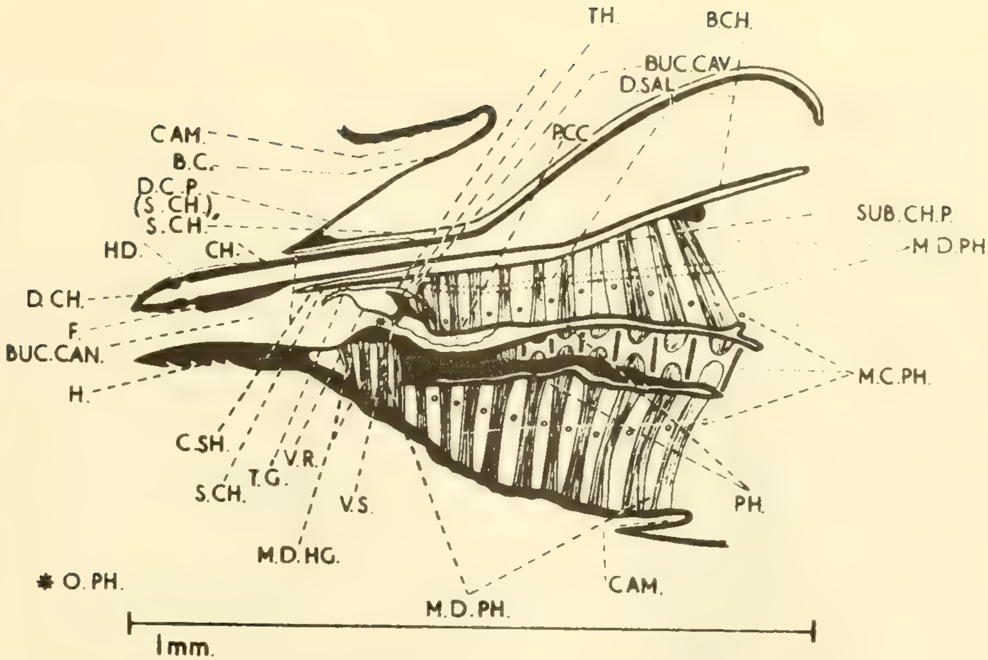
Following this, Christophers (loc. cit.) presented a more complete account of each structure and a generalized description of the digestive process in O. savignyi. This should be consulted by anyone interested in the internal anatomy and function of either species. Sections of Christophers' study dealing with the digestive system are abstracted below because of their relation to the ingestion, development, and passage of pathogenic spirochetes and other organisms, but it is advisable first to mention more recent studies of feeding organs and mechanism.

Feeding and Digestive Organs

The capitulum and related organs of O. moubata have been studied in considerable detail by Bertram (1939) and reviewed in relation to these organs throughout the Arachnida by Snodgrass (1948). Both papers, which also review previous studies and concepts, deserve careful study. Because of their specialized nature, a short abstract of either of these two studies hardly does it justice. Snodgrass observes that "the exact method by which a tick bites perhaps needs more study than has been given to it".

According to Bertram, the capitulum of O. moubata is essentially similar to that of other argasid ticks (see Christophers 1906 for O. savignyi, Robinson and Davidson 1913A,B,1914 for A. persicus, True 1932 for O. coriaceus, and Sen 1934,1935 for O. tholozani) although certain modifications in the eyeless tampan are either absent in other species or have not been adequately described. Bertram also differs widely from Sen in explanation of specific structures and fundamental interpretations.

The capitulum (Figures 59 and 60), situated in a depression (camerostome) of the anteroventral body surface, consists of a median hypostome flanked by a pair of four-segmented palpi and a pair of long, shaftlike chelicerae arising from a conical prolongation of the basis capituli. Each of these hollow appendages contains haemocoele. The hypostome is concave dorsally; ventrally it bears rows of distinctive retrograde denticles. The chelicerae distally each bear a small, triangular, articulated digit, attached by flexor and extensor muscles, with laterally directed denticles. These digits make the initial incision in the skin. A triple sheath arrangement of no little complexity encases the chelicerae proximally. The buccal canal (i.e. "mouth") lies between the dorsal chelicerae and the ventral hypostome; proximally it is much compressed. The size of this canal is somewhat increased by the medial emargination of the closely appressed cheliceral sheaths and by the dorsal groove ("gutter") of the hypostome which forms a food conduit. Extending into the center of the buccal canal is a hollow, "tongue-like process", the basal fusion of which with the hypostome forms a dorsal, blindly-ending pouch, the buccal cavity, into which a salivary duct issues at each posterolateral angle. The buccal canal opens directly into the pharynx, as one might logically assume it should, except that previous workers have found that in other ticks the basal fusion of the hypostome, palpi, and dorsal conical prolongation of the basis capituli causes the pharynx to open into the floor of the buccal cavity.



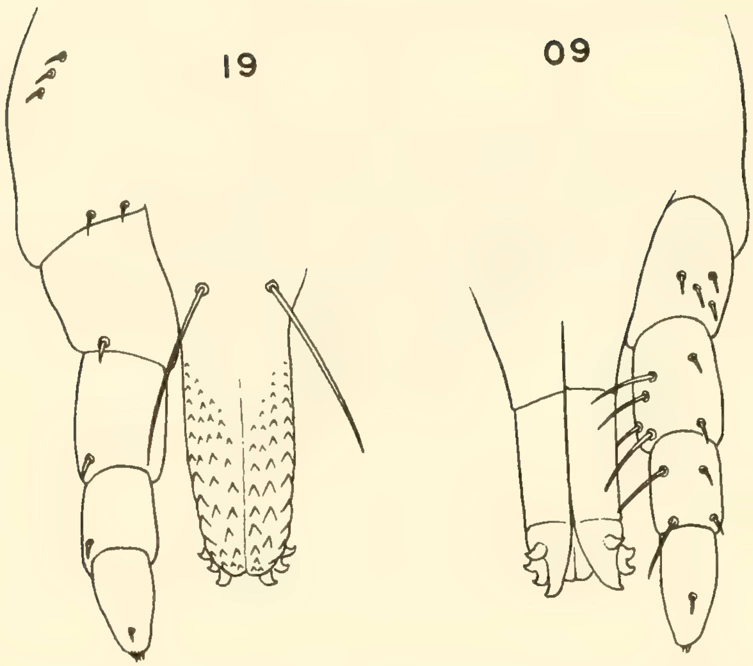
59

B.C.	basis capituli	M.D.HG.	dilator of hypostomal gutter
B.CH.	expanded base of chelicera	M.D.PH.	dilator muscles of pharynx
BUC.CAN.	buccal canal	O.PH.	pharyngeal orifice
BUC.CAV.	buccal cavity	P.C.C.	posterior part of closed chamber
CAM.	camerostome	PH.	pharynx
CH.	chelicera	S.CH.	outer sheath
C.SH.	cone sheath	S.CH.	inner sheath
D.CH.	digit of chelicera	SUB.CH.P.	subcheliceral plate
D.C.P.	dorsal conical prolongation of basis capituli	TG.	tongue-like process
D.SAL.	salivary duct	TH.	transverse bar formed by fusion of lateral thickenings of tongue-like process
F.	flange of chelicera		
H.	hypostome		
HD.	hood	V.R.	ventral rod of tongue-like process
M.C.PH.	constrictor muscles of pharynx	V.S.	ventral scutum in cavity of closed chamber

Figure 59. Longitudinal vertical section, diagrammatic [After Bertram (1939)]

ORNITHODOROS MOUBATA CAPITULUM

PLATE XXI



Figures 60 and 61, dorsal and ventral views

ORNITHODOROS MOUBATA CAPITULUM

PLATE XXII

When preparing to engorge, the tick inserts the chelicerae and hypostome (not the palpi) into the host skin as far as the dorsal conical prolongation of the basis capituli.

During feeding (according to Bertram), the dilatation and constriction of the pharynx by certain muscles cause the fluid contents of a closed chamber just posterior of the tonguelike process to be forced into and sucked out of this process through a vertical septum. Furthermore, relaxation of hypostomal muscles obliterates the hypostomal gutter as the dilated pharynx constricts to force ingested blood into the esophagus. The effect of this swelling of the tonguelike process and closure of the hypostomal furrow is to prevent the spilling back into the host's wound of any blood already in the pharynx. The tonguelike process also appears to play an essential part in the mechanism of ejection of salivary fluid into the blood as it is being ingested. Since the salivary fluid is discharged into the distal region of the buccal canal, it is assumed to reach the wound in the host (and thus might transmit disease-causing organisms contained in it).

As stated above, Bertram's study has considerable practical value, but must be read in its entirety to be fully appreciated. It should be noted that Snodgrass (1948) refers to the tongue-like process as the labrum in his noncommittal review of Bertram's findings and conclusions.

Alimentary canal: We now return to Christophers' (1906) study of O. savignyi, and it is interesting to note that he found the pharynx to open into the floor of the "mouth" (buccal canal) in contrast to Bertram's observation on O. moubata, mentioned above. At any rate, the pharynx leads to a narrow, straight esophagus. The latter, after perforating the central ganglion, enters the enormous saccular midgut, which, with its diverticula, forms the great bulk of body contents. Posteriorly, an extremely fine canal, which appears to be a functionless rudiment, joins the midgut with the rectal ampulla (but in O. moubata even this is absent and the alimentary canal ends in a completely closed sac separated from the rectal ampulla) (see below).

Esophagus and proventricular fold. The esophagus, a short, straight tube perforating the central ganglion in its course from pharynx to alimentary sac, is lined with a layer of clear columnar cells with small nuclei. The irregular outlines of these cells are mutually adapted to one another in a dovetailing arrangement. At the juncture of the esophagus and large blood sac there is a small solid organ. This organ, in section, consists of a thick fold of epithelium of the same general character as that in the esophagus but of more columnar and less irregular cells. In the fold are some thick circular bands of muscular tissue and outside are longitudinal fibers passing from the esophagus to the gut. The epithelium of the fold passes imperceptibly into that of the esophagus, but ends abruptly on reaching the wall of the alimentary sac. The organ is very similar to, though

MARINE BIOLOGICAL LABORATORY
LIBRARY
WOODS HOLE
MASS.

still more rudimentary than, the proventricular fold in the mosquito and probably has a similar function. The importance of this fold in the trypanosome infection of Culex makes its presence in ticks of concern in connection with spirochete infection.

Alimentary sac and its diverticula. These organs, when freshly distended with blood, form smooth, dark red, lobulated masses. As the amount of blood diminishes, the diverticula become almost black in color and exhibit innumerable small lobulations.

In the young, unengorged tick, the long, narrow diverticula show active pulsatile movements that probably have no effect in drawing blood from the host but serve to distribute fluid to different parts of the sac.

From the entrance of the esophagus and extending posteriad to the neighborhood of the rectum there is a large central reservoir. This reservoir extends anteriorly a little beyond the entrance of the esophagus so that this latter is situated upon the ventral surface of the sac. From the ventral surface posteriorly a conical tag passes ventrally behind the spermatheca towards the rectum. The basal part of this tag contains blood, but as it narrows it becomes a clear tube of capillary character. This portion of the canal appears functionally inactive and can play no part in the passage of matter from the sac to the rectum. In O. savignyi, therefore, the alimentary system is practically a closed one [but in O. moubata it is entirely closed; there is no passage between the small intestine and the rectal ampulla (Enigk and Grittner 1952)].

From the central reservoir a number of blind diverticula originate, the disposition and extent of which are constant in all ticks. There is an anterior, a lateral, and a posterior series. The anterior series, found only in Ornithodoros, is absent in Rhipicephalus and Hyalomma. It consists of a single, small median diverticulum extending anteriorly so as to lie over the gene's organ. The three pairs of lateral diverticula arise together at about the level of the entrance of the esophagus. The anterior lateral diverticulum is short, the median one is somewhat longer, and the posterior one is large and long. The anterior and middle branches divide into two or usually three blind pouches. The posterior branch divides into two branches that curve to the ventral surface. The more anterior of the branches ends beside the common genital duct. The most posterior surrounds the anus and ends a short distance anterior of this structure. Irregularities in diverticula arrangement are sometimes seen. The median lateral diverticulum may be large and give rise to the anterior of the two ventral branches.

The various sulci and prominences on the surface of *Ornithodoros* have relation to these alimentary diverticula. On the dorsum, the transverse sulcus limits posteriorly the central alimentary sac. Ventrally the region between the coxae supports upon its inner surface, with which the viscus is in actual contact, the caecal ends of the posterior lateral diverticula. The lesser prominences correspond in nearly every case with a particular diverticulum and the sulci with the intervals between two diverticula.

Structure of the alimentary sac. The structure of the sac and its diverticula is identical. The cavity is lined by a single layer of large cells resting upon a thin basement membrane. Externally, very large single muscular fibres, arranged circularly and longitudinally, form an open meshwork with square meshes as in the mosquito. The lining epithelial cells are large with reticular protoplasm and large vesicular nuclei, some of which project freely into the lumen. Such cells are especially large and have their inner portions much swollen and vacuolated; they may contain dense black globules as well as red cells in various stages of intracellular digestion. In addition to large projecting cells, smaller cells, whose nuclei are situated nearer to the basement membrane, are present. Practically all cells of the sac contain small black granules, evidently derived from the digestion of the blood in the lumen. In undistended diverticula, the epithelium may form a more or less continuous lining of the tube, but in the distended tube the cells become very unevenly distributed, being almost absent in some places and in others forming very striking projecting masses.

Rectum and malpighian tubules. The rectum, which lies immediately behind the spermatheca, or the white gland in the male, is an irregular sac having several capacious but short saccular dilatations. (In *O. savignyi*) it receives the rudiment of the intestine and the two malpighian tubules (but in O. moubata the rectum receives only the malpighian tubules and there is no connection between intestine and rectal ampulla). Its walls are extremely thin and consist of a single layer of flattened cells. It contains a white fluid identical with the secretion of malpighian tubules. The rectum therefore does not serve as an adjunct to the alimentary canal, but functions as an excretory receptable. The white matter passed per anum by ticks also cannot, strictly speaking, be regarded as feces.

The malpighian tubules are important because of their great length and functional activity and because of the frequency with which such organs are utilized by parasites in other animals. They consist of two long, fine white or transparent tubules arising on either side from the rectum, and after a complicated course among the viscera, ending blindly in the anterior portion of the body. These tubules come in relation with almost every important organ in the body and drain every quarter of the body cavity. The tubes in young ticks are of an even calibre throughout and contain small quantities of secretion only. They are often swollen in aged ticks to form sacs similar to, but smaller than, the rectum. After oviposition the tubes and rectum may be greatly distended with characteristic white fluid that is evident externally as patches of lighter color. It is probable that the appearance is that described as a "fungus" in these ticks by Wellman (1906A,D,1907B).

Feeding habits of O. moubata have been discussed in the section on the life cycle of this tick. Certain aspects of digestion and excretion of fluids are of considerable practical importance for they concern, at least, the fate of ingested spirochete parasites of relapsing fever (Borrelia spp.) and the discharge of these organisms onto or into a new vertebrate host when the tick subsequently feeds.

Digestion

The volume of a blood meal is from two to six times the tick's original body weight (Lees 1946B). During ingestion, the cuticle stretches to accomodate this huge amount of fluid. Engorgement is completed in about half an hour. In order to reduce this tremendous volume ingested so rapidly, fluid is discharged from the coxal organs while the tick is yet feeding. Rectal discharge is very slight. These two methods of excretion are discussed in separate sections below.

Digestion in O. moubata apparently is much like that in O. savignyi, as described by Christophers, abstracted below.

Twenty-four hours after a meal the greatly distended diverticula contain a soft coagulum from which a considerable amount of fluid blood may drain. Blood corpuscles are apparently unchanged. Scattered through the fluid are numbers of intensely black, globular granules measuring from 5u to .5u or less in diameter. In sections these granules are collected especially at the periphery of the (fresh) blood, but they are also present in large numbers scattered throughout the mass. The black granules are derived from a previous meal, and there is therefore a considerable degree of mixture between the new blood and the contents of the diverticula prior to the meal.

Diverticula examined at some considerable time after digestion show a number of reddish granules lying in the still partially fluid blood. These are free from attachments and when washed out fall to the bottom of the dish or among the viscera. Each is an entire cell containing a well-marked nucleus. Films of the sac contents made twenty-four hours after a blood meal show cells derived from the epithelium of the sac in addition to the host's leucocytes. Many of these are evidently the smaller undistended cells, previously noted as lying near the basement membrane, now detached in preparation of the specimen. They contain a large circular or oval nucleus and finely reticular or partially vacuolated protoplasm. Similar cells, but larger and with portions of the vacuolated protoplasm stored with black granules, are also seen. In addition to these cells of the sac epithelium, there are other large, dark staining, circular cells with rather small nucleus. Their substance is markedly vacuolated and crowded with matter that they evidently have engulfed, blood corpuscles, black granules, chromatin fragments, etc. In section specimens made even six hours after the ingestion of blood, they appear lying apparently in isolated positions far removed from the sac walls. These probably function as wandering digestive cells. Their relation to the epithelium of the sac is not clear. As digestion advances they become more and more replete with material and increase in size until readily visible to the naked eye as red granules already noted. In early stages of digestion, cells packed with chromatin bodies and superficially resembling macrophages, the nature of which is not clear, may be seen.

Although a prominent part in digestion is taken by the free cells just alluded to, epithelium lining the diverticula also takes an active part in the process. The swollen and vacuolated portion of the large projecting cells is crowded with products of digestion very much as is that of the free cells. Smaller cells lying nearer the basement membrane are also, as a rule, packed with fine black granules, though they rarely contain the large granules seen in the other cells.

The intensely black and opaque globules are highly characteristic of digestion in the tick and undoubtedly represent the ultimate condition to which blood remaining in the gut is reduced by the digestive process. These globules probably represent only the portion of food not assimilable, for in Ornithodoros ticks, which may be kept alive for long periods without food, the diverticula contain, after some weeks, an inky black material consisting entirely of these granules.

As diverticula contents are digested, the muscle fibres, which in the fully distended organ slightly indent the surface, sink more and more into the body of the viscus. The wall between the fibres becomes ballooned and eventually forms flasklike pockets with only a narrow opening connecting with the lumen. The epithelium is, as a rule, present in the pockets, though it is generally more noticeable on the ridges formed by the contracted muscular fibres. Remains of ingested blood, in the form of black granules, are present both in the pockets and in the lumen. Ticks examined months after a meal still have the diverticula loaded with the black material.

Waste matter is not passed into the rectum and any remnant of food not absorbed must remain in the diverticula until death of the tick. The method by which absorption takes place has not been ascertained. Black pigment is not detected in the tissue cells or in the body cavity. Note that excess fluid in the blood is excreted by the coxal organ during and following feeding so that a large amount of blood can be rapidly ingested; this is elucidated in the section on the coxal organ below.

Wigglesworth (1943) confirmed that in O. moubata, blood (haemoglobin) is absorbed by swollen epithelial cells of the wall of the large stomach and its diverticula. In these cells, which detach and remain free in the lumen, blood pigment is converted into black globules that are ultimately discharged into the gut cavity. Similar dark granules are dispersed through smaller cells of the gut wall, but no black pigment can be seen in other tissues or in the body cavity. The haemoglobin is digested more or less to protohaematin and is demonstrable in the tick's haemolymph probably as alkaline haematin. The gut contents are reddish brown with black haematin deposits. No free iron can be detected in the gut lumen or cells, or in other tissues, and no nephrocytes containing haemoglobin derivatives can be found.

The type of host from which O. moubata draws a blood meal may be identified by the precipitin test more than six months following feeding (laboratory studies at 20°C. and eighty percent relative humidity) (Weitz and Buxton 1953), or even for twelve months (fowl blood meal, kept at 30°C., ticks also fed on mouse) (Gozony, Hindle, and Ross 1914).

Rectal Excretion

As stated above, O. moubata has no passage between the small intestine and the rectal ampulla, and defecation does not occur. Excretion of water ("urination") from the malpighian tubules takes place only after the first nymphal stage has been reached and a blood meal has been absorbed; this excretion is viscous and dries within a few hours. In the weeks following the first excretion only a slight amount of water is irregularly excreted (but can be produced through various stimuli). This pattern is similar in each developmental stage after the larva.

Variations in tick excretion and a comparison of this function according to species, morphology, number of hosts, size, duration of development, quantity of blood ingested, and transmission of disease organisms to vertebrate hosts have been analyzed by Enigk and Grittner (1952).

Coxal Organ Morphology and Function*

Inasmuch as the volume of the blood meal is from two to six times the tick's original body weight and engorgement is usually completed in about half an hour, the tick must have a means of reducing the total intake volume and of preserving the internal medium while feeding. For this purpose coxal organs function as ionic (chloride) regulators and for ultrarapid excretion of a large volume of water during ingestion of blood. Coxal discharge, which commences about fifteen minutes after the tick has begun to feed, continues till completion of the meal and intermittently for about an hour afterwards. (See also Lavoipierre and Riek 1955).

Malpighian tubules do not function until about an hour after feeding is completed, and the amount of water they excrete is limited.

Chloride regulation. About half the ingested water is excreted in coxal fluid. The mean haemolymph chloride concentration before feeding is 1.00% and after feeding 0.96% NaCl; that of coxal fluid is 0.80% NaCl. These values are similar to those determined by Boné (1943).

Morphology of coxal organs. The flaskshaped coxal organs, which elaborate the bulk of fluid, consist of an outer filtration chamber with an inner tubule system leading to the external opening and of a small organ with glandular structure, the so-called accessory gland. The filtration chamber, which communicates with the tubules of only one point, is highly folded into an elaborate series of pockets and fingers that closely invest the tubules;

---

*Chiefly from Lees (1946B). See other remarks in section on life cycle. It should also be mentioned, for practical significance in relation to disease, that Lees found that O. delanoëi acinus and O. parkeri have coxal organs differing from those of O. moubata, and that in these species coxal fluid is liberated only after cessation of ingestion. It should also be noted that what Lees and others have called "coxal gland" is rather a coxal organ (Burgdorfer 1951) because it excretes fluid rather than secreting fluid, and the filter chamber histologically has no glandular structure.

numerous small muscle fibres inserted in these pockets pass outwards from the organ to attachments on the body wall. The histology of the two regions is entirely different. The filtration membrane is only one or two microns thick and its cellular origin is much obscured. The tubule walls, from five to thirty microns thick, are composed of cells with a dense, deeply-staining cytoplasm and are richly supplied with tracheae.

Function. The production of coxal fluid is under muscular control. It is believed that contraction of coxal organ muscles enlarges the filtration chamber and sets up a sufficient pressure difference across the membrane to initiate filtration into the organ. In subsequent passage of fluid down the tubules, threshold substances such as chloride are reabsorbed. That the coxal fluid is primarily an ultrafiltrate of the haemolymph is suggested by (a) the rapid passage of dyes and even haemoglobin into coxal fluid after injection into the haemolymph, and (b) the very high rate of fluid liberation. Serum albumin sometimes passes into coxal fluid after injection, but casein (and normal haemolymph proteins) are fully retained (Lees' summary).

Boné (1943) proposed somewhat different explanations concerning coxal organ function. Lees further indicates that Patton and Evans' (1929) opinions regarding the functions of the coxal organs are incorrect. An earlier work on the same subject is that of von Künssberg (1911).

The small accessory coxal glands have an unknown function. Rapid engorgement in argasid ticks is allowed by passive cuticular stretching. In ixodid ticks new cuticle is produced to allow for volume of intake and engorgement is much more slowly accomplished.

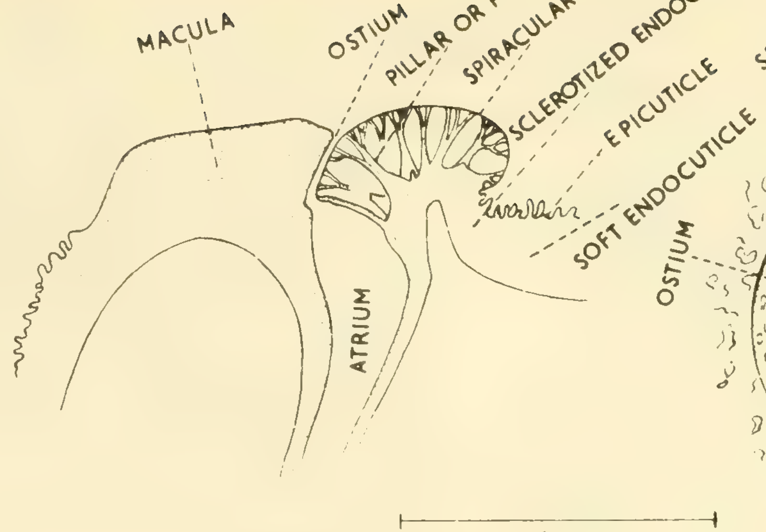
When specimens of O. moubata and other argasid ticks that possess coxal organs are warmed or irritated they exude from these organs a clear fluid. This may possibly serve in part as a defensive mechanism although the actual reason remains to be determined. Coxal organ discharge has been observed and reported, highly inaccurately, by Remy (1922A, and for Argas reflexus, 1921 and 1922B), who believed the exudate to be haemolymph containing haemocytes. Lees (1946B) has shown that these structures are actually small, globular clusters of refractive granules, possibly derived from partial regression of the salivary glands during molting or from granule-bearing cells in the accessory organs. The density of these granules in the coxal fluid of newly molted but unfed ticks is much greater than in the fluid of engorged ticks, in which the granules are more widely dispersed in the greater amount of fluid.

Spiracular Morphology and Function

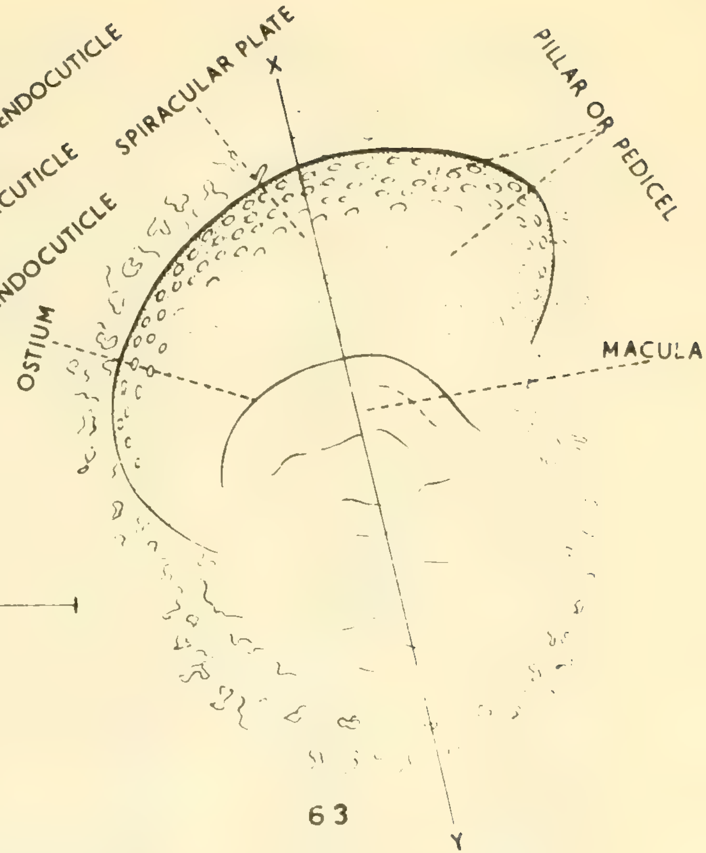
Argasid spiracles have been described by Robinson and Davidson (1913), Cunliffe (1921), Mellanby (1935) and Browning (1954A). The last two workers paid particular attention to the spiracular structure and function of O. moubata.

As described by Mellanby, the spiracle consists externally of a semicircular cribiform plate inserted into a smooth macula of thickened skin, with a slitlike ostium between these. The thin external layer of the plate is supported by rodlike pedicles. The external layer was stated to be pierced by minute pores opening into the tracheal atrium, which is a tube connected to the ostium. Muscular attachments of the macula allow opening and closing of the ostium.

If it were true that the external layer is pierced by pores, it would appear that there is no way for the tampan to close off the direct connection between the external air and the internal body tracheae. Since tampans show remarkable ability to withstand desiccation in the laboratory and in nature, Browning (1954A) was led to investigate the spiracle anew. He found that a surface view of the spiracular plate gives the impression of being porous. On examination of transverse sections these "pores" are shown to be expanded distal junctures of branching pillars (pedicels) arising from a basal, underlying layer of sclerotized endocuticle. These pillars support the very thin outer membrane, which is, however, not porous but continuous. The cavity between the basal cuticle and outer membrane and ramifying between the pillars is continuous between the atrium and the spiracle. From surface view the hard maculum can be seen between the inner curves of the crescent of the spiracular plate. The macula encloses a slitlike aperture, or ostium, connecting the atrium of the trachea with the outside air. The argasid spiracular plate functions to provide a pad against which the macula can impinge when depressed



62



63

Figure 62, transverse section about in plane X-Y in Figure 63.

Figure 63, surface view, with spiracle oriented with its dorsal aspect towards the top of the figure and its anterior towards the left.

ORNITHODOROS MOUBATA SPIRACLE
[After Browning (1954A)]

PLATE XXIII

and thus to form a very efficient seal of the ostium, a necessary condition for animals so likely to be exposed to desiccation. [It is of interest to compare Browning's study with that of Arthur (in press) on the spiracle of Ixodes].

According to Mellanby (1935), the physiological reaction that governs the opening and closing of the spiracular ostium is similar to that of insects. Browning (1954B) appears to accept this conclusion. The physiology of spiracular action has been discussed under Environmental Adaptability above.

Haller's Organ

The structure of haller's organ and its supposed value as a phylogenetic indicator has been discussed by K. W. Neumann (1943). Schulze (1941) also described and illustrated haller's organ, which functions as an organ of smell. Incidentally, Zumpt (1949) summarized his studies on the systematic importance of this structure as follows: Research up to now indicates that haller's organ will have to be considered in the future as having a role in tick systematics and should not be overlooked.

Abnormal Development

During examination of about eight thousand laboratory reared specimens of O. moubata, Robinson (1943A) encountered two examples of partial twinning of the posterior area in a third instar nymph and in a fifth instar nymph that subsequently molted to a male and female, each with abnormalities in internal anatomy. These specimens were normally fertile. Another peculiarly humped third instar nymph normally molted to a male that showed suppression of the postanal region. This male failed to copulate although the genital system was well developed and the sperm normal. Robinson (1944B) also noted many abnormalities of the legs during handling of about ten thousand tampans. Most cases were deficiencies due to partial regeneration of a leg damaged in a previous nymphal instar. Two cases of supernumerary segments of legs were also observed and illustrated. In the same batch a nymph that was much more completely twinned posteriorly than previous examples was observed. This specimen molted to a partially twinned female, mated normally, refused to feed, and deposited a small egg batch (not particularly unusual for unfed females). Some of these eggs developed into normal ticks but most were not delivered into the arms of gene's organ and therefore did not hatch. In the same paper, Robinson reviewed reports of partial twinning in other tick species. Leg anomalies have been reviewed by Campana (1947).

Symbiotes

Tissue cells of many normal insects and ticks harbor living microorganisms that for the most part exert no harmful effects on these cells. In fact, some of them may be distinctly beneficial to the hosts, carrying out their part of a mutually helpful relationship. [Steinhaus (1947)]

In some respects, the relationships between arachnids and their symbiotes are very similar to those between insects and theirs. Among noteworthy differences, however, appear to be the absence of mycetomes in ticks, though some mites have these structures. Furthermore, most tick symbiotes occur in the malpighian tubules and in the ovaries instead of in the alimentary tract, though this may not be true for certain of the rickettsiae. The two families of ticks are similar with respect to symbiotes; in both the same organs are associated with microorganisms. They differ, however, in the manner of ovarial infection. [Steinhaus (1947)]

Intracellular clusters of large masses of typical rickettsiae were discovered in salivary gland acini of O. moubata by Hertig and Wolbach (1924). Intracellular symbiotes were not found in larvae (?nymphs) of O. moubata by Cowdry (1925C,1926A,1927), though they were demonstrated in Argas persicus and in Otobius megnini. Other extensive reviews of symbiotes in ticks are those of Mudrow (1932) and Jaschke (1933).

In O. moubata, unlike ixodid ticks, symbiotes, probably of a bacterial nature, do not occur in the anterior ends of the malpighian tubes but rather in about one-fifth of the length of the tubes just posterior of the anterior ends. In this, O. moubata differs from A. persicus, in which Jaschke observed intracellular symbiotes in masses as large as five microns in diameter and containing as many as forty individual organisms each.

In *O. moubata* and other argasids, symbiotes may migrate from the malpighian tubes to the ovaries and developing eggs, thus differing from ixodids in which they directly invade the first sex cells (Mudrow 1932). This worker sought the explanation of symbiotic bacteria in the realm of physiologic relations of nutrition. (See three paragraphs below).

Argasid symbiotes do not appear to be as pleomorphic as those of ixodids and are usually of the rod or coccus type though they are grouped into apparently gelatinous masses or colonies. Rows or chains of granules or filamentous bundles are not seen in these masses. Tick symbiotes have not been artificially cultivated although Steinhaus attempted to do so with those from *Argas persicus* by utilizing fluids and tissues of the chick embryo. [Steinhaus (1947)]

With reference to the "bactericidal action" in the guts of insects and *A. persicus* and *O. moubata* (Duncan 1926), the reader is referred to subsequent findings in the following series of papers on work done with *A. persicus*: Anigstein, Whitney, and Micks (1950A,B), Whitney, Anigstein and Micks (1950), and Micks, Whitney, and Anigstein (1951). The intestinal tract of blood-engorged ticks exhibited significantly higher antibacterial titer than those that had not been fed. Study of animal blood itself revealed erythrocytic enzymatic hydrolysates showing marked *in vitro* antibacterial effect over a relatively wide spectrum of most gram-positive and a few gram-negative organisms. The active principle of the hydrolysate appears to be a peptide amino acid complex, called sanguinin, which, as a powerful enzymatic inhibitor, represses the growth of several organisms including streptococci, both *in vitro* and *in vivo*.

The role of symbiotes in producing growth-promoting substances in *O. moubata* (and in bedbugs) has been studied briefly by De Meillon and Goldberg (1947A,B). Feeding nymphal and adult ticks on thiamin-deficient rats resulted in almost doubling the time necessary for completing the tampan's life cycle, increasing the interval between blood meals and molting, and an additional molt before reaching maturity. Normal growth and reproduction, however, follow feeding on riboflavin-deficient rats (De Meillon, Thorp, and Hardy 1947). The purpose of these experiments, following work by Brecher and Wigglesworth (1944) on the blood-sucking hemipteron Rhodinus prolixus, was to test the ability of symbiotes in the tick to produce growth-promoting vitamins in the absence of these substances in host blood. Thiamin, it appears, cannot be manufactured by symbiotes under these conditions but riboflavin can be produced in sufficient quantities for normal development and reproduction. Incidentally, it was noticed that the severity of host skin reaction to bites of O. moubata is greater in animals that are deficient in thiamin than it is in normal rats. In the former, an extensive hemorrhage develops at the site of each bite (De Meillon and Goldberg 1947A,B, De Meillon 1949).

Laboratory Rearing Methods

This subject has been discussed in more or less detail by all students of the life cycle, mentioned above. Methods for rearing O. moubata, care of hosts, caging, precautions, host diet and handling, etc., have been presented by Harvey (1947).

Artificial Feeding

A capillary tube method for the artificial feeding of O. moubata and other ticks for studies of disease transmission and physiology has been developed by Chabaud (1950A).

Prevention and Control*

Prevention

Travellers in infested areas should be cautious especially in choosing sleeping and sitting sites. Indigenous habitations whenever possible should be avoided for sleeping, and care should

---

*Although it is not the policy of this study to deal with control and prevention subjects because these are more logically included in a separate report now being prepared, an exception is made in the case of O. moubata. The control and preventive measures required for this species are unique among African ticks, and its biological and host predilections are different from all others. Moreover, it is possibly the only medically important African tick that has little or no veterinary importance.

be taken to protect one's self from tampan bites in rest houses, barracks, meeting places, and sometimes in European houses. In Tanganyika, Morstatt (1914) noted, those huts that were exposed to the rain were free of ticks while others in places more protected from the elements harbored tampans. Morstatt suggested camping in grassy spots some distance from huts.

Any program of labor introduction from an infested area should include an initial inspection of newcomers' personal effects, bedding rolls, and extra clothes.

Strict sanitary measures are of proven success in labor camps. If floor and walls are hard, dry, and free from all cracks and if dust and unnecessary objects that might provide concealment are removed, the tampan's hiding places may be kept to a minimum. Frequent inspection of personal effects, which should be kept in tightly closed boxes or cabinets, or hung away from walls, are of proven success. Persons living in barracks should be warned to report the presence of ticks. Beds must be provided and mosquito nets may be necessary. In infested buildings, placing of bedlegs in cans of kerosene has been recommended to deter hungry tampans.

Special tickproof construction of military huts in heavily infested East African areas has been recommended (Hynd 1945). The base is a six-inch deep bitumen floor (or cheaper hard-beaten tar and earth) with a metal strip inserted at the outer edge midway through its thickness and projecting three inches outwards to prevent ticks from reaching the floor level from outside. A second strip, about one foot above the floor level and extending both inside and outside, helps to confine the searching area for ticks brought in on clothes and gear. Hynd found that the tampan climbs upwards only when it is not able to burrow into the ground. It searches for hiding places in wall cracks or roofing but cannot circumvent horizontal metal strips extending outward from walls.

Jack (1928,1938,1942) suggested that pigsties be constructed of smooth concrete that is easily cleaned and does not provide a hiding place for tampans.

A valuable account of building methods to eliminate tampan infestation has recently been published by Annecke and Quin (1952) and Annecke (1952). Reinforced concrete buildings, which replaced wattle and daub huts at a cost of L 13 per person, are said to have reduced deaths from relapsing fever on a large South African citrus plantation from forty to a single case annually. Additional benefits resulted from employees' social and economic betterment. These buildings were constructed by casting walls in a steel framed mold and raising precast concrete roof sections over them. Floors were made from a vermiculite and cement mixture. Acceptability to indigenous labor, ease of cleaning, and crack-proof construction were important considerations. As the economic level of African labor rises, such prevention methods will become normal and expected, but today they are revolutionary.

The effect of domestic animals on O. moubata populations in houses appears to be moot. Under usual conditions it seems that domestic animals allowed to live in human habitations tend to allow an increase of ticks in these buildings. An exception is cited by Walton (1950A), who believes that in areas of high humidity additional moisture provided by domestic animals in huts is enough to discourage the tampan. Rooms in which goats are kept in humid Kenya hills are free of ticks (Teesdale 1952).

Inasmuch as chickens often are said to be a favorite nymphal host, they probably should be excluded from buildings except possibly for periodic forays to feed on ticks near the surface of the ground. Knowles and Terry (1950) reported that chickens in Tanganyika are heavily infested with nymphal O. moubata, but Phipps (1950) found no significant relation between the presence of ticks and fowls in the same area.

Chemical Control

Gammexane (Hexachlorocyclohexane, BHC or benzene hexachloride) is generally considered to be the most promising chemical for controlling O. moubata.

Ticks coming in contact with 0.5 per cent dust lose co-ordination after five or six hours. During the first day they lose much of their body weight by excessive coxal fluid loss, defecation of milky fluid, and possibly by increased integumental permeability. Their color darkens; they become more or less immobile and usually die in a little over a week. Those that live fail to produce viable eggs. Application of 0.5 per cent gammexane dust to floors and lower parts of walls sprinkled from perforated cigarette tins at the rate of three or four pounds of dust per hundred square feet is recommended, but frequent checks should be made where reinfestation is liable to occur (Jepson 1947).

Application of Jepson's findings on a township scale in Tanganyika was described in detail by Knowles and Terry (1950) using "G dust" (D220 compound one part, and diatomite four parts). These authors found that although total eradication is probably impossible, a townshipwide control program can almost eliminate relapsing fever in a fairly static population and is much cheaper than hospital treatment of the disease. Sampling methods and application methods were also stressed.

Factors to be considered in a control program and need for further research were discussed by Phipps (1950), who indicated the necessity of using tested diluents and making accurate surveys before and after treatment. The incidence of ticks and disease should also be checked before large scale programs are instituted for, in Phipps' opinion, not all places in which ticks abound are disease foci.

In Annecke and Quin's (1952) extensive chemical control program on a heavily infested South African citrus plantation, it was found that BHC applied as a spray to inner walls of huts in concentrations of 300 mg. gamma isomer (or upwards) per square foot (emulsion of 17% BHC with 4% gamma isomer) gave effective control. With lesser concentrations, tick populations increased rapidly after seven weeks. Surviving ticks from sprayed huts deposited considerably fewer eggs than normal females.

Nevertheless, the same authors report, reintroductions were so frequent that the authorities finally resolved to construct tickproof habitations. In spite of comparatively high initial cost in comparison with daub and wattle huts, this was found to be the only realistic approach to reducing deaths and man hours lost to relapsing fever.

Subsequently, Annecke (1952) reported that all huts treated with 600 mg. gamma isomer per square foot BHC remained free of O. moubata for at least 27 months. When 300 mg. per square foot were used, huts remained free of ticks for twelve months.

The small amounts of BHC used in malaria control programs, 25 to thirty mg. gamma isomer per square foot BHC wettable powder, applied twice three months apart, has little effect on O. moubata, but Annecke (loc. cit.) believes the cumulative effect may reduce or destroy the tick.

The above remark immediately suggests the potentiality of tampan resistence to chemicals. So far as known, none has yet been demonstrated.

A control program in Fort Jameson township of Northern Rhodesia has recently been reported by Holmes (1953). Heavy spraying with a five percent BHC solution resulted in general diminution of the tick population but did not result in its elimination. It was found that the most economical form for achieving a hundred percent kill was five percent BHC powder mixed with 95% (by weight) sawdust diluent, or with chaff left from pounding corn. To obtain a sackful of this mixture, a container holding 6¼ pounds of forty percent BHC cattle dip wettable powder was mixed with fifty pounds of sawdust. This mixture was then laid as a four inch wide barrier, thick enough to insure that ticks must come in contact with it when passing, at the base of all inside walls of the house. The barrier was maintained for three weeks and frequently inspected, especially where it passed door openings, to insure that it was not scattered. This time period should reach all nymphs hatching from eggs laid before the chemical is applied (more or less exceptionally a somewhat longer hatching period may be involved, but for practical purposes this time is probably usually effective - HH). Elimination of tampans was obtained by this method, but reinfestation occurred within a year to a year and a half. Fleas, Congo floor maggots, and bedbugs were also killed. In the following year, the number of cases of relapsing fever from treated houses was considerably reduced. The cost of this program was so low that other authorities commenced similar control programs.

A control program using 0.5 percent gammexane powder (D.034) was undertaken in houses in humid Kenya hills (Teesdale 1952). Reapplications had to be made every month or two to control nymphs that had hatched from eggs, the latter being resistant to the chemical. Killing effects diminished in treated huts fifty days after application. The low cost of gammexane was said to allow its purchase and use by Africans.

Although most recent workers favor BHC dusts over spray solutions, Anderson (1947) reported good control in Somaliland coffee houses with a three percent solution of gammexane in diesoline. "666 spray" (crude benzene hexachloride, 12% gamma isomer) at a dosage of 1,250 mgm. per square foot of soil was recommended by Hocking (1946), who found DDT at the same dosage less effective. On the basis of experiments in two localities in Kenya, Heisch and Furlong (1954) recommend a spray of gammexane wettable powder P.520 rather than gammexane insect powder for tampan control.

Investigators have reported that DDT is of less effectiveness than gammexane in controlling tampans. Among these, Jepson (1947) found that five percent DDT dust is slower and less effective than gammexane, although after about three weeks a mortality of fifty percent to eighty percent obtained. Holmes (1953) also indicated that gammexane provides a more complete and rapid kill than DDT. Annecke and Quin (1952) considered that various types of DDT applications lacked sufficient residual effect to be considered useful.

The inefficacy of many chemicals for killing O. moubata and the usefulness of gammexane and of E605F (diethyl-p-nitrophenyl-mono-thio-phosphate) for this purpose were reported by Enigk (1948). Belgian tests with three preparations of the gamma isomer have been reported by Pierquin (1950). Sprays of "Cyclotox" containing a large proportion of the gamma isomer killed about half the ticks in eight to ten days when applied in Belgian Congo huts. In the laboratory, where the ticks could be kept in closer contact with the chemical, all died after varying lengths of time with different concentrations and preparations (Himpe and Pierquin 1951). The authors conclude that spraying a volatile substance on soil is of less value than mixing it with soil.

The possibility of controlling O. moubata by feeding hosts on certain chemicals was explored by De Meillon (1946). Fifty mgm. of pure gamma isomer of gammexane were mixed with agar and water and fed to rabbits four or five times. The ticks fed only briefly and showed either incoordination or death afterwards. The domesticated tampan's predilection for human blood obviously limits the application of this interesting approach.

O. moubata is also susceptible to arsenic compounds in the blood of animals. Injections of neoarsphenamine have been used in rabbits for this purpose (De Meillon, Thorp, and Hardy 1948). The failure of 2:3 dimercaptopropanal (British anti-lewisite) to alter the toxicity of neoarsphenamine was described by Thorp, De Meillon, and Hardy (1948).

In testing insect and tick mortality when exposed to dry insecticidal film, Busvine and Barnes (1948) found that O. moubata nymphs are resistant to DDT but susceptible to gammexane and pyrethrins. Busvine and Nash (1953) also determined that films of oil solutions are better than dry films for testing insecticides because they give a sharper dose/kill relation.

The value of certain derivatives of phenol and naphthalene as soil-fumigants in hut floors has been suggested (Robinson 1944A).

Derris powder failed to affect nymphal O. moubata in Russian laboratory tests (Mironov, Nabokov, and Kachalova 1946). Pyrethrum sprays and dusts are highly toxic (Robinson 1942C,D,1943B,1944B) but field tests have not been undertaken, probably due to high cost of pyrethrum and effectiveness of cheaper BHC.

Sulfur dioxide or cyanide fumigation has little effect on O. moubata, and sprays of kerosene and formalin are not successful (Hopkins and Chorley 1940). A spray consisting of 30 cc. turpentine, 50 cc. twenty-five percent alcohol, 5 cc. kerosene and a little white soap was suggested by these authors, though it is expensive and troublesome to prepare. Their best recommendation was a coarse, roughly filtered spray consisting of 1½ pounds of paradichlorobenzene in one gallon of kerosene applied under high pressure at the rate of twelve to fourteen gallons per two thousand square feet of surface (also reported by Hargreaves 1936).

The ovicidal value of concentrated vapors of chloroform, sulfurous acid, ammonium sulfide, ethel dixanthogen, BHC, formalin, and phenol has been reported (Enigk and Grittner 1953).

A report of the resistance of O. moubata to various sheep dips (Blacklock 1912) is of little contemporary interest.

Disinfection of Personal Effects

Blankets, bedding, and clothing may be disinfected by exposure in a tight container to a temperature of 82°C. for half an hour (Hopkins and Chorley 1940).

Burning

In a carefully conducted experiment, Garnham (1926) found, contrary to certain textbook statements, that burning of African huts infested with O. moubata is an effective means of killing these ticks. He suggested pulling down the straw roofing and piling it inside mud hut walls for burning. This may be the only means of control where the indigenous population does not work for pecuniary gain. Otherwise burning is uneconomical unless the situation is serious. More permanent housing, in which infestation may be controlled or better still prevented, should be substituted whenever possible. Burning infested buildings has long been the indicated control method in many parts of Africa. Flame throwers are sometimes used to good effect where ticks are lodged in shallow cracks in buildings that withstand fire. Jack (1931) obtained control against tampans in nine-inch walls of pigsties by burning brushwood on both sides of them. Burning against only one side and spraying with a ten percent emulsion of paraffin (i.e. kerosene) had failed.

Hand-picking

A reward of sixpence for every twenty ticks collected on a South African farm yielded 73,000 ticks one year and over half a million in several years. Laborers placed a thin layer of drift manure along the inside walls of their huts and there collected the ticks as they came to hide. Small holes dug inside and outside the doors and filled with drift manure were also found to be favorite hiding places (Annecke and Quin 1952).

DISEASE RELATIONS

Man (In nature)

O. moubata is the only known tick vector of African tick-borne relapsing fever (Borrelia duttonii) of East, Central, and South Africa. A few cases of this disease have been reported from Equatoria Province in the Sudan. No evidence supports certain published maps showing known extensive distribution of tick-borne relapsing fever in many areas of the Sudan. It should be noted that populations of this tick from burrows of wild animals have not been found infested with spirochetes.

It is claimed that some specimens naturally infected with rickettsia, Coxiella burnetii, the causative organism of Q fever, have been found in Ruanda-Urundi, and that in Kivu others have been taken infected with an organism referred to as "Bashi virus-rickettsia".

The etiologic agent of food poisoning, Salmonella enteritidis, has been recovered from this tick in Africa.

O. moubata has not actually been found infected in nature with the pathogenic organisms of any other human disease, but experimental data strongly indicate further research in this respect.

Tampan bites may cause considerable irritation. Circumstantial evidence suggests that persons long victimized by bites of this tick may develop an immunity to them.

Fowls

O. moubata is an experimental vector of fowl spirochetosis (Borrelia anserina). It is of negligible importance in transmission of Salmonella bacteria and of Aegyptianella pullorum (a protozoan). The bacterium that causes avian cholera (Pasteurella avicida) survives only a few days in O. moubata.

Experimental Disease Relations

Viruses and Rickettsiae

The use of O. moubata and other Ornithodoros species for transporting a number of pathogenic organisms for experimental purposes has been suggested.

This species is easily infected with Q fever (Coxiella burnetii) and is capable of transmitting the organism by its bite. A diagnostic test for Q fever, using O. moubata for feeding on a suspected host, has been developed.

Rickettsia prowazekii, the causative organism of classical typhus, and R. typhi, that of murine typhus, develop in O. moubata. The former rickettsia can be transmitted transovarially and the latter can be found in eggs and coxal fluid of infected ticks. No multiplication of R. tsutsugamushi, the causative organism of scrub typhus, occurs in O. moubata; the tick is therefore not a likely vector of this unusually host-specific rickettsia.

O. moubata maintains infection with the virus of Russian spring-summer (Far Eastern) encephalitis. It has also been shown that these ticks can be infected with western equine encephalitis virus. The virus causing murine poliomyelitis (strain Columbia SK) is destroyed or inactivated in blood ingested by the tampan. Yellow fever is not transmissible by this tick. A Congo rickettsia of the boutonneuse fever type (boutonneux-pourpre) remains virulent in ticks fed on infected guinea pigs for two months but not for six months.

Bacteria

Tularemia (Bacterium tularense) is transmitted by the bite of O. moubata and is also transovarially transmitted to progeny. Bacillus anthracis, the causative organism of anthrax, is not transmissible and apparently kills the ticks, although it does remain virulent in the tick's body long after death. The etiologic agent of food poisoning, Salmonella enteritidis, has been recovered from this tick in Africa.

Spirochetes of Relapsing Fever

O. moubata is capable of harboring and transmitting other Borrelia species besides B. duttonii. This is of considerable interest since in other parts of the world many species of Borrelia are host-specific and tick hosts are spirochete-specific.

Spirochetes Other Than Relapsing Fever

Weil's disease (Leptospira icterohaemorrhagiae) survives for about forty days in living O. moubata, remains virulent in the body long after the tick's death, and can be transmitted when infected ticks bite.

Filariae

Filariae may develop in the body cavity of O. moubata but transmission appears to be unlikely.

Trypanosomes

Virulent trypanosomes may remain in the tick's gut for as long as five years, but transmission is apparently impossible and transovarial infection does not occur.

Toxoplasmosis

It appears that Toxoplasma gondii cannot be transmitted by O. moubata although the organism survives in the tick for almost two weeks after artificial inoculation.

Tropical Ulcer

The suggestion has been made that tick bites, such as those of O. moubata, may be initially responsible for tropical ulcer.

IDENTIFICATION

O. moubata might be confused only with O. savignyi in the African fauna. However, since O. moubata lacks eyes, which in O. savignyi are present as two pairs of small, round, equal sized, shiny black spots in the lateral groove, one pair above coxa I and one pair between coxae III and IV, there should be no real difficulty in distinguishing the species. Tarsal differences mentioned in Nuttall et al (1908) are too variable for application. Adults average about 8.0 mm. long by 6.0 mm. or 7.0 mm. wide, although freshly engorged females may reach 11.0 mm. in length. O. savignyi is usually somewhat larger, averaging about 11.0 mm. long. The mammillated integument, conspicuous tarsal dorsal protuberances, and absence of cheeks easily distinguish both O. moubata and O. savignyi from all other African species. Males are often a little smaller than females and their genital aperture is a short, rounded opening as compared with the broad slit of the female. Nymphs have no genital aperture, but in larger instars a small round depression is present in its place.

In a study of the sexual differences in this species, Nuttall (in Cunliffe 1921) has shown that the average male is smaller than the average female, though extremes overlap, and that the same is true for the size of the genital aperture of the two sexes.

An estimate of the stage of development of immature stages can be made on the basis of differences in mouthparts, legs, and spiracles (Cunliffe 1921).

ORNITHODOROS (ORNITHODOROS) SAVIGNYI (Audouin, 1827).

(Figures 8 to 12)

THE EYED TAMPAN*

DISTRIBUTION IN THE SUDAN

Central and northern Provinces (King 1908,1911,1926).

Localities reported in literature and from which I have seen specimens are:

Darfur: 15 miles northwest of Fasher (SGC). Nyala (horse; SVS). No locality (BMNH).

Kordofan: El Obeid (camel yard; SGC, SVS). "Several localities" (King 1911, Balfour 1911E).

Blue Nile: Wad Medani (camel yard; SGC, HH). Wad Raiya and Kosti (SGC).

Kassala: Karora and Goz Rageb (on human; SGC). Khor Mashi hills south of Tokar, Bir Qui Tiri (under tamarisk tree near well; SGC).

Khartoum: Khartoum (cattle quarantine station; HH). Khartoum, Shambat (H. W. Bedford 1939). "Oasis near Khartoum" (King 1911, Balfour 1911E).

Northern: Dongola (Dönitz 1906). Wadi Halfa and Abu Hamed (camel yards; HH).

DISTRIBUTION

O. savignyi is distributed locally through arid parts of North, East, and South Africa, the Near East, India, and Ceylon. The Near

*In South Africa, called "The Sand Tampan" (Theiler 1952A,B).

or Middle East probably was its original home. Transportation by caravans, lack of field search and of literature reports, and confused identification in Africa have combined to provide a still uncertain picture of this tampan's actual distribution within the noted range.

During Neumann's time *O. savignyi* was frequently confused with *O. moubata* and acceptance of many early records and of some even more recent reports is questionable. These two species never occur in the same ecological niches. They are close neighbors in some areas, as Somaliland, where *O. moubata* inhabits huts next to trees under which *O. savignyi* hides.

Brumpt (1936) summarized the known geographical distribution and medical relations of *O. savignyi*. He noted especially that even though this tampan is frequently found along remote camel trails, it is not known from Morocco in spite of considerable search for it there.

Brumpt (*loc. cit.*) also considered it surprising that *O. savignyi* has not been carried to Madagascar but that *O. moubata* is common in some areas of that island. Once the very different biology of these two species is understood, a reasonable explanation for this distribution pattern may be offered.

O. moubata is a highly domesticated parasite that inhabits man's dwellings and frequently hides among his personal effects. It was probably transported from Africa to nearby Madagascar among gear in seagoing vessels. This tick has not been able to survive elsewhere outside of tropical and southern Africa, where it is endemic.

O. savignyi, on the other hand, appears to have erratically invaded Africa from the East. It prefers more arid outdoor conditions than are found in most parts of Madagascar, and part of its spread probably has been by camels, which are not used in Madagascar. In southern Africa, the range of *O. savignyi* appears to be related to environment and wild animals rather than to the comparative recent introduction of camels, movements of domestic stock, or treks of hunters (Theiler, unpublished). In African regions where *O. savignyi* does occur, populations are often spotty, even in areas that appear favorable. This tampan's predilection for resting outdoors in the soil probably more closely confines its apread to overland routes than does O. moubata's propensity for hiding in goods or personal effects.

NORTH AFRICA: EGYPT (Savigny 1826. Audouin 1827. Koch 1875. Brumpt 1908A. Neumann 1911. Yakoub 1945. Halawani 1946. Davis 1947. Taylor and Hurlbut 1953. Hoogstraal 1954A. Davis and Hoogstraal 1954. Theiler and Hoogstraal 1955. Taylor et al 1955. Hurlbut 1956. Taylor, Work, Hurlbut, and Rizk 1956). LIBYA (Franchini 1927,1929A,E,1932B,1933A,B,C,D,1934B,1935A,B,C, 1937,1938C. Zavattari 1930,1932,1933,1934. Tonelli-Rondelli 1930B,1932A,B,D,1935. Gaspare 1933,1934. Garibaldi 1935. Theiler and Hoogstraal 1955). TUNISIA, including Ile de Djerba (Weiss 1911B,1912. Galli-Valerio 1911A. Nicolle, Blaizot, and Conseil 1912,1913A,B. Absence in oases: Langeron 1921. Nicolle and Anderson 1927. Colas-Belcour 1928,1929A,C,1930,1931). ALGERIA (Chalon 1923. Catanei 1929). [Apparently absent in Morocco (Brumpt 1936).]

WEST AFRICA: NIGERIA (Northern Province only: Simpson 1912A. Alcock 1915. Leeson 1953). FRENCH WEST AFRICA (Brumpt 1936. Kone 1949. Rousselot 1951,1953B). [Absent in Gold Coast: Selwyn-Clark, Le Fanu, and Ingram (1923) and Corson and Ingram (1923). Absent in Liberia: Bequaert (1930A).]

[CENTRAL AFRICA: No substantiated records. Not known from Belgian Congo, but should be searched for there (Bequaert 1930A, 1931). O. savignyi caecus listed by Schwetz (1927C) is a synonym of O. moubata. Leeson (1953) lists O. savignyi, probably after Nuttall et al (1908) or Howard (1908) but these records are most likely repetitions of early misidentifications.]

EAST AFRICA: SUDAN (Not Koch 1875 or Neumann 1896, "Upper Nubia," cf. Eritrea. Dönitz 1906. Brumpt 1908A. King 1908,1911, 1926. Neumann 1911. Balfour 1911E,1912. Brumpt 1936. Kirk 1938B,1939. H. W. Bedford 1939. Hoogstraal 1954B. Theiler and Hoogstraal 1955).

ETHIOPIA (Nuttall et al 1908. Neumann 1911,1922. Wenyon 1926. Bruns 1937 statements questionable). ERITREA (Koch 1875 and Neumann 1896 from River Anseba, "Upper Nubia". Franchini 1929D, E. Tonelli-Rondelli 1930A. Niro 1935. Stella 1938A,1939A,1940). FRENCH SOMALILAND (Neumann 1922. Brumpt 1936. Stella 1938A,1939A, 1940). BRITISH SOMALILAND (Pocock 1900. Drake-Brockman 1913A,B, 1914,1915A,B,1920, biology and medical implications in part mixed with O. moubata. Neumann 1922. Stella 1938A,1939A,1940. Anderson 1947. Heisch 1950A. Falcone 1952, erroneous disease relations). ITALIAN SOMALILAND (Brumpt 1908B. Lees 1914. Paoli 1916. Franchini 1925,1927,1929C,E,1934. Tonelli-Rondelli 1930A, 1931. Mattei 1933. Niro 1935. Massa 1936A,B, medical implications questionable. Moise 1938,1950. Stella 1938A,1939A,1940. Lipparoni 1951,1954. Giordano 1953).

KENYA (The O. savignyi of Karsch 1878 refers to O. moubata. Dönitz 1906. Neave 1912. Neumann 1912. Anderson 1924A,B. Mackie 1927. Brassey-Edwards 1932. Lewis 1931A,C,1939A. Heisch 1937,1951A. Walton 1951). UGANDA (Bruce et al 1911. Neave 1912. Mettam 1932).

[?TANGANYIKA: ?As O. morbillosus: Gerstäcker (1873). Neumann (1901,1907C,1910B,1911). Howard (1908) ?quoting Neumann. Absent in Bukoba: Morstatt (1914). The presence of this tick in Tanganyika remains questionable.]

SOUTHERN AFRICA: [?ANGOLA: Neumann (1896) listed specimens from Landana that Bequaert (1930A) quite logically believes were O. moubata. Subsequent statements (Santos Dias 1950C) are merely a repetition of Neumann and disease relations are incorrect. "RHODESIA": Report of Lounsbury (1900C), obviously referring to O. moubata, quoted by other authors. No subsequent reports of O. savignyi. ?MOZAMBIQUE: Neumann (1896) ?should be O. moubata. Lounsbury (1900C) should be O. moubata. Theiler (1943B) states O. savignyi doubtfully recorded but possibly present. Santos Dias (1953B) evidence not presented. Mozambique records are considered incorrect by Theiler and Robinson (1954).]

NYASALAND (Wilson 1950B). BECHUANALAND (Bedford 1926,1927, 1932B,1934. Theiler and Robinson 1954). SOUTHWEST AFRICA (Lounsbury 1900C, possibly referring to O. moubata. As O. pavimentosus: Neumann 1901,1911. Dönitz 1907C,1910B. Howard 1908. Trommsdorff 1914. Bedford 1926,1927,1932B,1934. As O. moubata: Mönnig 1949.

Leeson 1953. Theiler and Robinson 1954. Theiler and Hoogstraal 1955). UNION OF SOUTH AFRICA [Lounsbury 1899C, 1900B,C (confused with O. moubata), 1903B,1904A. Howard 1908. Dönitz 1910B. Bedford 1920,1926,1927,1932B,1934. Alexander 1931. Bedford and Graf 1934,1939. R. du Toit 1942B,C,1947A,B. Theiler and Robinson 1954. Theiler and Hoogstraal 1955.]

NEAR EAST: ADEN (Nuttall et al 1908. Patton and Cragg 1913. Cunliffe 1922. Hoogstraal ms.). YEMEN (Mount 1953. Hoogstraal, ms.). PALESTINE (Theodor 1932. Smith 1936 quoted by Brumpt 1936. Bodenheimer 1937). IRAQ (Leeson 1953).

MIDDLE EAST: INDIA (Christophers 1906. Neumann 1911. Patton and Cragg 1913. Donovan 1913. Fletcher 1916. Cross and Patel 1922. Rao and Ayyar 1931. Sen 1938. Sharif 1938. Kapur 1940. Joshi 1943). CEYLON (Nuttall et al 1908. Brumpt 1936. Crawford 1937. Chow, Thevasagayam, and Tharumarajah 1954).

HOSTS

Camels are most frequently mentioned as hosts. O. savignyi appears to be present in most areas in which dromedaries are used. Fowls are sometimes attacked and all domestic animals may serve as hosts (Lounsbury 1900B). For instance, this tampan is common in cattle yards at Mawar, India (Joshi 1943) and under trees where mules are tethered in Somaliland (Lipparoni 1951). Human beings are frequently bitten, especially when they sleep in camel yards or sit under trees commonly used by domestic animals for shade. Any laboratory animal may serve as a host. Dogs are satisfactory laboratory hosts (Lounsbury 1904A).

Game animals are said to be attacked, but evidence is scant. The rhinoceros, lion, and buffalo may serve as hosts in Kenya according to Walton (1951). Neumann (1912) reported numerous specimens from a Kenya locality where a giraffe had been standing.

BIOLOGY

Life Cycle

Eggs of O. savignyi are deposited in sandy soil where adults hide. Individual females, observed by Cunliffe (1922) at 30°C., laid from 100 to 417 eggs, averaging 219. Other individuals that had fed four times laid five egg batches totalling about 900 eggs over a thirteen month period (Patton and Cragg 1913). The embryonic development, described by Christophers (1906), is essentially like that of O. moubata.

Larvae, like those of O. moubata, are nonmotile and do not feed. Although some undergo ecdysis in the egg, most larvae free themselves from the eggshell before molting to nymphs (Cunliffe 1922). After splitting the eggshell, larvae molt to nymphs in five hours (Davis 1947) to ten hours (Patton and Cragg 1913).

Four nymphal instars over a period of about 84 days and seven nymphal feedings were observed by Patton and Cragg (1913). Cunliffe (1922), on the other hand, noted that males appeared after four to six molts and females usually after the sixth molt. Reasons for differences in number of instars among argasids remain to be ascertained.

The very active nymphs commence feeding two or three days after molting and require fifteen to thirty minutes to reach repletion. Adults normally feed for similar periods but the presence of both stages along remote camel trails would indicate that on occasion some tampans may remain longer on the host.

Females in Cunliffe's (1922) studies lived between 292 and 420 days at 30°C. and for an average of 775 days at 22°C.

Spermatophores superficially similar to those of O. moubata are utilized by this species (in Egypt), although Christophers (1906) and Nuttall and Merriman (1911) questioned their presence.

Other details of the life cycle have been reported by the above mentioned observers and by Rousselot (1953B). However, more extensive and refined studies are still necessary.

Ecology

O. savignyi, among the tick species studied by Lees (1947), shows the greatest ability to limit water loss at high temperatures. The critical level for this species is 75°C. while for O. moubata it is 63°C. Even xerophilic hyalommas abruptly increase water loss at 45°C. (cf. page 154). This factor explains in part how the eyed tampan can exist in deserts where little other life is sustained. Cunliffe's (1922) studies, from which he concluded that the temperature and humidity requirements of both these tampans are much the same, should be repeated with special attention to extreme levels.

Famous for the viciousness of its attack, this tampan is usually well known wherever it occurs. Natives quickly lead one to infested animal corrals, trees under which man and beasts rest, and well sides where the eyed tampan is superficially burrowed awaiting its prey. In Somaliland, Lipparoni (1951) reported, O. savignyi is common under trees where soldiers tether their mules and O. moubata infests huts beside these trees. Although the adventitious presence of O. savignyi in buildings must be expected, early records from human habitations appear to be based on misidentification. For instance, Drake-Brockman's various reports of O. savignyi in British Somaliland buildings have been questioned by Anderson (1947). Anderson found O. savignyi exclusively outdoors in the same area, and O. moubata, previously thought to be nonexistant in the area, exceedingly common in huts and coffee houses.

We have never observed O. savignyi in sites directly exposed to the sun. Indeed, at the Khartoum quarantine one may see a long, seething line of thousands of hungry tampans helplessly confined to the shade of a row of acacia trees. A few yards away, separated only by the hot, nine o'clock sun, newly arrived cattle tied to a post fence tempt the tampans to cross the glaring strip. The next morning, in the coolness of seven o'clock, those tampans under the trees are all blood bloated and resting comfortably in the sand, others are dragging back from their hosts across the now nonexistant barrier, and the legs of the cattle are beaded with yet other podshaped ticks taking their fill of blood in a regular line just above the hoof.

Laboratory rats and mice, as noted by Heisch (1950A), assail this tampan. Rats feast on nymphs and adults. Mice commonly assault nymphs, but only particularly bold mice attack adults. These rodents, in turn, facilely escape bloodthirsty but lumbering adults, although small, active nymphs more easily attack them. Predators in nature do not appear to have been reported.

REMARKS

Christophers' (1906) extensive study on morphology and digestion of *O. savignyi* has been reviewed in the section on *O. moubata*, which also contains a number of other data pertaining to both species.

The nymphal instars may be approximately determined according to Cunliffe's (1922) data, also presented by Campana-Rouget (1954).

The haller's organ of *O. savignyi* has been described and illustrated (Schulze 1941).

Jakob (1924) used this tampan to illustrate certain theories separating the ixodids from the argasids on the basis of differences in external grooves, ridges, and prominences. He did not believe, as a result of these studies, that *Argas* developed from *Ornithodoros*, but rather that both genera had a common origin in the Uropodidae, a member of which, *Discopoma africana* Vitzhum, was illustrated.

DISEASE RELATIONS

MAN. The bite of *O. savignyi* may have severely painful sequelae but this tampan has never been found infected with pathogenic organisms in nature, and transmission of pathogens has not been demonstrated until recently. Even the earlier assertions that the eyed tampan transmits human relapsing fever (*Borrelia* spp.) have been cast into considerable doubt by subsequent research.

DOMESTIC ANIMALS. Camels and cattle suffer greatly and may even be killed by the volume of blood lost to numbers of eyed tampans in their pens.

EXPERIMENTAL. *Leishmania donovani*, which causes kala azar in human beings, does not develop in *O. savignyi*. *Trypanosoma cruzi* undergoes development in this tick in the laboratory. *T. evansi* cannot be transmitted from the tick to animals except by inoculation of a suspension of infected ticks.

Experiments on transmission of heartwater (*Rickettsia ruminantium*) of cattle by means of *O. savignyi* have been unsuccessful.

West Nile virus remains viable for at least three months in *O. savignyi*, and transmission of the virus to mice by the bite of parenterally-infected ticks has been demonstrated. Similarly, specimens experimentally infected with Sindbis virus transmit the organism when biting.

Spirochetosis of chickens (*Borrelia anserina*) is not transmitted by this tampan.

IDENTIFICATION

See remarks under *O. moubata*, pages 189 and 190.

FAMILY IXODIDAE

INTRODUCTION

All tick genera, save those in the family Argasidae and *Nuttalliella*, in the family Nuttalliellidae*, fall into the *family Ixodidae* and are referred to as "hard ticks" or "ixodids". The use of the term ixodid is not confined to the genus *Ixodes*. In Sudani Arabic, hard ticks are called "gurad" (جُراد).

All ixodid genera that normally inhabit Africa also occur in the Sudan with the exception of *Rhipicentor***. This genus is represented by *R. gladiger* (Neumann, 1908) (= *bicornis* Nuttall and Warburton, 1908) in neighboring Belgian Congo (Bequaert 1931) and further south in Africa. *R. nuttalli* Cooper and Robinson, 1908, occurs on various animals in South Africa and in Southwest Africa.

---

*The family Nuttalliellidae (Schulze 1935) contains only a single, exceedingly rare species, *Nuttalliella namaqua* Bedford, 1931(A), described from Little Namaqualand, Southwest Africa. This family appears to be a "missing link". A scutal outline is present but not structurally differentiated from the leathery, papillated integument. Though the mouthparts are anterior as in Ixodidae, the palpal segments are movable as in Argasidae, but an inner groove on the second segment is suggestive of the reduction in Ixodidae, in which the terminal segment is essentially merely a small appendage of the penultimate segment. The biology of this strange species is unknown.

***Rhipicephalus* (*Pterygodes*) *fulvus* Neumann, 1913, a remarkable aberrant parasite of Northwest Africa, is frequently treated as a monotypic genus and sometimes as a subgenus of *Rhipicephalus*. See Neumann (1913) for description of male and Colas-Belcour (1932) for description of female, nymph, larva, hosts, biology, and disease relations.

In addition to African genera discussed herein, several others have been described from other continents, chiefly by Schulze. Many of these genera, however, meet with little general acceptance among contemporary specialists. A useful summary, including Schulze's and others' genera, may be found in Baker and Wharton (1952). In general, however, "textbook genera", as used by Neumann and by Nuttall and Warburton, usually suffice and are of considerable practical and scientific value. They should be little tampered with if at all. Special groups of ticks may be readily categorized at the subgeneric level to provide a useful sounding board for their acceptance by specialists.

Ixodid ticks occur throughout the world wherever terrestrial vertebrates are found. They attack most land mammals and some marine forms. Some ixodids parasitize birds and reptiles, some feed on amphibians. Adults of few if any ixodids regard man as a host of predilection but many attack him in the absence of other available hosts. Larvae and nymphs are much more common and serious pests of man than adults.

Morphologically, these ticks differ from argasids by the presence in all stages of a dorsal scutum. Ixodid mouthparts are always anterior and visible from above; the body is oval. Larvae have six legs; nymphs have eight legs and a female type scutum but lack both porose areas on the basis capituli and the genital aperture of the female. The female scutum covers only the anterior portion of the dorsum, the male scutum extends to the posterior margin of the body. Eyes may be present or absent. Nymphs and adults have a spiracular plate situated laterally, posterior of each hind leg. Palpi, clearly segmented and movable in argasids, are limited in ixodids to segments 2 and 3 and to a more or less well developed segment 1; segment 4 is inserted ventrally into a pit of segment 3.

Biologically, the majority of ixodids display comparative uniformity within rather narrow limits. Exceptions are notorious but few. The number of species is small, somewhere around five hundred. Ixodids are highly adapted to parasitic life but one is prone to wonder how they have succeeded in the battle for survival. Their aimless wandering habit and dropping from hosts and their indiscriminate oviposition proves fatal to many individuals, even though they survive long periods without food. Their extended life cycle subjects them to many adversities depending on season and the peregrinations of their hosts. The requirement of two or more kinds of hosts, often with divergent habits, limits their distribution to certain faunal areas. The comparatively large size of females makes them subject to injury and tempting food for predatory arthropods and vertebrates. Certain pathogenic organisms, fungi, and hymenopterous parasites kill them. Ticks have little protection against an enemy except their ease of concealment. They are particularly susceptible to attack during the lethargic premolting and the weak postmolting period.

On the other hand, many biological features enable ticks to survive especially well. They lay numerous eggs and withstand a comparatively wide temperature and humidity range with greater ease than many other arthropods. They survive for months or years without food and often gain considerable protection from the concealed places in which they feed on the host. They frequently are offered a wide choice of appropriate hosts. Should they annoy the host, the animal is usually powerless to rid itself of the parasite. Ticks' slow metabolic rate has certain advantages and the leathery, usually inconspicuous, integument offers some protection from living enemies, water, and chemicals. Parthenogenesis, possibly a common occurrence though not well studied, may aid survival.

The genus Ixodes, as a biological unit, shows much divergence from the usual patterns of ixodids. The biology of this genus must be considered independently but in relation to other genera. Review summaries frequently leave the student with the impression that the unique biological characters of Ixodes ticks are also characteristic of other ixodid genera.

The degree of host specificity in ixodid ticks varies from genus to genus or within certain subgroups of various genera. Generalizations on this point should be very carefully qualified.

Eggs are laid only once; promiscuously; at one time and place; and are always numerous, sometimes numbering over 10,000. Eggs hatch in from two weeks to several months, depending mostly on climatic factors.

Larvae are active and sometimes are easily visible as hundreds or thousands of them rest on grass awaiting a host. Larvae often parasitize small mammals, birds, and reptiles, sometimes in their nests or dens. Only a few kinds choose larger animals for hosts. Thickness of the host skin is possibly an important factor in restricting larvae to smaller animals. Larvae seldom feed within a week after hatching.

After some days of feeding, larvae molt to nymphs on the same host (two-host type of life cycle), or drop from the host and some time later molt to nymphs (three-host type of life cycle) on the ground. Exceptions are the single-host boophilid ticks (and a few others) that molt and remain on a single host during their lifetime. Nymphs that have molted on the ground seek a new host, sometimes the same type they fed on as larvae but, more commonly, animals similar to hosts preferred by adults. After several days of feeding, nymphs drop to the ground; become quiescent for a time, then molt to adults. There is only a single instar in the nymphal stage (see footnote, page 141). Some species may undergo one or another of these variations in life cycle, depending on climatic, seasonal, or nutritional factors, most of which are still poorly evaluated.

There is evidence that in certain three-host species (in which larvae characteristically feed on small mammals) larvae that feed on a somewhat larger animal, such as a hare, may remain on the host, molt to nymphs, and continue feeding. They drop from the larval-nymphal host only before molting to the adult stage.

Nymphs and females become tremendously engorged and new cuticle is developed during the rather slow feeding process in order to accommodate the huge volume of blood ingested. Males become only slightly distended if at all, apparently, as in argasid ticks, by stretching the integument although they may remain in a feeding position for months, even after the slaughtered host's skin has been removed.

As reservoirs of a great variety of pathogenic organisms, ixodids are pre-eminently important, whether they act as vectors or not. As vectors, they transmit a greater variety of organisms than any other arthropod. This variety is said to be greater on continental Africa than anywhere else in the world. Other injury, apparently due to toxins, in the form of tick paralysis may be locally important. Death, lameness, or serious debilitation of the host by exsanguination or as the result of secondary infections at the site of attachment is not uncommon. Economic loss due to numerous punctures of animal hides by the mouthparts of large ticks is frequently reported.

AMBLYOMMA

INTRODUCTION

Of about a hundred *Amblyomma* species in the world, some twenty occur in Africa and eight in the Sudan. The specific identity of most common African species appears to be settled and only in exceptional instances are specimens likely to be confused. One of the chief remaining taxonomic problems among common African amblyommas is the *A. marmoreum* group, in which the range of species variation needs to be determined for several somewhat differing forms. Observations from the present study indicate need for further research on the relationship between *A. variegatum* and *A. pomposum* and suggest that the latter may be no more than a subspecies of the former. Recently a few workers have designated certain African populations by subspecific ranks that challenge further investigation. Several West African species are known from so few specimens that their validity is questionable.

This genus has been the subject of an extensive review by Robinson (1926) comprising volume four of Nuttall's Monograph on Ticks. The African species have been keyed by Rageau and Vervent (1953).

The immature stages of most African amblyommas remain to be described with satisfactory criteria for distinguishing them.

Economically, two African species have thus far been shown to harbor or transmit human disease organisms. *A. hebraeum* is considered an important boutonneuse fever ("tick typhus") vector in South Africa and *A. variegatum* has been found naturally infected with Q fever in French Equatorial Africa near the Sudan border. Several species are important transmitters of veterinary diseases, cause damage to animal skins, or debilitate animals through the volume of blood withdrawn or by initiating wounds that develop into ugly secondary sores.

Biologically, many gaps exist in our knowledge of African *Amblyomma* distribution, host-preferences, especially of immature stages, and life history. Birds are important immature-stage hosts but the full extent of their importance as hosts remains to be studied. Nymphal preferences may differ from those of adults, although in some species this may not be true. Host size appears to be of some importance, for most larvae parasitize small animals; nymphs attack larger animals; and adults feed on the largest available animals, except carnivores. Immature stages, however, more frequently parasitize carnivores. Cattle and, to some extent, other domestic animals are important adult hosts and wild antelopes are also frequently parasitized. The African tortoise, rhinoceros, elephant, and buffalo harbor species mostly restricted to themselves. In general, the domestic animal parasitizing species are well represented in study collections; others are seldom collected.

Amblyomma ticks are usually three-host parasites and, so far as known in Africa, there is usually only a single generation annually.

KEY TO SUDAN SPECIES OF *AMBLYOMMA*

MALES

1. Lateral grooves extending anteriorly at least to middle of scutum....................................2

   Lateral grooves absent...7

2. Eyes small, hemispherical, situated in a well defined depression (i.e. orbited)....................3

   Eyes flat or very slightly convex, not in a depression..5

3. Festoons with two colors. (Scutal ornamentation always as illustrated)................*A. LEPIDUM*
   Figures 68 and 69

   Festoons only dark colored..................................4

4. Scutum with numerous coarse punctations, and with a red lateral spot. (Rare in Sudan)..*A. POMPOSUM*
Figures 80 and 81

Scutum smooth, with few scattered coarse punctations or none; usually without red lateral spot. (Common in Sudan)..............*A. VARIEGATUM*
Figures 92 and 93

5. Scutum smooth, with only very fine punctations. Eyes slightly convex. (Chiefly from buffalo).........................*A. COHAERENS*
Figures 64 and 65

Scutum with scattered large punctations. Eyes flat. (Chiefly from cold-blooded vertebrates)..6

6. Smaller than *A. marmoreum* group, maximum size 5.5 mm. x 4.5 mm. Dark scutal areas more widely separated by pale areas than in *A. marmoreum* (see Figures).........*A. NUTTALLI*
Figures 76 and 77

Size at least 6.0 mm. x 5.0 mm. Dark scutal areas less widely separated from each other by pale areas than in *A. nuttalli*......................................*A. MARMOREUM*
Figures 72 and 73

7. Scutum dark, ornamented areas small, punctations only small. (Medium size, drab tick, chiefly from elephants)...............*A. THOLLONI*
Figures 88 and 89

Scutum extensively ornamented, some large punctations present. (Very large, colorful tick, chiefly from rhinoceros)...............................*A. RHINOCEROTIS*
Figures 84 and 85

FEMALES

1. Eyes in a well-defined depression (i.e. orbited), hemispherical or strongly convex....................................2

   Eyes not in a depression, flat or slightly convex....................................4

2. Scutal punctations very coarse, uneven, some confluent; surface rugose posteriorly; ornamentation absent or consisting of only a small pale area in posterior field; length often no greater than width. Eyes may be convex but not hemispherical. (Extremely rare in Sudan)........................*A. POMPOSUM*
   Figures 82 and 83

   Scutal punctations not so coarse, surface not rugose, pale areas more extensive (unless faded). Eyes hemispherical. (Common)....................................3

3. Scutum narrowly rounded posteriorly; large punctations chiefly in mediolateral area, more or less confluent.............*A. LEPIDUM*
   Figures 70 and 71

   Scutum more widely rounded posteriorly, large punctations generally distributed but nonconfluent..............................*A. VARIEGATUM*
   Figures 94 and 95

4. Scutum with central and lateral areas largely pale colored; punctations either large or fine....................................5

   Scutum with either central or lateral areas largely dark colored; punctations only fine....................................7

5. Scutum with some large punctations scattered over entire surface; length usually equalling or greater than width*. Eyes flat....................................6

Scutum with few large punctations only on anterior half; wider than long, mostly pale (reddish brown). Eyes slightly convex. (Very large tick, chiefly from rhinoceros)..............A. RHINOCEROTIS
Figures 86 and 87

6. Scutum with extensive pale median area that is broadly rounded posteriorly. (Large tick, chiefly from tortoise)....................................A. MARMOREUM
Figures 74 and 75

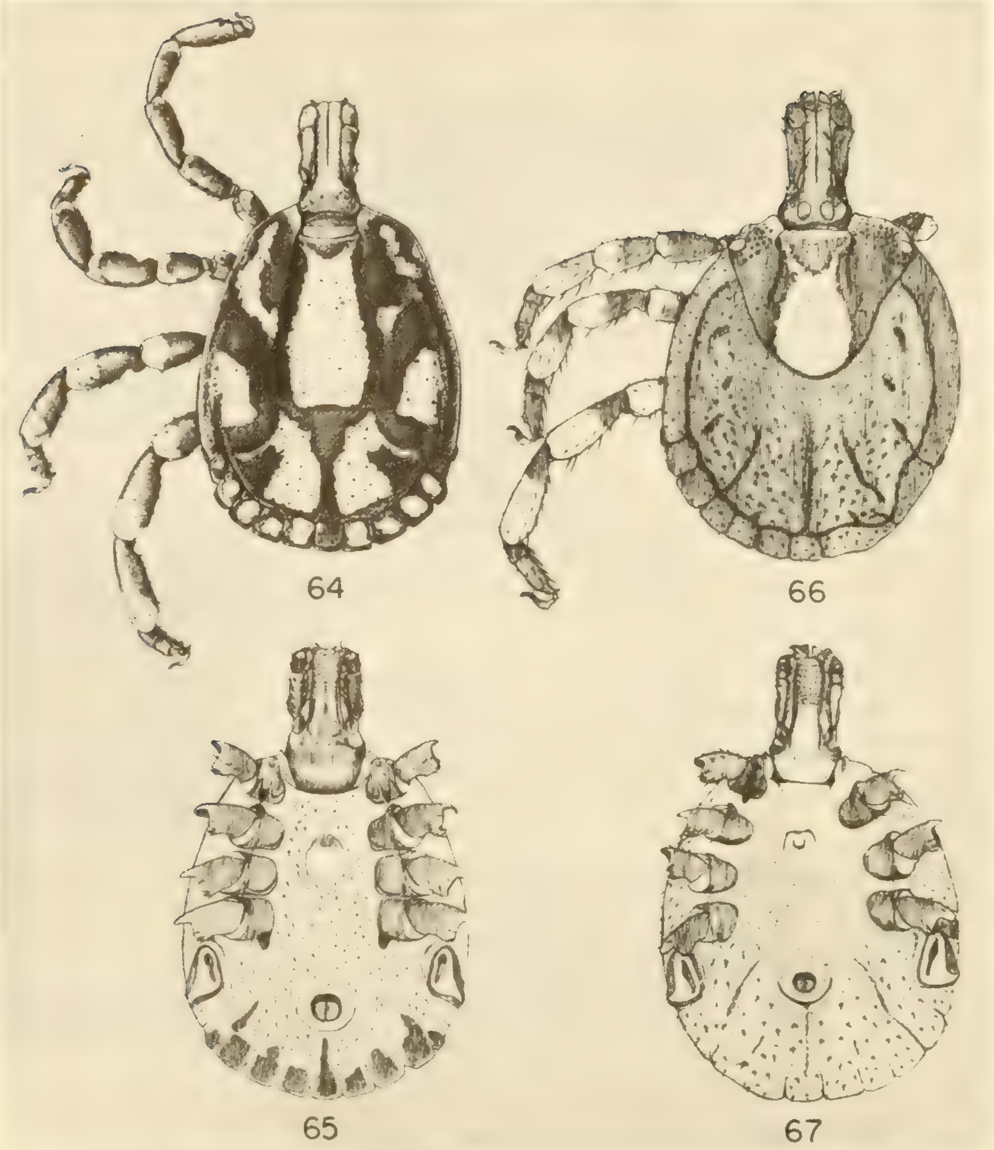
Scutum with less extensive pale median area that narrows to a point posteriorly. (Medium size tick, chiefly from tortoise and leguan lizards)...............A. NUTTALLI
Figures 78 and 79

7. Scutum dark centrally, small pale spot on posterior border, lateral fields with small pale spots or entirely dark. Eyes flat. Very narrow pale rings on legs. (Chiefly from elephant)..........A. THOLLONI
Figures 90 and 91

Scutum pale centrally, lateral fields with only small pale spots. Eyes slightly convex. Broad pale rings on legs. (Chiefly from buffalo)...............A. COHAERENS
Figures 66 and 67

---

*In the Sudan, exceptional specimens of A. marmoreum may have a scutal width of at least 1.3 greater than length (Figure 74), but in these, large punctations are scattered over the entire scutal surface.



Figures 64 and 65, ♂, dorsal and ventral views, Sudan specimen
Figures 66 and 67, ♀, dorsal and ventral views, Uganda specimen

AMBLYOMMA COHAERENS

Note: The ♀ illustrated is malformed in the following areas: left scutal margin anteriorly and right scutal margin laterally deformed, festoons on right side absent, only three legs on left side. Diagnostic criteria are not affected by these malformations.

PLATE XXIV

AMBLYOMMA COHAERENS Dönitz, 1909.

(Figures 64 to 67)

THE EAST AFRICAN BUFFALO TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
			34	Boma Plains	Syncerus caffer aequinoctialis	Dec
	*1			Obbo	Grammomys macmillani erythropygus	Mar
					Birds	
	*1			Obbo	Turdus libonyanus centralis	Mar
	*1			Torit	Francolinus clappertoni gedgii	Dec
	*1			Ikoto	Numida meleagris major	Dec

The Boma Plains specimens constitute the first and only definite record of A. cohaerens from the Sudan. If the tentative immature stage identifications are correct, we may expect that A. cohaerens occurs in other parts of Equatoria Province, especially where buffalos roam. The East African buffalo tick has not been found in Bahr El Ghazal or in Upper Nile Provinces, although buffalos are present in these Provinces and frequently have been examined for ticks by H. H. King, Sudan Veterinary Service personnel, and the writer.

DISTRIBUTION

A. cohaerens is an East and Central African buffalo parasite that reaches the northern limit of its range in Equatoria Province and extends southwards into Tanganyika.

---

*Tentative identification by Dr. G. Theiler.

CENTRAL AFRICA: [?CAMEROONS: Noted by Schulze (1941) without data. Recorded on (?imported) cattle at Yaounde by Rousselot (1951) but not repeated by him (1953B). Rageau (1951,1953A,B), apparently quoting Rousselot.] FRENCH EQUATORIAL AFRICA (Rousselot 1951,1953B).

BELGIAN CONGO and RUANDA-URUNDI (Nuttall and Warburton 1916. Robinson 1926. Schwetz 1927B,C,1932. Bequaert 1930A,B,1931. Rousselot 1951,1953B. As *A. cohaerens* and also as *A. hebraeum*: Schoenaers 1951A,B; see REMARKS below. Theiler and Robinson 1954. Van Vaerenbergh 1954).

EAST AFRICA: "EAST AFRICA" (Dönitz 1909).

SUDAN (Hoogstraal 1954B).

FRENCH SOMALILAND (Hoogstraal 1953D).

KENYA (Robinson 1926. Lewis 1934. Weber 1948). UGANDA (Neave 1912. Robinson 1926. Tonelli-Rondelli 1930A. Richardson 1930. Mettam 1932. Mettam and Carmichael 1936. Wilson 1948A, 1950C. Hoogstraal 1954C). TANGANYIKA (As *A. anceps*: Dönitz 1909. Hoogstraal 1954C).

[NOTE: The ANGOLA record by Sousa Dias (1950) is actually *A. astrion*, not *A. cohaerens* (Theiler, correspondence). See REMARKS below.]

HOSTS

All authors list the African buffalo, *Syncerus caffer*, as the chief host of *A. cohaerens*.

The East African buffalo tick is frequently reported to attack domestic cattle in areas where buffaloes are common or after large numbers of these animals have been shot out for disease control. Domestic cattle have been listed as hosts by Robinson (1926), Schwetz (1932), Schoenaers (1951B), and Rousselot (1951,1953B). Cattle are frequently parasitized when near game, especially buffalo (Wilson 1948A,1950C). In certain Uganda areas, *A. cohaerens*, together with *A. variegatum*, is the predominant cattle tick on old buffalo grazing grounds (Richardson 1930). It would be interesting to know how long the buffalo tick remains in an area as a cattle parasite after its chief host has been exterminated.

Other animals are rare hosts of adults. Elephants (Robinson 1926). Tortoise, and domestic sheep and goats (Mettam 1932). Eland (Lewis 1934, Weber 1948). Warthog (Theiler, unpublished). Black rhinoceros (Hoogstraal 1954C. Also 2♂♂ removed from a Tanganyika rhinoceros skin by a taxidermist - CNHM collections).

Hosts of nymphs (tentatively identified as this species) are ground birds and a tree rat (Equatoria Province records above). Dozens of *Thamnomys* tree rats have been examined by me in the Sudan and Kenya without finding other ticks on them. Several nymphs have been taken from a warthog near Lake Edward, Uganda, by Lt. Col. Don Davis, U.S.A. (HH collection).

BIOLOGY

Unstudied. In Ruanda-Urundi, *A. cohaerens* occurs as high as 2200 meters altitude (Schoenaers 1951B, as *A. hebraeum*).

DISEASE RELATIONS

Unstudied.

REMARKS

Sections of the mouthparts of *A. cohaerens* have been illustrated by Schulze (1936A), who also illustrated the form of haller's organ (1941), and (1950A) discussed the dentition of this species. Schulze also (1932C) utilized this tick to illustrate his concept of the relation of ornamental design to location of muscle attachments. A number of other remarks and illustrations concerning the exoskeleton of this species are presented in the same study.

The middle festoon of a few males may be largely pale and other festoons may be equally so; such specimens would key to A. hebraeum. There are no excessively pale festooned individuals in our own collection or in that of British Museum (Natural History), but some material in the Onderstepoort collections shows this variation (Theiler, correspondence). Such a specimen, seen in the Rocky Mountain Laboratory collection, was the cause of misidentification of A. cohaerens as A. hebraeum in Schoenaers' (1951B) list. A. hebraeum, though colorful, never shows as much iridescence as most other ticks of this genus (Theiler, correspondence).

Should specimens resembling A. cohaerens be found on the west bank in Equatoria Province, they should be checked against A. splendidum Giebel, 1877, of the Congo and West Africa (cf. Robinson 1926, pp. 123-125). A. splendidum males are somewhat larger, have a vermillion-red spot in the center of the scutum, and never have a falciform stripe. Females are indistinguishable from those of A. cohaerens although they are often a little larger.

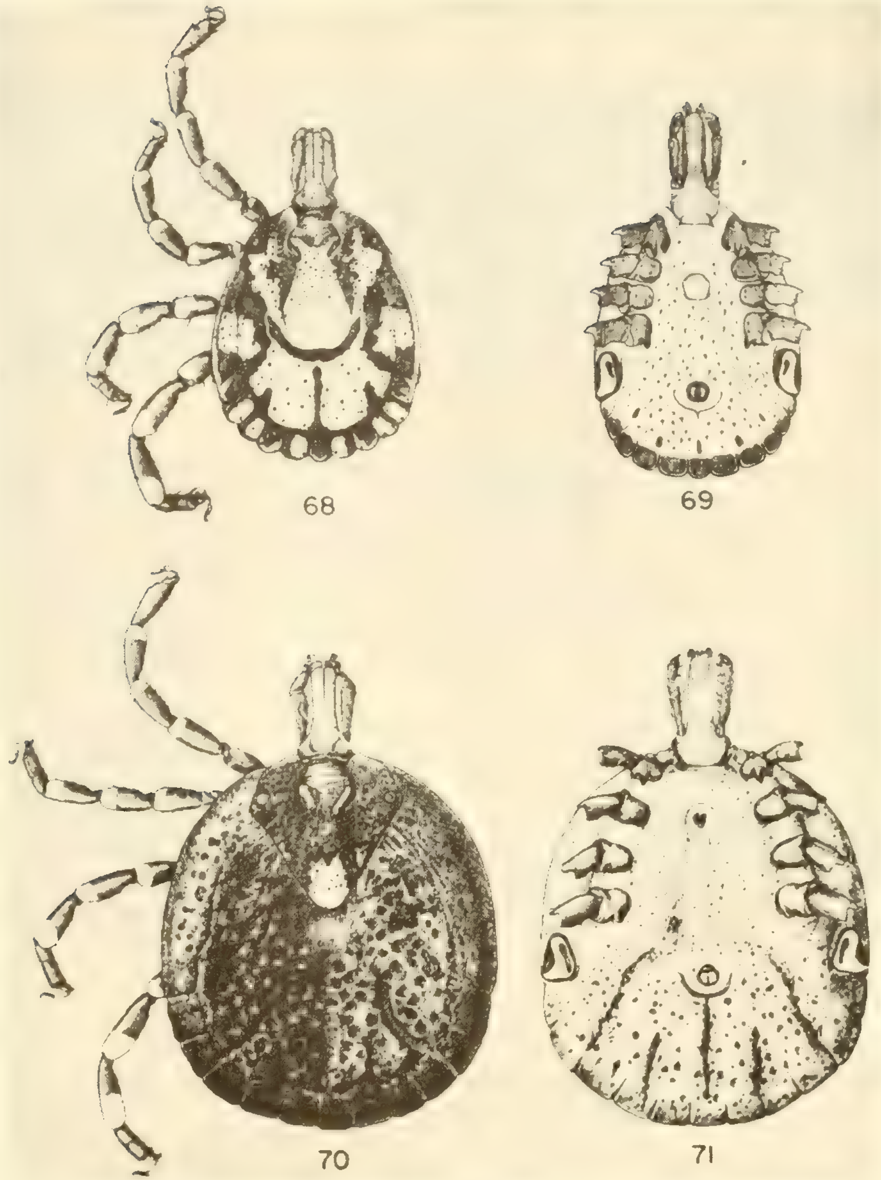
A. cohaerens also closely resembles A. astrion of West Africa. Sousa Dias (1950) confused A. astrion with A. cohaerens. Recent studies by Theiler indicate the distinctness of the two species. Since A. astrion is unlikely to be found in the Sudan tick fauna, it is unnecessary to mention further detail. However, students who may compare our nomenclature with that of Sousa Dias should be aware that this discrepancy exists.

IDENTIFICATION

A. cohaerens is easily recognized within the known Sudan tick fauna. Closely related species, some of which may occur in the Sudan, are mentioned above.

Males fall into a group in which the eye is not in a depression, although it may be very slightly convex; festoons are mixed dark and pale, scutal punctations are only fine, scutal ornamentation is as illustrated (Figure 64) but either with or without a falciform stripe; lateral grooves reach nearly to the eyes. This is a medium size tick, from 5.0 mm. to 6.0 mm. long and from 4.0 mm. to 4.7 mm. wide.

Females have a triangular scutum with only fine punctations and with an extensive pale central area; the lateral scutal areas are dark except for one or two very small light marginal spots. The eyes are not in a depression though they may be very slightly convex. Leg segments are ringed by broad bands. Females are of medium size, approximately 5.0 mm. long and 4.0 mm. wide. The scutum is approximately 2.8 mm. long and 2.9 mm. wide.



Figures 68 and 69, ♂, dorsal and ventral views
Figures 70 and 71, ♀, dorsal and ventral views

AMBLYOMMA LEPIDUM
Sudan specimens

PLATE XXV

AMBLYOMMA LEPIDUM Dönitz, 1909.

(Figures 69 to 71)

THE EAST AFRICAN BONT TICK.

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
			15	Boma Plains	Syncerus caffer aequinoctialis	Dec	
	8	1	3	Jebel Kathangor	Gazella granti brighti	Dec	
		1		Loronyo	Taurotragus oryx pattersonianus	Jan	
			2	Torit	Hippotragus equinus bakeri	Mar	
		1	2	Lafon	Hippotragus equinus bakeri	Dec	
	11		2	Torit	Alcelaphus buselaphus roosevelti	Dec	
			1	Terakeka	Damaliscus korrigum tiang	Jan	(SGC)
			1	Opari	Felis libyca ugandae	Jan	(SGC)
	4	4	7	Kapoeta	domestic cattle	Dec	(2)
		18	31	Kapoeta	domestic cattle	Jan	(SGC)
		1		Kapoeta	domestic cattle	Jul	
		2		Lolepori	domestic cattle	Dec	
		1	7	Iliu	domestic cattle	Oct	(SVS)
		2	5	Loronyo	domestic cattle	Dec	
	1		5	Torit	domestic cattle	Nov	(2)
			74	Torit	domestic cattle	Dec	(3)
		1	1	Torit	domestic cattle	Jan	
			1	Torit	domestic cattle	Feb	
			1	Torit	domestic cattle	Mar	
		1	9	Katire	domestic cattle	Oct	
		7	72	Gilo	domestic cattle	Dec	
		1	3	Kapoeta	domestic goats	Jul	
			2	Loronyo	domestic goats	Jan	
		3	1	Kapoeta	domestic sheep	Jan	
		1	7	Kapoeta	domestic sheep	Dec	
			2	Loronyo	domestic dog	Jan	
	1		1	Torit	domestic dog	Dec	
		1	1	Kapoeta	in rest house	Apr	
					Bird		
	2	1	2	Torit	Neotis cafra denhami	Jan	(2)

DISTRIBUTION IN THE SUDAN

A. lepidum occurs in all Provinces except Northern, though it does arrive at the Wadi Halfa quarantine in Northern Province on cattle from the South (King 1926).

All available Equatoria Province specimens originate from Eastern District and Torit District with the single exception of a male from a tiang at Terakeka (H. H. King legit), on the west bank of the Nile.

The following Sudan locality records are all from cattle and all from the Sudan Government collection unless otherwise noted:

Bahr el Ghazal: Lau and Yirol (SVS), Guar, Gogrial Sub-district (giraffe; SVS), Aliab (buffalo; SVS). Akot (dying bull; SVS). Eight miles west of Yirol (head of greater bustard; SVS). I doubt that A. lepidum is widely established, if at all, in Bahr el Ghazal Province. Each collection consists of only a single male, except for one male and female from great herds of migrating cattle at Yirol, 22 April 1954 (SVS).

Upper Nile: Pibor Post. Akobo. Maban (domestic cattle and goats; SVS). Pariak (SVS). Bor (SVS). Melut (mule). Rom (buffalo). Kaka (roan antelope). Er Renk (domestic sheep). Makier (SVS). Malakal (HH). Specimens from Tonga, that were identified as A. lepidum by Dönitz in 1912, were the basis of King's (1911) report of A. hebraeum-variegatum from the Sudan according to Nuttall's notes for Lot 529 in his logbook in British Museum (Natural History).

Blue Nile: Hosh. Tibna. Roseires. Wad el Nail. Singa (camel). Wad Medani (domestic cattle, mules, and camel; SGC, HH. One ♂ feeding between toes of man, August 1954; Eisa El Minesi legit). Abu Hashim (camel). Sennar (camel). Lake Ras Amer (camel). Abu Zor. Hassa Heissa (camel; G. B. Thompson, correspondence). Sennar area (cheetah; Robinson 1926). Kosti (Gordon College collection).

Kassala: Kassala (SVS).

Darfur: Radom (SVS).

Kordofan: Umm Berembeita (SGC).

[Northern and Khartoum: Specimens from cattle at the Wadi Halfa Quarantine station, from Ethiopian cattle at Khartoum, and from "A.O.F." native horses [French West (?Equatorial) Africa] (at Khartoum) are also present in Sudan Government collections.]

See BIOLOGY below for further remarks on distribution in the Sudan.

DISTRIBUTION

A. lepidum is an East African herbivore parasite and is not known to occur elsewhere. It becomes uncommon in Tanganyika but is more common locally northwards to the semidesert belt of the Sudan.

EAST AFRICA: "EAST AFRICA" (Dönitz 1909).

SUDAN (As A. hebraeum variegatum: King 1911. King 1926. Robinson 1926. Hoogstraal 1952A,1954B).

ETHIOPIA (Stella 1940). ERITREA (Franchini 1929D. Tonelli-Rondelli 1932C. Niro 1935. Stella 1940). ITALIAN SOMALILAND (Paoli 1916. Tonelli-Rondelli 1926A. Franchini 1926A,1927, 1929C,E. Niro 1935. Stella 1938A,1940. See also adult host records below). Note: Numerous reports of A. hebraeum from former Italian East African possessions probably refer in part to A. lepidum and in part to A. gemma.

KENYA (Robinson 1926. Lewis 1931C,1939A. Dick and Lewis 1947). UGANDA (Mettam 1932. Lewis 1939A. Wilson 1948A,1950C, 1953). TANGANYIKA (Evans 1935. Cornell 1936. Lewis 1939A. J. B. Walker; small numbers; unpublished; see HOSTS below).

OUTLYING ISLANDS: ZANZIBAR (Dönitz 1909. Robinson 1926).

IMPORTED SPECIMENS: Cairo, EGYPT (Dönitz 1909). A. lepidum still arrives almost daily at the Cairo slaughterhouse on Sudan cattle but has not established itself in Egypt (Mason 1915, Hoogstraal 1952A). Almost every specimen is a male. Numerous males are also not infrequently found on traders' camels reaching the environs of Cairo from the Sudan.

This species has been taken from imported cattle at East London, South Africa (Robinson 1926), but is definitely not established in the UNION OF SOUTH AFRICA (Theiler, correspondence). PALESTINE records (Bodenheimer 1937) probably also represent imported specimens.

HOSTS

A. lepidum is chiefly a cattle parasite with smaller domestic animals and a scattering of wild herbivores as second choice. Large ground birds and carnivores are rarely attacked. A single adult has been taken feeding on man. Nymphs have been found on antelopes, bustards, and domestic cattle and dogs. The host predilection of immature stages is still poorly known.

Domestic animals: All investigators listed above refer to cattle as hosts of this tick. Sudan records are almost the only ones available for other domestic animals. These include camels, horses, mules, goats, sheep, and dogs. Individual camels on occasion are heavily infested. Although camels appear to be rather important hosts in central Sudan, local camels in the north are not known to harbor this tick. Evans (1935) listed sheep and dogs as hosts in Tanganyika.

Wild animals: Buffalo (Robinson 1926, King 1926, Wilson 1950C, various Sudan records above). Rhinoceros (Wilson 1950C). Grant's gazelle and hartebeest (Wilson 1950C, Sudan records above). Roan antelope eland, giraffe, tiang, wildcat, and greater bustard (various Sudan records above). Burchell's zebra and spotted hyena (Theiler, unpublished records). Cheetah (Robinson 1926). Ostrich (1♂ and 1♀ in Hoogstraal collection, from "west of Afmadu", Somalia, 1952, Col. D. Davis legit). Of 49 Thomson's gazelles examined in Tanganyika, only two yielded eight males and one female A. lepidum; none were found on numerous other game animals examined there (J. B. Walker, unpublished).

Man: Blue Nile Province record above.

Nymphal hosts: The Sudan hosts appear to be the only ones recorded for nymphs. These are Grant's gazelle, Roosevelt's hartebeest, rarely domestic cattle and dogs, and greater bustard. Nymphs were identified by Dr. G. Theiler.

BIOLOGY

A. lepidum is common in many of the semiarid regions of East Africa. It inhabits economically marginal areas and is not known to be a vector of animal or human disease pathogens. Therefore, not even the industrious veterinarians (in Africa they do most of the legwork on ticks for zoologists and for medical researchers) have investigated this tick's life history. It would, however, be surprising indeed to find that the life cycle were any other than the three-host type. J. B. Walker reports (correspondence) that larvae fed on a rabbit did not molt but that a few larvae in her laboratory have engorged on pigeons.

In his interesting and important ecological survey of certain tick vectors of East and Central Africa, Wilson (1953) has noted the common occurrence of *A. lepidum* in the Karamoja area, the driest district of Uganda. Wilson includes this species in his discussion of the *R. pravus* - *A. gemma* association, reviewed herein on page (cf. also *A. variegatum*, page 681). [These sections should be consulted to obtain a better impression of what is now known of the ecology of *A. lepidum*.] Other species associated with it in Karamoja are *R. e. evertsi*, *H. rufipes*, and *H. truncatum*.

For additional background, the following biological information, as written in the manuscript before Wilson's (1953) paper became available, remains of value.

Lewis (1939A) considered *A. lepidum* to be a desert species but, on the contrary, it appears to prefer more arid savannah country and, to some limited extent, semidesert regions. In Uganda it is most common in dry thorn country (Wilson 1950C). Although Sudan cattle bound for the Cairo abattoir constantly carry the East African bont tick through the deserts and cultivated riparian areas of northern Sudan and Egypt, this parasite has not established itself in these places. I failed to find it in the French Somaliland semidesert.

In the Sudan, A. lepidum is common in the central grasslands and in less rigorous semideserts but quickly disappears with the approach of extreme desert conditions. It also becomes more rare in mixed forest and in forested savannah country. Except for a few specimens mentioned in the paragraph below, fewer than ten specimens have been found in Sudanese areas with over fifty inches annual rainfall (see Bahr el Ghazal records above).

The presence of this tick at Katire and Gilo, in the high rainfall area of the Imatong Mountains, is difficult to explain. These specimens were taken from cattle said to have been in the Imatongs for "a long time", but most cattle, sent as adults, were soon slaughtered as required for lumbermill workers there.

Although A. lepidum thrives in moderately low rainfall areas, it should be borne in mind that in the central grasslands, where this species is common, hosts often graze in marshy areas for months during the wet season, and that the dry season grazing area (toich) is also mucky for extended periods. Just where and when these animals acquire their infestations would be of interest.

DISEASE RELATIONS

In the Sudan, one frequently finds that large, ugly sores have developed on cattle and horses at the site of attachment of A. lepidum.

REMARKS

Features of haller's organ of A. lepidum were noted by Schulze (1941), who also (1950A) discussed the dentition of this species.

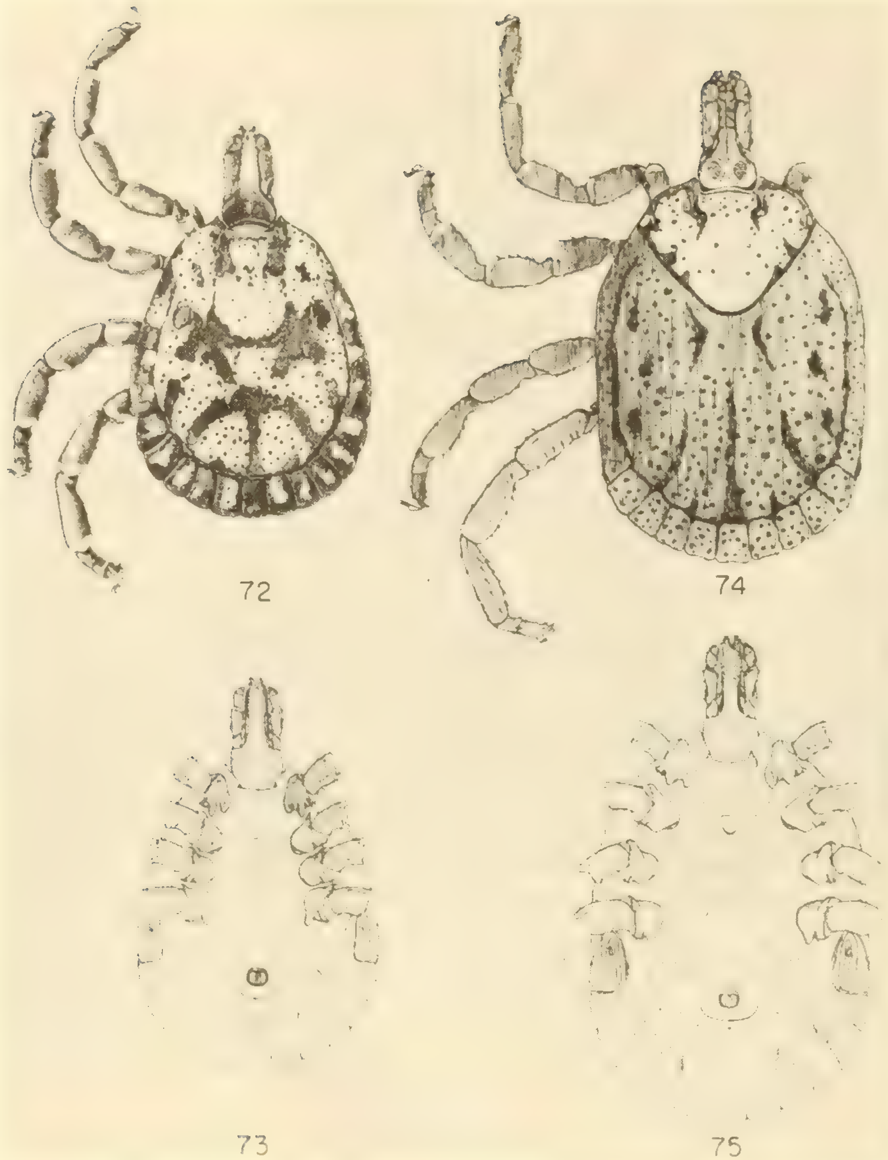
IDENTIFICATION

Male: The eyes are small, hemispherical, dark, and in a depression (i.e. orbited). Scutal ornamentation is as illustrated

(Figure 68); note especially the pigmented spot at scutal mid-length that is both within and outside of the lateral groove; also the six or eight partially pigmented festoons. Some large, deep punctations are scattered over the scutum; these are fewer than in *A. pomposum* but more numerous than in *A. variegatum*. The lateral groove is long. This is a medium size tick measuring approximately 5.0 mm. long and 4.0 mm. wide and is easily distinguished from all other species.

Female: Easily identified in typical specimens but its critical characters are more variable than those of the male. Rather few females are extant in collections and when this species and *A. variegatum* are collected from the same herd a few questionable specimens may present themselves.

Typically, the scutal contour is much more narrowed posteriorly than that of *A. variegatum*, but intermediate individuals do exist. Scutal punctations, usually coarse and crowded only in the lateral fields, sometimes spill over into the central field; small punctations scattered over the scutum tend to become rather large in a few individuals. Pigmentation of most specimens consists of a narrowly elongate area in the central field posteriorly and a pair of small spots laterally, but this character is somewhat variable. Eyes, coloration, and relative size are like those of males.



Figures 72 and 73, ♂, dorsal and ventral views
Figures 74 and 75, ♀, dorsal and ventral views

AMBLYOMMA MARMOREUM GROUP
Sudan (Juba) specimens from tortoise
For note on scutal length-width ratio of ♀, see IDENTIFICATION.

PLATE XXVI

AMBLYOMMA MARMOREUM Koch, 1844 (GROUP)*

(Figures 72 to 75)

THE LARGE REPTILE-AMBLYOMMA.

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	4		1	Torit	Varanus n. niloticus**	Dec
		1	1	Torit	Kinixys b. belliana**	Jan
	6	5	20	Juba	Kinixys b. belliana**	Dec

Torit and Juba appear to be the only locality records available for the Sudan. A number of Varanus lizards and tortoises in Torit and Juba Districts and elsewhere in the Sudan have been examined but this tick was found only on the three reptiles listed above. Sudan Government collections also contain specimens from Atiambo, formerly in this Province but now a part of Uganda.

---

*Sudan specimens referable to A. marmoreum fall into what is believed to be a group of closely related African species in need of careful study before definite names can be satisfactorily applied. References here are for any ticks for which the name A. marmoreum has been used. The term "A. marmoreum group", as here used, includes specimens that can be keyed to this name in the Robinson (1926) key, or that come close to it but do not equal related species such as A. nuttalli. The A. falsomarmoreum of Tonelli-Rondelli (1935) also falls into this group. The disposition of this group dictated by Schulze (1932A) is hopelessly unnatural and practically useless.

**The distribution of V. niloticus and related species is stated on page 283. K. b. belliana ranges as far west as Cameroons, where the subspecies nogueyi also occurs; the latter extends westward to Sierra Leone (Loveridge, correspondence).

DISTRIBUTION IN THE SUDAN

[Khartoum: Omdurman (King 1926). Khartoum (Nuttall 1914A, Robinson 1926). Specimens from Omdurman and Khartoum in Sudan Government collections are from captive tortoises from unstated localities and probably represent the records or parts of the collections on which King's, Nuttall's, and Robinson's statements were made. No evidence is at hand to show that this tick occurs in nature in Khartoum Province.]

DISTRIBUTION

A. marmoreum ranges throughout the Ethiopian Faunal Region, except in the Arabian extension of this area. It appears to be more common in eastern and in southern Africa than it is in western and central Africa.

[NORTH AFRICA: ALGERIA (As A. sparsum: Neumann 1899. This specimen was actually collected in the Paris Zoological Garden* (Bequaert, correspondence). The occurrence of A. marmoreum in Algeria and North Africa is questionable. See footnote, page 228).]

WEST AFRICA: FRENCH WEST AFRICA (Neumann 1911). SIERRA LEONE (Entomological Report 1916. Hoogstraal 1954C).

CENTRAL AFRICA: BELGIAN CONGO (Neumann 1911. Nuttall and Warburton 1916. Bequaert 1930A,1931).

Note: According to Theiler (correspondence), the record for Ruanda-Urundi in Santos Dias (1954D) is incorrect.

EAST AFRICA: SUDAN (King 1911,1926. Nuttall 1914A. Robinson 1926. Hoogstraal 1954B).

---

*Hesse (1920) reported a female from the Leipzig Zoological Gardens and Hoogstraal (1954C) another from the London Zoological Gardens.

ETHIOPIA (Neumann 1922. Stella 1938A,1939A,1940. Charters 1946). ERITREA (Tonelli-Rondelli 1930A. Stella 1940). "SOMALILAND, Gueldessa" (Robinson 1926). BRITISH SOMALILAND (Neumann 1922. Stella 1938A,1939A). ITALIAN SOMALILAND (Paoli 1916. Tonelli-Rondelli 1932E, see also Tonelli-Rondelli 1935 as _A. falsomarmoreum_ sp. nov. Niro 1935. Stella 1940).

KENYA (Neumann 1899,1901,1911,1912. Neave 1912. Anderson 1924A,B. Robinson 1926. Bequaert 1930A. Lewis 1931A,C,1932A, 1934,1939A. Loveridge 1936B). UGANDA (Hirst 1909. Robinson 1926. Mettam 1932. Wilson 1950C. Binns 1952). TANGANYIKA (Howard 1908. Neumann 1907C,1910B,1911. Morstatt 1913. Loveridge 1923C, as A. _marmoreum_ is actually A. _nuttalli_ according to Bequaert 1930A. Robinson 1926. Loveridge 1928. J. B. Walker, unpublished; see HOSTS below).

SOUTHERN AFRICA: ANGOLA (Specimens in HH collection). MOZAMBIQUE (Howard 1908. Neumann 1911. Robinson 1926. Santos Dias 1947A,1951A,1952D,1953B. Hoogstraal 1954C).

NORTHERN RHODESIA (Neave 1912. Robinson 1926). SOUTHERN RHODESIA (Jack 1921,1928,1937,1942). NYASALAND (Neave 1912. Robinson 1926. Wilson 1950B).

BECHUANALAND (Robinson 1926). SOUTHWEST AFRICA (Tromsdorff 1914). UNION OF SOUTH AFRICA (Koch 1844. Neumann 1899,1901, 1911. Lounsbury 1905*. Howard 1908. Dönitz 1910B. Moore 1912. Bedford 1920,1926,1927,1932B. Robinson 1926. Curson 1928. Alexander 1931. Bedford and Graf 1934,1939. Neitz 1948).

OUTLYING ISLANDS: ZANZIBAR (Neumann 1899,1901,1911).

HOSTS

The chief hosts of the components of the "A. _marmoreum_ group" await to be determined. Tortoises and the rhinoceros were mentioned by all early workers, mostly without further data (see REMARKS).

---

*See Robinson (1926).

Contemporary reports of the rhinoceros, Rhinoceros bicornis subspp. as a host are chiefly those of Robinson (1926) who recorded half a dozen collections from Kenya, Nyasaland, and Rhodesia. My collection and that of the Museum of Comparative Zoölogy contain specimens from rhinoceros in Kenya. Miss Walker's Tanganyika collections (correspondence) contain 47 males and seven females from four rhinoceros hosts. The white, or square-lipped, rhinoceros, Ceratotherium s. simum, is a host in Zululand (Curson 1928).

Recent records from tortoises, Testudo spp. or Kinixys belliana, are those of Neumann (1922), Robinson (1926) with numerous collections from throughout the tick's range, and Hoogstraal (1954C) from Sierra Leone. Bedford's (1932B) statements and Theiler's unpublished records from South Africa indicate that tortoises are commonly infested in Transvaal and are the tick's chief host there. Other scattered records for tortoises are those of the Sudan specimens above, Mettam (1932) for Uganda, Wilson (1950B) for Nyasaland, and Santos Dias' (1953B) summary of Mozambique ticks in which no other hosts are listed for A. marmoreum. A single collection from Tanganyika consists of six males and nine females (J. B. Walker, unpublished).

The warrener or leguan lizard, Varanus spp., is sometimes attacked. More recent reports are the single collection of Robinson (1926) and that from the Sudan listed above, Mettam's (1932) Uganda note, Loveridge's (1936A) Kenya record, a few lots in the Onderstepoort collection (Theiler, unpublished), and a few lots in the HH collection including one from Angola.

Some snakes are hosts, apparently only exceptionally*. Neumann's (1911) A. sparsum (said to be a synonym of A. marmoreum)

---

*The hosts of A. s. sparsum Neumann, 1899 (according to Robinson 1926 a synonym of A. marmoreum) were reported by Neumann to be Spilotes variabilis and Testudo mauritanica from Algeria and East Africa. S. variabilis is a synonym of S. p. pullatus, a large South American tree snake (Loveridge, correspondence). Therefore, since A. marmoreum (= A. sparsum) does not occur in South America, either Neumann's locality record or host record is incorrect. The fact that the "Algerian" material of A. sparsum was collected in a European zoological garden (cf. page 226) would suggest that both data are difficult to assess. It further suggests that the validity of the synonymy of A. sparsum should be reinvestigated.

came from Spilotes p. pullatus (= variabilis). Puff adders, Bitis spp., have been reported by Hirst (1909), Robinson (1926), Loveridge (1928), Bequaert (1930A), and Hoogstraal (1954C); Miss Walker's Tanganyika collection (correspondence) contains four males and a female from one puff adder. Python sp. has been listed by Neumann (1911) and Lewis (1934).

Mammals, other than the rhinoceros, are also occasional hosts. Theiler's unpublished records include some adults from domestic cattle and sheep. Lewis (1939A) found specimens rarely on buffalo and on domestic cattle. Two buffaloes were listed by Bequaert (1930A,1931) and one by Robinson (1926); my collection contains 37 specimens from a single buffalo in Kenya. Neumann (1911) recorded a genet, Genetta pardina, Robinson (1926) an eland, and Tonelli-Rondelli (1930A) a bushpig. In my collection are numerous adults from giraffes in Kenya. Alexander (1931) was unable to induce adults to feed on domestic animals.

Among birds, the guineafowl has been recorded as a Uganda host by Mettam (1932).

Man was reported as an actual host by Charters (1946) in Ethiopia.

Nymphs are sometimes taken with adults from tortoises. Dr. Theiler (unpublished records) has numerous nymphs from fowls. Seven nymphs were removed from the African hoopoe, Upupa africana, in Mozambique (Hoogstraal 1954C). Lounsbury (1905*) and Howard (1908) reported that larvae and nymphs feed readily on lizards, cattle, goats, tortoises, and birds.

In the Onderstepoort laboratory, larvae and nymphs feed readily on guineapigs but adults do not (Theiler, correspondence). Kenya larvae and nymphs from females from tortoises feed well on the ears of rabbits, and resulting adults on the scrotum of a ram. This is a hardy species, and sixteen-month old nymphs feed quite well while adults remain alive for 23 months without feeding (J. B. Walker, correspondence). See REMARKS below.

---

*See Robinson (1926).

The sorting out of these host records awaits a thorough biological and taxonomic study on this interesting group of ticks.

BIOLOGY

(See also REMARKS below)

Life Cycle

Lounsbury (1905*) stated that adults will not feed on goats or on oxen if they have not first fed from a tortoise in an earlier stage. Adults attached to the host before seeking the other sex, unlike many other species of *Amblyomma*. Lounsbury also provided observations on time required for each stage and for feeding. These data are not abstracted here for in the light of confused nomenclature it is questionable whether the species with which Lounsbury worked is the same as that in the Sudan. Note that Alexander (1931) was unable to induce South African adults of *A. marmoreum* to feed on cattle.

Ecology

In the Ethiopian Faunal Region, this group of ticks occurs in a variety of faunal areas. Where tortoises are common these ticks are often abundant, but this incidence is by no means universal in Africa.

On tortoises, these ticks are usually deep in the host's axillae and it is necessary to kill or anesthetize the animal to see or secure all of the specimens.

DISEASE RELATIONS

Textbook statements that *A. marmoreum* actually has been incriminated as a vector of boutonneuse fever of man refer merely to a remark that this was one of several tick species found on patients.

---

*See Robinson (1926).

Experimental attempts to transmit heartwater (Rickettsia ruminantium) of cattle through this species have failed.

REMARKS

A. marmoreum is considered by most workers to parasitize chiefly the rhinoceros and tortoise but Theiler (correspondence) has found so much variation in morphology and host data on specimens sent from various parts of Africa that she prefers to refer to all specimens as "A. marmoreum group" until they can receive more intensive study. Most of her specimens come from tortoises, a few from Varanus lizards and cattle. She considers the rhinoceros to be an accidental host, or else the host of a separate, as yet unrecognized, species or subspecies. She has large numbers of nymphs of this group from fowls.

Schulze (1932A) realized the complexity of the marmoreum group and proposed new names for specimens from various parts of Africa. Reasons for these differentiations appear quite invalid.

A definitive species name for Sudan material awaits assignment. The range of variation in even the rather small series of Sudan specimens at hand casts considerable doubt on the validity of all those "related species" that are based on certain aspects of scutal ornamentation or on coxal spur characters.

The structure of the larval eye and its sense organs in specimens of the A. marmoreum group has been described and illustrated by Gossel (1935).

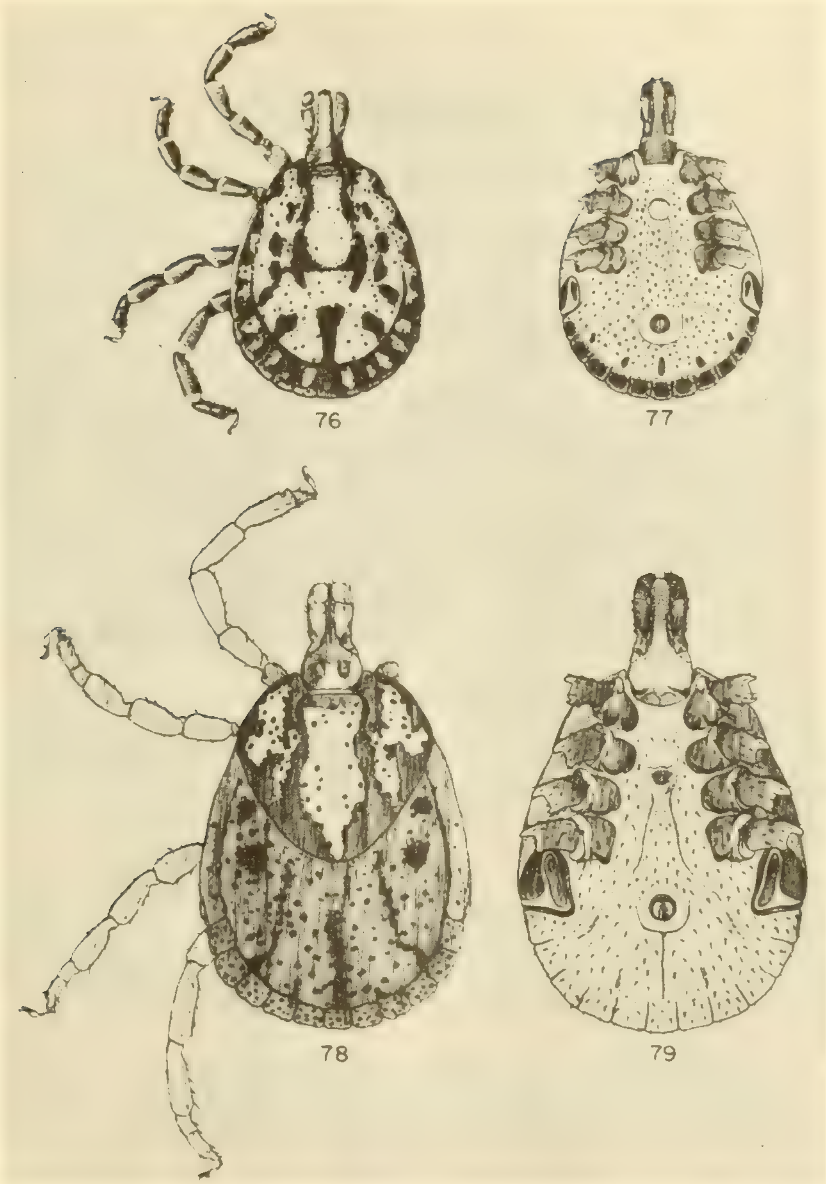
Nuttall (1914A) reported on a malformed specimen of A. marmoreum, from the Sudan, and Schulze (1941) noted characteristics of the haller's organ of this species.

IDENTIFICATION

Males: Large, at least 6.0 mm. x 5.0 mm. Scutum with reddish-yellow ornamentation that is variable but essentially as illustrated; pale areas in this species are more separated from each other by dark stripes than they are in _A. nuttalli_; festoons bicolored; punctations consisting of few, scattered large and numerous small; lateral grooves deep and long; eyes flat.

Females: Large, from 7.0 mm. to 30.0 mm. long and from 6.0 mm. to 20.0 mm. wide, depending on degree of engorgement. Scutum extensively pale ornamented and with central pale area broadly rounded posteriorly; large punctations scattered over surface including from five to twelve on posterior half; eyes flat.

Although the scutal length of _A. marmoreum_ group typically equals its width or is slightly greater than the width, the Sudan specimen illustrated (Figure 74) is exceptional in that its width is considerably greater than length.



Figures 76 and 77, ♂, dorsal and ventral views
Figures 78 and 79, ♀, dorsal and ventral views

AMBLYOMMA NUTTALLI
Sudan specimens

PLATE XXVII

AMBLYOMMA NUTTALLI Dönitz, 1909.

(Figures 76 to 79)

THE SMALL REPTILE-AMBLYOMMA

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
				Reptiles			
			7	Farajok	Kinixys b. belliana	Mar	
		1	3	Torit	Kinixys b. belliana	Aug	
			3	Meridi, 50 mi. northeast of	Kinixys b. belliana	Oct	(SVS)
	1			Torit	Varanus n. niloticus	Dec	
	1			Torit	Varanus e. exanthematicus	Jan	
				Mammal			
	1			Torit	Ourebia ourebi aequatoria	Feb	
				Bird			
	1			Torit	Francolinus clappertoni gedgii	Jan	

These specimens indicate the presence of A. nuttalli on both the east and west banks of the Nile in Equatoria Province.

Sudan Government collections contain specimens only from Ossa River (H. H. King legit, 1913), now a part of Uganda. King (1926) mentioned no Sudan locality records for this species.

DISTRIBUTION IN THE SUDAN

Kordofan: As A. werneri (Schulze 1932A), a single specimen from Talodi. The host is most probably the "Cinixys belliana" mentioned by Werner (1924).

DISTRIBUTION

A. nuttalli is widely spread throughout the African continent within the Ethiopian Faunal Region.

WEST AFRICA: NIGERIA (Simpson 1912A,B. Robinson 1926). GOLD COAST (Robinson 1926. Stewart 1937). FRENCH WEST AFRICA (Villiers 1955). PORTUGESE GUINEA (Tendeiro 1951C,D,1952A,C,D,1953,1954).

CENTRAL AFRICA: CAMEROONS (Dönitz 1909. Rageau 1951,1953A,B). BELGIAN CONGO (Schwetz 1927C. Bequaert 1931. Theiler and Robinson 1954).

EAST AFRICA: SUDAN (King 1926. As A. w. werneri: Schulze 1932A. Hoogstraal 1954B).

ITALIAN SOMALILAND (See REMARKS below).

KENYA (Loveridge 1929. Bequaert 1930A). UGANDA (King 1926, see DISTRIBUTION IN THE SUDAN above. Robinson 1926. Mettam 1932. Wilson 1950C). TANGANYIKA (Dönitz 1909. Robinson 1926. Loveridge 1923C as A. marmoreum is actually A. nuttalli, see Bequaert 1930A).

SOUTHERN AFRICA: SOUTHERN RHODESIA (Dönitz 1909. Jack 1942). MOZAMBIQUE (Santos Dias 1949B,1950A,B,1951A,1952D,1953B,1955A,B). UNION OF SOUTH AFRICA (Curson 1928. Alexander 1929,1931. Bedford 1932. Neitz 1948).

HOSTS

Adults

All authors list land tortoises (Kinixys spp. or Geochelone pardalis) as the chief hosts of adult A. nuttalli. A record of the side-neck turtle, Pelomedusa s. subrufa (= P. galeata), as a host (Santos Dias 1953B) was based on misidentification of Pelusios s. sinuatus, "a species of lesser importance as a host" (Santos Dias 1955B).

Infrequent hosts of adults are monitor lizards (Varanus spp.) (Robinson 1926, Tendeiro 1951D, and Sudan record above), Agama lizard (Loveridge 1929, Bequaert 1930A), python (Bedford 1932B), hedgehog (Robinson 1926), man (Schwetz 1927C), and one specimen from a domestic goat (Theiler, unpublished).

Nymphs and Larvae

Immature stages infest tortoises and also Varanus lizards, birds, and hares. Guineapigs may be used for laboratory rearing. Owing to the paucity of field records for immature stages it is impossible to determine their host preference in nature. It is unusual to find a tick that normally feeds on warm blooded animals in the immature stages and on cold blooded animals in the adult stages; the reverse is usually true. Yet Theiler (correspondence) has nymphs from South African hares and from a turkey on a farm where the mountain tortoise is also common. Further field study of this matter is indicated but, as A. nuttalli appears to be curiously localized and seldom abundant, the success of such investigation will depend on local factors. Note that in Equatoria Province, single nymphs were found on each of two species of Varanus lizards, on an oribi (antelope), and on a francolin partridge, but none were taken from the many tortoises examined.

Various literature records for "iguana" lizard, a non-African reptile, should be "leguan" or monitor lizard (Varanus spp.).

Alexander (1931) was unable to induce adults to feed on laboratory animals.

See also BIOLOGY below.

BIOLOGY

Santos Dias (1950A) reared this species using guineapigs and tortoises as hosts. He subsequently reported (1955B) that the life cycle is a three-host type. A maximum of 22,891 eggs from a single female were noted with the claim that this is the greatest number of eggs yet observed in any of the Ixodoidea. The minimum period for completion of the life cycle is estimated at 134 to 151 days, the maximum period 217 to 296 days. This paper is illustrated with photographs of both sexes feeding from the interstices of the host's shields. Our Torit adults, however, were taken in the host's axillae (during a native big-game hunt and stored in a hunter's ear, plugged with mud, for three hours until our lost vials could be recovered).

DISEASE RELATIONS

Experimental attempts to transmit heartwater (*Rickettsia ruminantium*) of cattle by this tick species have failed.

It is claimed that specimens have been found infected with Q fever (*Coxiella burnetii*) in Portugese Guinea.

As with the *Aponomma* parasites of lizards and snakes, it is of interest to conjecture that the small reptile-amblyomma may be a vector of the hemogregarines of tortoises.

REMARKS

Misshapen specimens have been reported (Santos Dias 1949B, 1950A,1955A).

Amblyomma werneri werneri Schulze, 1932(A), described from *Kinixys b. belliana* (see Werner 1924) from Talodi, Kordofan, Sudan, appears to be a synonym of *A. nuttalli*. Following Schulze's practice of applying species names to any variant, he distinguished a single specimen as different from *A. nuttalli* for the following reasons: the dark marking not blackish-brown, but light red brown on a light reddish brown background; darker markings bounded with a coppery color (in *A. nuttalli* dark yellow brown without copper borders); median stripes more irregular than in *A. nuttalli* and broadened at the ends; lateral groove sharply defined against the scutum, in *A. nuttalli* irregular; and ventral median muscleplate smaller.

All characters proposed to separate *A. werneri* from *A. nuttalli* fall well within the normal range of variation due to age, nutrition, or methods of preservation. In long series of any *Amblyomma* species, some specimens vary in roundness, flatness, development of the ventral muscleplate, and sharpness of the lateral groove. Comparison of many specimens of this genus preserved in alcohol with those preserved as dry specimens shows that those preserved in alcohol frequently develop a coppery sheen due to chemical change. Theiler has made similar observations in this respect. The obscurity of the color pattern and its overlay with a basic color in some specimens in any extensive collection of amblyommas from even a single host is taken for granted by most students. Using the above mentioned criteria, proposed by Schulze, large collections of A. variegatum and A. lepidum from single herds of cattle have been examined. It has been found that each collection contains no less than four "species" and up to seven "species".

Comparison of Sudan specimens with others from various parts of Africa and of the type specimens of A. nuttalli in British Museum (Natural History) reveals no significant differences to obtain between any of them.

It is for these reasons that it has been proposed (Hoogstraal 1954B) to consider A. werneri werneri Schulze, 1932(A), as a synonym of A. nuttalli Dönitz, 1909.

It is also of some interest to consider the status of A. werneri poematium Schulze, 1932, described on the basis of two males from a young rhinoceros, at the Amsterdam zoological gardens, from East Africa. This subspecies was distinguished by "a wonderful metallic, copper, partly greenish gloss (with) brown elements of the conscutum bordered in copper", in one of the two specimens, but in the other "the structure producing the metallic coloration was in greatest part destroyed, only in a few places did the greenish coppery sheen show up". The size of these specimens was also larger than that of the subspecies werneri.

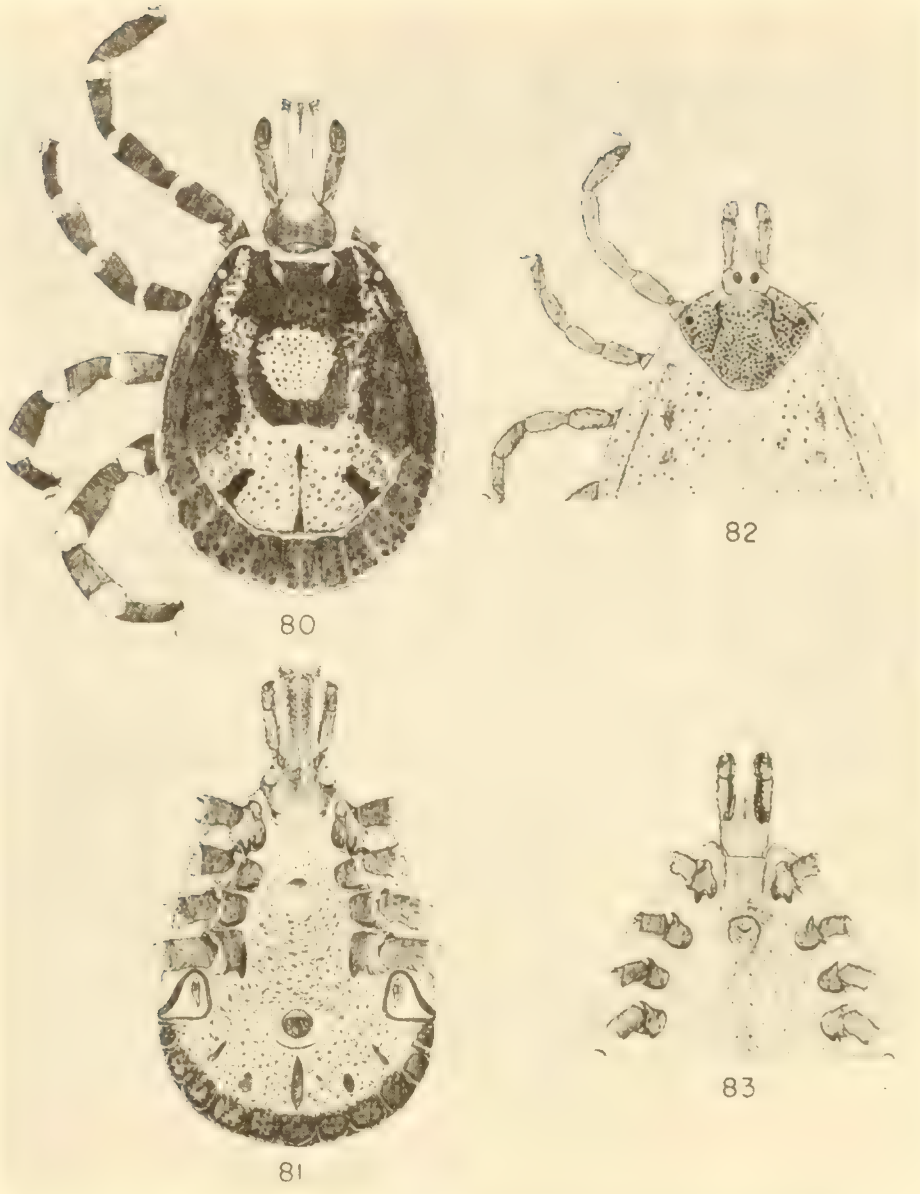
I have seen a male specimen taken from a Somali tortoise (#17691, Rocky Mountain Laboratory, Hamilton, determined as A. werneri by Dr. E. Stella). This tick answers the description of A. w. poematium but has a somewhat rugose scutum suggestive of injury during molting or during an immature stage. The specimen resembles a teneral individual, i.e. one that has been preserved shortly after molting while still bloated and before the colors are fast.

Santos Dias (1954G) opines that (1) A. poematium is a separate species, (2) A. schlottkei Schulze, 1932, might be a synonym, and (3) A. faiai Santos Dias, 1951, definitely is a synonym. The specificity of A. poematium is hardly convincing on the basis of descriptions and illustrations, though there is a possibility that comparison of specimens may provide yet unmentioned clues to separate this morphologically from A. nuttalli. Breeding experiments are also indicated.

IDENTIFICATION

A. nuttalli is similar to A. marmoreum in characters mentioned under that species, except for the following: Males: Size is smaller, always less than 6.0 mm. long. Pale ornamentation of the scutum is somewhat variable, but all specimens are like the one illustrated in that the dark areas are less extensive and more broadly separated from each other by light areas than they are in A. marmoreum.

Females: This sex is also smaller than that of A. marmoreum (body approximately 7.0 mm. long, 5.5 mm. wide; scutum about 3.2 mm. long, 3.3 mm. wide); the central pale scutal ornamentation tapers to a narrow point posteriorly and is therefore very distinctive.



Figures 80 and 81, ♂, dorsal and ventral views
Figures 82 and 83, ♀, dorsal and ventral views

<u>AMBLYOMMA</u> <u>POMPOSUM</u>
♂ specimen from Belgian Congo
♀ specimen from the Sudan

PLATE XXVIII

AMBLYOMMA POMPOSUM Dönitz, 1909.

(Figures 80 to 83)

THE HIGHLAND BONT TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
		1		Yei	domestic cow	Jan

This specimen, identified by Dr. G. Theiler, is the only one of this species from the Sudan. It represents an apparently rare intrusion into the western half of Equatoria Province from the Belgian Congo. Ecologically, the Yei area, except for a few hill masses, does not seem suitable for the survival of this mountain-inhabiting species though other localities in the eastern highlands of Equatoria Province might well meet its requirements. See A. superbum, REMARKS below.

DISTRIBUTION

A. pomposum is a highland tick of eastern Central Africa, adjacent parts of East Africa, and northern parts of southern Africa. See also REMARKS and IDENTIFICATION below.

CENTRAL AFRICA: BELGIAN CONGO and RUANDA-URUNDI (Nuttall and Warburton 1916. Seydel 1925. Robinson 1926. Schwetz 1927A. Bequaert 1931. Neitz 1947. Schoenaers 1951A. Theiler and Robinson 1954. Note: Santos Dias 1953E refers most of these Congo reports to his A. superbum sp. nov. However, correspondence with curators reveals that he had not examined the specimens on which these references were based).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

KENYA (See Note under IDENTIFICATION below). UGANDA (Hoogstraal 1954C). TANGANYIKA (Dönitz 1909).

SOUTHERN AFRICA: ANGOLA (Leitao 1942. Robinson 1926. Santos Dias 1950C. Bacelar 1950. Sousa Dias 1950, this report referred to A. superbum sp. nov. by Santos Dias 1953E; see IDENTIFICATION below. Theiler and Robinson 1954. Rousselot 1953B). MOZAMBIQUE [Robinson 1912*, 1926*. Santos Dias 1947A,1953B*,1954A,C*. According to Theiler (correspondence), A. variegatum govurensis Santos Dias (1950B), from the extreme north of Sul do Save Province, is synonymous with A. pomposum. Recently, Santos Dias (1953E) has agreed with this view; see IDENTIFICATION below].

NORTHERN RHODESIA (Robinson 1926. Matthysse 1954. Theiler and Robinson 1954). SOUTHERN RHODESIA (See REMARKS below).

HOSTS

Domestic cattle are referred to as hosts of A. pomposum by most authors, but Matthysse (1954) found it only on wild hosts, and then rarely, in Northern Rhodesia. Mules (Nuttall and Warburton 1916. Robinson 1926. Sousa Dias 1950). Horses (Theiler, unpublished records). Sheep, goats, dogs, donkeys (Sousa Dias 1950).

Man (As synonymous A. variegatum nocens: Robinson 1912* and subsequently frequently quoted without additional observations).

"Striped antelope" (Dönitz 1909). Sable antelope, roan antelope, and eland (Robinson 1926, Schwetz 1927A; Congo specimens in Onderstepoort collection). Hartebeest, kudu (Robinson 1926). Zebra (Schwetz 1927A). Buffalo (Jack 1942*). Warthog (Schoenaers 1951A). Ankole topi, Damaliscus korrigum ugandae (Hoogstraal 1954C). The nymphal specimen from a monkey, mentioned by Santos Dias (1954C), should be checked against A. variegatum. "Wild hosts only in Northern Rhodesia" (Matthysse 1954).

BIOLOGY

See REMARKS and IDENTIFICATION below. All authors who refer to collecting localities for A. pomposum stress the fact that it is a highland species.

---

*This record should be read in conjunction with statements in REMARKS and in IDENTIFICATION below.

DISEASE RELATIONS

MAN*: A. pomposum is said to attack African children's heads and causes sloughing of the skin. This has not been substantiated.

CATTLE: Inflammation and sloughing of mammae. Heartwater (Rickettsia ruminantium).

HORSES: Pyolymphangitis.

REMARKS

According to Robinson (1912*), A. pomposum (= A. variegatum nocens) occurs in the Rhodesias and Mozambique chiefly in bushveld from 2000 to 3000 feet elevation and seldom above 4000 feet. He further stated that this tick is notorious for the damage it does to stock in the Rhodesias, where it is known as the "Pyaemia tick". However, Morris (1933,1935,1936) attributed "tick-pyaemia" in Northern Rhodesia to A. variegatum. In Southern Rhodesia, Jack (1918) referred "ixodic lymphangitis" to A. variegatum, Sinclair (1916) associated skin diseases of cattle with A. variegatum, and Jack (1928,1937,1942) also mentioned only A. variegatum with reference to abscesses and sloughing of the hosts' skin. In his first two papers Jack did not differentiate between A. variegatum and A. pomposum, but in his 1942 report he stated that the local highlands where A. pomposum would be expected to occur, are free of amblyommas but that some male specimens of A. variegatum from the lowlands may show a tendency to resemble A. pomposum. See also IDENTIFICATION below.

Theiler (correspondence) calls attention to the following facts that may modify many of the above reports concerning A. pomposum. Robinson's (1912,1926) remarks concerning A. pomposum in Mozambique and Southern Rhodesia are based on statements of Mr. E. M. Jarvis. Jack's records for Southern Rhodesia apparently are quoted from the same source, for no further data are presented. The extensive Onderstepoort collection has no specimens from Southern Rhodesia. Theiler's correspondence with Dr. Lawrence, Assistant Director (Research) of the Southern Rhodesia Veterinary Department, indicates that he is not aware that A.

*This record should be read in conjunction with statements in REMARKS and in IDENTIFICATION below.

pomposum occurs in this territory and that he considers the Jarvis statements as "sheer nonsense". It appears, therefore, that earlier literature records for A. pomposum in Mozambique and Southern Rhodesia are open to question.

Wherever A. pomposum occurs it seems to be present in good numbers. Its distribution, so far as Theiler has determined (correspondence), is mainly in the Rhodesia Highland Savannah type of vegetation, certainly not in the moist vegetation of the Umtali-Melsetter district and adjoining Manicaland.

More extensive search for and study of this species is required. Statements regarding damage to cattle and to children by this tick in Southern Rhodesia appear to be questionable.

Sousa Dias (1950) writes concerning A. pomposum, which is common in the Angolan highlands, as follows: "It is considered by breeders to be one of the most harmful ectoparasites of stock for it causes wounds that are most difficult to heal. It is probable that (this tick) is one of the factors that favors the dispersal of bovine dermatoses so common in Angola". He surmises that A. pomposum is a heartwater vector in Angola inasmuch as it occurs in heartwater areas in the absence of other recognized vectors. [Neitz (1947) showed that A. pomposum is a vector of heartwater.]

A. pomposum is close morphologically to A. lepidum and to A. variegatum. The latter, biologically, is a most versatile tick except that it shuns desert and rainforest areas. A. lepidum is a semiarid country and savannah species. A. pomposum appears to be chiefly a highland species. See also remarks on A. superbum in section below.

A gynandromorph of this species has been described by Santos Dias (1954). Schulze (1932C) discussed certain features of the ornamentation of A. pomposum in relation to other species in this genus.

IDENTIFICATION

Both sexes have hemispherical eyes situated in a depression, and are distinct from *A. variegatum* and *A. lepidum* in possessing very coarse scutal punctations.

Male scutal ornamentation, inside the lateral groove, is like that of *A. lepidum* except that a small red spot may be present laterally in *A. pomposum*, but no red color is found on *A. lepidum*.

The *female* scutum may be variable in length-width ratio, that of some specimens being only as long as wide, of others longer than wide; its rugosity is very distinct; it may be unornamented but usually has a small white or pale spot in the posterior field. [Robinson (1926) stated that ♀♀ are unornamented. Nevertheless a number of those in the Nuttall collection, which comprised his chief reference material, have ornamented spots on the scutum. These, as well as others similar to them have been observed in different collections.]

Specimens from the Sudan referable to these characteristics should be checked against authoritatively identified specimens from the known range of *A. pomposum* before this name is applied. Characters provided here are generalized; an exhaustive survey of the subject is precluded by our uncertainty over variability between this species and *A. variegatum*, as indicated below.

Note

In some large collections of *A. variegatum*, a few robust male specimens, or, more rarely, a few pygmy male specimens, may be suggestive of *A. pomposum* owing to unusually heavy scutal punctations. Associated females are also more heavily punctate and may have a wider scutum than normal. Jack (1942) referred to similar males from Rhodesia (see REMARKS above). I have collected a few lots of such specimens in the Sudan and in the mountains of Yemen (Arabia). The most distinctive collection in this category is one recently presented to me by Dr. C. B. Philip, who collected it from a herd of cattle near Kabete in the mountains of central Kenya. The single female has a wide scutum and is heavily punctate but not rugose and the punctations are not confluent. Of the males, four are slightly more punctate than is usual for A. variegatum, one is slightly more punctate than the first four, and the last two are so heavily punctate that, alone, there would be little question of their identity as A. pomposum. Such specimens, in addition to various queries already mentioned, suggest the possibility that A. pomposum is a heavily punctate, mountain or heavy forest subspecies of A. variegatum and that intergradation does occur.

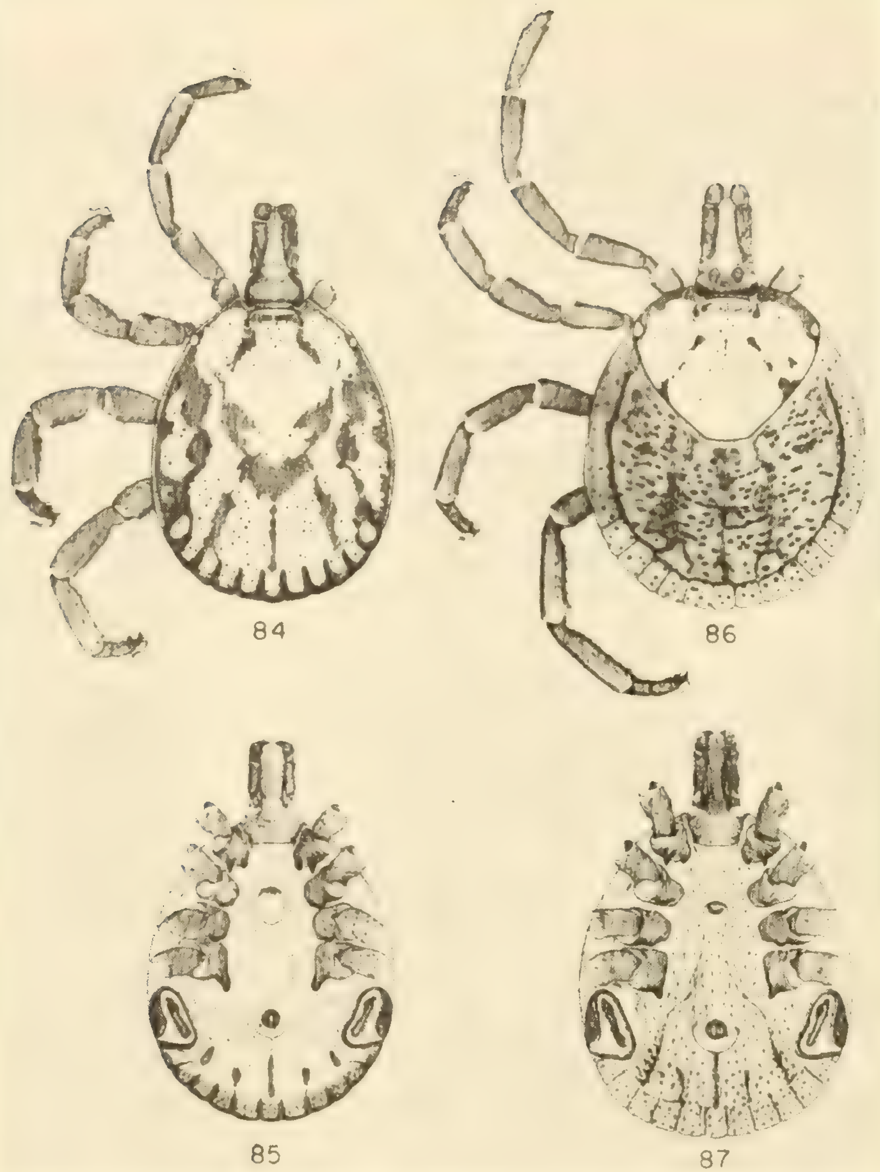
It appears that A. variegatum govurensis of Santos Dias (1950B,1954H) is an intermediate form between the almost nonpunctate A. variegatum and the heavily punctate A. pomposum. Santos Dias' description adds weight to the concept that A. pomposum is actually no more than a variant form or subspecies of A. variegatum. Rearing of progeny from isolated females in lowlands and in highlands and transporting some of their progeny to different altitudinal levels for development under different ecological conditions may solve this question.

Since the above was written, Santos Dias' (1953E) paper describing A. superbum sp. nov. has appeared. In it, A. variegatum govurensis is placed in synonymy under A. pomposum. A. superbum is considered to differ from both A. variegatum and A. pomposum chiefly on the basis of size, depth, and distribution of punctations. Even more recently, the same author (1954H) has reaffirmed the validity of his variety of A. variegatum, with no indication of what he proposes to do about A. superbum.

On ecological grounds, A. superbum (or A. variegatum govurensis) might be a useful niche in which to drop the Sudan specimen and certain other Central African lowland specimens. Variable and confusing series of specimens still confront us. Unfortunately, however, A. superbum does not answer the problems this material poses. No recourse offers itself but to maintain the present systematic status of A. variegatum and A. pomposum, undertake biological studies suggested in the paragraph above, and only then judge the presently considered questionable validity of A. superbum as a real species and the range of variation in A. variegatum and A. pomposum.

Santos Dias (1953E) further refers the Belgian Congo records of *A. pomposum* by Nuttall and Warburton (1916), Schwetz (1927A), Bequaert (1931) and Schoenaers (1951A) to *A. superbum*. Since no adequate descriptions for differentiating Congo specimens were provided by these authors, the validity of this proposed synonymy is highly questionable. Belgian Congo specimens that have been seen in British Museum (Natural History) collections, in Museum of Comparative Zoology collections, and in the HH collection are typically *A. pomposum* by comparison with specimens from everywhere within the range of this species.

In conclusion, one may only belabor the point: the status of heavily punctate specimens morphologically intermediate between *A. variegatum* and *A. pomposum* remains to be ascertained by biological studies, not by museum-type studies.



Figures 84 and 85, ♂, dorsal and ventral views
Figures 86 and 87, ♀, dorsal and ventral views

AMBLYOMMA RHINOCEROTIS
Sudan specimens

PLATE XXIX

AMBLYOMMA RHINOCEROTIS (de Geer, 1778) (= A. PETERSI Karsch, 1878)

(Figures 84 to 87)

THE RHINOCEROS AMBLYOMMA

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
		4		Torit	on grass	Dec	(SGC)
		2	2	Kajo Kaji	on grass	-	(BMNH)

The Sudan Government collection specimens were collected by H. H. King. British Museum (Natural History) specimens were taken by Captain C. M. Stigand.

DISTRIBUTION IN THE SUDAN

Upper Nile: Bor (King 1926).

DISTRIBUTION

A. rhinocerotis occurs in central, eastern, and southeastern Africa apparently wherever the rhinoceros is found.

[WEST AFRICA: LIBERIA: Bequaert (1930A) states that Neumann's (1901,1911) Liberian records of this species, repeated by Bedford and Hewitt (1925) and by Bedford (1932B) are in error. FRENCH EQUATORIAL AFRICA: Neumann (1899) listed A. aureum (a synonym of A. rhinocerotis) from "Ngourou Plains, Zanzibar". It is probable that this locality is actually N'Gourou, Ubangi-Shari, French Equatorial Africa.]

CENTRAL AFRICA: BELGIAN CONGO (Schwetz 1927A. River Misisi, Schwetz 1927C, p. 92, is in Uganda. Tonelli-Rondelli 1930A. Bequaert 1931).

NOTE: According to Theiler (correspondence), the record for Ruanda-Urundi by Santos Dias (1954D) is in error.

EAST AFRICA: SUDAN (King 1926. Hoogstraal 1954B,C).

BRITISH SOMALILAND (Neumann 1922. Stella 1938A,1939A,1940). ITALIAN SOMALILAND (Tonelli-Rondelli 1930A. Stella 1940).

KENYA (Neave 1912. Neumann 1913,1922. Anderson 1924A,B. Robinson 1926. Bedford 1932B. Lewis 1931C,1934. Weber 1948). UGANDA (Neave 1912. Neumann 1922. Robinson 1926. Schwetz 1927C, p. 92, as Belgian Congo. Bequaert 1930A, p. 803. Mettam 1932, 1933. Wilson 1950C). TANGANYIKA (Neumann 1901,1907C,1910B,1911. Neave 1912. Morstatt 1913. Robinson 1926. J. B. Walker; unpublished).

SOUTHERN AFRICA: NORTHERN RHODESIA (Neave 1912. Robinson 1926). SOUTHERN RHODESIA (Jack 1942). NYASALAND (Neave 1912. Robinson 1926. Wilson 1950B). MOZAMBIQUE (Karsch 1878. Neumann 1911. Santos Dias 1947A,1953B). UNION OF SOUTH AFRICA (Breijer 1915. Bedford and Hewitt 1925. Curson 1928. Bedford 1932B, 1936).

[OUTLYING ISLANDS: MADAGASCAR: Neumann (1901,1911). Poisson (1927). Locality record probably erroneous, cf. Hoogstraal (1953E). ZANZIBAR: Neumann (1899) probably in error, see WEST AFRICA above.]

[Note: Neumann (1899) listed JAVA for the synonymous *A. aureum* but subsequently (1908) he stated that the specimen on which this record was based was actually *A. testudinarium*.]

HOSTS

All workers list as hosts either the black rhinoceros, *Diceros bicornis*, or the white or square-lipped rhinoceros, *Ceratotherium simum*, the latter in both the northern and southern areas of its range. Other animals that uncommonly serve as hosts are: eland (Neumann 1907C,1910B,1911), tortoise (Bedford 1936), and python (Mettam 1932). Domestic cattle: numerous adults, in a single lot; Uganda Veterinary Service collections.

BIOLOGY

Unstudied.

DISEASE RELATIONS

Unstudied.

REMARKS

The frequent records of specimens taken from grass are due to the large size and conspicuousness of the rhinoceros amblyomma.

This species often has been referred to as *A. petersi* (Karsch, 1878), but according to Schulze (1932A), this name is synonymous with *A. rhinocerotis* (de Geer, 1778). This decision is acceptable for the present, but it must be noted that Theiler (correspondence) is far from certain of its validity. Obviously needed is a careful study of the original material and literature by a competent contemporary student with full access to pertinent specimens.

The specific name *rhinocerotis* (de Geer, 1778) frequently has been applied to *Dermacentor rhinocerinus* (Denny, 1843). However, as Bequaert (1930B) pointed out, Dönitz (1910B) has long ago indicated that de Geer's specimens belonged in the genus *Amblyomma* because of their longer palpi.

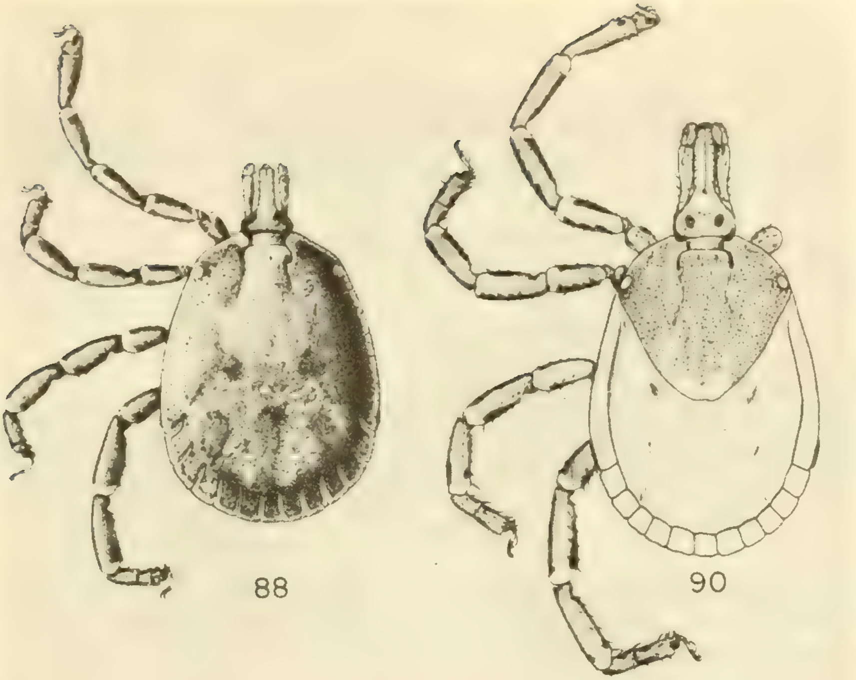
The remarkable parallel or convergent evolution of rhinoceros-infesting *Amblyomma* and *Dermacentor* ticks, and the relationship of *Cosmiomma hippopotamense* (Denny, 1843), a hyalommalike beast, is worthy of special study.

The capsule of larval haller's organ in *A. rhinocerotis* has been noted by Schulze (1941), who also (1950A) discussed the adult dentition of this species.

IDENTIFICATION

Males, at least 8.0 mm. long and 7.0 mm. wide, are as large as any other African amblyomma. The scutum lacks lateral grooves, has bicolored festoons, small and flat eyes, extensive pale (yellowish) ornamentation on a dark (reddish-brown) background, and a few large scattered punctations. The leg segments have narrow pale distal rings.

Females are also very large, approximately 9.0 mm. long and 8.0 mm. wide. The scutum is largely pale (reddish or golden) with lateral margins and small internal areas dark reddish-brown; it bears few coarse punctations on the anterior half but numerous fine punctations; eyes are flat or very slightly convex. The leg segments exhibit narrow, pale distal rings.



88 90 89 91

Figures 88 and 89, ♂, dorsal and ventral views
Figures 90 and 91, ♀, dorsal and ventral views

AMBLYOMMA THOLLONI
Sudan Specimens

PLATE XXX

MARINE BIOLOGICAL LABORATORY
WOODS HOLE
LIBRARY
MASS.

AMBLYOMMA THOLLONI Neumann, 1899.

(Figures 88 to 91)

THE ELEPHANT AMBLYOMMA

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		19	178	Lotti Forest	Loxodonta africana oxyotis	Apr
		8	15	Tereteina	Loxodonta africana oxyotis	Feb
		2	4	Torit	Loxodonta africana oxyotis	Dec
		4	8	Torit	Loxodonta africana oxyotis	Dec
	1*			Lokila	Chameleo g. gracilis	Oct (SVS)

King (1926) listed Equatoria Province without localities and his specimen vials include no further data. The nymph from a chameleon was identified by Dr. G. Theiler.

DISTRIBUTION IN THE SUDAN

Although it may have been reasonable to expect that A. tholloni occurs on elephants in Bahr El Ghazal and Upper Nile Province and on the west bank of Equatoria Province, no specimens have been collected to indicate its presence in these places. Ticks from several elephants shot near Yirol and Kenisa in Bahr El Ghazal and Upper Nile Provinces in 1911, 1953, and 1954, have all been R. simus simus, R. simus senegalensis, or intergrades of these two subspecies.

DISTRIBUTION

A. tholloni occurs through much of tropical Africa, wherever the African elephant, Loxodonta africana subspp., is found, except possibly along the northern and southern margins of the host's range.

WEST AFRICA: LIBERIA (Bequaert 1930A). SIERRA LEONE (Simpson 1913. Robinson 1926). IVORY COAST (Rousselot 1951,1953B. Villiers 1955).

CENTRAL AFRICA: CAMEROONS (Neumann 1901,1911. Ziemann 1905, 1912A. Rageau 1951,1953A,B). RIO MUNI (Robinson 1926). FRENCH EQUATORIAL AFRICA (Neumann 1899. Tonelli-Rondelli 1930A. Fiasson 1943B. Rousselot 1951,1953B. Rageau 1953B).

BELGIAN CONGO (Neumann 1899,1911. Nuttall and Warburton 1916. Roubaud and Van Saceghem 1916. Robinson 1926. Schwetz 1927A,B,C, 1932. Schouteden 1929. Tonelli-Rondelli 1930A. Bequaert 1930A,B, 1931. Rodhain 1936. Fain 1949. Theiler and Robinson 1954. Van Vaerenbergh 1954).

NOTE: According to Theiler (correspondence), the record for Ruanda-Urundi by Santos Dias (1954D) is in error.

EAST AFRICA: SUDAN (King 1911,1926. Robinson 1926. Hoogstraal 1954B).

KENYA (Neumann 1922. Lewis 1931C,1932. Mulligan 1938). UGANDA (Neave 1912. Robinson 1926. Tonelli-Rondelli 1930A. Mettam 1932. Wilson 1950C. See HOSTS below). TANGANYIKA (Neumann 1899,1907C, 1910B,1911. Morstatt 1913. Robinson 1926. Hoogstraal 1954C. J. B. Walker, unpublished; see HOSTS below).

SOUTHERN AFRICA: ANGOLA (Gamble 1914. Robinson 1926. Santos Dias 1950C). MOZAMBIQUE (Santos Dias 1947A,B,1948C,1949C,D,1950B, 1953B,1955A. Bacelar 1950. Tendeiro 1952F). NYASALAND (Neumann 1899*. Neave 1912. Robinson 1926. Wilson 1950B).

[A. tholloni has not yet been recorded from the UNION OF SOUTH AFRICA, but Theiler (correspondence) believes that this is probably because it has not been looked for and that it possibly occurs on Kruger Park elephants and on remote herds in Southwest Africa. The possibility that this tick is incapable of following its normal

---

*The reference to "region du Nyassa" by Neumann (1899), for specimens collected by Ed. Foa, may refer to Niassa Province, Mozambique.

host into the southern periphery of the host's range should be considered in view of its apparent total absence on elephants in Bahr El Ghazal Province of the Sudan.7

HOSTS

All authors list the African elephant, Loxodonta africana subspp., as chief host. Uncommon hosts that have been reported for a few specimens are: gazelle (Neumann 1901,1907C,1910B), antelope and domestic horse (Neumann 1911), rhinoceros (Neumann 1922), leopard (Robinson 1926), bushpig and large lizard (Schwetz 1927B), domestic dog (Santos Dias 1953B) and buffalo (Hoogstraal 1954C). Dr. Theiler has larvae, nymphs, and a male specimen from a bird, Pitta reichenowi, another indication of ground birds as hosts of immature Amblyomma species. In our collection are several nymphs and a male with massive legs taken from a hippopotamus in Kazinga Channel of Lake Edward by Lt. Colonel Don Davis, U.S. Army. Miss J. B. Walker has a collection consisting of seven males and four females from a Tanganyika black rhinoceros; also others from an elephant there.

The small nymph collected at Lokila, Equatoria, from a chameleon by E. T. M. Reid is an unusual record. Santos Dias (1948C) states that larvae and nymphs are rarely found on elephants. The only other records for nymphal hosts in nature are those of the bird and hippopotamus listed above, and one nymph in the Onderstepoort collection (Theiler, unpublished) with adults, from an elephant at Toro, Uganda.

BIOLOGY

Adult specimens of the elephant amblyomma may be found on any part of the host's body, Immature stages previously have been reported only by Santos Dias (1948C), who states that larvae and nymphs are rarely taken on elephants. Santos Dias experimentally reared larvae and nymphs on guinea pigs and reported that six months were required to complete the three-host life cycle. He observed a chalcid wasp parasite, Hunterellus hookeri, infesting nymphs. Fiasson (1943B) reported 3000 eggs from an engorged female.

Mr. J. Owen, who furnished the 197 specimens from a single elephant in a plains herd passing through Lotti Forest, reported that his "boys" could have collected at least twice as many from this elephant if they had had more containers for them. No specimens other than the few listed could be found on the three other Equatoria Province elephants noted above. Numerous other newly killed elephants in this Province have been examined without finding ticks of any sort.

DISEASE RELATIONS

A. tholloni is possibly a vector of Nuttallia loxodontis of elephants.

REMARKS

The stage to stage growth of A. tholloni has been charted by Campana-Rouget (1954). Misshapen specimens have been described and illustrated by Santos Dias (1947B, 1949C, 1955A).

Larval and nymphal stages of A. tholloni were described and illustrated by Santos Dias (1949D).

Variations in male scutal patterns from Mozambique were illustrated by Santos Dias (1947A). Within the geographical range of the elephant amblyomma there are two scutal color patterns, one drab and lightly pigmented with small areas of color, the other brightly marked, usually with more extensive pigmented areas. The bright form is particularly common among numerous specimens seen from West Africa and rare among those from East Africa; the drab form is common in East African specimen and rare in West African material. After having examined all of the numerous A. tholloni specimens in British Museum (Natural History) collections, which represent almost all areas of the geographic range of this species, one may only conclude that these two color patterns do not appear to be genetic variants and are probably not associated with temperature or rainfall factors or with methods of preservation. They may possibly derive from nutritional factors. A biological study of living specimens is the only means of determining the reason for these two color patterns. [Since the above was written, Rageau (1953B) has reported that Cameroons specimens and others that he has seen from French Equatorial Africa all show the reduction in ornamentation that has appeared to me to be more common in East than in West African specimens.]

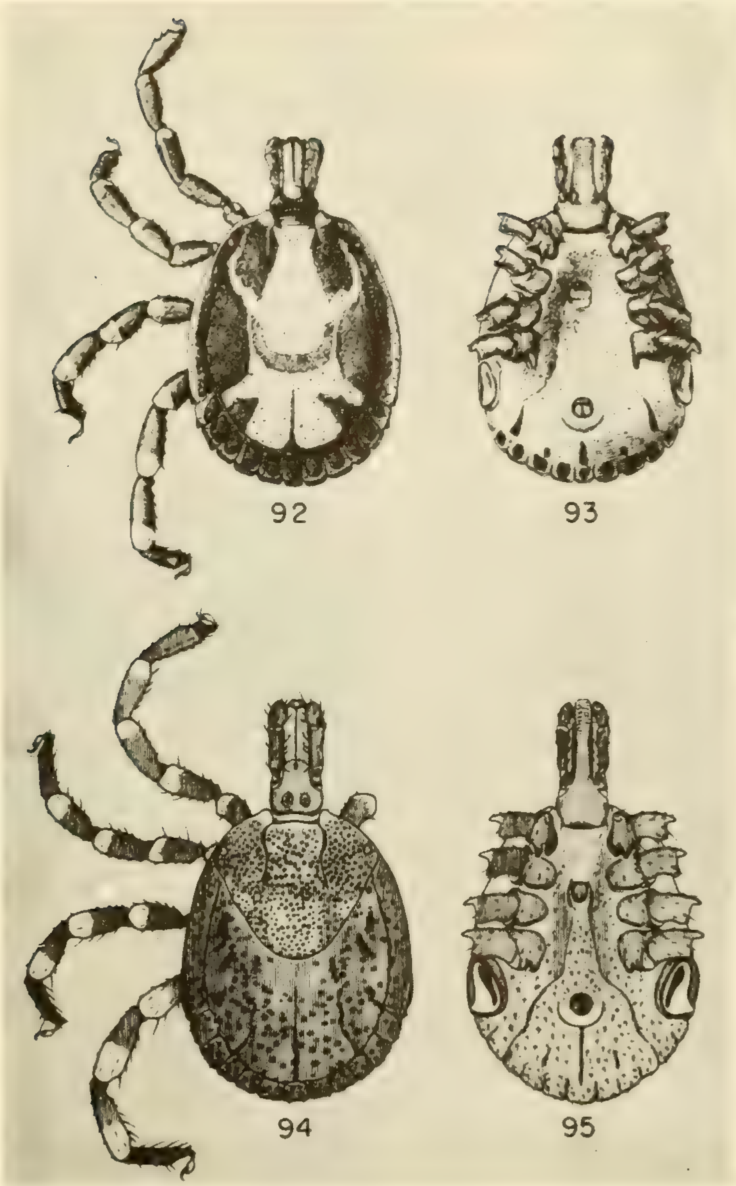
Robinson (1926) stated that a large pale spot in each lateral field of the scutum and a stout spur on coxa IV are female diagnostic characters. I have examined Nuttall's lot 3381 in British Museum (Natural History), on which Robinson's species definition and illustrations were based, and find it to be the most heavily and liberally ornamented material, along with a few others from Sierra Leone, of any representatives of this species in the collection. Actually, lateral field pale spots are absent in most of these specimens. The stoutness of the spur on coxa IV is also a variable character and the specimen selected by Robinson is an extreme example. In most specimens, this spur is merely a small pointed projection from or near the posterior coxal margin.

All Sudan specimens at hand are drably colored and their pigmented areas are no more extensive than those illustrated (Figure 90). On some, ornamentation is almost obsolete.

IDENTIFICATION

Males. No other African amblyomma can be confused with this species because of the smallness of its pigmented areas, flat eyes, and absence of both lateral grooves and of large scutal punctations. Males measure about 5.0 mm. long and 4.0 mm. wide.

Females are equally easily distinguished from all others in Africa by the absence of large scutal punctations, triangular scutal shape with narrow posterior margin, and distribution of color pattern that is usually only an irregular spot in the posterior point but sometimes also has small lateral spots. The cervical grooves are short and eyes are large, flat, and pale. Females, unengorged, are usually about 6.0 mm. long and 4.7 mm. wide.



Figures 92 and 93, ♂, dorsal and ventral views
Figures 94 and 95, ♀, dorsal and ventral views

AMBLYOMMA VARIEGATUM
Sudan Specimens

PLATE XXXI

AMBLYOMMA VARIEGATUM (Fabricius, 1794).

(Figures 92 to 95)

THE TROPICAL BONT TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	1			Ikoto	MAN (feeding on)	Feb
	1			Torit	Atelerix pruneri oweni	Nov
	6			Torit	Euxerus erythropus leucoumbrinus	Dec
	2			Kapoeta	Lepus capensis subsp.	Apr
	1			Jebel Kathangor	Crocuta crocuta subsp.	Dec
1				Torit	Genetta tigrina aequatorialis	Dec
	2			Torit	Canis aureus soudanicus	Dec
2	3			Torit	Canis aureus soudanicus	Apr
5	1			Kapoeta	Herpestes sanguineus sanguineus	Apr
		3	52	Boma Plains	Syncerus caffer aequinoctialis	Dec
			3	Holo	Syncerus caffer aequinoctialis	Mar
			1	Koss Valley	Syncerus caffer aequinoctialis	Jan
		2	9	Laboni	Syncerus caffer aequinoctialis	Feb
			16	Torit	Syncerus caffer aequinoctialis	Jan
		3	4	Kapoeta	Hippotragus equinus bakeri	Dec
		1		Lafon	Hippotragus equinus bakeri	Dec
			1	Torit	Hippotragus equinus bakeri	Apr
			1	Torit	Hippotragus equinus bakeri	Jan
	8			Jebel Kathangor	Gazella granti brighti	Dec
	2	2	3	Torit	Sylvicarpa grimmia roosevelti	Feb (2)
	3		1	Torit	Rhynchotragus guentheri smithii	Dec
	15			Torit	Rhynchotragus guentheri smithii	Apr
	1			Lokila	Ourebia ourebi aequatoria	Feb
	1	1	1	Torit	Alcelaphus buselaphus roosevelti	Apr
	8			Loronyo	Alcelaphus buselaphus roosevelti	Jan
	7	1	1	Loronyo	Taurotragus oryx pattersonianus	Jan

2	2	2	Kapoeta	domestic cattle	Dec
2	2	12	Nagichot	domestic cattle	Dec
		3	Nagichot	domestic cattle	Jul
	3	29	Torit	domestic cattle	Nov (2)
7	6	23	Torit	domestic cattle	Dec (5)
	1	10	Torit	domestic cattle	Jan (2)
		11	Torit	domestic cattle	Feb (2)
		30	Torit	domestic cattle	Apr (2)
	1	3	Goniryo	domestic cattle	Mar
2	13	38	Katire	domestic cattle	Jan
	2	6	Gilo	domestic cattle	Dec
	34	78	Juba	domestic cattle	Dec (4)
1			Juba	domestic cattle	Jan
	7	4	Rejaf	domestic cattle	Aug (SGC)
	7	5	Gondokoro	domestic cattle	May (SGC)
		3	Tombe	domestic cattle	Mar (SVS)
		1	Muni	domestic cattle	Mar (SVS)
		1	Terakeka	domestic cattle	Mar (SVS)
		3	Yei	domestic cattle	Dec
5	1	5	Yei	domestic cattle	Jan
8	5	1	Yei	domestic cattle	Feb
5	5	19	Yei	domestic cattle	Dec
	2	5	Lorella (Yei River)	domestic cattle	Jan (SGC)
26	56	152	Kajo Kaji	domestic cattle	Dec (2)
	8	10	Kajo Kaji	domestic cattle	Jun (SGC)
	15	15	Meridi	domestic cattle	Apr (SVS)
		103	Meridi	domestic cattle	May (SVS)
		12	Amadi	domestic cattle	Apr (SVS)
		4	Yambio	domestic cattle	Jan
	98	148	Li Rangu	domestic cattle	Apr
2			Kapoeta	domestic sheep	Dec
	1	3	Juba	domestic sheep	Dec (SGC)
		4	Kaguada	domestic sheep	Dec
2			Katire	domestic goats	Jan
86		8	Kajo Kaji	domestic goats	Dec
9			Kajo Kaji	domestic dogs	Jan
8			Katire	domestic dogs	Jan
1	1	7	Katire	domestic dogs	Dec
8			Juba	domestic horses	Jan
9			Katire	domestic pig	Jan
		1	Torit	on grass	Apr

BIRDS

	1	Torit	*Tchagra senegala erlangeri*	Jan
	2	Torit	*Sphenorhynchus abdimii*	Jan
	5	Kapoeta	*Numida meleagris major*	Dec
3	2	Kapoeta	*Lissotis m. melanogaster*	Dec (2)
	12	Torit	domestic chicken	Jan
	7	Katire	domestic turkey	Jan

DISTRIBUTION IN THE SUDAN

A. variegatum occurs in Equatoria, Bahr El Ghazal, Kordofan (= Nuba Mountains) and Upper Nile Province, and has been found on Upper Nile cattle at the Wadi Halfa quarantine, but is not established in Northern Province according to King (1926).

The following are Sudan localities from which specimens, *all from cattle unless otherwise noted*, have been studied.

Bahr El Ghazal: Meshra el Req (SGC). Lau, Akot, Yirol, Tali Post, Kuru, Lake Nyubor, Peth, Raga, Khor Shamman, and Boro (SVS). Wau (domestic horses, sheep, donkeys, pigs, cattle; SVS, HH). Busseri (domestic horse; SVS). Njambo (buffalo; SGC). Raga (domestic goat, cattle; SGC). Aweng (domestic dog, cattle; SVS). Fanjak (SVS, HH). Guar and nearby areas in Galual-Nyang Forest (common on many individuals of tiang, buffalo, giraffe and roan antelope; also on warthog, hartebeest, and domestic dog; nymphs from spurfowl, *Francolinus clappertoni*; SVS, HH). 15 miles north of Tonj (tiang; SVS). Atet (tiang; SVS). Malek (nymph on *Francolinus* sp.; SVS). Lau River, 37 miles west of Yirol (nymph on cane rat; SVS). Nymphs are very numerous on tiang in the dry season and were also taken on buffalo and *engorging on man*. In the wet season, adults replace nymphs on wild animals.

Upper Nile: Khor Atar and Taufikia (SGC). Duk Fadiat (cattle, HH; warthog, wild pig; SVS). Malakal (SVS, HH). Ler (SVS). Bor (SVS, HH).

Darfur: 'Idd el Ghanam (SGC). Radom (SVS).

Blue Nile: Roseires (SGC).

Kordofan: Talodi (SVS). Cattle from Kordofan at the Wadi Halfa Quarantine (SGC).

[Khartoum: Abyssinian cattle at Khartoum (probably at the Quarantine Station) (SGC). Balfour (1906) reported specimens on trypanosome-infected cattle arriving from the south.]

It will be noted that 12°N. is about the northern limit of this species. Rare isolated populations may exist slightly further north in the Sudan.

DISTRIBUTION

A. *variegatum* is distributed generally throughout the Ethiopian Faunal Region except in northern Sudan, most of Southwest Africa, much of Mozambique, and the entire Union of South Africa. The range includes mountainous Southwest Arabia and the tropical bont tick has become established in the Madagascan archipelago. It has also established itself from imported specimens in the West Indies and in the Cape Verde Islands. A record from Guatemala (Neumann 1899) has not been confirmed in later literature.

"AFRICA" (Fabricius 1794)

NORTH ATLANTIC OCEAN: CAPE VERDE ISLANDS (Tendeiro 1954X).

WEST AFRICA: NIGERIA (Neumann 1899. Ziemann 1905. Simpson 1912A,B. Johnston 1916. Connal and Coghill 1917. Robinson 1926. Pearse 1929. Beaton 1939. Mettam 1947,1948,1951. Unsworth 1949, 1952. Gambles 1951). FRENCH WEST AFRICA (As A. *venustum*: Koch 1844. As *Ixodes elegans*: Guerin-Meneville 1843. Neumann 1899, 1911. Joyeux 1915. Robinson 1926. Andre and Lamy 1931. Brumpt 1934. Lloverol, Philippe, and Adjovi 1942. Girard and Rousselot 1945. Rousselot 1951,1953B. Villiers 1955).

TOGO (Ziemann 1905). SIERRA LEONE (Neumann 1899. Simpson 1913. Yorke and Blacklock 1915. Entomological Report 1916. Robinson 1926). GAMBIA (Simpson 1911. Robinson 1926). GOLD COAST (Simpson 1914. Macfie 1915. Beal 1920. Robinson 1926. Stewart

1933). PORTUGESE GUINEA (Howard 1908. Tendeiro 1947,1948,1949B, 1951A,C,D,F,1952A,C,D,E,1953,1954. Bacelar 1950). BIJAGOS ISLANDS (Tendeiro 1953X).

CENTRAL AFRICA: CAMEROONS (Ziemann 1912A. Warburton 1927. Joncheres 1934. Bardez 1934. Rageau 1951,1953A,B. Rousselot 1951,1953B. Unsworth 1952. Dezest 1953). RIO MUNI ("North Central Rio Muni": Hoogstraal collection). FRENCH EQUATORIAL AFRICA (Fiasson 1943B. Blanc, Brunneau, and Chabaud 1950A. Giroud 1951. Rousselot 1951,1953A,B).

BELGIAN CONGO and RUANDA-URUNDI (Newstead, Dutton, and Todd 1907. Massey 1908. Roubaud and Van Saceghem 1916. Nuttall and Warburton 1916. Van Saceghem 1918. Seydel 1925. Robinson 1926. Schwetz 1927A,B,C,1932,1933B,1934. Schouteden 1929. Bequaert 1930A,B,1931. Tonelli-Rondelli 1930A. Bouvier 1945. Giroud and Jadin 1950. Giroud 1951. Jadin and Giroud 1951. Schoenaers 1951A,B. Rousselot 1951,1953B. Reference to Belgian Congo by Berge and Lennette 1953 should be French Equatorial Africa. Theiler and Robinson 1954. Santos Dias 1954D. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (Balfour 1904,1906. King 1908,1911,1926. Hoogstraal 1952A,1954B).

ETHIOPIA (Pavesi 1884A. Neumann 1899,1902B,1911,1922. Robinson 1926. Stella 1938A,1939A,B,1940. Roetti 1939. Charters 1946. D'Ignazio and Mira 1949. Hoogstraal 1954C). ERITREA (Franchini 1929D,E. Tonelli-Rondelli 1930A. Niro 1935. Stella 1938A,1939A, 1940. Ferro-Luzzi 1948). FRENCH SOMALILAND (Robinson 1926. Stella 1940. Hoogstraal 1953D). ITALIAN SOMALILAND (Franchini 1926A, 1927,1929C. Niro 1935. Stella 1938A,1939A,1940).

KENYA (Neave 1912. Neumann 1922. Anderson 1924A,B. Robinson 1926. Daubney 1927,1930A,B,1933,1934,1936B. Walker 1927, 1929. Tonelli-Rondelli 1930A. Lewis 1931A,B,C,1932A,B,1934, 1939A,B. Daubney and Hudson 1931A,B,1934. Roberts 1935. Loveridge 1936A. Fotheringham and Lewis 1937. Mulligan 1938. Dick and Lewis 1947. Weber 1948. White 1949. Binns 1951. van Someren 1951. Worsley 1952. Wilson 1953. Wiley 1953. Hammond 1954. See also IDENTIFICATION under <u>A</u>. <u>pomposum</u>, p. 245).

UGANDA (A. Theiler 1910A. Bruce et al 1911. Neave 1912. Neumann 1922. Robinson 1926. Richardson 1930. Mettam 1932,1933. Carmichael 1934. Mettam and Carmichael 1936. Wilson 1948A,B,C, 1950C,1953. Clifford 1954. Hoogstraal 1954C. Taylor 1954). TANGANYIKA (Gerstäcker 1873. Neumann 1911. Neave 1912. Morstatt 1913. Jarvis 1918. Robinson 1926. Moreau 1933. Cornell 1936. Reichenow 1941B. Beakbane and Wilde 1949. Wilson 1953. Smith 1955).

SOUTHERN AFRICA: ANGOLA (Neumann 1899,1911. Santos Dias 1950B. Sousa Dias 1950). MOZAMBIQUE (Karsch 1878. Howard 1908. Neumann 1911. Robinson 1926. Theiler 1943B. Santos Dias 1947A,1949E, 1950B,1954H,1955A. Bacelar 1950. Wilson 1953).

NORTHERN RHODESIA (Neave 1912. Robinson 1926. Morris 1933, 1935,1937,1938,1939,1940. LeRoux 1934,1937,1947. Matthysse 1954. Theiler and Robinson 1954). SOUTHERN RHODESIA (Koch 1903. Sinclair 1916. Jarvis 1918. Jack 1921,1928,1937,1942). NYASALAND (Old 1909. Neave 1912. De Meza 1918A,B. Robinson 1926. Wilson 1943,1946,1950B).

[UNION OF SOUTH AFRICA: Absent (Alexander 1931). "Rarely present" (Theiler 1943B). Dr. Theiler (1950 correspondence) states that A. variegatum is actually absent from the Union and from SOUTH-WEST AFRICA. See REMARKS below. Early literature records for this species in the Union of South Africa are: Howard 1908, Galli-Valerio 1909, Moore 1912, Bedford 1920, Curson 1928, Cooley 1934, Bedford and Graf 1939.]

OUTLYING ISLANDS: ZANZIBAR (Neumann 1899,1911. Neave 1912. Aders 1917). MAURITIUS (Neumann 1899,1911. De Charmoy 1914,1915. Robinson 1926. Moutia and Mamet 1947). MADAGASCAR (Neumann 1899, 1911. Joyeux 1915. Robinson 1926. Bück 1935,1948A,C,1949. Bück and Metzger 1949. Millot 1948. Zumpt 1950B. Courdurier, Bück and Quesnel 1952. Hoogstraal 1953E). REUNION (Neumann 1899. Millot 1948. Gillard 1949). COMORES GROUP (Millot 1948).

ARABIA: YEMEN (Franchini 1930. Girolami 1952. Mount 1953. Sanborn and Hoogstraal 1953. Hoogstraal ms.). "SOUTHERN ARABIA" (Hoogstraal 1954C).

IMPORTED SPECIMENS: Records in the literature for EGYPT (Guerin-Meneville 1829-1843), one of the type localities of synonymous Ixodes elegans) should be discounted. Although A. variegatum frequently arrives at the Cairo abattoir on cattle from the Sudan and from other areas of East Africa, the species has never become established here (Hoogstraal 1952A). Extremely few females are found by the time cattle reach Cairo.

A. variegatum has become established and is a serious problem in the WEST INDIES (St. Kitts, Guadeloupe, Antigua). As early as 1895, Barber wrote an account, both pleasant and critical, of the ravages of "the gold tick", A. variegatum (= Hyalomma venustum) in Antigua. See also: Neumann (1899,1911), Ticks in the West Indies (1914), Ford (1919), Saunders (1914A,B,1915,1919), Senevet (1938), and Mauze and Montigny (1954). It appears that A. variegatum has been found in GUATEMALA (Neumann 1899,1911), but there have been no subsequent reports of its presence there. There has been some question about West Indies records among American workers who have not visited these islands. Numerous specimens from West Indies may be seen in British Museum (Natural History) collections.

Three males are stated to have been found on a dog in southwestern FRANCE (Lamontellerie 1954).

MISCELLANEOUS: The distributional map of Tendeiro (1947) which includes Egypt and Sinai and omits the Sudan and parts of Ethiopia, Eritrea, and the Somalilands, should be modified.

TUNIS has been listed as a collecting locality based on specimens labelled from a hedgehog on Djerba Island collected by A. Weiss (Galli-Valerio 1911A). Colas-Belcour and Rageau (1951), with ample reason, consider this record doubtful. It may be based on misidentification of an immature Hyalomma sp.

HOSTS

Where it occurs, A. variegatum is often the most common tick on cattle. Its incidence on other domestic animals varies locally but is usually less than on cattle. Among wild animals, the buffalo and numerous kinds of antelopes are important hosts. Other wild animals are either rather seldom infested by adults or those that more frequently harbor them, such as the rhinoceros, generally are not numerous in nature. Carnivores are only exceptionally attacked. Man is rarely utilized as a host by adults, though nymphs attach more frequently and larvae are sometimes serious pests. Our knowledge of the host preference of immature stages is fragmentary. Nymphs feed on moderate size to large animals including all domestic animals and larvae attack mostly birds and small mammals from the size of hares to goats.

Adult Hosts

Domestic animals: Cattle (Practically every reference in the DISTRIBUTION section above pertains to parasitism of cattle by *A. variegatum* and these need not be repeated here. Selected references to parasitism of other domestic animals are presented below inasmuch as many phases of these relationships are much less obscure than those with cattle). Camels (Robinson 1926*. Hoogstraal, ms.). Sheep (Robinson 1926, Schwetz 1927C, Daubney 1930A, Daubney and Hudson 1931A,B,1934, Lewis 1931C,1932B,1934, Tendeiro 1948, Rousselot 1951, Sudan records above). Goats (Robinson 1926, Schwetz 1927C, Lewis 1934, Beaton 1939**, Tendeiro 1948, Sudan records above). Horses (Simpson 1911, Robinson 1926, Schwetz 1927B,

---

*Hosts listed by Robinson (1926) are based chiefly on the extensive data in the Nuttall collection now in British Museum (Natural History), where it is available to those who would make a further study of host-relationships.

**Though pinpoint blemishes in the tanned skins of goats are attributed by the (Nigerian) trader to the bites of ticks, this animal has been found to remain uncommonly free of ticks, particularly in the dry season. In the rains, when all domestic animals become grossly infested if not hand dressed, the goat is usually only parasitized by .... *A. variegatum* and then to any extent only in the hollow of the heels, the clefts of the hoof, and in the perineum. These exceedingly tenacious parasites set up a local inflammation with pus formation due to infection of the wound by organisms of necrosis, particularly in the feet. Severe lameness may be caused, and virus diseases, e.g., heartwater may be transmitted. (Beaton 1939).

Bück 1935,1948A,C, Gillard 1949, Rageau 1951, Rousselot 1951, Sudan records above). Donkeys (Robinson 1926, Tendeiro 1948, Rousselot 1951, Sudan records above). Dogs (Simpson 1912B, Robinson 1926, Tendeiro 1948, Sudan records above. BMNH collections contain four adults from a dog from Senegal). Cat (Robinson 1926). Pigs (Schwetz 1927A, Lloverol, Philippe and Adjovi 1942, Rousselot 1951, Sudan records above).

Man: In Madagascar and French West Africa (Joyeux 1915).

Antelopes: Reedbuck (Robinson 1926*, Weber 1948, Wilson 1950B, Santos Dias 1953B). Bushbuck (Robinson 1926). South African bushbuck (Santos Dias 1953B). Steinbuck (Lewis 1932A). Waterbucks, various (Robinson 1926, Tendeiro 1952C, Santos Dias 1953B). Roan antelope, various (King 1926, Lewis 1934, Sudan records above). Sable antelope (Robinson 1926, Wilson 1950B, Santos Dias 1953B). Hartebeest, various (Simpson 1914, Robinson 1926, Lewis 1934, Sudan records above). Kongoni (Robinson 1926). Tiang (Sudan records above). Eland, various (Robinson 1926, Bequaert 1930B,1931, Lewis 1934, Weber 1948, Wilson 1950C, Sudan records above). Nyala (Santos Dias 1953B). Duiker (Loveridge 1936A, Wilson 1950B, Sudan records above). Grant's gazelle (Lewis 1934). Bright's gazelle, Smith's long-snouted dikdik, and Roosevelt's duikerbok (Sudan records above). Oribi, various (Wilson 1950B, Santos Dias 1953B, Matthysse 1954, Sudan records above).

Other mammals: Giraffe (common on many Bahr El Ghazal giraffes examined, records above). Zebra (Neumann 1911, Robinson 1926*, Lewis 1932A,1934, Weber 1948, Matthysse 1954). Black, or narrow-lipped rhinoceros (Karsch 1878, Neumann 1911, Robinson 1926, Lewis 1932A, Wilson 1951C). White, or square-lipped rhinoceros (Tonelli-Rondelli 1930A). Elephant (Robinson 1926). Buffalo (King 1926, Robinson 1926, Richardson 1930, Bequaert 1930B, 1931, Fiasson 1943B, Wilson 1950C, Rageau 1951, Santos Dias 1953B, Sudan records above). Warthog (Massey 1908, Robinson 1926, Santos Dias 1953B, Sudan records above). Bushpig (Tonelli-Rondelli 1930A, Matthysse 1954, Sudan records above). Antbear (Lewis 1932A). Leopard (captive) and hares (Tendeiro 1947,1952C). Cheetah (Lewis 1934). Lion (Theiler, unpublished).

---

*Hosts listed by Robinson (1926) are based chiefly on the extensive data in the Nuttall collection now in British Museum (Natural History), where it is available to those who would make a further study of host-relationships.

Birds: Spurwing geese (tick identification questionable: Bedford 1932B). Gray hornbill (*Lophoceros n. nasutus*) and ground hornbill (*Bucorvus abyssinicus*), domestic and wild chickens, spurfowl, guineafowl (Tendeiro 1947,1948,1952C).

Snake: *Bitis arietans* (Neumann 1911).

Snail: A curious case, said to be parasitism by *A. variegatum* on a snail, *Limicolaria adansoni* Pfr., in Senegal, has been reported by Neumann (1911) and by Andre and Lamy (1931). This record bears further investigation.

Nymphal Hosts

Nymphs feed on a great variety of mammals of medium and large size, including occasionally man. Birds are frequently parasitized but reptiles are rarely attacked.

Man: In French West Africa, nymphs do not attack man so frequently as do larvae (Joyeux 1915). In the Sudan a single nymph was taken feeding on man in Equatoria and several in Bahr El Ghazal Province.

Domestic animals: Nymphs are common on domestic stock in Kenya (Lewis 1934). Survey of our Equatoria and Bahr El Ghazal Province records above shows a small number of nymphs on cattle and often many on goats, especially during the dry season. Few were found on other domestic animals, pigs, horses, dogs, and sheep. Sudan Government collections contain nymphs from cattle, sheep, goats, dogs, pigs, donkeys, and horses. Tendeiro (1948) listed cattle and goats as nymphal hosts. Among a collection from Madagascar, Zumpt (1950B) found nymphs from cattle and dogs. Theiler (correspondence) has specimens from elsewhere in Africa from the same animals as well as from camels and domestic cats. Poultry has been listed as a nymphal host by Wilson (1950B), Tendeiro (1948), Hoogstraal (1953E), and we found this stage on chickens and turkeys in the Sudan (records above). Daubney and Hudson (1931A,B,1934) referred to the comparative rarity of immature stages on sheep in Kenya. Fiasson (1943B) noted immature specimens on sheep at Libreville.

Wild mammals: Insectivores: Hedgehog (Wilson 1950B, Sudan record above). Madagascar tenrec (Hoogstraal 1953E). Carnivores: Jackal (Neumann 1902B, Lewis 1934, Matthysse 1954, Sudan records above). Cheetah (Wilson 1950B). Long-eared fox, Otocyon megalotis (Lewis 1934). Spotted hyena and mongoose (Sudan records above). Lagomorphs: Hares (Wilson 1950B, Matthysse 1954, Sudan record above). Rodents: Cane rat (Wilson 1950B, Bahr El Ghazal record above). Ground squirrel (Sudan record above). Antelopes: Hartebeest, Thomson's gazelle, klipspringer (Lewis 1934). Western defassa waterbuck (Tendeiro 1947). Waterbuck in Uganda and "forest antelope" from Rio Muni (HH collection). Oribi (Hoogstraal 1954C, Sudan record above). Sudan records are from Bright's gazelle, Roosevelt's duikerbok, Smith's long-snouted dikdik, oribi, common eland, Roosevelt's hartebeest, tiang, and buffalo. Nymphs are especially numerous on tiang in Bahr El Ghazal Province during the dry season. In Northern Rhodesia, Matthysse (1954) found all stages on zebras.

Wild birds: Coucals, various (Theiler, unpublished. Hoogstraal 1953E). Ground hornbill, Bucorvus abyssinicus (Warburton 1927). Raven (Hoogstraal 1954C). Spurfowl (Pternistis sp. or Francolinus sp.) (Lewis 1934, various Sudan records above). Long-legged bustard and hooded vulture (Theiler, unpublished). Guinea fowl (Lewis 1934 and Sudan records above). Abdim's stork, lesser bustards, tchagra shrike (Sudan records above). An undetermined passerine bird (arveola) (Tendeiro 1952C). For domestic birds, see Domestic animals above.

Reptiles: Chameleon in Madagascar (Hoogstraal 1953E).

Larval Hosts

Man has been listed as a larval host by Wilson (1950B). Larvae commonly attack man at the beginning of the dry season in Upper Guinea, French West Africa (Joyeux 1915). In Cameroons they are serious pests of man (Rageau 1953B) and attach on the legs and about the belt. Ziemann's (1912B) mention of being badly bitten by tick larvae in the Cameroons may refer to this species. According to De Meza (1918A), in Nyasaland larvae are serious pests of people working about cattle. Larvae just visible to the eye burrow under the skin of human legs and cause severe irritation that may be associated with rash and pus if the ticks are numerous.

Birds: Spurfowl (*Pternistis* sp. or *Francolinus* sp.) (Lewis 1932B). Helmeted guinea fowl (Lewis 1934). "Rural chickens" (*galinha do mato*) (Tendeiro 1952C). Lesser bustard (Sudan record above).

Mammals: Hare (Lewis 1934). Reedbuck (Lewis 1931C). Zebra and jackal (Matthysse 1954). Genet, jackal, and mongoose (Sudan records above). Domestic goat (Lewis 1934, Sudan record above) and cattle (Lewis 1931C, Sudan record above). Domestic dog in Madagascar (Hoogstraal 1953E).

Stage not stated but probably immature

Hedgehog (*Atelerix spiculus*) and gerbil (*Taterillus gracilis angelus*) (Pearse 1929). Hedgehog (*Atelerix albiventris* Wagner) (= *A. adansoni* Roch.) and white-tailed mongoose (*Ichneumia albicauda*) (Rousselot 1951).

BIOLOGY

Life Cycle

This three-host tick is frequently the most common cattle parasite within its range. Hosts of each stage are listed above. Most workers have experienced difficulty in rearing *A. variegatum* but J. B. Walker states (correspondence) that she finds this species quite easy to rear. With nonfeeding ticks maintained at from 25°C. to 27°C., the minimum periods for the life cycle are as follows:

PERIOD	DAYS (Minimum)		
	Walker	Lewis 1932A	Lewis 1939B
Preoviposition	12	18 (24-27°C)	
Oviposition to hatching	53	86 (19-26°C)	
Larval prefeeding period	7	7	
Larva feeds	5	7	5-8
Premolting period	14	22 (25-27°C)	
Nymphal prefeeding period	7	7	
Nymph feeds	5	7	6-13
Premolting period	19	24 (24-27°C)	
Adult prefeeding period	7	7	
Adult (Female) feeds	12	10	14-22
Total	141	195	-

The prefeeding periods in the above table are arbitrary and in nature may be shorter than the figures indicate. Walker fed larvae and nymphs on a rabbit and adults on a ram. Lewis (1932A) used hares, chickens, and sheep as hosts.

Nuttall (1915) recorded attachment periods twice as long as Lewis' and stated that males may remain on the host for from four to eight months, and may even die there. At 30°C., larvae emerge from eggs after sixteen to 31 days; at 15°C. larvae fail to hatch.

On the other hand, Mettam (1933) reported that in his Uganda laboratory "times occupied during feeding, molting, etc. are much shorter than the one obtained by .... Lewis", but these observations apply only so far as the nymphal stage.

Larvae feeding on man drop off the host after twelve hours (Joyeux 1915).

Under laboratory conditions, the longevity of A. variegatum (? unfed adults - HH) is 732 days (Lewis 1939B).

In those parts of its range with but one rainy season annually, the tropical bont tick has only a single generation a year, as reported for Nyasaland by Wilson (1950B) and for Northern Rhodesia by Matthysse (1954). In Kenya and Uganda, with two rainy periods each year, multiplication is faster and two or three generations may breed during a twelve months' period (Wilson 1953).

Females engorge and oviposit during the wet months, larvae engorge early in the dry season, and nymphs live through the dry season. The periods of preoviposition and embryonic development in nature should be more carefully investigated. A delay or diapause phenomenon of some three months or more for these combined periods in the rainy season appears likely.

Ecology

The typical seasonal cycle, as explained for Northern Rhodesia by Matthysse (1954), applies to the Sudan and other single rainy season areas of Africa. Details for other areas with two rainy seasons are not certain, and there appears to be more overalpping of different stages in such situations. Adults appear towards the end of the dry season, first males and then females. Populations increase in numbers and remain high through the rainy season and decrease rapidly in the dry season, although a few specimens may be found even then. Larvae and nymphs gradually become more numerous in the dry season, and while some nymphs are found during the rains they are scarce.

Adults and nymphs are most common on the udders, scrotum, flanks, dewlap, and brisket; larvae feed on the ears and head of the host (Wilson 1948B,1949). Beakbane and Wilde (1949) also noted adults on the perineum and indicated means of control with respect to the feeding sites of ticks infesting cattle.

In Cameroons, larvae of this tick have been observed in immense numbers on tall herbage along paths, waiting for a suitable host to pass (Rageau 1953B). Similar, vivid remarks by Ziemann (1912B) for Cameroons suggest that his observations may also have referred to A. variegatum.

"The fully fed female of A. variegatum works her way into the soil to lay her eggs, and unfed adults are frequently seen, waiting for a passing host on the foliage of bushes three or four feet high" (Lewis 1934).

A. variegatum has been found from sea level to 8500 feet elevation. In the Yemen (Arabia), this species is common on cattle in well vegetated valleys and hillsides between 2500 and 5000 feet elevation, but absent in deserts at lower elevations and rare in more barren higher elevations (Hoogstraal, ms.). Franchini's (1930) record of A. variegatum from Hodeida, on Yemen's coastal plain, is due either to erroneous locality labels or represents specimens from highland cattle arriving for slaughter. This species is common at Asmara, Eritrea, 7500 feet elevation (HH collecting), but Schoenaers (1951B) states that it does not occur over 2000 meters (6500 feet) elevation in Ruanda-Urundi.

In East and Central Africa, Wilson (1953) has nicely defined the presence of two very distinct ecological relationships between ticks and cattle. One of these, the R. appendiculatus-A. variegatum association, occurs in areas with rainfall well above 25 inches per annum (and is of considerable importance in relation to East Coast fever and heartwater transmitted to cattle by the respective ticks). The second, the R. pravus (= R. neavi)-A. gemma association, occurs where rainfall very seldom exceeds twenty or 25 inches per annum (and is of negligible veterinary importance). For a summary of Wilson's second association, see R. pravus (page 681).

The distribution of the R. appendiculatus-A. variegatum association corresponds to what veterinarians previously referred to as "dirty areas" (i.e. East Coast fever endemic areas). As stated above, rainfall here is at least 25 inches annually, usually well above this figure, and falls below this level only once in every twenty or 25 years. This association includes the highlands of Kenya and Tanganyika, a 25 to thirty mile belt bordering Lake Victoria in Kenya, Uganda, and Tanganyika, and continues down the Rift Valley in the country adjacent to Lake Tanganyika and Lake Nyasa, and (a short distance) into Mozambique. It also includes the humid seacoast plains, which are only a few miles wide in Kenya but much wider in Tanganyika. Within drier areas (i.e. those of the first association) are isolated islands in the "rain shadow" of hills and mountains where higher precipitation results in more dense vegetation than that of the surrounding plains. In these islands, the R. appendiculatus-A. variegatum association persists. The soil and vegetation on which this association occurs vary tremendously with slope of terrain, altitude, underlying rock formation, and temperature. The single common factor in their ecology is relatively high rainfall. Within their areas of distribution, these ticks vary in relative prevalence and density, due in part to approaching thresholds or extremes within the range of tolerance. A very definite line of demarcation, uneffected by the movement of cattle along trade routes, exists between these two zones.

Huts of pastoral peoples in which cattle and other domestic animals frequently rest harbor the tropical bont tick. Smith (1955) noted its presence in human habitations and a similar situation may have accounted for Robinson's (1912) remarks concerning parasitism on children by the so called variety nocens.

The red-billed oxpecker or tickbird, Buphagus e. erythrorhynchus (Stanley), which attends all the larger herbivores except the elephant and the hippopotamus, has been shown by Moreau (1933) to be a predator of some importance on A. variegatum and other economically important ticks. Of the 58 tickbirds examined in Tanganyika, 186 specimens of A. variegatum were found in the stomach contents of sixteen; the number of ticks per stomach ranged from one to 109.

In Kenya, van Someren (1951) took specimens of the tropical bont tick from stomachs of a few of the same birds that he examined. He also found unidentified ticks in Tanganyika birds, B. a. africanus. van Someren's interesting biological study of the red-billed oxpecker includes observations on the birds' habit of irritating sores on domestic animals.

Buphagus erythrorhynchus and B. africanus subspp. range through African savannahs and frequently are seen clinging to the flanks or legs of domestic and wild animals. Lang (1924) noted the tickbird acting as a sentinel for elands. Loveridge (1928) reported specifically unidentified ticks in stomachs of Tanganyika tickbirds and Dr. J. P. Chapin found ticks in their stomachs in the Congo and in Kenya (Bequaert 1930B). I am told that the best account of tick-eating habits of these birds is quoted in Bannerman's Birds of Tropical West Africa (Volume 6, page 105).

Assertions that the white heron, or cattle egret, Bubulcus spp., is a tickivore are not supported by evidence. Dr. Chapin found no ticks in cattle egret stomachs and their actions do not indicate that they commonly feed on these parasites (Bequaert 1930B, Plowes 1950). In Southern Rhodesia, "Egret" (1938) reported, these birds may pick grasshoppers off grazing cattle but do not search for ticks on them. Colleagues and I have found no ticks in stomachs of many cattle egrets examined in Africa and elsewhere and Kirkpatrick (1925) found none in stomachs of many Egyptian birds of this type.

REMARKS

Special attention is called to the taxonomic and biological status of heavily punctate specimens of *A. variegatum*, discussed under *A. pomposum* (page 245).

Remarks by Theiler (1951 correspondence) are of value in understanding distributional factors of this species and in illustrating the care that must be taken in evaluating older literature. She writes: "..... statements made (Theiler 1943B), to the effect that this species is found in the Union of South Africa, were based on records in the literature, i.e. before we had studied the South African tick survey material ..... Our abundant material did not produce one specimen from anywhere in the Union or in South-West Africa. Bedford's statements are based on incorrectly identified nymphal material. Robinson's record in the Monograph, I take to be a record of an introduction into the country, which certainly has not been able to maintain itself. Nor does *A. variegatum* seem to be as widely spread in Southern Rhodesia as one gathered from some of the earlier workers. On the contrary, *A. hebraeum* seems to be more prevalent than was first thought. When reading reports of earlier workers (1896-1906), one must bear in mind that they are still reporting on a period during which cattle had been, or were being, introduced from East Africa and from Madagascar, bringing *A. variegatum* and *Boophilus fallax* with them. Possibly some of these ticks come into areas in which they could maintain themselves for a year or two, or possibly even longer."

Brumpt (1922,1934) reported on gynandromorphic specimens of *A. variegatum*. Malformed specimens have been noted by Santos Dias (1949E,1955A), and Tendeiro (1951F). Certain aspects of the chitinization of the exoskeleton and gut and of the musculature of this species have been discussed by Ruser (1933). *A. variegatum* has been used to illustrate the double oblique-striation of tick musculature by Kruger (1935). Variations in scutal ornamentation among specimens from a restricted area were illustrated by Tendeiro (1949B,1951F). The eye structure and related sense organs were described and illustrated by Gossel (1935).

DISEASE RELATIONS

MAN and ANIMALS: Q fever (*Coxiella burnetii*). Larvae and nymphs commonly attack man under local conditions and may cause severe irritation.

CATTLE: Heartwater (*Rickettsia ruminantium*). Bovine lymphangitis, large septic sores, and severe inflammation of mammae. Possibly transmits a fungus, *Cryptococcus* (= *Actynomyces*) *farciminosus*.

A. variegatum has been mentioned in connection with bovine rickettsiosis (*Rickettsia bovis*), but the tick's role does not appear to have been defined. This tick does not transmit East Coast fever (*Theileria parva*).

SHEEP: Nairobi sheep disease (virus). Heartwater (*R. ruminantium*).

GOATS: Heartwater (*R. ruminantium*). Severe secondary infection and lameness.

PIGS: Possibly a vector of porcine piroplasmosis (*Babesia trautmanni*).

WILD ANIMAL INJURY: In the Sudan I removed a live nymph from a thigh abscess that was almost completely overgrown by the skin of the jackal host.

IDENTIFICATION

Males: There is no question of identity of this important species in the Sudan tick fauna or throughout most of its range. The combination of characters including hemispherical, orbited eyes, long lateral grooves, entirely black festoons, and paucity of large scutal punctations easily distinguishes *A. variegatum*. The scutal ornamentation is as illustrated (Figure 92) except that in about five percent of specimens an additional coppery spot may be found just inside (not outside) of the lateral grooves at the level of the scutal midlength. Specimens with these spots are readily distinguished from *A. lepidum* and *A. pomposum* by their dark festoons and lack of large scutal punctations.

Note: According to Jack (1942) males from eastern parts of Southern Rhodesia approach *A. pomposum* in that they have coarse scutal punctation. No females were available for comparison. A few confusing specimens such as these from the Sudan, East Africa, and Yemen (Arabia) have been observed (See IDENTIFICATION of *A. pomposum*, page 245).

Females: This sex is sometimes more difficult to identify with certainty than the male. Hemispherical, orbited eyes are also found in *A. lepidum* and *A. pomposum*. In the latter, the very rugose, broad, short scutum easily separates it. The posterior margin of *A. variegatum* is comparatively more broadly rounded than that of *A. lepidum*. One may have considerable difficulty in deciding whether a female scutum is widely or narrowly pointed posteriorly. There appears to be some variation in this character, but a thorough study has been impossible because, in all available collections, no more than eighty female specimens of *A. lepidum* have been seen. No large series from any single area has been represented and until such time as more material comes to hand it is preferable to hold the study of this feature in abeyance.

APONOMMA

INTRODUCTION

African Aponomma ticks, small, eyeless parasites of large snakes and of monitor lizards (Varanus spp.), are seldom represented in collections. They are markedly host-specific and rarely feed on animals other than their normal hosts.

Originally considered as Amblyomma, species of the genus Aponomma are now treated as a separate generic offshoot from Amblyomma. In this genus the eyeless condition is considered by some to have resulted from disuse since certain members feed under the host's scales. Parallel instances also occur among those Amblyomma ticks that have indistinct or vestigial eyes and that parasitize scaly hosts. This interpretation might hold for those Aponomma species that attach below snakes' scales but may hardly account for the eyeless condition of others attacking only scaleless lizards. Possibly Aponomma ticks became adapted to lizards as a concomitant to the loss of vision.

The biology of aponommas is poorly known. Adults and nymphs are frequently found on the same host.

The nomenclature of the few African species has been confused until the recent works of Theiler (1945A,B). Most African specimens are now easily identified to species. More recently, Santos Dias (1955C) has redescribed the type material of A. ochraceum Neumann, 1901, from Tanganyika and Zanzibar, and of A. fraudigerum Schulze, 1935, from a host, Varanus griseus, presumed to have come from North Africa.*

---

*V. griseus ranges over the entire northern Sahara region, reaching the Mediterranean only in southern Tunisia, Libya, and Egypt, and extends to the Central Provinces of India (Loveridge, correspondence). The source of the type material of A. fraudigerum, Fuhlsbüttelterrarium, probably refers to the grounds of an animal dealer at Fuhlsbüttel, a suburb of Hamburg, and the collector, Karl Peter, is probably not the famous African explorer but rather the animal dealer (Theiler, correspondence).

Aponomma species are more numerous in the Oriental Region than in Africa but their taxonomic status is uncertain. For Indo-china, Toumanoff (1944) lists three species, Anastos (1950) records four from Indonesia, and Roberts (1953) studied nine from Australia. None occur in Europe and Neumann's (1899) locality label for *A. laeve* from Patagonia was possibly incorrect. In the Americas, four species have been described by Schulze (1932A,1936E,1941X) but specimens available in collections throughout the world are few indeed. Specific concepts in this genus are much in need of careful study.

KEY TO SUDAN SPECIES OF *APONOMMA*

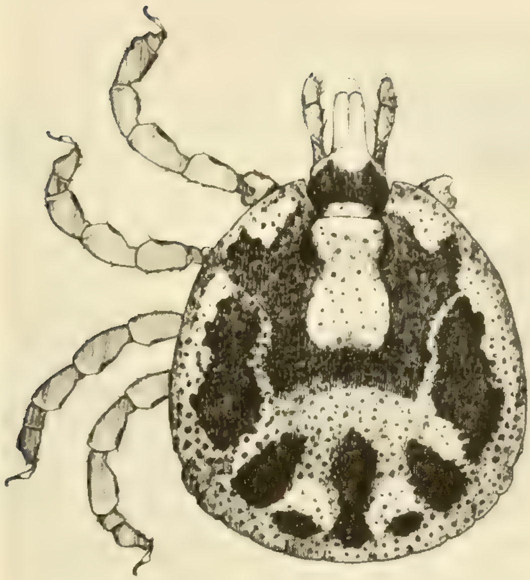
MALES AND FEMALES

Shiny dark brown with green or copper markings on scutum. (Usually on *Varanus* lizards).....................................*A. EXORNATUM*
Figures 96 to 99

Light to dark brown with no markings on scutum. (Usually on snakes)..........................*A. LATUM*
Figures 100 to 103

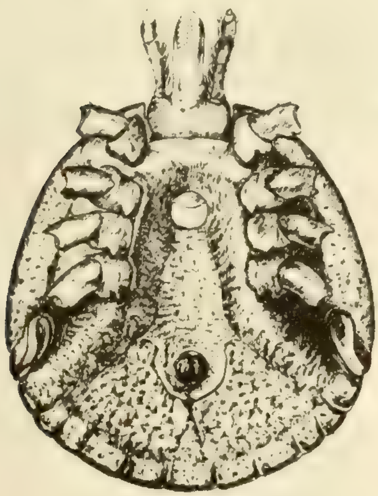
NOTE

Ornamentation of *A. exornatum* is entirely lost in some preserved specimens. If a question arises, *A. exornatum* males may be separated from those of *A. latum* by the presence of well-marked festoons (inconspicuous in *A. latum*), numerous large punctations (almost none in *A. latum*), and deep, inverted, commashaped cervical grooves (obsolete in *A. latum*). The last character also separates females of these species.

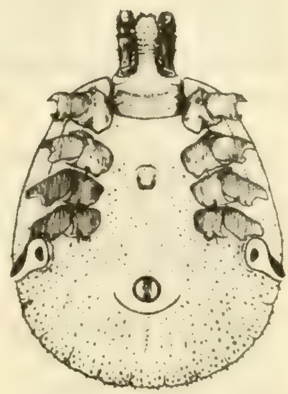


96

98



97



99

APONOMMA EXORNATUM
Sudan specimens, with exceptionally bright ornamentation

PLATE XXXII

APONOMMA EXORNATUM (Koch, 1844).

(Figures 96 to 99)

THE MONITOR LIZARD TICK.

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
	2	1	2	Yei	Varanus n. niloticus	Apr	
			2	Torit	Varanus n. niloticus	Dec	
		1	6	Torit	Varanus n. niloticus	Jan	(2)
		2	2	Khierallah	Varanus n. niloticus	-	(SGC)
	7	2	13	Torit	Varanus e. exanthematicus	Aug	
	2	1	2	Nimule	Varanus sp.	Aug	(BMNH)

Equatoria Province (King 1926). The British Museum (Natural History) specimens from Nimule are in Nuttall lot 1427.

DISTRIBUTION IN THE SUDAN

The following additional material, all from Varanus lizards, has been seen:

Upper Nile: Er Renk (SGC).

Blue Nile: Singa (SGC). Hassa Heissa [Specimens not seen but identified by G. M. Kohls (G. B. Thompson, correspondence)].

Kassala: Butana (SGC).

Kordofan: Khuwei, from V. e. exanthematicus; specimens in HH collection; presented by Sudan National Museum.

[Khartoum: Khartoum (SGC; probably from lizards in zoological gardens).]

DISTRIBUTION

The distribution of A. exornatum is the same as that of African Varanus lizards* (Theiler 1945A). To the best of my knowledge, V. griseus is seldom or never infested by this species (for range of this lizard see page 279).

NORTH AFRICA: ALGERIA (Neumann 1899,1911. Theiler 1945A).

WEST AFRICA: NIGERIA (Northern part, Simpson 1912A). FRENCH WEST AFRICA (As Ixodes flavomaculatus: Lucas 1846. Neumann 1899, 1911. Tonelli-Rondelli 1932E. Theiler 1945A. Rousselot 1951, 1953B. Villiers 1955). PORTUGESE GUINEA [As Aponomma sp.: Tendeiro (1947). As A. halli sp. nov. (nomen nudum): Tendeiro (1948). Described by Tendeiro (1950). Also noted by Tendeiro (1951C,D,1952A,C,D,1953,1954**). See IDENTIFICATION below and Hoogstraal (1954B)]. GOLD COAST (Hoogstraal 1954C).

CENTRAL AFRICA: FERNANDO PO (Schulze 1943B, p. 131 footnote). CAMEROONS (Ziemann 1912A. Rageau 1953A,B). FRENCH EQUATORIAL AFRICA (As A. arcanum: Karsch 1879A. Schulze 1936E. Specimens in CNHM, cf. HOSTS below). BELGIAN CONGO (Neumann 1911. Nuttall and Warburton 1916. Schwetz 1927A,B,C,1932. Bequaert 1930B,1931. Fain 1949. Theiler 1945A. Theiler and Robinson 1954).

NOTE: According to Theiler (correspondence), the record for Ruanda-Urundi by Santos Dias (1954D) is in error.

EAST AFRICA: SUDAN (King 1911,1926. Hoogstraal 1954B).

---

*V. n. niloticus is a widely ranging savannah form. Another subspecies, ornatus, occurs in West African rainforests. V. e. exanthematicus ranges from Senegal to the Sudan. In Ethiopia, the Somalilands, and Mozambique, V. e. microstictus (= V. ocellatus) occurs. In Mozambique south of Zambesi, Angola, and southern Africa, V. e. albigularis occurs. [Loveridge, correspondence]

**Tendeiro (1951D) also noted an "unnamed Aponomma species" from the same hosts in Portugese Guinea.

ERITREA (Tonelli-Rondelli 1930A. Stella 1940). FRENCH SOMALILAND (Neumann 1899,1922. Stella 1938A,1939A). ITALIAN SOMALILAND (Paoli 1916. Stella 1938A,1939A,1940). KENYA (Loveridge 1923B, 1936B. Lewis 1932A. Theiler 1945A. Heisch 1954G). UGANDA (Bruce et al 1911. Mettam 1932. Theiler 1945A). TANGANYIKA (Loveridge 1923D. Barbour and Loveridge 1928. Bequaert 1930A. Theiler 1945A).

SOUTHERN AFRICA: ANGOLA (Neumann 1899. Gamble 1914. Santos Dias 1950B. Hoogstraal 1954C). MOZAMBIQUE (Santos Dias 1947D, 1948A,1953A,B. Bacelar 1950. Tendeiro 1951B,F).

NORTHERN RHODESIA (Theiler and Robinson 1954). SOUTHERN RHODESIA (Jack 1942). NYASALAND (Neave 1912. De Meza 1918A. Wilson 1950B).

BECHUANALAND (Theiler 1945A). SOUTHWEST AFRICA (Tromsdorff 1914. Sigwart 1915. Warburton 1922. Theiler 1945A). UNION OF SOUTH AFRICA (Koch 1844. Lewis 1892. Neumann 1899. Howard 1908. As *A. neglectum*: Hirst and Hirst 1910. Dönitz 1910B. Curson 1928. Bedford 1932B,1936. Theiler 1945A).

[MADAGASCAR: Neumann (1901). Howard (1908). Poisson (1927). Bedford (1932B). Bück (1948A). Millot (1948). Zumpt (1950B). These records appear to be a repetition of Neumann (1901). The presence of this species on Madagascar is questionable (Hoogstraal 1953E).]

HOSTS

Most investigators list only the lizards *Varanus niloticus* subspp. and *V. exanthematicus* subspp. as hosts. These are sometimes called warrener or leguan lizards by the British in Africa. References to "iguana" lizards in Africa pertain to *Varanus* but iguanas are actually New World species.

Other animals may be parasitized occasionally. Records, among mammals, are domestic dogs (Howard 1908, Neumann 1914), pangolin, *Manis tricuspis* (Fain 1949), fruit bat (Hoogstraal 1954C), ground squirrel (Villiers 1955), and a larva and nymph from a spiny-tailed squirrel, *Anomalurus f. fraseri*, in French

Equatorial Africa (CNHM). Reptiles reported to be attacked are crocodile (Schwetz 1927B, Villiers 1955), cobra (Loveridge 1923C), tortoise (Loveridge 1936B), python (Howard 1908), tortoise and snakes (Mettam 1932), snake (Theiler 1945A), and blind lizard, Acontias plumbeus (Bedford 1936). A bird, the black-chested harrier eagle, is also known as a host (Theiler, unpublished).

BIOLOGY

Aside from remarks in the generic introduction and host review, nothing additional has been reported for this species.

DISEASE RELATIONS

It is of interest to conjecture that these ticks may transmit the hemogregarines so frequently found in reptiles.

It is claimed that natural infections of Q fever (Coxiella burnetii) have been found in this species.

REMARKS

A complete summary of the taxonomy, morphology, and distribution of this species has been presented by Theiler (1945A). Malformed specimens have been described by Santos Dias (1948A), Schulze (1950B), and Tendeiro (1951B). Schulze (1943B) discussed certain aspects of the nymphal gut of this species, and (1941) features of the haller's organ, and (1950B) of the dorsal foveae and festoons.

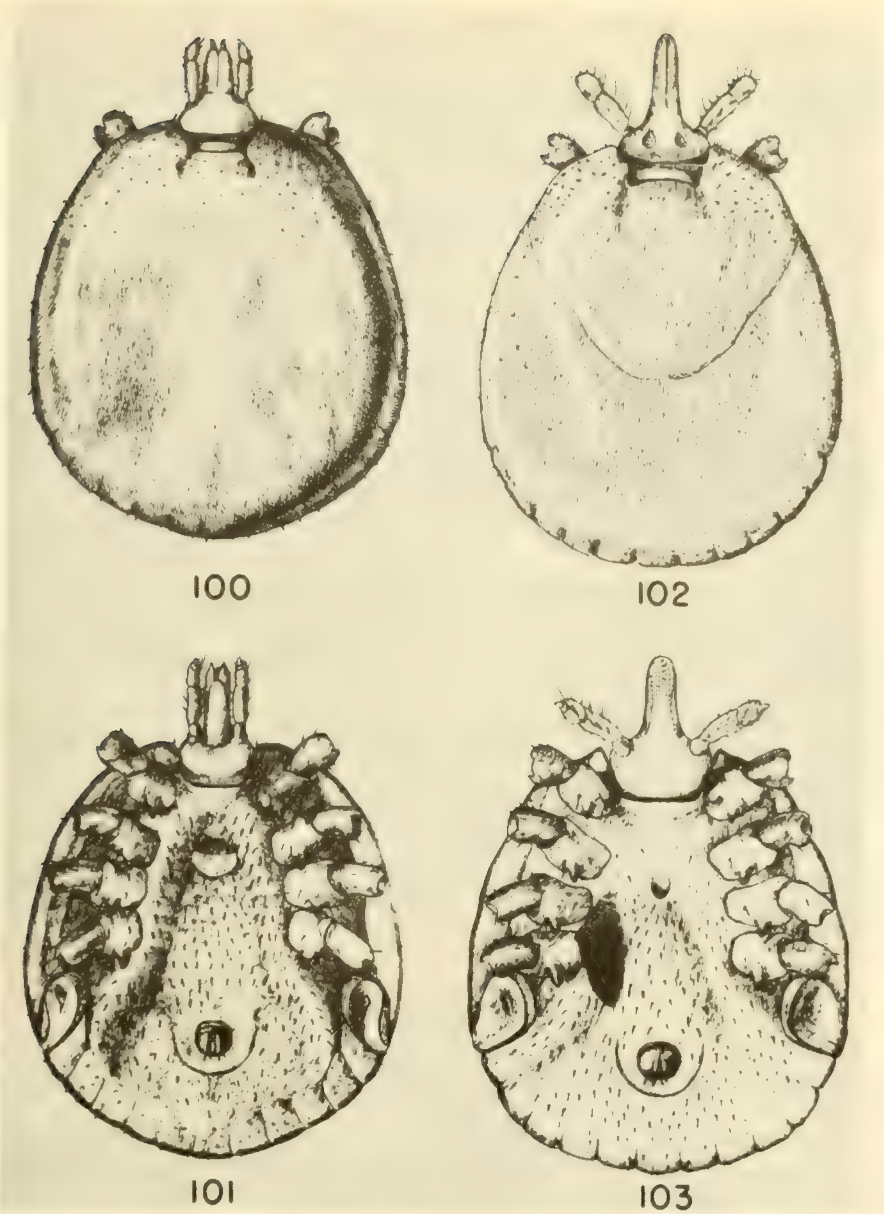
Should male specimens with only narrow lateral ornamentation be found, the presence of A. ochraceum Neumann, 1901, or of A. fraudigerum Schulze, 1935, should be considered (cf. Theiler 1945A and Santos Dias 1955C for descriptions and illustrations).

Tendeiro (1948) mentioned A. halli sp. nov., without description (i.e. a nomen nudum) and (1950) described as A. halli sp. nov. specimens from Portugese Guinea that conform to all specimens studied from the Sudan. The first coxal spur is single; there is a protuberance on the fourth tarsus; and the scutal ornamentation is somewhat different from that usually described for this species (compare with Theiler 1945A description and illustration). However, Theiler (correspondence), who has had more experience with this genus in Africa than anyone else, writes: "*A. halli* .... to me, is but an extreme variation of *A. exornatum*, being as far as I can see, the exact replica of *A. arcanum* Karsch, 1879". In view of this opinion and with Dr. Theiler's permission, *A. halli* Tendeiro, 1950, has been synonymized under *A. exornatum* (Koch, 1844) (Hoogstraal 1954B).

IDENTIFICATION

Theiler (1945A) described and illustrated the immature stages and redescribed the adult stages of *A. exornatum*.

Males and *females* are easily identified by generic characters plus the presence of scutal ornamentation consisting of green or coppery markings on the shiny dark brown surface. Other characters are mentioned in notes under the key to this genus.



Figures 100 and 101, ♂, dorsal and ventral views
Figures 102 and 103, ♀, dorsal and ventral views

<u>APONOMMA</u> <u>LATUM</u>
Sudan specimens

PLATE XXXIII

APONOMMA LATUM (Koch, 1844)(= A. LAEVE Neumann, 1899, of authors).

(Figures 100 to 103)

THE SNAKE TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	2	1	3	Torit*	Naja melanoleuca	Dec
		1	1	Torit	Naja haje	Dec
		3		Torit	Python regius	Nov
			2	Torit	Dendroaspis p. polylepis	Jan
			1	Katire	Boaedon l. lineatus	Sep (CNHM)

DISTRIBUTION IN THE SUDAN

Equatoria and Upper Nile: Without locality data (King 1926).

Bahr El Ghazal: Galual-Nyang Forest, Naja haje, 1953, collected by H. Hoogstraal and R. E. Kuntz. Same locality, from "cobra", 1953, (SVS). Yirol, from "python", 1954, E. T. M. Reid legit. Specimens in HH collection.

Upper Nile: Kenisa, Nasir, and Er Renk, from cobras, 1909, H. H. King legit (SGC).

DISTRIBUTION

The snake tick is distributed throughout the Ethiopian Faunal Region.

WEST AFRICA: NIGERIA (Hoogstraal 1954C). LIBERIA (Bequaert 1930A). FRENCH WEST AFRICA (Villiers 1955). SIERRA LEONE (Entomological Report 1916). GOLD COAST (Curson 1916). PORTUGESE GUINEA (Tendeiro 1951C,D,1952C).

---

*Torit snake collections have been studied by Loveridge (1955).

CENTRAL AFRICA: CAMEROONS (Rageau 1953A,B). FRENCH EQUATORIAL AFRICA (Fiasson 1943B). BELGIAN CONGO (Neumann 1899,1911. Nuttall and Warburton 1916. Schwetz 1927C,1932. Bequaert 1930A,1931).

NOTE: According to Theiler (correspondence), the record for Ruanda-Urundi by Santos Dias (1954D) is in error.

EAST AFRICA: SUDAN (King 1908,1911,1926. Hoogstraal 1954B).

ETHIOPIA (Tonelli-Rondelli 1930A. Stella 1940).

KENYA (Lewis 1931C,1934. Loveridge 1936B. Hoogstraal 1954E). UGANDA (Theiler 1945B. Wilson 1950C. Hoogstraal 1954E). TANGANYIKA (Neumann 1907C,1910B,1911. Dönitz 1910. Morstatt 1913. Loveridge 1923C,1928. Bequaert 1930A).

SOUTHERN AFRICA: ANGOLA (Howard 1908. Bacelar 1950). MOZAMBIQUE (Howard 1908. Santos Dias 1948A,1952D,1953B. Bacelar 1950).

NORTHERN RHODESIA (Theiler 1945B). SOUTHERN RHODESIA (Jack 1942). NYASALAND (Theiler 1945B. Wilson 1950B).

SOUTHWEST AFRICA (Warburton 1922. Theiler 1945B). UNION OF SOUTH AFRICA (Koch 1844. Neumann 1901. Howard 1908. Dönitz 1910B. Curson 1928. Bedford 1932B,1936. Schulze 1936E. Theiler 1945B. Hoogstraal 1954C).

HOSTS

Snakes, without predilection for any one group (Theiler 1945B). Host genera recorded by various authors are: *Python*, *Simocephalus*, *Pseudaspis*, *Naja*, *Lycophidion* (= *Lycophidium*), *Mehelya*, *Sepedon*, *Dendroaspis* (= *Dendraspis*), *Causus*, *Bitis*, *Dasypeltis*, *Boaedon*, and *Rhamphiophis*. Also the Debasian snake *Crotaphopeltis* (= *Leptodira*) *hotamboeia* (Neumann 1907C,1910B). In addition to some of these same host genera, Miss J. B. Walker's (correspondence) Tanganyika collections contain specimens from *Rhamphiophis oxyrhynchus rostratus*. *Philothamnus i. irregularis* (= *Chloropis emini*) (Hoogstraal 1954C). Most host records are for large, poisonous snakes, possibly because of the great interest they always arouse when collected. Yet I have examined hundreds of smaller African snakes without finding *Aponomma* ticks on them.

Acontias plumbeus, a blind, limbless, viviparous lizard has been listed as a South African host (Bedford 1936).

A single female in BM(NH) collections was taken with A. exornatum from Varanus e. albigularis, the coastal monitor lizard, in Kenya, and another female has been noted from a porcupine in Zululand (Hoogstraal 1954C).

BIOLOGY

The snake tick sometimes occurs in great numbers on a single host. Loveridge (1923C) states: "This snake (Dasypeltis scabra) was literally covered with ticks, 75 of which I collected". Larvae, nymphs and adults are often taken from a single host (Lewis 1934, Rageau 1953B).

Specimens are usually found between the host's dorsal scales, especially just behind the neck, sometimes on the head, rarely on the venter.

DISEASE RELATIONS

Unstudied.

REMARKS

The most complete recent work on this species is by Theiler (1945B). The taxonomic review shows that A. laeve Neumann, 1899, is actually a non African species and that A. latum (Koch, 1844) has priority for the African species. Immature stages were described and illustrated and adults were redescribed and illustrated in the same study.

Should specimens agreeing with characters of this species but having a very wide, quadrate body outline be encountered in the Sudan, they should be checked (cf. Theiler 1945B) for A. transversale Lucas, 1844, the python tick, which Theiler states (correspondence) may be expected to occur in this area. The male of A. transversale lacks an anal groove and is incompletely chitinized on the posterior third of the dorsum. The female is similarly broad; its scutal margin is notched or concave posteriorly rather than broadly rounded. These two snake ticks are the only inornate aponommas known to occur in Africa.

IDENTIFICATION

Males and females are easily identified in the African tick fauna by key characters and notes.

BOOPHILUS

INTRODUCTION

Boophilus ticks are practically unique in that their entire life cycle from larva to engorged, mated adult is confined to a single host. Females drop to the ground to oviposit. This single-host type of life cycle has numerous biological advantages. It also allows for particularly easy control by dipping infested animals, a benefit partially negated by the development of boophilid strains resistant to chemicals.

The boophilid type of life cycle eliminates danger-ridden periods between two or three different kinds of hosts, possibly in inhospitable areas and for indefinite periods. The predilection of these ticks for large domestic animals particularly favors widespread dispersal and survival, not only within a continent but also from continent to continent on imported hosts.

Cattle are the chief hosts throughout the world, horses, other domestic stock, and wild antelopes and deer are less frequently attacked. Other wild animals are uncommonly infested. The veterinary importance of *Boophilus* ticks is considerable and they are suspect as reservoirs of some human disease pathogens.

Collectors who wish to be assured of accurate identification of their boophilid material should make every effort to obtain long series and to find the small, yellowish males as well as the heavier, more conspicuous, podshaped females.

Two of the three species presently recognized in this genus occur in the Sudan. One of these, *Boophilus decoloratus* (Koch, 1844), is endemic and ranges widely throughout African areas with relatively high rainfall and with some shrub cover; it is well known practically everywhere on the continent south of the great northern deserts and semideserts.

The second species is *B. annulatus* (Say, 1821) (= *B. congolensis* Minning, 1934), African populations of which cannot be distinguished from the famed American Texas fever vector, *B. annulatus*. This species is poorly known, more restricted, and less common in the Ethiopian Faunal Region than *B. decoloratus* and has been introduced from elsewhere. Data in the present report are the only published facts that give any information on the biology or ecology of B. annulatus on this continent. North African and Near Eastern populations usually called B. calcaratus subspp. appear to be identical to B. annulatus.

The third species, B. microplus (Canestrini, 1888) (= B. fallax Minning, 1934), is not yet known from the Sudan. This pantropical cattle parasite appears slowly to be extending its present southern and eastern African range northwards after once having been more widely distributed on Africa because of frequent importation of infested cattle from Madagascar. Differential characters for this species are provided in the following key and additional notes concerning it may be found following the discussion of the two related species.

What has been considered the classic taxonomic work on Boophilus is that of Minning (1934,1935,1936). He divided the genus into three subgenera: Boophilus (sensu strictu), Uroboophilus, and Palpoboophilus and described a number of "new" species. These subgenera have been given the status of genera in many published papers, probably because Minning himself, curiously enough, failed to place a generic designation before them in his discussion of species. Several later workers (Cooley 1946, Anastos 1950, and others) have questioned the worth of these findings, and in the present instance the Minning reports are of little value. The method appears to have been to hastily examine a few specimens from widely scattered areas, to describe and illustrate them inadequately, and whenever possible to apply names based on assumed, uncritically regarded, slight morphological variations. There is little or no correlation between the present and other extensive collections of boophilids collected from several geographical areas throughout the world, and Minning's illustrations and remarks about species collected in the same localities. Anastos (1950) has abandoned these three subgenera with the hearty concurrence of many serious colleagues.

Anastos (loc. cit.) on the other hand, would confine the known Boophilus species of the world to the three discussed herein. Although it appears that his view is most likely correct, a painstaking study of extensive, worldwide series of specimens will be necessary before any final judgement on all subspecies and related species may be vouchsafed.

Speciation in this genus has been extremely conservative and restricted geographical "species" do not appear to have evolved. Many superficial "morphological variations" derive from degree of engorgement, method of preservation, or angle of examination.

Boophilids are exceptionally difficult to study taxonomically owing to superficial variability, small size, and crowding of diagnostic characters. The state of engorgement of many routinely-collected females tends to modify certain features so that they are frequently difficult to evaluate.

For discussion of the Sudan *Boophilus* fauna in relation to that of North Africa, southern Europe, and the Near East, see REMARKS under *B. annulatus* below.

KEY TO THE GENUS BOOPHILUS*

MALES

1. With caudal appendage..2

   Without caudal appendage. Hypostome dentition 4/4 (see Note below). Palpal basal segment without ventral bristle-bearing protuberance on inner margin. Adanal shields without posterior spur..............B. ANNULATUS
   Figures 104 and 105

2. Hypostome dentition 3/3 (rarely 3.5/3.5). Palpal basal segment with ventral, inner bristle-bearing protuberance. Adanal shields with long, narrow internal spur usually extending beyond body margin...............................B. DECOLORATUS
   Figures 108 and 109

   Hypostome 4/4. Palpal basal segment without ventral, inner bristle-bearing protuberance. Adanal shields with inner margin hardly extended if at all and not reaching body margin.....................B. MICROPLUS**
   Figures 112 and 113

---

*Preserved specimens must be entirely free of surface sheen from liquid preservatives before identification can be attempted. The caudal appendage of ♂ B. decoloratus is very variable in size and the palpal basal bristle-bearing protuberance of either sex can be seen only when the mouthparts are absolutely clean; the bristles are frequently broken off. Turning the specimen at an angle to the light may be necessary to see this character as well as the groove of coxa I.

**B. microplus does not occur in the Sudan but there is some likelihood that it may reach the Sudan within a few years. The inclusion of B. microplus in this key makes it serviceable for all known species, according to contemporary concepts of the genus.

FEMALES

1. Coxa I with shallow, rounded emargination separating internal and external spur. Palpal basal segment and hypostome as in male.............................B. ANNULATUS
   Figures 106, 107, and 117

   Coxa I with deep elongate "inverted V" shape cleft dividing spurs...................................2

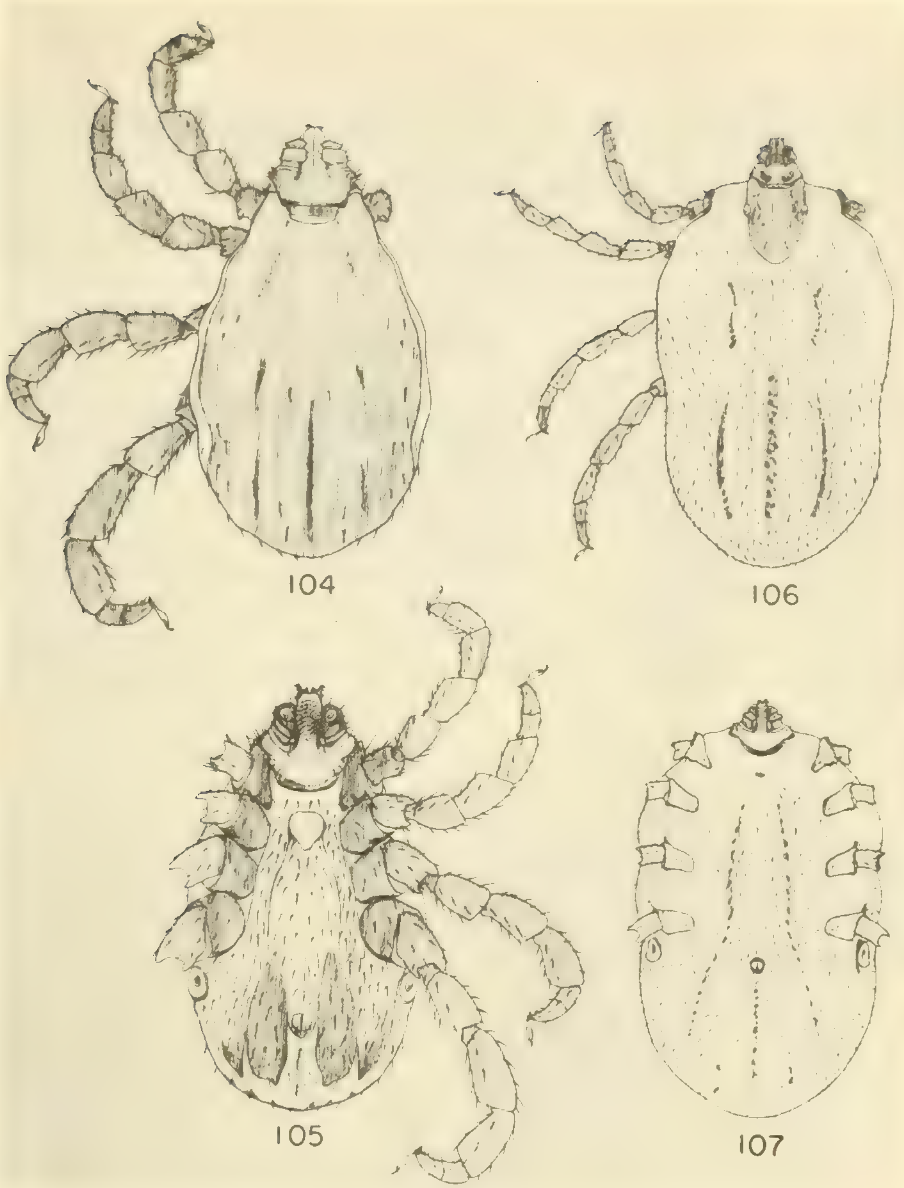
2. Hypostome 3/3 (rarely 3.5/3.5). Palpal basal segment with ventral, inner bristle-bearing protuberance...............B. DECOLORATUS
   Figures 110, 111, and 116

   Hypostome 4/4. Palpal basal segment ventrally with inner margin concave and lacking bristle-bearing protuberance..B. MICROPLUS
   Figures 114, 115, and 118

Note

The number of longitudinal files of denticles on each side of the hypostome is expressed by a formula such as 4/4 or 3/3. The number of these files is constant in most species of ticks, but the number of denticles in each file may be more variable. The formula 3.5/3.5 indicates that there are three complete and one shorter file of few denticles anteriorly on each side of the hypostome.

Following Minning, the length/width ratio of the female scutum has usually been considered to be an important diagnostic character. Examination of large numbers of field-collected specimens from Africa and elsewhere reveals wide variation in this feature within each species and no valid data for diagnostic purposes.



Figures 104 and 105, ♂, dorsal and ventral views
Figures 106 and 107, ♀, dorsal and ventral views

<u>BOOPHILUS</u> <u>ANNULATUS</u>
Sudan specimens

PLATE XXXIV

BOOPHILUS ANNULATUS (Say, 1821) (= B. CONGOLENSIS Minning, 1934).

(Figures 104 to 107 and 117)

THE TEXAS FEVER TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		3	2	Meridi	Taurotragus derbianus gigas	Feb (SVS)
		1		Nagichot	domestic cattle	Dec
		1		Katire	domestic cattle	Jan
		1		Torit	domestic cattle	Nov
	9	39	10	Tombe	domestic cattle	Mar (SVS)
		10	2	Muni	domestic cattle	Mar (SVS)
		10		Terakeka	domestic cattle	Mar (SVS)
		1		Yambio	domestic cattle	Jan
		11		Meridi	domestic cattle	Feb (SVS)

DISTRIBUTION IN THE SUDAN

In addition to the above Equatoria Province specimens, the following others have been seen, all from cattle except those which were collected at Wau from donkeys:

♀	♂	Locality	Province	Date	Collector
11	1	Malakal	Upper Nile	Jan 1952	A. M. Dahab (SVS)
4	1	Ler	Upper Nile	Jan 1952	A. W. Polden (SVS)
1		Bor	Upper Nile	Jan 1952	P. Durran (SVS)
6	2	Akobo	Upper Nile	Mar 1914	C. Webb (SGC)
11	5	Lau	Bahr El Ghazal	Jan 1914	J. J. Soutar (SGC)
6		Wau	Bahr El Ghazal	Sep 1950	E. T. M. Reid (SVS)
2		Wau	Bahr El Ghazal	Feb 1953	H. Hoogstraal
7	1	Wau	Bahr El Ghazal	Feb 1953	Gordon College Collection
29	1	Wau	Bahr El Ghazal	Jul 1953	E. T. M. Reid (SVS)
18	1	Fanjak	Bahr El Ghazal	Jan 1953	H. Hoogstraal
2	1	Fanjak	Bahr El Ghazal	Mar 1953	E. T. M. Reid (SVS)
34	19	Yirol	Bahr El Ghazal	Apr 1954	E. T. M. Reid (SVS)
19	3	Talodi	Kordofan	Dec 1926	J. W. Cowland (SGC)
3		Wadi Halfa Quarantine Station from Kordofan cattle (SGC)			

The Sudan distribution picture is a curious one. Although we have a fair number of collections from cattle in that half of Equatoria Province that is east of the Nile, none contain specimens of *B. annulatus* except two from high altitudes (1♀ from Katire, 3500 feet elevation, 1♀ from Nagichot, 6500 feet elevation) and one from Torit, at the general two thousand foot level of the plains in this area. Yet collections from the southern part of Upper Nile Province, which is just north of the east bank of Equatoria Province, include a good number of specimens. Climatic, faunal, or floral differences can hardly account for the rarity of *B. annulatus* in Torit and Juba districts. The most easterly record, Akobo, Upper Nile Province, is on the Ethiopian frontier (7°47'N., 33°01'E.). On the west bank of the Nile, this species is here recorded from several localities to as far north as Talodi, Kordofan Province (10°37'N.).

Some specimens reach the Halfa Quarantine station in Northern Province but *Boophilus* ticks have never been collected from indigenous cattle in Northern Province.

DISTRIBUTION

Thus far we know *B. annulatus* only from West Africa, Central Africa, and certain parts of southern Sudan near the periphery of East African biotic Provinces. As early as 1905, Dönitz recognized that this tick inhabited only "tropical Africa" and was absent in eastern and southern Africa. He tentatively applied the name *B. australis* Fuller to it, although he stated clearly that he could not differentiate African material from descriptions of American *B. annulatus*. Unfortunately, he had no American specimens for comparison for it appears that this perspicacious student might otherwise have saved future generations much misunderstanding. Instead, this species subsequently has been either completely overlooked or subjected to numerous ambiguous remarks and names.

Many African specimens undoubtedly have been identified as *B. decoloratus*, and earlier workers who have recognized specimens as different from *B. decoloratus* have referred to them by various names. The actual species with which various investigators were dealing cannot be determined without seeing their specimens. For instance, Nuttall's lots identified as *B. australis*, which have been examined in British Museum (Natural History), contain both *B. decoloratus* and *B. annulatus*.

B. annulatus is a North American cattle tick that one may assume originally parasitized deer and buffalo. It also has been introduced into the Mediterranean basin. In North Africa and the Near East, it frequently is referred to as *B. calcaratus* (Birula, 1894), to which Minning appended several subspecies. These all appear to be the same as American and African populations of *B. annulatus*. The name also has been used by students of the Oriental fauna but examination of pertinent specimen material is indicated to establish the validity of these identifications.

Records presented below are the only ones from Africa that are known to pertain to *B. annulatus*, with a few additional, annotated references that might be pertinent. Quite possibly other isolated populations are maintaining themselves outside of the presently recognized range of the Texas fever tick in the Ethiopian Faunal Region, having been introduced on cattle from West or North Africa, the Near East, or North America.

WEST AFRICA: NIGERIA (Hoogstraal 1954C). LIBERIA (Specimens from cattle at Harbel, Firestone Rubber Company Plantation, H. A. Beatty *legit*; MCZ collections). SIERRA LEONE (Hoogstraal 1954C). [PORTUGESE GUINEA: *B.* (= *Margaropus*) *annulatus* listed by Monteiro da Costa (1926) and Sant'anna Barreto (1929); quoted by Tendeiro (1951A), but not subsequently repeated in faunal lists by this author although it would not be surprising to find this tick here.]

NOTE: Records below are for "*B. congolensis*".

CENTRAL AFRICA: FRENCH EQUATORIAL AFRICA (Minning 1934. Rousselot 1953B. Theiler and Robinson 1954). CAMEROONS (Rageau 1953A,B). BELGIAN CONGO (Theiler and Robinson 1954. Minning 1934 stated, apparently as a guess, that the *B. annulatus calcaratus* specimens of Newstead, Dutton, and Todd 1907, from Coquilhatville, are "*B. congolensis*").

EAST AFRICA: SUDAN (Hoogstraal 1954B,C. Balfour 1911F referred to "*B. australis*" in the Sudan, but since he also stated that *B. decoloratus* is absent there his remarks are difficult to interpret).

HOSTS

Cattle (All references). Rarely giant eland and domestic donkey (Sudan records above). In America, other domestic animals, deer, and buffalo have been reported as infrequent hosts (Cooley 1946).

BIOLOGY

Life Cycle

Like other boophilids, the Texas fever tick is a single host parasite. Its life cycle has not been studied in Africa, where it is not known to occur under cold conditions.

After dropping from the host, the female commences oviposition in about three or four days but after twenty to forty days in winter (southern United States). The oviposition period ranges from eight or nine days in summer to 42 days in winter. The number of eggs average 1911, with a maximum of 3806. With abundant moisture, eggs may hatch in as little as from 17 to 21 days, but up to 44 days is more common. Winter incubation may require between five and six months. A few hours after hatching, larvae collect in masses at the tip of grass, and may remain alive from 49 to 159 days awaiting a host. Once an animal is found larvae preferentially attach to the legs, belly, or dewlap, but if numerous they are found everywhere on the body. The larval-nymphal molt occurs seven to twelve days later and nymphs molt to adults five to ten days afterwards. Females feed for from four to fourteen days, during which time they mate, and then drop to the ground, oviposit, and die. These data are extracted from the very complete work of Hunter and Hooker (1907) in the United States.

Ecology

Most African specimens are from collections containing more numerous *B. decoloratus*, with the exception that during the rainy season the numbers of *B. annulatus* have in some instances exceeded those of *B. decoloratus*. In Cameroons (Rageau 1953B), this tick is less common than *B. decoloratus* but both species are found together. Our first suspicion, that this might be a species acclimated to humid West Africa, is negated by finding it in Sudan localities with long, severely hot, dry seasons. The Texas fever tick occurs in the Sudan in areas with from 800 mm. to 1500 mm. annual rainfall.

The ecology of B. annulatus is unstudied in Africa and the results of research on this subject are awaited with considerable interest. In North and Central America, B. annulatus is entirely a tropical and subtropical tick that dies out when introduced into the northern states.

DISEASE RELATIONS

Unstudied in Africa. B. annulatus in America is the famed vector of Texas fever of cattle (Babesia bigemina).

REMARKS

Minning (1934) considered West African populations to differ from New World B. annulatus and called them B. congolensis. Numerous B. annulatus specimens from the United States and Central America have been examined in collections of British Museum (Natural History), Rocky Mountain Laboratory, Museum of Comparative Zoölogy, as well as Louisiana material kindly presented by Dr. F. C. Bishopp from United States Department of Agriculture collections. None of these can be distinguished from African "B. congolensis".

The chief characters presented for differentiating males are the pointed outer spur of coxa I of "B. congolensis" and the blunt outer spur of coxa I of B. annulatus. In a few African specimens this spur is blunt, in many American specimens pointed. The American specimens in the Nuttall collections at British Museum (Natural History) are mostly blunt-spurred with few pointed-spur specimens, but those at the Rocky Mountain Laboratory in Montana are almost entirely pointed-spurred. Specimens from Louisiana in the present collection have pointed spurs. It is evident, therefore, that this character is a variable one with no diagnostic significance as to species. The shape of the eyes of African and American specimens is similar. Examination of other so called differentiating characters has also failed to reveal differences.

Similarly, no points of differentiation may be detected between female specimens from Africa and America. The chief diagnostic characters proposed for these, arching of the eyes and shape of the distal margin of the third palpal segment, appear similar, as are all other morphological features of specimens from both continents. Minning stated that the scutum of American *B. annulatus* bears hairs and the scutum of "*B. congolensis*" does not. Several African specimens with scutal hairs and some American *B. annulatus* without scutal hairs are available, though they may have been rubbed off the latter.

Theiler (1943B) has already observed that the relation of the position of the eye to scutal margin in *Boophilus* ticks is subject to variation according to degree of engorgement. As already stated (page 296) no differences between length/width ratio of the female scutum can be determined in field-collected material of each species.

As stated above, it appears that there are no constant differences between American and African populations of *B. annulatus*. Likewise, it is impossible to differentiate between American and African populations of *B. annulatus*, and specimens collected in North Africa, Southern Europe, and the Near East, which Minning (*loc. cit.*) referred to as *B. schulzei* and as *B. calcaratus* subspp.

In their classic work on this parasite in America, Hunter and Hooker (1907) open by observing "It is safe to state that no more important problem than the eradication of ...... (*B. annulatus*) ...... confronts the farmers of any country. Not only the cattle raising industry but the whole economic condition of a large section of country is affected".

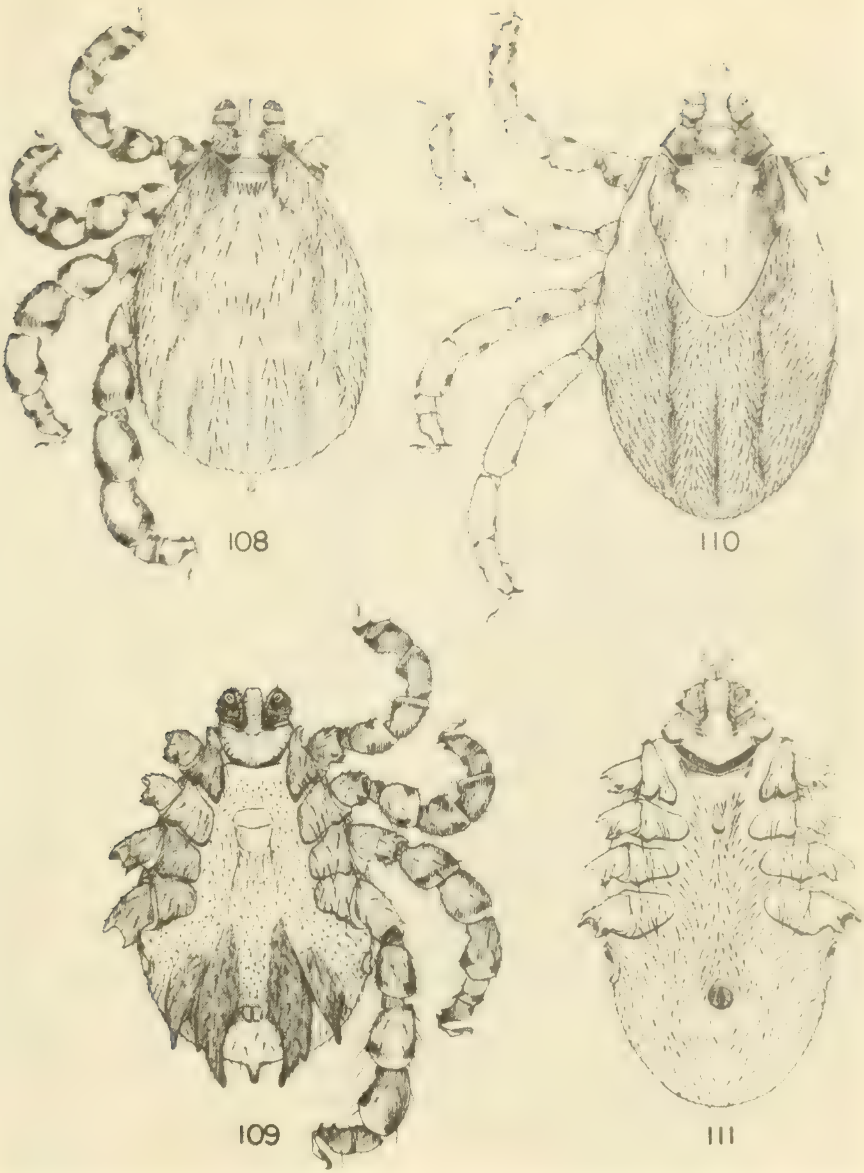
The Texas fever tick is now completely eradicated from the United States except for periodic introductions from Mexico, where it still exists. At the turn of the century it ranged through Mexico and the sixteen southern states of the United States from the Atlantic to the Pacific. The history-making discovery by Smith and Kilbourne (1893) that *Babesia bigemina* is the cause of Texas fever of cattle was followed by their finding that this tick is the vector. The life history and morphology of the tick have been reported handsomely by Curtice

(1892), Salmon and Stiles (1902), Hunter and Hooker (1907), and Hooker, Bishopp, and Wood (1912). The latter report contains a useful summary of the antecedent literature.

IDENTIFICATION

Males are easily identified in the African fauna. They have no caudal appendage on the posterior body margin and the inner margin of the adanal shields does not project posteriorly as a spine. Palpal segment I is without a ventral bristle-bearing protuberance. The hypostome formula is 4/4 and the denticles are noticeably finer than those of *B. decoloratus*. In size, males are about the same as those of *B. decoloratus*.

Females are usually readily separated from *B. decoloratus* by absence of a deep gap between the inner and outer spurs of coxa I. A shallow concave emargination replaces this gap. There is no bristle-bearing protuberance on the internal ventral margin of palpal segment I; this margin is fairly elongate and mildly concave. The scutal margins anterior of the eyes are usually straight and parallel. The scutum is definitely longer than wide. The hypostome formula is as for the male. The color of this species is usually paler than that of *B. decoloratus*.



Figures 108 and 109, ♂, dorsal and ventral views
Figures 110 and 111, ♀, dorsal and ventral views

BOOPHILUS DECOLORATUS
Sudan specimens

PLATE XXXV

BOOPHILUS DECOLORATUS (Koch, 1844).

(Figures 108 to 111, and 116)

THE BLUE TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		15	1	Tereteina	*Alcelaphus buselaphus roosevelti*	Feb
		1	1	Torit	*Alcelaphus buselaphus roosevelti*	Dec (2)
		10	3	Meridi	*Taurotragus derbianus gigas*	Feb (SVS)
	7	2		Nagichot	domestic cattle	Jul
		9	1	Nagichot	domestic cattle	Dec (2)
		1		Ileu	domestic cattle	Oct
	1	9		Katire	domestic cattle	Jan
		8		Katire	domestic cattle	Oct
		30		Gilo	domestic cattle	Dec
	1	4		Torit	domestic cattle	Jan
	2	7		Torit	domestic cattle	Feb
	4	10		Torit	domestic cattle	Nov
	4	9	1	Torit	domestic cattle	Dec (2)
		6		Juba	domestic cattle	Dec
		1		Tombe	domestic cattle	Mar (SVS)
	13	1		Muni	domestic cattle	Mar (SVS)
	11			Terakeka	domestic cattle	Mar (SVS)
	1	4		Kajo Kaji	domestic cattle	Dec
		10		Yei	domestic cattle	Mar (SGC)
	2	8	1	Meridi	domestic cattle	May (SVS)
		4		Yambio	domestic cattle	Jan
			2	Li Rangu	domestic cattle	Apr
			1	Kapoeta	domestic sheep	Dec
		3	2	Juba	domestic horse	Jan
		3	2	More (Yei River)	domestic donkey	Jan (SGC)
			1	Gilo	domestic dog	Dec

DISTRIBUTION IN THE SUDAN

Equatoria, Bahr el Ghazal, Upper Nile, Kordofan and Blue Nile Province; specimens also taken from cattle arriving at the Halfa

Quarantine in Northern Province, but it is by no means certain that the species is established there (King 1926).

Specimens have been seen from the following localities, except Blue Nile Province, all from domestic cattle unless otherwise noted:

Upper Nile: Fangak and Ler (SVS). Maban (domestic pigs; SVS). Bor, Pariak, Malakal (SVS, HH). Akobo and Taufikia (SGC). Daga-Kigille Road (Tora hartebeest; SGC).

Blue Nile: Fung District (Singa headquarters) (= Funo) (King 1926).

Bahr El Ghazal: Wau (domestic donkeys, horses and cattle; SVS, HH). Busseri (domestic horse; SVS). Fanjak (domestic dogs and cattle; SVS, HH). Galual-Nyang Forest (hartebeest and sick domestic donkeys; SVS; tiang; HH). Sixty miles north of Aweil (domestic goat; SVS). Khor Shammam, Boro, near Raga, Lau, Karu, Akot, Yirol, and Peth (SVS).

Kordofan: Talodi (SVS). El Obeid (SVS and Gordon College collection).

Khartoum: Khartoum (horse; Gordon College collection). Khartoum Quarantine Station (on Darfur cattle; HH).

Darfur: Radom, Nyala, Sibdo, and Zalingei (domestic horses and cattle; SVS). Near Safaha (domestic sheep; SVS).

Kassala: Kassala and Port Sudan (SVS). Only four female specimens are known from this Province.

/Northern: Quarantine Station specimens from southern cattle; SGC./

Since it appears that *B. decoloratus* is not established in Northern Province and is very rare in Kassala Province, Sudan evidence corroborates earlier expressed beliefs that 15°N. is about the northern limit of this species. The most northern Sudan locality in which *B. decoloratus* commonly occurs is El Obeid, at 13°11'N. In Kassala Province, the blue tick is rare and is found, in association with either local humid coastal situations or with cattle movements, as far north as Port Sudan, which is at almost 20°N. latitude. Small populations also exist in more humid riverside garden areas in and around Khartoum.

DISTRIBUTION

The blue tick is distributed throughout most of the Ethiopian Faunal Region, barring the northern and southern periphery of this region on continental Africa. Within its range, *B. decoloratus* occurs widely everywhere except in more open, dry areas, and in tropical forests. It is usually common where a fair degree of shade and humidity is present. Outlying specimens have been reported from other continents but whether these are from imported hosts or from established populations is not clear.

NORTH ATLANTIC OCEAN: CAPE VERDE ISLANDS (Howard 1908. Bacelar 1950).

WEST AFRICA: NIGERIA (Simpson 1912B. Unsworth 1949,1952. Mettam 1951. Gambles 1951). GOLD COAST (Simpson 1914. Beal 1920. Stewart 1933,1934. Minning 1934). FRENCH WEST AFRICA (Minning 1934. Rousselot 1951,1953B. Villiers 1955). LIBERIA (Minning 1934). PORTUGESE GUINEA (Monteiro da Costa 1926. Tendeiro 1946A, B,1948,1951C,1952A,C,D,E,1953,1954. Bacelar 1950). SIERRA LEONE (Hoogstraal 1954C).

CENTRAL AFRICA: CAMEROONS (Ziemann 1912A. Minning 1934. Rageau 1951,1953A,B. Rousselot 1951,1953B. Unsworth 1952. Dezest 1953). FRENCH EQUATORIAL AFRICA (Minning 1934. Fiasson 1943B. Rousselot 1951,1953A,B).

BELGIAN CONGO and RUANDA-URUNDI (Newstead, Dutton and Todd 1907. As *B. capensis*: Massey 1908. Roubaud and Van Saceghem 1916. Nuttall and Warburton 1916. Seydel 1925. Schwetz 1927A,B,C,1932, 1933B,1934. Schouteden 1929. Bequaert 1930A,B,1931. Minning 1934. Van Slype and Bouvier 1936. Bouvier 1945. Fain 1949. Schoenaers 1951A,B. Rousselot 1951,1953B. Theiler and Robinson 1954. Santos Dias 1954D. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (Balfour 1911F incorrectly stated that *B. decoloratus* does not occur in the Sudan. King 1908,1911,1926. Hoogstraal 1954B,C).

ETHIOPIA (Minning 1934. Stella 1938A,1939A,B,1940. Roetti 1939). ERITREA (Franchini 1929D. Niro 1935. Stella 1938A,1939A, B,1940. Ferro-Luzzi 1948). FRENCH SOMALILAND (Hoogstraal 1953D). BRITISH SOMALILAND (Stella 1940). ITALIAN SOMALILAND (Niro 1935. Stella 1938A,1939A,B,1940).

KENYA (Neave 1912. Montgomery 1919. Anderson 1924A,B. Lewis 1931A,B,C,1932B,1934,1939A,B,1943. Fotheringham and Lewis 1937. Mulligan 1938. "Kenya Vet. Serv." 1939A,1949,1952. Piercy 1948. Weber 1948. Binns 1951,1952. van Someren 1951. Wiley 1953. Hammond 1955). UGANDA (A. Theiler 1910A. Bruce et al 1911. Neave 1912. Richardson 1930. Mettam 1932,1933. Minning 1934. Mettam and Carmichael 1936. Wilson 1948B,C,1950C). TANGANYIKA (Dönitz 1905. Neave 1912. Morstatt 1913. Knuth and du Toit 1921. Moreau 1933. Minning 1934. Cornell 1936. Lewis 1939A. Reichenow 1941B. J. B. Walker, unpublished; see HOSTS below).

SOUTHERN AFRICA: ANGOLA (Howard 1908. Manetti 1920. Santos Dias 1950C. Sousa Dias 1950. Bacelar 1950. Theiler and Robinson 1954). MOZAMBIQUE (Howard 1908,1911. Nuttall 1911B. De Oliveira 1915. Present in Tete District only: Theiler 1943B,1949A. Santos Dias 1947B,1950B,1952D,1953A,B,1954H. Bacelar 1950).

NORTHERN RHODESIA (Neave 1912. Chambers and Smith 1914. Le Roux 1937. Matthysse 1954. Theiler and Robinson 1954). SOUTHERN RHODESIA (Robertson 1902,1904A,B. Koch 1903. Dönitz 1905. Bevan 1912,1915,1919. Edmonds and Bevan 1914. Jack 1921,1928,1937,1938, 1942. Lawrence 1935,1942). NYASALAND (Old 1909. Neave 1912. De Meza 1918A,B. Wilson 1943,1946,1950B).

SOUTHWEST AFRICA (Howard 1909. Tromsdorff 1913,1914. Minning 1934. Schulz 1939. Theiler 1949A). SWAZILAND ("Agricola" 1946. Barnard 1949).

UNION OF SOUTH AFRICA (Koch 1844. Dixon and Spruell 1898. Lounsbury 1899C,1900A,C,1904A,1905B. Neumann 1901,1911. A. Theiler and Stockman 1904. A. Theiler 1905A,C,1906,1909B,C,1910B,C,D,E, 1911B,1912A,1921. Laveran and Vallee 1905. Warburton and Nuttall 1909. A. Theiler and Christy 1910. Dönitz 1910B. Moore 1912. Van Saceghem 1914. Bedford 1920,1924A,1926,1927,1929B,1931B, 1932B,1934. Cowdry 1925C,1926A,1927. Curson 1928, P. J. du Toit and Viljoen 1929. P. J. du Toit 1931. Alexander 1931. Bedford and Graf 1934,1935,1939. Pijper and Dau 1934. Cooley 1934. Minning 1934. M.D. 1936. Pijper and Crocker 1938. Neitz and du Toit 1938. J. H. S. Gear 1938. McIntyre 1939. R. du Toit 1942B,C,1947A,B,1948. Cluver 1944. Theiler 1949A: important biological survey. Meeser 1952. J. Gear 1954).

On arsenic resistance and BHC control and resistance in South Africa: du Toit, Graf, and Bekker 1941. Bekker 1942,1944, 1945,1947,1953. "Anxious" 1943. Bekker and Koch 1943. Dell 1943. Mullins 1944. Bagshawe-Smith 1944. Omer-Cooper and Whitnall 1945. Whitnall and Fenwick 1945A,B. Whitnall and Bradford 1945,1947A,B,1949. Bekker and Graf 1946. "Agricola" 1946. Thorburn 1947,1952. Whitnall 1947. Cooper 1947,1953. Thorburn 1947. Whitnall, Bradford, McHardy, Whitehead, and Meerholz 1948, 1949A,B. Whitnall, Thorburn, Whitehead, McHardy, and Meerholz 1949. Bekker, Graf, Malan and Van der Merwe 1949. Daly 1950. Whitnall, McHardy, Whitehead, and Meerholz 1951. Kruger 1951. Fiedler 1952. Whitnall, Thorburn, McHardy, Whitehead, and Meerholz 1952. Hitchcock 1953. Blomefield 1954. Busvine 1955. Metcalf 1955.

OUTLYING ISLANDS: ZANZIBAR (Neave 1912. Aders 1917).

MALAGASY GROUP: From present evidence, B. decoloratus is not established in the Madagascan archipelago (Hoogstraal 1953E). Neumann (1901) listed Madagascar and Mauritius. Bück (1935) listed the former island, De Charmoy (1914,1915) and Moutia and Mamet (1947) the latter, and Gillard (1949) mentioned Reunion. Minning (1934) referred Neumann's material to B. microplus (= B. fallax). Bück (1948A,C) reports that B. decoloratus has never been found on Madagascar or on other islands in this group.

NOTE: Specimens of B. decoloratus from North Syria, West Kurdestan, and Buenos Aires (South America) have been noted (Minning 1934), but without mention of whether populations are maintaining themselves in any of these localities. The blue tick is sometimes found on cattle from the Sudan and East Africa at the Cairo abattoir. This species has never been found on native cattle in Egypt.

HOSTS

Cattle are the chief host of the blue tick and most papers listed in DISTRIBUTION above refer mainly to this animal and effects of this tick's feeding upon it. Domestic horses and, less frequently, sheep and goats are attacked. Among wild animals, antelopes are important hosts but few others are infested. Wild carnivores are almost never parasitized by this tick. This is a single host tick, therefore hosts of the immature stages are the same as those of adults.

Domestic animals: Cattle (Most papers listed in DISTRIBUTION above). Horses (Howard 1908, A. Theiler 1911, Lewis 1931C, Mettam 1932, Minning 1934). Mules (Howard 1908). Donkeys (Howard 1908, Minning 1934, Sousa Dias 1950, Sudan records above). Sheep (Howard 1908, Schwetz 1927C, Mettam 1932, Lewis 1934, Minning 1934, Wilson 1950B, Sousa Dias 1950, Sudan records above). Goats (Howard 1908, Lewis 1931C, Bedford 1932B, Mettam 1932, Cooley 1934, Tendeiro 1948, Wilson 1950B, Sousa Dias 1950, Sudan records above). Pigs (Knuth and du Toit 1921. Sudan records above). Dogs (Lounsbury 1904A reared the blue tick on dogs, but only a few specimens completed their life cycle on these animals. Howard 1908, Bedford 1932B, Mettam 1932, Sousa Dias 1950. Bahr el Ghazal specimens in Sudan records above were collected from dogs belonging to Dinka herdsmen; these animals sleep in cattle huts). Camels (King 1926). Water buffalo (Theiler, unpublished).

Man: (Nuttall 1911B, Bedford 1920).

Antelopes: Grant's gazelle (Weber 1948). Sable antelope (Bedford 1932B, Cooley 1934, Jack 1942. Roan antelope (Simpson 1914, Jack 1942). Blue wildebeest (Bedford 1932B). Gnu (Santos Dias 1950B). Hartebeest (Lewis 1934, Santos Dias 1950B, Sudan records above). Nyala (Santos Dias 1950B,1952D). Tiang (Sudan records above). Impala (Bedford 1932B, Cooley 1934, Jack 1942, Meeser 1952, Santos Dias 1952). Reedbuck (Santos Dias 1950B). Bushbuck (Mettam 1932, Lewis 1943, Santos Dias 1950B). Waterbuck (Bedford 1932B). Eland (Lewis 1943. Sudan records above). Sitatunga (Bequaert 1931). Oryx (Minning 1934). Duikers (Mettam 1932, Cooley 1934). Topi (In Miss J. B. Walker's collections from numerous game animals in Tanganyika, the blue tick is represented only by several females and a male from two of these hosts).

Other wild animals: Hares (Tromsdorff 1914, Bedford 1932B, Cooley 1934). Zebra (Bedford 1932B). Bushpig (Santos Dias 1950B). Buffalo (Old 1909, Schwetz 1927B,C, Mettam 1932, Jack 1942).

BIOLOGY

Life Cycle

B. decoloratus is a one-host tick. Females lay their eggs on the ground. When larvae find a suitable host they remain on it, either on the dewlap and neck or on the ears, at the tip or along the upper edge of the pinna. On the ears, larvae are often associated with immature stages of R. appendiculatus. At this locus larvae molt to nymphs and nymphs molt to adults. Adults usually move to the belly and flanks of the host, and mate on the animal. The life cycle is completed entirely on the host except for oviposition, in from three weeks (A. Theiler 1911B) to a month (Lewis 1939B). Lounsbury (1905B) stated that females leave the host 23 days after having attached as larvae, but males may remain on the host for another month. He listed the pre-oviposition period as six to nine days. Eggs hatch after five weeks and larvae molt one week after having completed feeding. Wintertime egglaying and hatching is much slower. Unfed larvae may survive for over eight months (Theiler 1949A).

Ecology

A. Theiler (1911) reported such a heavy infestation of B. decoloratus on a horse that it died of acute anaemia. Half of the ticks were collected; they weighed fourteen pounds. More recent literature on arsenic-resistance in South African blue ticks also frequently refers to and illustrates markedly heavy infestations of host animals.

Because of their unique life cycle, boophilids are readily controlled by dipping cattle, and there are numerous reports of the eradication of B. decoloratus from large areas. New control problems are posed, however, by the development of resistant strains.

From Theiler's (1949A) survey of conditions under which the blue tick exists in South Africa she concludes that the most important factor in limiting its spread is increasing aridity. In most parts of South Africa, the critical level is represented by an annual rainfall below fifteen inches. B. decoloratus is absent in deserts except for introductions that do not become established. It is present at all altitudes from sea level to high mountains, and can withstand both frost and high temperature. Similar though less detailed observations were reported by A. Theiler (1921). In tropical African forest, the blue tick occurs probably only in open, cleared areas (Theiler and Robinson 1954).

The data confirm Lewis' (1939) findings for Kenya, where B. decoloratus inhabits moist regions, highlands up to over 8000 feet altitude, and forests and glades but seldom open, dry, scrub areas. In Kenya, it is also resistant to heat and cold provided moisture is available. In Ruanda-Urundi the altitudinal range does not exceed 6500 feet (Schoenaers 1951B).

In the Belgian Congo, Bequaert (1931) found the blue tick to be so common that it was unnecessary to list all the localities from which specimens were secured. Yet Van Vaerenbergh (1954) reports this species as generally distributed in the Congo and Ruanda-Urundi but represented by a small number of specimens or absent from many lots in his collections. The discrepancies in the inferences of these two authors undoubtedly result from differences in collection areas and methods, interests of collectors, number of ticks taken and hosts examined, and other factors. Similar situations have provided widely differing reports for the incidence of other species of ticks elsewhere, as for instance R. s. simus on cattle in Nyasaland and in South Africa and R. s. sanguineus on dogs in eastern and southern Africa. It is obviously impossible to generalize on population abundance in large areas and difficult to evaluate generalizations not supported by data. After having seen Dr. Bequaert's extensive collections, it should be confirmed that the blue tick is certainly numerous in many Congo areas and that it is uncommon or absent at high elevations and in dense forest areas.

In Nigeria this is said to be the second most common tick from domestic animals and represented 28% of the specimens collected from domestic animals in all Provinces (Mettam 1951). Only A. variegatum at 45%, is more common in these collections.

Wilson (1953) has stressed that the factors governing the distribution of this tick in East and Central Africa require further study.

In untreated Northern Rhodesian cattle, "blue ticks in all stages were present ..... throughout the full year's observation. These ticks quickly became very abundant, the cattle being grossly infested through May, June and July. There was no evidence of decrease in infestation throughout the dry season apart from a slight decrease in late July and August. The blue tick infestation did not build up during the wet season". [Matthysse (1954)]

The red-billed oxpecker or tickbird, Buphagus e. erythrorhynchus (Stanley), which attends all of the larger herbivores except the elephant and hippopotamus, is a predator of some importance on B. decoloratus and on other economically important ticks. Of 58 tick-birds examined in Tanganyika, 51 blue ticks were found in the stomach contents of thirteen; the number of ticks per stomach ranged from one to ten (Moreau 1933). In Kenya, van Someren (1951) found 38 blue ticks in stomach contents of four out of twelve of these birds that he examined. See p. 275 for a discussion of this subject.

REMARKS

Schulze (1936A) remarked that the spurlike prolongation of the male adanal shield is sometimes separated from the base in a position similar to that of the subanal shields of Hyalomma species. Two hundred and fifty males have been examined from various parts of Africa without seeing a similar condition. Schulze also (1932C) compared the adanal shields of B. decoloratus with morphological peculiarities of fossil Eophrynus. The triple capsule of the haller's organ in B. decoloratus has been described and illustrated by Schulze (1941). Double diagonal striations of the nerve fibers have been noted and illustrated by Kruger (1935). The blue tick has been employed by Gossel (1935) to delineate features of the eyes and their related cells in ticks. Abnormal specimens have been noted (Warburton and Nuttall 1909, and Bedford 1924A).

DISEASE RELATIONS

MAN: Evidence that this tick transmits boutonneuse fever (*Rickettsia conorii*) appears to be entirely presumptive. The bite may in itself result in severe inflammation, but man is probably seldom attacked by this tick. Q fever (*Coxiella burnetii*) is claimed to have been found in specimens from Portugese Guinea.

CATTLE: Redwater or Texas fever (*Babesia bigimina*). Spirochetosis (*Borrelia theileri*). Gallsickness (*Anaplasma marginale*). Not a vector or heartwater (*Rickettsia ruminantium*). The virus of "a specific transmissable petechial fever of cattle" survives in this tick.

HORSES, SHEEP, and GOATS: Spirochetosis (*B. theileri*). Not a vector of equine piroplasmosis (*Babesia equi*).

PIGS: Possibly a vector of porcine babesiosis (*Babesia trautmanni*).

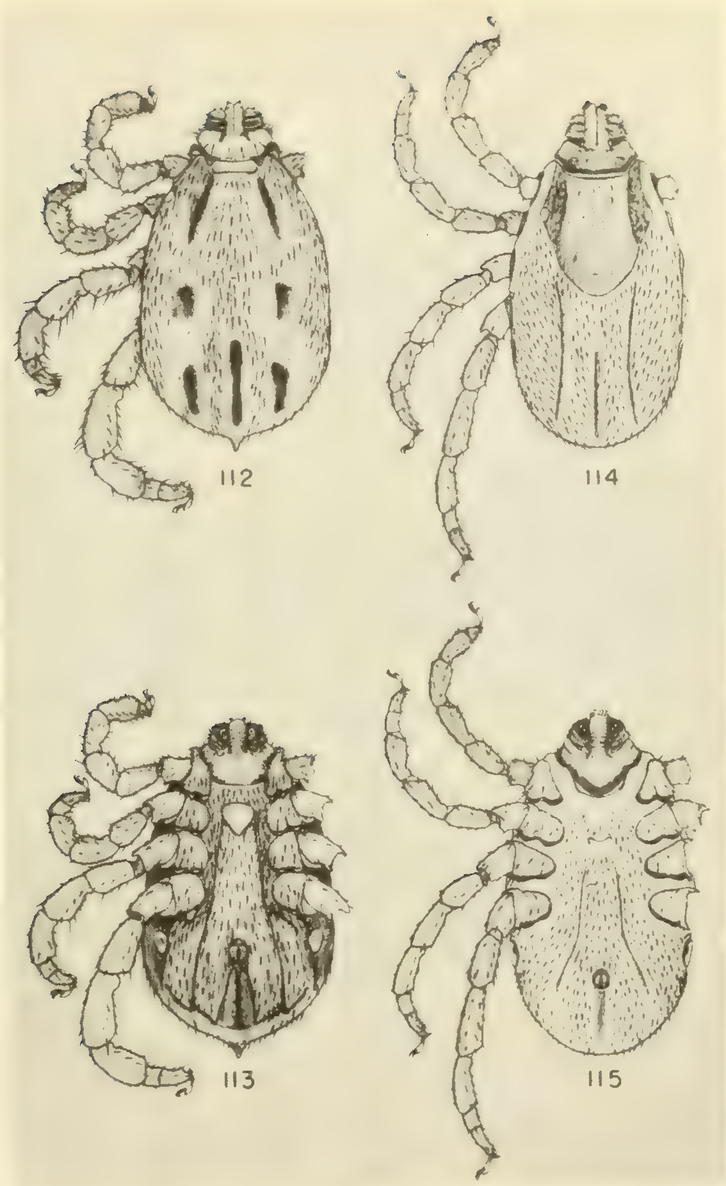
Domestic animals may be so severely irritated that their health is impaired and deaths from the bloodsucking of huge numbers of *B. decoloratus* have been recorded.

A toxin from the egg of *B. decoloratus* has been described.

IDENTIFICATION

Males are easily determined by the presence of a small taillike caudal appendage, which varies considerably in size, on the posterior body margin and by a narrow spurlike elongation of the internal margin of the adanal shield, which reaches to or more commonly extends beyond the posterior body margin. The unique, small bristle-bearing protuberance on the internal ventral surface of the basal palpal segment is most important; this feature may be difficult to discern in small specimens and the bristles are often broken, though the knobs may usually be seen. Hypostome dentition is 3/3, rarely 3.5/3.5. Size is very small, about 2.7 mm. long and 1.5 mm. wide.

Female characters may be difficult to determine satisfactorily in greatly engorged, preserved specimens. Coxa I has two well-defined spurs discernably separated by a narrow but deep, inverted V-shaped cleft. Palpal segment one ventrally has an internal knob bearing one or two bristles; these bristles may be broken or obscured by crowding in preserved, engorged material. The scutum rarely may be approximately as broad as long, but more commonly is slightly longer than broad; the scutal margin, anterior of the eye, curves very slightly outwards. The hypostome formula is as in the male. Engorged individuals may reach 12.0 mm. or more in length and about 8.0 mm. in width. The normal slatish color of the engorged female and the blue of the nymph gives this tick its common name. Most specimens in my collection contrast with the usually paler females of the other two boophilids.



Figures 112 and 113, ♂, dorsal and ventral views
Figures 114 and 115, ♀, dorsal and ventral views

BOOPHILUS MICROPLUS
Northern Rhodesia Specimens
Presented by Dr. G. Theiler

PLATE XXXVI

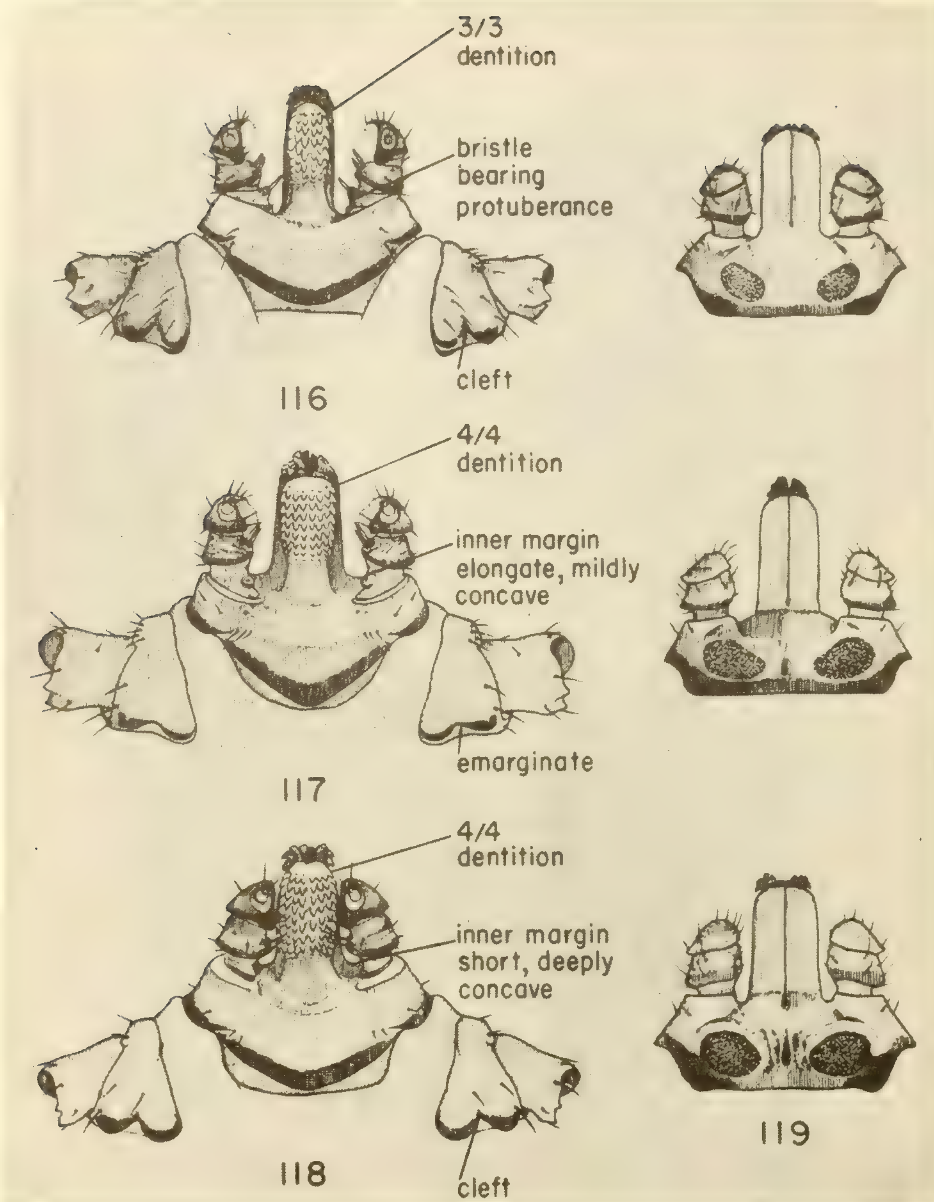


Figure 116, B. decoloratus, ventral view (Sudan).
Figure 117, B. annulatus, ventral view (Sudan).
Figure 118, B. microplus, ventral view (N. Rhodesia).
Figure 119, dorsal view of same species.

DIFFERENTIATION OF BOOPHILUS FEMALES

PLATE XXXVII

NOTES ON

BOOPHILUS MICROPLUS (Canestrini, 1888)

(= B. FALLAX Minning, 1934).

(Figures 112 to 115 and 118)

THE PANTROPICAL CATTLE TICK

According to current concepts, the three Boophilus species of the Ethiopian and Malagasy Faunal Regions are the only ones known to comprise this genus throughout the world and subspecific designations are of questionable accuracy. The identification of these species has been much confused in literature. The single species not yet known from the Sudan, B. microplus (= B. fallax), threatens to encroach upon these borders, therefore succinct notes on this latter tick are interpolated in spite of the general practice of excluding non-Sudanese species from this report.

As elucidated below, it is impossible to differentiate so-called diagnostic differences between specimens from African populations of B."fallax" and specimens of B. microplus from populations in the Near and Middle East, various parts of Asia, and South America. Lengthy study of long series of material from these areas causes me to agree with Anastos (1950) that all these populations appear to represent a single species.

On the other hand, Theiler reports (correspondence) that not only can she distinguish between B. fallax and B. microplus, but students with only basic knowledge of tick identification easily separate both species when presented as unknowns to be keyed! This matter is one of the very few items concerning which agreement has not been reached with Theiler, after an extended exchange of notes and ideas.

Theiler states (correspondence) that in her experience in the more southerly parts of Africa, B. "fallax" is usually locally restricted, but where it does occur it is frequently numerous.

There is a generalized, vague impression among students of the African fauna that B. *fallax* is an endemic Madagascan tick that has been introduced into Africa. However, the predilection of the *Boophilus* ticks for ruminants, absent in the endemic Madagascan fauna, as well as the apparently slow evolution of boophilids would appear to negate any possibility that the species may have evolved there within the few centuries that cattle have been introduced to these islands. It seems more likely that cattle from southern Asia brought their characteristic ticks with them to Madagascar. For over half a century there have been periods of heavy importation of Madagascan cattle into South and East Africa, and these probably introduced this tick into Africa. Export of cattle from infested African areas to Madagascar may have returned some ticks to the areas of their immigrant ancestors.

DISTRIBUTION

"B. *microplus* is found in Central America, South America, Australia, the Oriental Region, in the southern part of Florida, and in parts of Africa ...... After examining specimens of *B. fallax* Minning from South Africa .... I am convinced that this species is a synonym of *microplus*" (Anastos 1950).

The following are selected records from the Ethiopian and Malagasy Faunal Regions for "*B. fallax*".

EAST AFRICA: UGANDA (Wilson 1948A,1950C). TANGANYIKA (Minning 1934. Theiler and Robinson 1954).

SOUTHERN AFRICA: MOZAMBIQUE (Theiler 1943B. Santos Dias 1953B, 1954H,1955A). NORTHERN RHODESIA (Matthysse 1954. Theiler and Robinson 1954). SOUTHERN RHODESIA (Theiler and Robinson 1954). NYASALAND (Wilson 1946,1950B. Theiler and Robinson 1954). UNION OF SOUTH AFRICA (As *B. australis*: Fuller 1899 and Lounsbury 1905. As *B. annulatus*: Dönitz 1910B. As *Margaropus annulatus australis* and as *B. microplus*: Howard 1908. Minning 1934. Theiler 1943B. Theiler and Robinson 1954).

MALAGASY REGION: MADAGASCAR (Minning 1934. Bück 1935,1948A,C. Bück and Metzger 1940. Bück and Ramambazafy 1950. Zumpt 1950B.

Cordurier, Bück, and Quesnel 1952. Hoogstraal 1953E. The B. "*caudatus*" of Colas-Belcour and Millot 1948 may refer to this species. Minning 1934 refers all reports of *B. decoloratus* from Madagascar and other islands in this group to *B. microplus* (= *B. fallax*). It appears that *B. decoloratus* has not established itself in this archipelago). MAURITIUS (De Charmoy 1915. Moutia and Mamet 1947. Millot 1948. Hoogstraal 1953E). REUNION (Gillard 1949. Hoogstraal 1953E. The "*B. caudatus*" reported by Neumann 1897 may refer to this species). COMORES GROUP (Minning 1934. Millot 1948. Hoogstraal 1953E). SEYCHELLES (Desai 1952).

HOSTS

All authors report domestic cattle as the chief host. Minning (1934) also noted specimens from a domestic horse and Theiler (1943B) from domestic sheep and goats. Bück (1935,1948A,C) found material on domestic sheep and Bück and Ramambazafy (1950) on domestic horses. The only wild animal known to have served as a host in Africa is a lion (Theiler 1943B).

Anastos (1950) reports chiefly domestic cattle but also a variety of other domestic animals as hosts of *B. microplus* in Indonesia. He noted that records from wild mammals and birds and from domestic chickens are extant.

BIOLOGY IN ETHIOPIAN AND MALAGASY FAUNAL REGIONS

Life Cycle

This is a single host tick. Engorged females leave the host from 35 to 149 days after having attached as larvae, and there may be from two to three generations a year in South Africa (Lounsbury 1905).

Wilson (1946) observed no seasonal periodicity of adults in Nyasaland. He found larvae with nymphs and adults on cattle only once. Nymphs and adults were usually found together. Nymphs and adults are almost constantly restricted to the udders, flanks, and belly; larvae to the inner side of the ears of the host.

Elsewhere, a number of biological studies on this species have been reported. Among these are Sapre (1940) for high altitudes in India, Tate (1941) for Puerto Rico, Legg (1930) for Australia.

Ecology

As already stated, B. microplus occurs only locally in Africa but where present it may be very common. In Northern Province of Nyasaland it is more numerous on cattle than B. decoloratus (Wilson 1946). In the Malagasy Region, B. microplus is largely a lowland species with scattered foci around urban highland localities (Bück 1948A,C). In Africa it survives best in natural forest conditions (Theiler 1943B).

Early in the century, the range of B. microplus in eastern and southern Africa was wider than it now is, probably because of more frequent importation of infested cattle from Madagascar at that time. Climatic conditions have reduced these populations to their present more localized foci (Theiler 1943B) but extensions of these infestations should be anticipated. This tick was introduced into southern Africa after the 1896 rinderpest outbreak (Theiler and Robinson 1954).

REMARKS

A misshapen specimen has been described and illustrated by Santos Dias (1955A). My collection contains two gynandromorphs.

The synonymous B. australis Fuller, 1899, was described in South African literature. Fuller also gave a differential diagnosis for the three forms presently recognized as comprising this genus.

DISEASE RELATIONS

Unstudied in Africa. The following references are for the Americas, Asia, and Australia.

Cattle: Redwater or Texas fever (*Babesia bigemina*). Babesiosis (*Babesia berbera*). Anaplasmosis or gallsickness (*Anaplasma marginale*).

Sheep: Babesiosis (*Babesia ovis*).

Horses: Biliary fever (*Nuttalia equi*).

Wherever and under whichever name it occurs, this tick appears to be of considerable veterinary importance.

IDENTIFICATION

Male: This small, yellowish to reddish brown tick varies from about 1.6 mm. to 2.5 mm. in overall length, and from 1.0 mm. to 1.4 mm. in width. The presence of a short, tapering caudal appendage is noteworthy (absent in *B. annulatus*, present in *B. decoloratus*, but in *B. microplus* the internoposterior juncture of the adanal shields does not extend beyond the posterior body margin). The hypostome dentition is 4/4 (typically 3/3 in *B. decoloratus*); and the inner margin of the basal palpal segment ventrally is concave (bearing a bristle-bearing protuberance in *B. decoloratus*). The scutum is quite hirsute.

Minning (1934) indicated, as his primary critical difference between *B. fallax* and *B. microplus*, the bluntness or acuteness of the inner spur of coxa I. This character is variable among specimens from Africa and other continents; figure 112 illustrates a specimen from Northern Rhodesia in which this spur is blunt on one side and acute on the other!

Female: After some experience females should be easily recognized in African collections, provided one carefully and methodically observes clean specimens from which the wet surface film of preservatives has been removed.

Like that of *B. annulatus*, this sex has 4/4 hypostome dentition. *B. microplus* can be distinguished because the spurs of coxa I are divided by a deep, inverted "V" shape cleft, while those of *B. annulatus* are separated merely by a shallow, concave emargination (this character should be ascertained by placing the specimen obliquely against the light). No bristle-bearing protuberance is found on the inner margin ventrally of the basal palpal segment. The inner margin of the basal segment is short and deeply concave by comparison with that of *B. annulatus*. The palpi usually appear more compact and less acutely ridged.

Minning's (1934) character for separating *B. microplus* and *B. fallax* on the basis of the anterior curvature of palpal segment 3 applies only to his illustrations, not to specimens. The scutum, normally slightly longer than wide, may be widened by engorgement (from 0.40 mm. to 0.58 mm. long and from 0.34 mm. to 0.50 mm. wide). The eyes are generally oval and raised above the scutal surface but this character may be difficult to discern. Size varies from about 2.0 mm. to 12.5 mm. long, and from 1.0 mm. to 7.9 mm. wide, depending on degree of engorgement.

DERMACENTOR

INTRODUCTION

Dermacentor, a medically important genus in many parts of the world, is represented by only three species in tropical Africa. Small populations of two of these, D. c. circumguttatus and D. rhinocerinus, occur in Equatoria and Bahr El Ghazal Provinces of the Sudan. In Africa they are always rather rare and largely confined to the rhinoceros and elephant. As such, they are of little more than academic interest. The identity of these species may be determined easily from the following keys and illustrations.

The third African species, D. hippopotamensis (Denny, 1843) (= Ixodes bimaculatum Denny, 1843, and Amblyomma hippopotami Koch, 1844), was originally described from Hippopotamus amphibius of South Africa. Schulze (1919) erected the genus Cosmiomma for this species on the basis of its Hyalomma-like characters although it lacks accessory shields and subanal shields. Zumpt (1951) sank Cosmiomma under Dermacentor but Theiler states (correspondence) that Schulze's definition justifies its retention as a genus. Other authors have placed it in Hyalomma. Still another study by a qualified student on the original material appears necessary before an acceptable systematic niche can be found for D. (C.) hippopotamensis.

D. (C.) hippopotamensis has been reported from South Africa and between "Zanzibar" (i.e. East Africa) and the Great Lakes (Tanganyika). For over a century, the only positively known specimens have been the types described by Denny and by Koch, which have been seen again by later students. In the collections of the East African Veterinary Organization there is a single male taken from vegetation at Manyani, Teita District, Kenya, 5 November 1951, D. L. W. Sheldrick legit. This specimen, according to J. B. Walker (correspondence), is almost exactly like the type material illustrated by Dönitz (1910B). One or two specimens are in the collection of the Veterinary Department at Kabete, Kenya.

D. (C.) hippopotamensis is a large, brightly colored Amblyomma-like tick. The male scutum is described as pale straw-yellow with symmetrical black markings and a few small punctations; ventrally the legs are a deep liver-red. The female scutum is lightly punctate, largely pale in color with two submedian longitudinal black stripes and a pair of vertical black stripes near the posterior margin. The dorsal surface of the female posterior of the scutum is dull crimson with two large nearly circular, slightly elevated orange spots near the lateral margin. The apex and lateral margin of the palpi are dull crimson. The last tarsal segment and ventral surfaces of the legs are colored as in the male. This all but extinct beast should not be difficult to recognize.

Another species, D. niveus Neumann, 1897, parasitizes wild boars in Tunisia, Algeria, and Spanish Morocco (Senevet, Colas-Belcour, and Gil Collado 1933), and various other animals in Europe and Asia.

It is difficult to determine what "D. reticulatus Neumann," listed by Stella (1938A,1939A,1940) from Ethiopia and by Niro (1935) from Somaliland, actually is. D. reticulatus, which does not appear to be a synonym of D. marginatus Sulz., 1776, as stated by Schulze (1933C), inhabits Europe and Asia. If its range does extend into the Ethiopian mountains, it would represent a unique ixodid distributional pattern, but conceivable on the basis of geographic distribution of other invertebrates.

Although it has not been our policy to discuss non-Sudanese species, the above remarks and a few additional taxonomic notes are inserted inasmuch as no review of the genus Dermacentor in Africa is available. Extra-Sudan species have not been demonstrated to be of medical importance and will not be included in subsequent volumes of this undertaking.

In various papers on Dermacentor, Schulze has divided the genus into several genera that show interrelationships within a closely circumscribed group and can, by contemporary concepts, be considered at most only as subgenera. These are of only slight interest in Africa, especially as the moot subject of subgenera will be further revised in future studies. D. circumguttatus was placed in the subgenus Puncticentor, which was subsequently synonymized (Zumpt 1951) under the subgenus Amblyocentor, in which D. rhinocerinus had been placed. The usefulness of the latter category is questionable in the absence of study of the entire genus. These same remarks are possibly pertinent to the subgenus Cosmiomma, originally proposed as a full genus embracing only D. hippopotamensis.

KEY TO SUDAN SPECIES OF *DERMACENTOR*

MALES

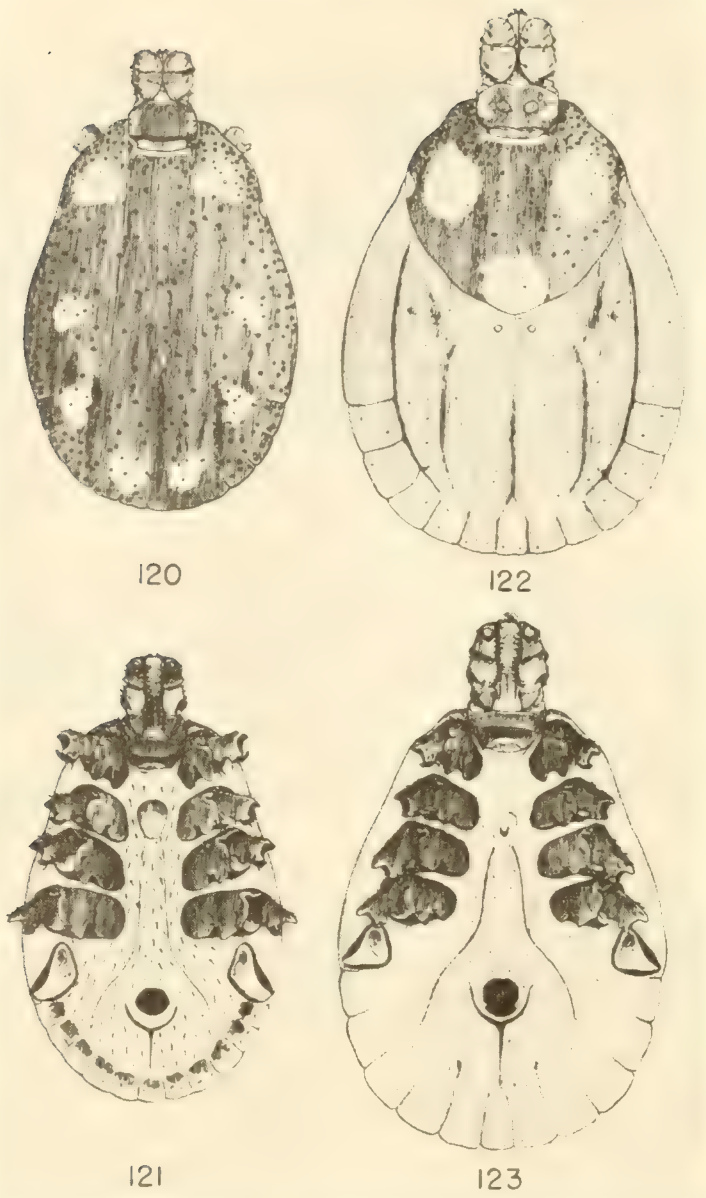
Ornamentation consisting of eight small, pale spots near scutal periphery; festoons and central scutal area dark.................. *D. c. CIRCUMGUTTATUS*
Figures 120 and 121

Ornamentation consisting of seven large pale spots, which cover most of scutum, and of smaller peripheral and festoon spots... *D. RHINOCERINUS*
Figures 124 and 125

FEMALES

Scutum largely dark, ornamented with three pale spots............................ *D. c. CIRCUMGUTTATUS*
Figures 122 and 123

Scutum largely pale, a few small dark spots present or absent........................... *D. RHINOCERINUS*
Figures 126 and 127



Figures 120 and 121, ♂, dorsal and ventral views
Figures 122 and 123, ♀, dorsal and ventral views

<u>DERMACENTOR</u> <u>C</u>. <u>CIRCUMGUTTATUS</u>

Uganda Specimens
Loaned by British Museum (Natural History)

PLATE XXXVIII

DERMACENTOR CIRCUMGUTTATUS CIRCUMGUTTATUS Neumann, 1897.

(Figures 120 to 123)

THE ELEPHANT DERMACENTOR

L	N	♀	♂	EQUATORIA PROVINCE RECORD			
		1	1	Kajo Kaji	on grass	Dec	(BMNH)

British Museum (Natural History) specimens, collected by Captain C. H. Stigand in the early 1900's, are the only ones extant from the Sudan (Hoogstraal 1954B,C). This is the most northern and eastern record for the occurrence of the rare West African elephant dermacentor. It is unlikely to be found elsewhere in the Sudan other than on the west bank of Equatoria Province and possibly in Bahr El Ghazal Province.

DISTRIBUTION

D. c. circumguttatus, a Central and West African elephant parasite, extends into East Africa only so far as the western parts of Uganda and the Sudan. In Mozambique, a separate subspecies is tentatively recognized on the basis of somewhat larger size and more irregular spotting.

WEST AFRICA: LIBERIA (Bequaert 1930A). SIERRA LEONE (Simpson 1913). IVORY COAST (Rousselot 1951,1953B).

CENTRAL AFRICA: CAMEROONS (Neumann 1901. Ziemann 1905. Rageau 1951,1953A,B). FRENCH EQUATORIAL AFRICA (Neumann 1897. Tonelli-Rondelli 1930A. Rousselot 1951,1953B. Rageau 1953B). BELGIAN CONGO (Neumann 1897. Nuttall and Warburton 1916. Schwetz 1927A,B,C. Schouteden 1929. Bequaert 1930A,B,1931. Tonelli-Rondelli 1930A. Rodhain 1936. Fain 1949. Schoenaers 1951A. Theiler and Robinson 1954).

NOTE: According to Theiler (correspondence), the record for Ruanda-Urundi by Santos Dias (1954D) is incorrect.

EAST AFRICA: SUDAN (Hoogstraal 1954B).

UGANDA (Neave 1912. Mettam 1932. Wilson 1948A,1950C).

HOSTS

All authors report this species from elephants, *Loxodonta africana* subsp. Mettam (1932) also listed the "common duiker".

BIOLOGY

Unstudied. In Banningville territory of Belgian Congo "all sick elephants carry this tick and *Amblyomma tholloni*, sometimes in great numbers" (Fain 1949).

DISEASE RELATIONS

It has been suggested that either this species or *Amblyomma tholloni* may transmit piroplasmosis (*Nuttallia loxodontis*) of elephants in the Congo.

REMARKS

Schulze (1941) noted features of the tarsus and haller's organ of this tick.

Santos Dias (1952F) has separated Mozambique populations into another subspecies, *D. circumguttatus cunha-silvai*. These specimens are larger than those from more northerly parts of Africa and exhibit more irregular pale scutal coloration in several smaller, more divided spots rather than in three large spots as in females of the typical subspecies and eight large regular spots as in males of the typical subspecies. These differences, however, appear to be similar to individual variants of *D. rhinocerinus*, reported by Bequaert (1930B), and larger subsequent collections may indicate the necessity of dropping this subspecies.

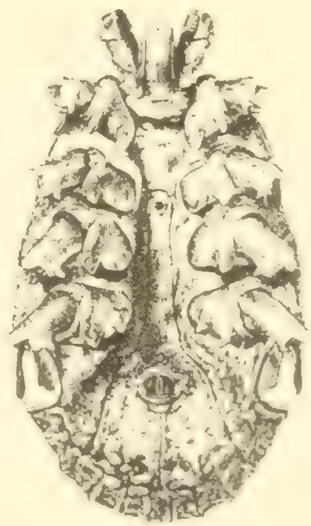
IDENTIFICATION

Characters in the generic key readily identify this tick and separate it from the only other species in the Sudan.

124

126

125



127

Figures 124 and 125, ♂, dorsal and ventral views
Figures 126 and 127, ♀, dorsal and ventral views

DERMACENTOR RHINOCERINUS

Sudan Specimens

PLATE XXXIX

DERMACENTOR RHINOCERINUS (Denny, 1843) (= D. RHINOCEROTIS of authors)

(Figures 124 to 127)

THE RHINOCEROS DERMACENTOR

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		1	1	Magwe	on grass	Feb (SVS)
		1	1	Nimule (just west of)	on grass	Jan
				Localities uncertain		
		4	2	Acholi (Lado)		May (SGC)
		8	12	Atiambo (Lado)		Jun (SGC)
		8	10	Azzar (Mongalla)		May (SGC)
		8	13	How River (Lado)		Mar (SGC)

The material from uncertain localities near the Sudan-Uganda border, which was the basis of King's (1911,1926) reports of the rhinoceros dermacentor from the Sudan, was collected by him in 1909 and 1911.

The recent specimens from Magwe and from the game reserve just west of the Nile near Nimule establish this species on both the west and east banks of Equatoria Province.

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: All specimens from grass, near Yirol to 25 miles west of Yirol; 23 November 1954, E. T. M. Reid legit (7♂♂, 5♀♀). 9 June 1954, P. Blasdale legit (1♀). Material in HH collection.

DISTRIBUTION

D. rhinocerinus parasitizes the black and the white rhinoceros in eastern and southern Africa and in the Belgian Congo.

CENTRAL AFRICA: BELGIAN CONGO (Schwetz 1927C. Bequaert 1930A, B,1931. Tonelli-Rondelli 1930A).

NOTE: According to Theiler (correspondence), the record for Ruanda-Urundi by Santos Dias (1954D) is in error.

EAST AFRICA: SUDAN (King 1911,1926. Hoogstraal 1954B).

ETHIOPIA (Warburton 1910. Neumann 1922. Stella 1940). ERITREA (Stella 1940). ITALIAN SOMALILAND (Pavesi 1895. Paoli 1916. Tonelli-Rondelli 1930A. Niro 1935. Stella 1938A,1939A, 1940).

KENYA (Neumann 1912,1913,1922. Neave 1912. Anderson 1924A, B. Brassey-Edwards 1932. Lewis 1932A,1934). UGANDA (Neave 1912. Mettam 1932,1933. Wilson 1950C). TANGANYIKA (Gerstäcker 1873. Neumann 1907C,1910B,1913,1922. Morstatt 1913. Bequaert 1930A. Evans 1935. Schulze 1944A. J. B. Walker, unpublished, see HOSTS below).

SOUTHERN AFRICA: ANGOLA (Karsch 1878. Howard 1908. Bacelar 1950). MOZAMBIQUE (Howard 1908. Bedford 1932B. Santos Dias 1953B).

NORTHERN RHODESIA (Hoogstraal 1954C). SOUTHERN RHODESIA (Jack 1942. Specimens from Sebungwe: Theiler, correspondence). NYASALAND (Old 1909. Neave 1912. De Meza 1918A).

SOUTHWEST AFRICA (Theiler, unpublished). UNION OF SOUTH AFRICA (Denny 1843. Gerstäcker 1873. Howard 1908. Dönitz 1910B. Breijer 1915. Curson 1928. Bedford 1932B. The localities in the first four references cannot be accepted without question; only Zululand records are sure (Theiler, correspondence).

Specimens of "subspecies permaculatus" (see REMARKS below) from "Zambeze" were reported by Neumann (1907C,1910B).

NOTE: Records from ZANZIBAR (Howard 1908, quoted by later authors) probably result from the use of this name for East Africa by early writers.

HOSTS

The black rhinoceros, Diceros bicornis subspp., and the white, or square-lipped, rhinoceros, Ceratotherium simum subspp., are listed as hosts by all authors. The hosts of our Equatoria Province specimens listed above, if they were rhinoceros, represent both genera inasmuch as only the black rhinoceros occurs near Magwe east of the Nile and only the white rhinoceros occurs across from Nimule west of the Nile.

In Tanganyika each of several rhinoceros hosts of various ticks yielded small numbers of this species (J. B. Walker, unpublished).

King (1926) suspected, from the places in which he found specimens of this tick, that it may also attack the hippopotamus. Evans (1935) recorded domestic cattle and sheep as hosts in Tanganyika. Lewis (1934) mentioned a domestic donkey in Kenya and De Meza (1918A) took specimens from domestic cattle in Nyasaland and from elephants in Tanganyika. Neumann (1907C,1910B) listed an eland as host, and Mettam (1932) noted the jackal from Uganda.

BIOLOGY

Unstudied. Specimens are commonly reported from the hosts' genitalia.

DISEASE RELATIONS

Unstudied.

REMARKS

That the specific name rhinocerotis de Geer (1778), used by many authors for this species, actually applies to a distinct species in the genus Amblyomma was indicated by Dönitz (1910B).

Schulze (1932A) suggested that D. rhinocerinus be placed in the genus Amblyocentor on the basis of minor morphological peculiarities. There is, however, little utility in fragmenting tick genera on the basis of insignificant characters. Amblyocentor is therefore considered as a subgenus of Dermacentor.

A few male specimens have the anterior spots of the scutum partially or completely fused, thus resembling the female scutum. Neumann (1907C, 1910B) described the subspecies permaculatus on the basis of these differences. Subsequent investigators with the exception of Tonelli-Rondelli (1930A), have disregarded this name and considered these characters to be no more than individual variation (Bequaert 1930B).

A "provisional name", D. rhinocerotis arangis, was applied by Lewis (1934, p. 39) to specimens of variable color but after comparison with other specimens this name was withdrawn (footnote of same page).

Females have two large patches of reddish brown hairs and scattered lighter hairs near the posterior margin of the body dorsally. These, and the cuticle of this species, have been studied by Schulze (1944A) and Jakob (1924). Schulze (1941) noted features of the tarsus and haller's organ, and (1950A) of the dentition of this tick.

IDENTIFICATION

Key characters readily separate and identify the two Dermacentor species discussed in this report.

HAEMAPHYSALIS

INTRODUCTION

Haemaphysalids are so small and inconspicuous, except when the females become greatly engorged, that they are seldom adequately represented in collections. Collectors frequently overlook them when larger and more colorful ticks are present. Many species show a marked predilection for seldom examined hosts such as hyraxes, birds, and hedgehogs. Some haemaphysalids appear to be actually quite rare in nature.

In tropical and southern Africa, the genus Haemaphysalis is represented by the ubiquitous H. leachii subspp., chiefly a carnivore parasite, and by approximately fifteen less common species. In the nearby Madagascan archipelago, among whose ten known endemic tick species are nine haemaphysalids, most are distinctly related to the Oriental fauna. Asia has some fifty or more haemaphysalid species, which, in proportion to the total tick fauna, are to that continent what rhipicephalids are to Africa. A dozen forms are listed in the Russian fauna (Pomerantzev 1950). Of a total of eighteen ixodid species in the Philippines (Kohls 1950), not including the cosmopolitan kennel tick, one third are haemaphysalids. The Americas and Europe claim only about five species each.

Since Nuttall and Warburton's (1915) revision of this genus, the African haemaphysalid fauna has received but little attention from biologists, systematists, or collectors. Many records included here represent considerable extensions of known range. Obviously, some few African species remain to be discovered and described. Differentiation of most African haemaphysalids is relatively easy, either by certain combinations of characters or by unique characters for individual species. Morphological characters and facies of most species are comparatively quite constant. An important exception is H. leachii subspp., among the African forms of which there is very considerable variation.

Haemaphysalids are usually three-host parasites, although exceptions do occur. The life cycles of H. l. leachii and of H. aciculifer have been fairly well studied in the laboratory, but few reliable biological data are available for African species. Factors governing morphological and biological variations of *H. leachii* subspp. pose an especially intriguing problem.

Medically, the only African haemaphysalid of known importance is *H. l. leachii*, a vector of boutonneuse fever (tick typhus) of man and of malignant jaundice of dogs. The same species may also be a reservoir of Q fever. The high potential of *H. bequaerti* as a medically important species has been recently suggested and others probably eventually will be incriminated in disease transmission of academic or practical interest.

KEY TO SUDAN SPECIES OF <u>HAEMAPHYSALIS</u>

MALES

1. Coxa IV with needlelike spur that is longer than coxal width. (On southern ruminants)............................H. ACICULIFER
Figures 128 and 129

   Coxa IV with spur much shorter than coxal width or without spur.................................2

2. Palpal segment 2 with strong dorsal retrograde spur. Lateral grooves extending anteriorly only to scutal midlength. (Equatoria mountains, rare)..H. PARMATA
Figures 134 and 135

   Palpal segment 2 with no dorsal retrograde spur..3

3. Palpal dorsal basal margin forming a straight line; basal salience at right angles to long axis of palpi. Basis capituli rectangular. Scutum comparatively broad with large punctations. (Avian parasite)..................H. HOODI HOODI
Figures 136 and 137

   Palpal dorsal basal margin angular, forming a more or less well developed, caudally-directed spur or recurved point. (Mammal parasites)..........................4

4. Trochanter I with a strong ventral spur. Each coxa with a spur reaching next coxa. Tarsi short, stout, abruptly tapered. (Common on ground-squirrels only)..................................H. HOUYI
Figures 140 and 141

   Trochanter I without ventral spur..............................5

5. Coxae without overlapping, pointed spurs and with few hairs all shorter than coxal length. Palpal outline deeply concave laterally and with much reduced basal angle dorsally and ventrally; segment 3 ventrally with wide, bluntly rounded, short retrograde spur. (Rare parasite of hyraxes)..H. BEQUAERTI
Figures 132 and 133

Coxae with a short, pointed spur on at least two pairs. Palpal outline laterally straight or very slightly concave (deeply concave only in exceptional, small specimens), and usually with large pointed basal angle or spur dorsally and ventrally; segment 3 ventrally with narrow, pointed, fairly long retrograde spur. (Commonly on carnivores, rare on other animals)..6

6. Scutum narrowly elongate (approximately twice as long as wide); punctations numerous, small, usually discrete; length from 2.3 mm. to 3.8 mm., width from 1.2 mm. to 1.9 mm. Basis capituli laterally usually diverging only slightly, cornua strong, elongate. Palpal lateral margins straight or slightly concave. Coxae each with a distinct, overlapping spur. Tarsi II to IV elongate, gradually tapering. (Common on canines; less common on other carnivores)..........................H. LEACHII LEACHII
Figures 144, 145, and 148

Scutum wider (approximately 1.6 times as long as wide); punctations few to moderate, medium to large, shallow, nondiscrete; size smaller, length from 1.3 mm. to 2.2 mm., width from 0.8 mm. to 1.2 mm. Basis capituli laterally widely diverging, cornua usually short and wide. Palpal lateral margins usually concave. Coxae with a small but definite spur. Tarsi usually short, may be more or less humped and abruptly tapering. (Common on small carnivores; rare on antelopes)................................H. LEACHII MUHSAMI
Figures 150 and 151

FEMALES

1. Palpal segment 3 with basal margin strongly angled or spurred dorsally. Scutal width and length approximately equal. (Equatoria and Bahr El Ghazal; uncommon)..2

Palpal segment 3 with basal margin dorsally forming a straight line with no spur or angle.....................................3

2. Palpal segment 3 dorsally with basal margin sharply angled. Basis capituli with strong cornua. Scutal length and width equal or very slightly longer than wide. Coxa I with inner basal angle produced to a small spur.............H. ACICULIFER
Figures 130 and 131

Palpal segment 3 dorsally with a retrograde spur. Basis capituli with small cornua. Scutum wider than long. Coxa I with small spur overlapping outer basal margin; no inner basal spur..................................H. PARMATA
Figures 136 and 137

3. Palpal basal margin straight dorsally, without angle or spur. Basis capituli almost straight laterally, cornua almost obsolete. Scutal length and width approximately equal. (Avian parasite)................H. HOODI HOODI
Figures 138 and 139

Palpal basal margin angled or spurred dorsally. Basis capituli diverging laterally, cornua moderate to strong. (Mammal parasites).......................................4

4. Palpi ventrally with a comparatively long, narrow spur basally, margin dorsally sharply pointed sublaterally; segment 3 ventrally with narrow elongate, pointed spur. Coxae each with a strong spur and a few, short hairs; trochanter I ventrally with a strong spurlike ridge (that does not overlap trochantal margin); tarsi abruptly tapering, short, stout, somewhat humped, claw and tarsal length approximately equal. Scutum only slightly longer than wide, broadly rounded posteriorly; punctations few, shallow, mostly anterior. (Ground-squirrel parasite)......................H. HOUYI
Figures 142 and 143

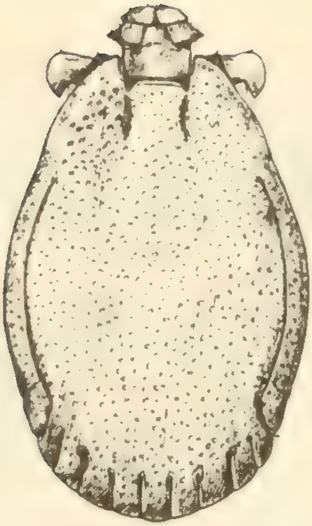
Combinations of characters differ as below. (Not normally ground-squirrel parasites)..5

5. Coxae without overlapping spurs. Palpi without basal spur dorsally or ventrally; basal margin acutely angled sublaterally; segment 3 ventrally with very short, broad spur. Basis capituli with small cornua. Scutal length and width approximately equal but outline abruptly converging posteriorly; punctations scattered, shallow, moderate numbers of varying size. Tarsi tapering distally. (Hyrax parasite; rare)............................<u>H. BEQUAERTI</u>
Figures <u>134 and 135</u>

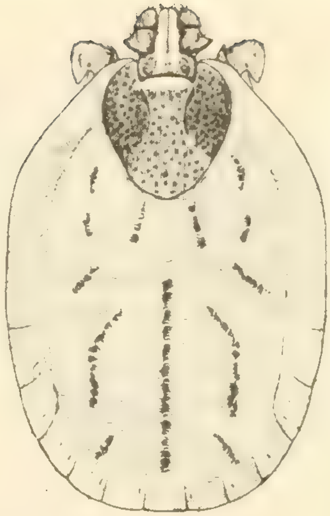
Coxae with an overlapping spur on at least two pairs. Palpi usually with a definite basal spur dorsally or ventrally or both; segment 3 ventrally with an elongate, pointed, narrow retrograde spur; lateral outline straight or slightly curved; less commonly concave. Basis capituli with strong cornua. (Common carnivore parasites; seldom on other animals)..6

6. Scutum elongate, 1.25 longer than wide, gradually narrowing posteriorly; punctations comparatively small, numerous, discrete. Palpal spurs usually all large and definite, lateral margins straight or slightly curved. Tarsi elongate and tapering. (Commonly from canines)...............................<u>H. LEACHII LEACHII</u>
Figures <u>146, 147, and 149</u>

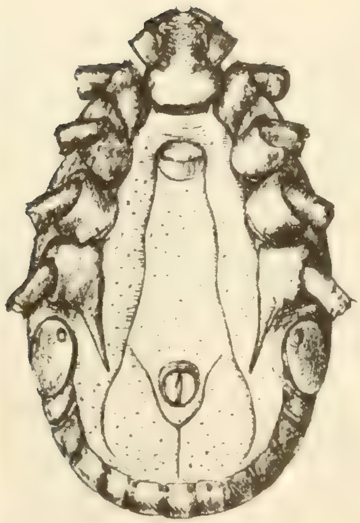
Scutum shorter, length and width approximately equal, broadly rounded posteriorly; punctations comparatively moderate in size and numbers, shallow. Palpal basal spurs frequently reduced, lateral margins more or less concave. Tarsi short, usually abruptly tapered, sometimes humped. (Usually from smaller carnivores, sometimes on larger carnivores and ruminants; not common on canines)..........................<u>H. LEACHII MUHSAMI</u>
Figures <u>152 and 153</u>



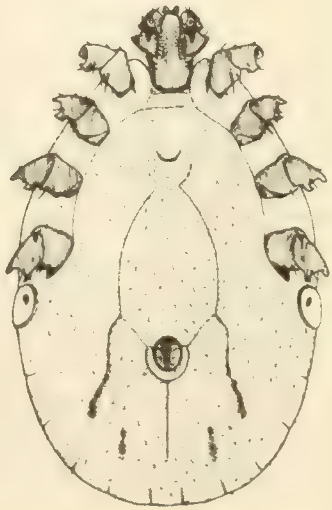
128



130



129



131

Figures 128 and 129, ♂, dorsal and ventral views
Figures 130 and 131, ♀, dorsal and ventral views

HAEMAPHYSALIS ACICULIFER
Sudan specimens

PLATE XL

HAEMAPHYSALIS ACICULIFER Warburton, 1913.

(Figures 128 to 131)

THE SHARP-SPURRED HAEMAPHYSALID

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
1				Lotti Forest	*Praomys tullbergi sudanensis*	Apr
	1			Torit	*Lemniscomys striatus massaicus*	Dec
	1		2	Torit	*Ourebia ourebi aequatoria*	Apr
		1		Torit	*Alcelaphus buselaphus roosevelti*	Apr
			2	Atiambo (Alungwe)	*Alcelaphus buselaphus* subspp.	Jun (SGC)
("several")				Muragatika	*Kobus defassa* subspp.	Aug (Weber 1948)
		1		Nagichot	domestic cattle	Jul

Lotti Forest is at 4500 feet elevation and Nagichot is at 6500 feet elevation. Weber's (1948) report is the only previous one of this species from the Sudan.

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: All from tiang, *Damaliscus korrigum tiang*, 1953. 1♂, 2♀♀, 15 miles north of Tonj, March, E. T. M. Reid *legit* (with adults of *Amblyomma variegatum*). 4♂♂, 7♀♀, Galual-Nyang Forest, July, N. A. Hancock *legit*. Material in HH collection.

DISTRIBUTION

H. aciculifer ranges across Africa in scattered highlands and forests from Bahr El Ghazal Province south to Mozambique. It has been transported on cattle to the Union of South Africa, where it has become established locally (Theiler 1945C).

WEST AFRICA: NIGERIA (Unsworth 1949,1952. Gambles 1951). GOLD COAST (Simpson 1914. Nuttall and Warburton 1915).

CENTRAL AFRICA: CAMEROONS (Unsworth 1952). FRENCH EQUATORIAL AFRICA (Rousselot 1951; not repeated 1953B). BELGIAN CONGO (Tonelli-Rondelli 1930A. Bequaert 1931. Theiler and Robinson 1954).

NOTE: According to Theiler (correspondence), the record for Ruanda-Urundi by Santos Dias (1954D) is in error.

EAST AFRICA: SUDAN (Weber 1948. Hoogstraal 1954B).

KENYA (Lewis 1931C,1932A,1934. Theiler 1945C). UGANDA (Warburton 1913. Tonelli-Rondelli 1930A. Mettam 1932. Theiler 1945C. Wilson 1950A,C). TANGANYIKA (J. B. Walker, unpublished; see HOSTS below).

SOUTHERN AFRICA: MOZAMBIQUE (Santos Dias 1953B). UNION OF SOUTH AFRICA (Bedford 1932B,1934. R. du Toit 1942B,1947A. Introduced from East Africa: Theiler 1945C).

NOTE: *H. aciculifer* does not occur on Madagascar (Hoogstraal 1953E).

HOSTS

Antelopes are the most common hosts of adult *H. aciculifer*. Other wild animals and domestic animals are rarely attacked. Rodents, small antelopes, and possibly hares appear to be the chief hosts of the immature stages.

Domestic cattle have been reported as hosts in Uganda (Wilson 1950A,C), Kenya (Lewis 1934 and Theiler 1945C), and the Union of South Africa (Theiler 1945C). Lewis (1932A) noted a single specimen from a domestic goat in a Somali village between Karati Forest and Naivasha. Rousselot (1951) reported a female from a domestic dog in French Equatorial Africa.

Antelopes hosts of adult ticks are the Uganda kob (Warburton 1913), reedbuck (Simpson 1914, Nuttall and Warburton 1915, Bedford 1932B, Theiler 1945C), bushbuck (Lewis 1931C,1932A, Mettam 1932, Theiler 1945C), waterbuck (Lewis 1931C,1932A, Mettam 1932), various duikers (Mettam 1932, Lewis 1932A), Thomson's gazelle (Lewis 1934), oribi and Roosevelt's hartebeest (Equatoria Province records above), and tiang (Bahr El Ghazal Province record above).

Miscellaneous hosts of adults are buffalo (Lewis 1931C), serval cat (Bedford 1936, Theiler 1945C), mongoose (Theiler 1945C), and wild cat (*Felis lybica* group) (Hoogstraal, Kenya collecting). The probability that Mettam's (1932) records of this species from unidentified birds refer to *H. hoodi hoodi* should be considered.

Nymphs have been found on the bushbuck, waterbuck, duiker, buffalo, warthog, and hare according to Lewis (1932A), but these records need checking for accuracy of identification. Lewis (1932A) reared *H. aciculifer* on hares. Examination of 49 Thomson's gazelles in Tanganyika yielded only a single nymph and no further specimens of this tick were found on many other game animals examined there (J. B. Walker, unpublished). Our Equatoria Province collections contain nymphs from a striped grassmouse, *Lemniscomys striatus massaicus*, and from an oribi, *Ourebia ourebi aequatoria*.

A larva from a forest rat, *Praeomys tullbergi sudanensis*, in Lotti Forest (listed above) is apparently the only record extant for this stage in nature.

BIOLOGY

Life Cycle

Lewis (1932A) reared the three-host *H. aciculifer* on laboratory hares in a minimum of 107 days. His data, are as follows:

PERIOD	DAYS
Preoviposition	9 (19°C. to 21°C.)
Oviposition to hatching	20 (22°C. to 25°C.)
Larval prefeeding period	7
Larva feeds	3
Premolting period	22 (21°C. to 24°C.)
Nymphal prefeeding period	7
Nymph feeds	3
Premolting period	22 (21°C. to 25°C.)
Adult prefeeding period	7
Adult (female) feeds	7
	107

Ecology

In Kenya, *H. aciculifer* is found usually in forested areas at about 7500 feet elevation (Lewis 1932A). The writer's experience in Kenya and Sudan confirm that this is mostly a highland species (4500 to 8000 feet elevation) but that it is also present at lower altitudes (Torit, 2000 feet elevation). Records tend to indicate that where this species occurs at lower altitudes it is in more humid habitats but this subject requires further field study.

Theiler (1945C) discussed the distribution of *H. aciculifer* on cattle in localized areas of northern and eastern Transvaal where it sometimes occurs on neighboring farms and at other times on distant isolated farms. The scattered distribution is believed to be due largely to the incidence of cattle importation from East Africa and to the ability of introduced ticks to maintain themselves in new areas.

In South Africa, *H. aciculifer* survives in regions with from fifteen to fifty inches of annual rainfall but especially where thirty or more inches fall each year. These include subtropical evergreen and deciduous tree and thorn forest areas, open parkland areas in highlands, subtropical parkland areas, tall grass areas, and rarely short grasslands adjacent to highveld. *H. aciculifer* ranges from lowlands to highveld at 4500 feet elevation and is present only where winters are not severe, though it may survive where occasional light frosts occur.

DISEASE RELATIONS

Unstudied.

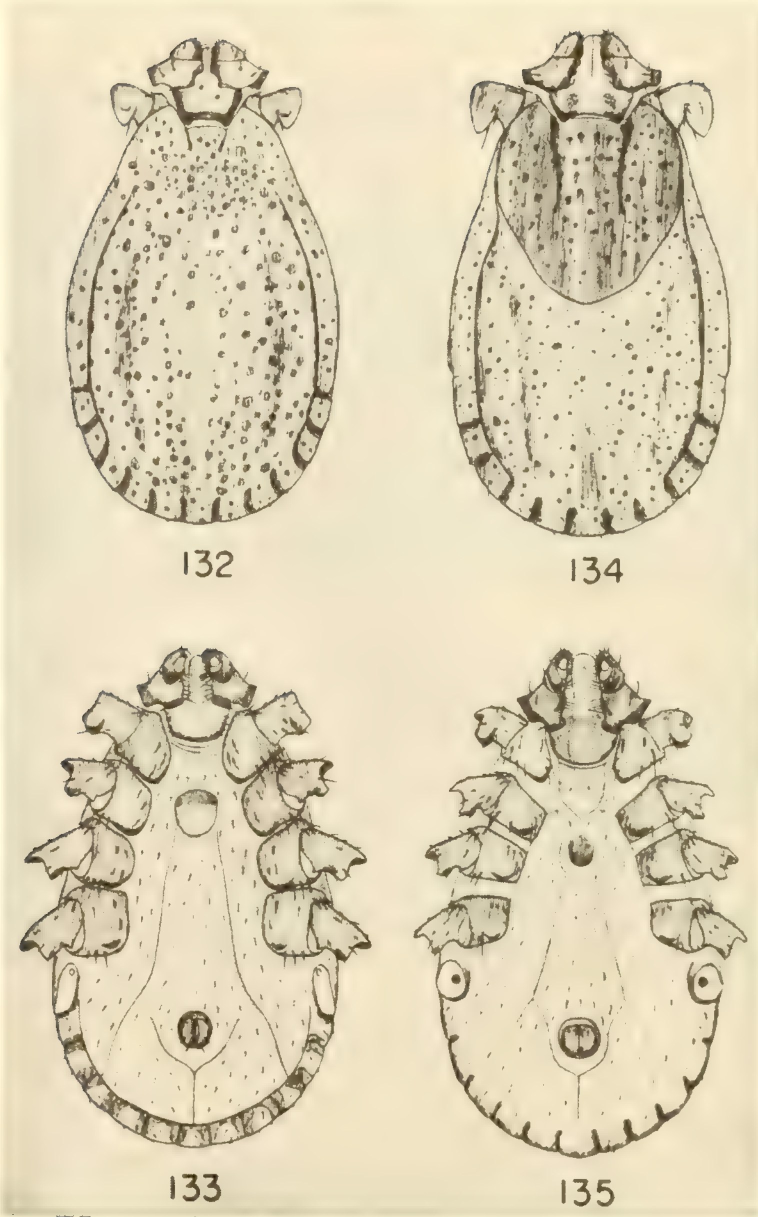
IDENTIFICATION

Males: Measure from 1.8 mm. to 1.9 mm. long, and from 1.1 mm. to 1.3 mm. wide. They may be recognized among the African fauna by the long, needlelike spur of coxa IV. The basis capituli is rectangular with well developed cornua; the palpal outline (Figures 128 and 129) is unique in the African fauna. The smooth scutum has small, shallow punctations; the lateral grooves may reach only the scutal midlength or they may be much longer.

Certain variations in material at hand suggest the need for more specimens from various parts of Africa for further morphological study.

Females: Engorged specimens measure from 6.0 mm. to 6.5 mm. long, and from 4.0 mm. to 4.5 mm. wide; unengorged, they are about 2.5 mm. long and 1.5 mm. wide. The scutal length equals or only slightly exceeds the width (0.8 mm. to 0.9 mm. long, 0.7 mm. to 0.9 mm. wide); the posterior margin is broadly rounded; cervical grooves are long, deep, and converging; punctations are small and inconspicuous. Palpal features are most distinctive (Figures 130 and 131). There is no dorsal projection on palpal segment 3. Coxae I to IV each have a small posterior spur and, in addition, coxa I has a small outer posterior spur; the spur of IV is short and wide thus differing greatly from that of the male. Palpal and scutal characters easily separate females from all other African species.

The larva and nymph have been described and illustrated by Theiler (1945C).



Figures 132 and 133, ♂, dorsal and ventral views
Figures 134 and 135, ♀, dorsal and ventral views

HAEMAPHYSALIS BEQUAERTI
Sudan paratypes

PLATE XLI

HAEMAPHYSALIS BEQUAERTI Hoogstraal, 1956(A).

(Figures 132 to 135)

THE EAST AFRICAN HYRAX TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	1	3	8	Imurok	Heterohyrax brucei hoogstraali	Feb (2)
			7	Lui	Procavia habessinica slatini	May

These records of H. bequaerti, from Torit District on the east bank of the Nile and from the far southwestern corner of the Sudan, are the only ones from this country.

DISTRIBUTION

H. bequaerti of Kenya and the Sudan is the most northern representative of three African hyrax-parasitizing ticks. The other two are H. orientalis Nuttall and Warburton, 1915 (= H. zambeziae Santos Dias, 1954) of Nyasaland and Mozambique, and H. cooleyi Bedford, 1929, of the Union of South Africa. For further details, see Hoogstraal (1956A).

EAST AFRICA: SUDAN (As Haemaphysalis sp. nov.: Hoogstraal 1954B. As H. bequaerti sp. nov.: Hoogstraal 1956A).

UGANDA and KENYA (Hoogstraal 1956A).

HOSTS

Hyraxes: Heterohyrax brucei hoogstraali, Procavia habessinica slatini, and P. capensis meneliki (Hoogstraal 1956A).

BIOLOGY

H. bequaerti in all its stages is apparently strictly host-specific on hyraxes. A rather large number of hyraxes examined in southern Sudan, Kenya, Yemen, Sinai, and the Eastern Desert of Egypt yielded no haemaphysalids other than the ones listed above. It would appear that this tick spends rather little time feeding and that, except possibly locally, hyrax-parasitizing haemaphysalids are rare in nature.

DISEASE RELATIONS

Unstudied. It is of interest to conjecture that this tick might be the vector of the piroplasm Echinozoon hoogstraali Garnham, 1951, found in the blood of the Equatoria Province hosts.

IDENTIFICATION

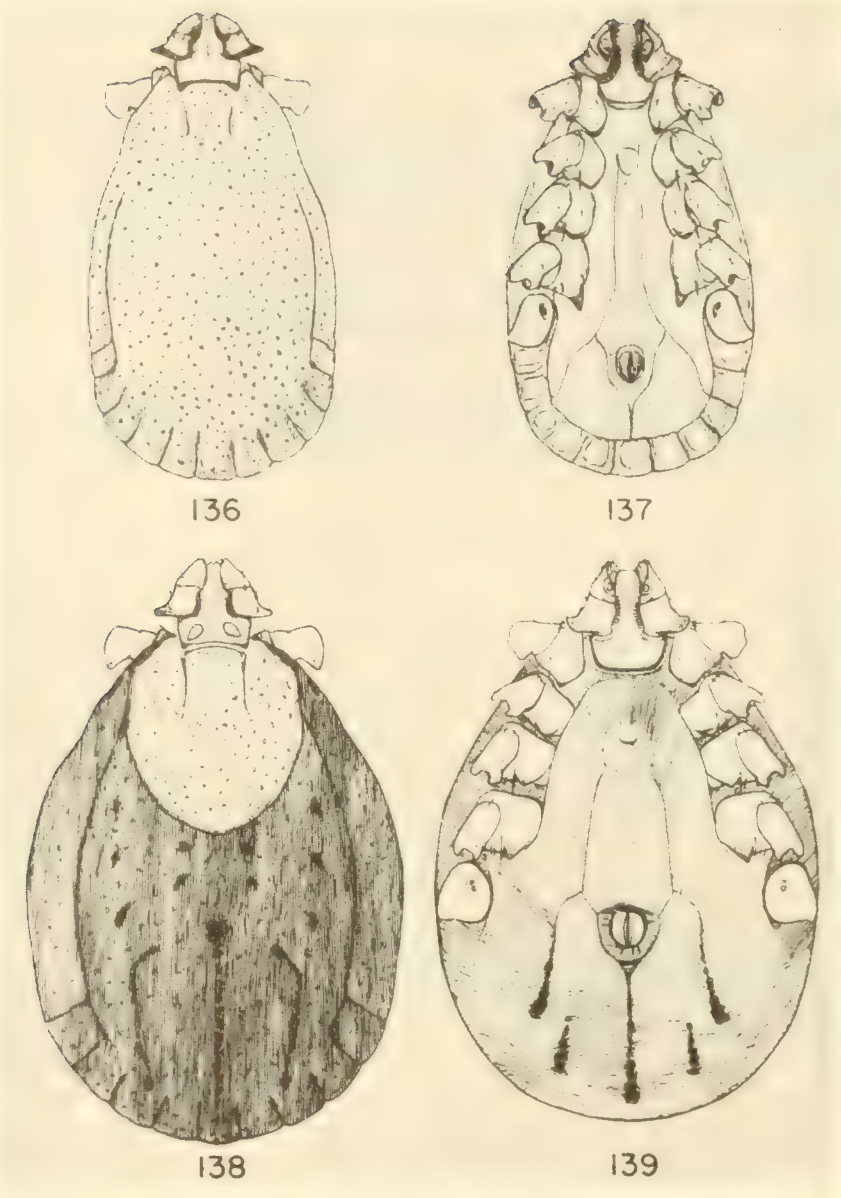
Males: This is a small species, varying from 1.66 mm. to 1.88 mm. in overall length and from 0.99 mm. to 1.22 mm. in width. It superficially resembles the ubiquitous H. leachii but may be easily differentiated from the subspecies muhsami and even more easily from the subspecies leachii by the short, broad, bluntly rounded ventral spur of palpal segment 3, the greater lateral concavity of the palpi, the reduction of basal palpal spurs and of coxal spurs, the few, short hairs on the coxae, and other characters.

The scutum has moderately numerous punctations, which are shallow, coarse, nondiscrete, mostly large, and widely scattered over the surface; cervical grooves faint to obsolete; lateral grooves enclosing first and second pairs of festoons (extension beside second festoon may be faint or obsolete), extending to anterior fourth of scutum. The coxae are only weakly armed with slight ridges and bear at most six small hairs; the tarsi taper gradually but may be more abruptly tapered in small specimens. The basis capituli diverges widely anteriorly and has bluntly pointed cornua about one fourth as long as the basis capituli. The palpi are short and salient with a weakly produced basolateral angle and a concave lateral margin; the ventral spur of segment 3 is short, wide and bluntly rounded.

Females: In this sex, the capitulum is like that of the male except for the more elongate palpi and generally smaller cornua.

The scutum is slightly longer than wide and posteriorly is rather abruptly narrowed and pointed; the cervical grooves extend to the scutal midlength; punctations are indistinct, shallow, large and medium size, few in number. Other characters recall those of the male. As in the male, the short, wide, bluntly rounded ventral spur of palpal segment 3 is a most important character in separating this species from *H. leachii* subspp., as are the short hairs of the coxae and the scutal shape.

The *larva* and *nymph* have been described by Hoogstraal (1956A).



Figures 136 and 137, ♂, dorsal and ventral views
Figures 138 and 139, ♀, dorsal and ventral views

HAEMAPHYSALIS HOODI HOODI
Sudan specimens

PLATE XLII

HAEMAPHYSALIS HOODI HOODI Warburton and Nuttall, 1909.

(Figures 136 to 139)

THE AFRICAN AVIAN HAEMAPHYSALID

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		1		Torit	*Francolinus clappertoni gedgii*	Dec
	2			Torit	*Sphenorhynchus abdimii*	Jan

In Torit District, we closely examined over 200 each francolins and Uganda tufted guineafowl (*Numida meleagris major*), and many other birds, without finding additional specimens of this tick. It would appear, therefore, that *H. hoodi hoodi* is uncommon in the savannah of eastern Sudan.

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: One ♀ from tchagra shrike, *Tchagra senegalo remigialis*, Guar, Gogrial Subdistrict, February, 1953, Ahmed Mohamed El Sayed *legit* (HH collection).

This and the Torit collections are the only Sudanese records of this avian parasite.

DISTRIBUTION

The African avian haemaphysalid ranges through tropical Africa and into southern Africa, but is possibly more common in western Africa and Uganda than elsewhere. A related subspecies, *madagascariensis* Colas-Belcour and Millot, 1948, occurs on Madagascar and other closely related species form a tight complex in the Oriental Region (Hoogstraal 1953E).

WEST AFRICA: GAMBIA (Warburton and Nuttall 1909). GOLD COAST (Nuttall and Warburton 1915). FRENCH WEST AFRICA (Villiers 1955). SIERRA LEONE (Simpson's 1913 record of *H. leachii* from a bush shrike possibly refers to *H. hoodi hoodi*. Nuttall and Warburton 1915). PORTUGUESE GUINEA (Tendeiro 1947,1948,1951C,D, 1952A,C,D).

CENTRAL AFRICA: CAMEROONS (Rageau 1953A,B. Numerous specimens seen by HH). FRENCH EQUATORIAL AFRICA (Specimens from Djambala, Moyen Congo; CNHM).

[BELGIAN CONGO: Bequaert (1931) states that while this species had not been found in the Congo, it can be expected to occur here.]

EAST AFRICA: SUDAN (Hoogstraal 1954B). UGANDA (Neave 1912. Nuttall and Warburton 1915. Mettam 1932. Lucas 1954. See HOSTS below). KENYA (Hoogstraal 1954C).

SOUTHERN AFRICA: NYASALAND (Neave 1912. Nuttall and Warburton 1915. Wilson 1950B). MOZAMBIQUE (As H. africana: Howard 1909A. Nuttall and Warburton 1915. Santos Dias 1952D,1953B, 1954C; see HOSTS below. Hoogstraal 1954C. Theiler, correspondence; see HOSTS below). UNION OF SOUTH AFRICA (Bedford and Hewitt 1925. Bedford 1932B. Theiler, correspondence; see HOSTS below).

HOSTS

H. hoodi hoodi parasitizes birds exclusively, chiefly those kinds that are habitual ground feeders. See BIOLOGY below.

"Fowls" (i.e. ?domestic chickens) (Warburton and Nuttall 1909). Domestic chickens (Tendeiro 1947. Lucas 1954).

Burchell's coucal, Centropus senegalensis burchelli (Howard 1909). Western blue-headed coucal, C. monachus occidentalis (Rageau 1953B. Others seen by HH). Senegal coucal, C. senegalensis (Tendeiro 1948, Villiers 1955, and Nuttall and Warburton 1915). Guinea fowl, Numidia meleagris, plaintain eater, Gymnoschizorhis leopoldi, and "partridge" (Nuttall and Warburton 1915). Redwing starling, Onychognathus (= Amydrus) morio (Bedford and Hewitt 1925). East African blue-eared starling, Lamprocolius chloropterus elisabeth (Santos Dias 1952D). Clapper lark, Mirafa fischeri zombae (French Equatorial Africa specimens noted above). Falcon (Theiler, unpublished). Tchagra shrike (Hoogstraal 1954B,C, Sudan record above). Double-spurred francolin, Francolinus bicalcaratus (Cameroons, J. Mouchet legit, HH det). Spurfowl or francolin (Francolinus spp., Pternistis sp.) (Santos Dias 1953D, 1954C, Hoogstraal 1954B,C, and Sudan record above). White-browed scrub robin, Erythropygia leucophrys limpopoensis (Santos Dias 1954D). Abdim's stork (Hoogstraal 1954B, Sudan record above).

Uganda hosts of specimens identified for the Museum of Comparative Zoology are: grey hornbill, Lophoceros n. nasutus; Grant's crested francolin, F. sephaena grantii; yellow-beaked francolin, F. icterorhynchus; Abyssinian gonolak, Laniarius erythrogaster, and several individuals of both kinds of guinea fowl already noted from Equatoria Province, Sudan.

Additional, recently obtained host data (Theiler, correspondence) is as follows: Centropus superciliosus from Uganda; "partridges" from East London, eastern Cape, and southern Transvaal, South Africa; Turdoides jardinei and Orthochagra senegal from Maringua, Mozambique; and Falco biramicus from Pietermaritzburg, Natal.

The possibility that the record of a nymphal H. leachii muhsami from a tchagra shrike in Mozambique (Santos Dias 1954C) refers actually to H. hoodi hoodi should be considered.

The subject of parasitism of birds by ticks has been reviewed briefly by Schulze (1932B).

BIOLOGY

Aside from indications that H. hoodi hoodi feeds exclusively on birds, chiefly on those that feed on the ground, and that all of its stages occur on a single host, little else is known of their biology. If domestic chickens were frequently attacked, more reports probably would have appeared in the literature. In Portugese Guinea, however, Tendeiro (1947) reports this parasite to be common on domestic chickens and in Entebbe, Uganda (Lucas 1954), a flock of chickens was found so heavily infested that a number of hosts died or were badly debilitated.

The distribution of H. hoodi hoodi presumably is much more continuous in tropical Africa than present meagre records indicate. Phylogenetically, H. hoodi and related species, all of which closely resemble it, represents an old, quite static lineage. In Africa, Madagascar, Asia, and outlying islands these ticks parasitize only birds. Related species infest primitive mammals such as hedgehogs (insectivores), and also reptiles.

DISEASE RELATIONS

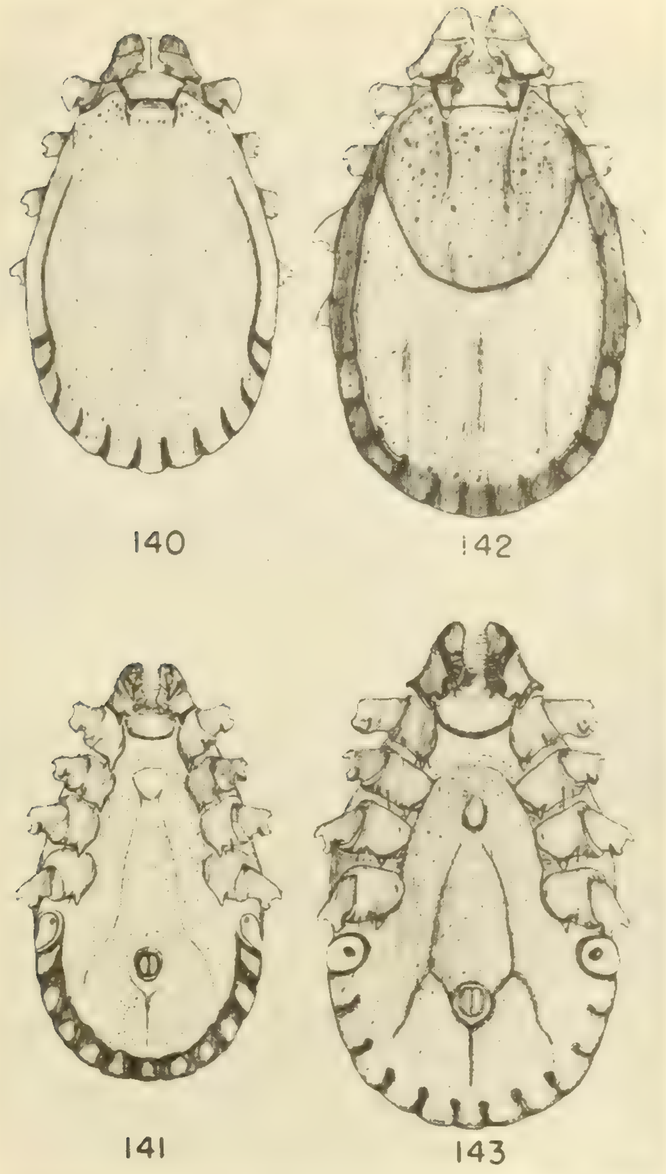
DOMESTIC CHICKENS. Fatal anaemia has been reported.

IDENTIFICATION

Males. Palpi basally are widely salient, straight and lacking dorsal or ventral spurs; laterally they are sharply and narrowly recurved basally and thence taper gradually to a narrow apex; segment 3 approximates segment 2 in length and medially bears a notably small and wide spur that is usually medially directed. The rectangular basis capituli has small but distinct cornua. The scutum is beset with a moderate number of fairly large, shallow punctations; lateral grooves include the first festoon and extend to the anterior third of the scutum; cervical grooves are shallow, concave, and extend more or less to the apical level of the lateral grooves. Coxae bear a small posterior spur, that of III may be obsolete and that of IV may be smaller than illustrated (Figure 137). Tarsi are moderately short and abruptly tapered; they bear a very small ventral apical hook. Size varies from 1.3 mm. to 2.0 mm. long and from 1.0 mm. to 1.4 mm. wide.

Female palpi are like those of the male except that they are slightly less salient basally and more conical and elongate. The basis capituli is rectangular with very small cornua and a slightly concave basal margin; the porose areas are shallow and indistinct, The scutum is broadly oval, slightly longer than wide, and gradually converging posteriorly; punctations are evenly scattered and rather large; cervical grooves are slightly concave and may reach the posterior third of the scutum. Tarsi taper somewhat more gradually than in males. The body becomes considerably extended when engorged.

The larvae and nymph have been described and illustrated by Nuttall and Warburton (1915).



Figures 140 and 141, ♂, dorsal and ventral views
Figures 142 and 143, ♀, dorsal and ventral views

HAEMAPHYSALIS HOUYI
Sudan specimens

PLATE XLIII

HAEMAPHYSALIS HOUYI Nuttall and Warburton, 1915.

(Figures 140 to 143)

THE WEST AFRICAN GROUND-SQUIRREL TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		1		Kapoeta	*Euxerus erythropus leucoumbrinus*	Dec
			8	Torit	*Euxerus erythropus leucoumbrinus*	Jan (2)
	4	8	4	Torit	*Euxerus erythropus leucoumbrinus*	Feb
		2	1	Torit	*Euxerus erythropus leucoumbrinus*	Mar
2	28	12	13	Torit	*Euxerus erythropus leucoumbrinus*	Dec (4)
		1	1	Latome	*Euxerus erythropus leucoumbrinus*	Apr (SVS)
	1		1	Yei	*Euxerus erythropus ?lacustris*	Apr

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: All from Galual-Nyang Forest, from five specimens of *Euxerus erythropus* subspp., in 1953, by H. Hoogstraal: 6♂♂, 1♀, 17 February; 4♂♂, 5♀♀, 4 nymphs, 19 February; 2♂♂, 16 February.

Upper Nile: Bor, ex "*Xerus rutilus*", 2♂♂, 21 May 1909, H. H. King *legit* (S.G.C.). (This host name is a misidentification for *Euxerus erythropus* subspp.).

Blue Nile: As ♀ of *H. calcarata*: Roseires, from ground squirrel (Neumann 1910A); also records two ♂♂ that are probably *H. houyi*; Ch. Alluaud *legit*; cf. Hoogstraal (1955D). Kamisa, Dinder River, 1♂, 1♀, W. P. Lowe *legit* [BM(NH)].

DISTRIBUTION

H. houyi is a ground-squirrel parasite extending in a belt across the widest part of Africa from the Atlantic Ocean through French West Africa, Cameroons, the Sudan, and Uganda to the northwestern corner of Kenya, west of the Rift Valley. It is closely related to *H. calcarata* that parasitizes a different genus of ground squirrels in East Africa east of the Rift Valley (Hoogstraal 1955D). See also HOSTS and BIOLOGY below.

WEST AFRICA: FRENCH WEST AFRICA (Rousselot 1951,1953B. Hoogstraal 1955D. Villiers 1955).

CENTRAL AFRICA: FRENCH EQUATORIAL AFRICA (Bate, "New Cameroons") (Nuttall and Warburton 1915. Hoogstraal 1955D).

EAST AFRICA: SUDAN (As ♀ of H. calcarata: Neumann 1910A. As H. houyi: Hoogstraal 1954B,1955D).

UGANDA and KENYA (Hoogstraal 1955D).

HOSTS

Ground-squirrels, Euxerus erythropus subspp. (All authors). King's specimen from "Xerus rutilus" at Bor (SGC) is based on a misidentification of the host. E. erythropus is the common ground-squirrel of West Africa, and of Northcentral and East Africa west of the Rift Valley. East of the Rift Valley it is replaced by Xerus rutilus subspp., parasitized by H. calcarata Neumann, 1902*. In Kenya, Xerus is confined to hot lowlands and Euxerus to higher, arable mountains from 2000 feet to 6000 feet elevation, but mostly above 3000 feet. If, as now seems apparent, it is true that these two ticks are so host specific, this would seem to be a bolstering argument against lumping these two squirrel genera in one genus, as some mammalogists advocate (Hoogstraal 1955D).

BIOLOGY

Aside from the fact that all stages may be found on a single ground-squirrel, little is known concerning the biology of H. houyi. This tick and its host inhabit savannah country with few or scattered trees, and upland grasslands. Along the southern border of the squirrel's range it extends into forested districts, but only in tongues of grassland with scattered trees between thicker forest. As already stated under HOSTS, in Kenya, where the two host genera and the two related tick species occur near each other, the host of H. houyi is confined mostly to arable uplands and that of H. calcarata inhabits warmer and more arid lowlands.

*The record of H. calcarata from Dahomey (Villiers 1955) undoubtedly is based on misidentification.

In the Galual-Nyang forest area of Bahr El Ghazal, each of five host specimens examined was infested. In Torit District of Equatoria, a third of the 27 hosts examined yielded specimens of *H. houyi*.

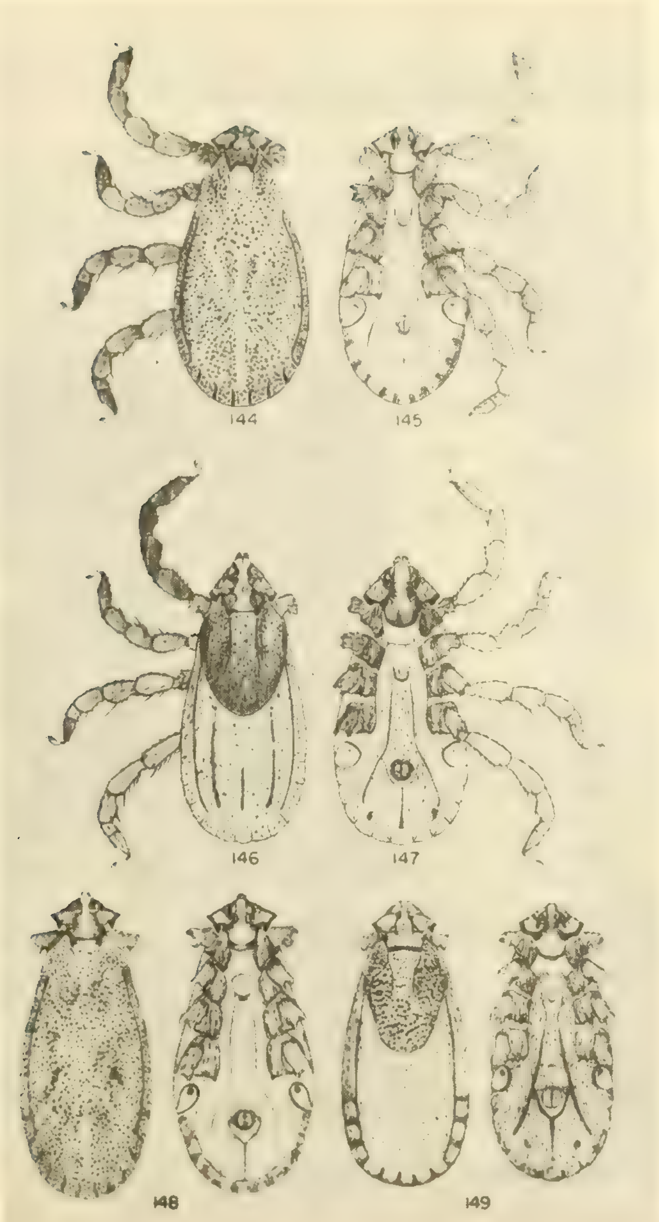
DISEASE RELATIONS

Unstudied but potentially important.

IDENTIFICATION

The following characters easily distinguish *males* among the Sudan haemaphysalid fauna: strong ventral spur on trochanter I; all coxae with distinct spurs; tarsi short, robust, and abruptly tapered; palpi widely expanded basally, without a developed dorsal spur basally, with basal spur ventrally and spur from segment 3 ventrally; basis capituli strongly diverging anteriorly and with moderate cornua; dentition 4/4; scutum with long, deep lateral grooves enclosing first festoon, and few, scattered, shallow, inconspicuous punctations of mixed sizes; size ranges from an overall length of 1.71 mm. to 2.15 mm. and width of 0.99 mm. to 1.20 mm.

Females are also easily recognized by the raised spurlike, non-projecting ventral ridge of trochanter I, coxae and tarsi almost exactly like those of male; palpi essentially like those of male but larger and more elongate, basis capituli short, wide, and with prominent cornua and anteriorly diverging lateral margins; dentition 4/4; scutum only very slightly longer than wide and broadly rounded posteriorly, with few, shallow, scattered punctations of various sizes mostly on anterior half. The size is somewhat greater than that of males.



Figures 144 and 145, ♂, from domestic dog (Kajo Kaji)
Figures 146 and 147, ♀, from domestic dog (Kajo Kaji)
Figures 148 and 149, ♂ and ♀, from civet (Obbo)

<u>HAEMAPHYSALIS</u> <u>LEACHII</u> <u>LEACHII</u>
Sudan Specimens

PLATE XLIV

HAEMAPHYSALIS LEACHII LEACHII (Audouin, 1827).

(Figures 144 to 149)

THE YELLOW DOG-TICK

L	N*	♀	♂	EQUATORIA PROVINCE RECORDS		
	4			Torit	*Crocidura nyansae toritensis*	Feb
	5			Lotti Forest	*Praomys tullbergi sudanensis*	Apr (2)
	2			Torit	*Tatera benvenuta benvenuta*	Dec
	2			Kapoeta	*Arvicanthis niloticus jebelae*	Apr
		12	5	Juba	Burrows of *A. n. jebelae*	Dec (4)
	5			Nimule	*Acomys hystrella*	Mar
			1	Torit	*Ichneumia a. albicauda*	Apr
	2	1	7	Yei	*Ichneumia a. albicauda*	Apr
	2	2	10	Obbo	*Civettictus civetta congica*	Apr
		1	1	Torit	*Civettictus civetta congica*	Feb
			3	Torit	*Civettictus civetta congica*	Jun
	1	11	88	Torit	*Canis aureus soudanicus*	Apr (2)
		14	17	Torit	*Canis aureus soudanicus*	Nov
		5	48	Torit	*Canis aureus soudanicus*	Dec (2)
		15	21	Yubo	*Canis mesomelas elgonae*	Mar
		3	7	Torit	*Panthera leo leo*	Mar
		6		Gilo	Domestic dogs	Dec (4)
		8		Katire	Domestic dogs	Jan (2)
		5	5	Katire	Domestic dogs	Oct (2)
		4	2	Torit	Domestic dogs	Jan (2)
		5	2	Torit	Domestic dogs	Dec (2)
		4	2	Kajo Kaji	Domestic dogs	Dec (2)
			1	Beringi, Yei River	Domestic dog	Feb (SGC)
			1	Bundle, Kheirallah	Domestic dog	Mar (SGC)

*The subspecies of these nymphs is not entirely certain.

DISTRIBUTION IN THE SUDAN

King (1926) listed Equatoria, Bahr El Ghazal, Upper Nile, Blue Nile, Kordofan, Khartoum, and Kassala Provinces, and noted that although *H. leachii* (subspecies not differentiated) has a wide range in the Sudan, it is a relatively rare species here. We now know that *H. l. leachii* occurs in every Province of the Sudan. In most areas it is probably fairly common, though usually only on medium-size carnivores, especially jackals, foxes, and domestic dogs.

The following is Sudanese material seen:

Bahr El Ghazal: Wau (Domestic cat; SVS. Domestic dogs; HH). Galual-Nyang Forest (Domestic dog; HH).

Upper Nile: Akobo Post (Lion; SGC). Sobat (Domestic dog; SGC).

Blue Nile: Magangani (*Caracal c. nubicus*; MCZ).

Kordofan: Delami (Domesticated wild cat; SGC). Umm Dona, (Mustelid; SGC).

Darfur: Fasher (Domestic dogs; SVS).

Khartoum: Khartoum, near (*Vulpes a. aegyptiaca*; HH). (Domestic dogs; Balfour 1911F).

Kassala: Port Sudan (Domestic dogs; HH).

Northern: Wadi Halfa and Atbara (*Vulpes a. aegyptiaca*; HH).

DISTRIBUTION

Haemaphysalis leachii leachii is a ubiquitous tick of tropical and southern Africa. In Egypt, it occurs in and at the edge of the Nile Valley and Delta almost to the Mediterranean coast. It has been reported to range along the Mediterranean littoral at least as far west as Algeria but these records require careful checking for accuracy of identification. *H. l. leachii* is fairly common in the mountains of the Yemen in southern Arabia (Sanborn and Hoogstraal 1953; Hoogstraal, ms.), which is an outlying part of the Ethiopian Faunal Region. It is not known from Madagascar (Hoogstraal 1953E) and I have not seen it in Turkey.

In Europe, H. leachii has been said to occur in Yugoslavia (Oswald 1938) and in Greece (Oswald 1938, Pandazis 1947) but these records are considered questionable. A German specimen found on a migrant stork from Africa was mentioned by Schulze (1937A). Soviet records (Olenev 1928) refer to different species and Pomerantzev (1950) does not consider it to be a member of the Russian fauna.

The exact relationships of Oriental Faunal Region forms ascribed to this species by Nuttall and Warburton (1915) are at present under study. Apparently most, except the subspecies indica Warburton, 1910, represent different species. Numerous species, obviously derived from an H. leachii prototype, range throughout Asia and its nearby islands, the Near East, and the Madagascan archipelago.

It appears from remarks by Dumbleton (1953), that this tick has not been found in New Zealand since the original record by G. E. Mason (1921), that Mason's ticks may have been a different species. Mason's distributional concepts for this species most probably require revision.

Note

In the following list, all available references to "H. leachii" are noted, though it is usually impossible to determine whether authors are referring to the subspecies leachii or muhsami. I have seen actual specimens of tne subspecies leachii from all geographical areas and from almost all political territories listed below. The following records are those for continental Africa and Arabia.

As stated above, it is uncertain whether the subspecies leachii occurs outside of the Ethiopian Faunal Region and parts of the Mediterranean Subregion of the Palearctic Region. Analysis of studies of the distribution of this tick will be presented subsequently.

NORTH AFRICA: EGYPT (Savignyi 1826. Audouin 1827. Neumann 1911. Mason 1916).

[The following North African records require checking for accuracy of identification: LIBYA: Tonelli-Rondelli (1926B). Franchini (1927,1929A,E). TUNISIA: Colas-Belcour and Rageau (1951). See Hoogstraal (1955B). ALGERIA: Neumann (1897) from a "nightingale" and from grass. Some of the H. leachii reported by Neumann (1897) were later (1905) described by him as H. numidiana, which is a synonym of H. erinacei Pavesi, 1884.]

WEST AFRICA: NIGERIA (Simpson 1912A,B. Nuttall and Warburton 1915. Johnston 1916. Pearse 1929). TOGO (Neumann 1901,1911). GOLD COAST (Simpson 1914. Nuttall and Warburton 1915. Beal 1920). FRENCH WEST AFRICA (Rousselot 1951,1953B. Villiers 1955). PORTUGESE GUINEA (Tendeiro 1948,1951A,D,1952A,B,C,D,F,1953,1954). SIERRA LEONE (Simpson 1913. Nuttall and Warburton 1915. Entomological Reports 1916). GAMBIA (Simpson 1911. Nuttall and Warburton 1915).

CENTRAL AFRICA: CAMEROONS (Neumann 1901,1911. Ziemann 1912A. Nuttall and Warburton 1915. Rageau 1951,1953A,B. Rousselot 1951, 1953B. Dezest 1953). FRENCH EQUATORIAL AFRICA (Nuttall and Warburton 1915. Fiasson 1943B. Rousselot 1951,1953B. Giroud 1951. Giroud and LeGac 1952). LIBERIA (Bequaert 1930A).

BELGIAN CONGO and RUANDA-URUNDI (Newstead, Dutton, and Todd 1907. Massey 1908. Neumann 1911. Nuttall and Warburton 1915, 1916. Seydel 1925. Schwetz 1927A,B,C. Bequaert 1930A,B,1931. Tonelli-Rondelli 1932E. Wanson, Richard, and Toubac 1947. Fain 1949. Giroud and Jadin 1950,1955. Giroud 1951. Jadin and Giroud 1951. Jadin 1951B. Schoenaers 1951A,B. Rousselot 1931, 1953B. Theiler and Robinson 1954. Santos Dias 1954D. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (Balfour 1911F. King 1911,1926. Nuttall and Warburton 1915. Hoogstraal 1954B).

ETHIOPIA (Neumann 1902B,1922. Nuttall and Warburton 1915. Tonelli-Rondelli 1930A. Stella 1938A,1939A,1940. Charters 1948. D'Ignazio and Mira 1949). ERITREA (Nuttall and Warburton 1915. Tonelli-Rondelli 1930A. Stella 1938A,1939A,1940). ITALIAN SOMALILAND (Paoli 1916. Franchini 1929C. Tonelli-Rondelli 1935. Niro 1935. Stella 1940). FRENCH SOMALILAND (Stella 1940).

KENYA (Neave 1912. Nuttall and Warburton 1915. Neumann 1922. Anderson 1924A,B. Lewis 1931A,B,C,1932B,1934,1939A. Roberts and Tonking 1933. Kauntze 1934. Roberts 1935. Loveridge 1936A. Dick and Lewis 1947. Weber 1948. Heisch 1950B. Binns 1951,1952. Wiley 1953. Weyer 1955). UGANDA (Neave 1912. Nuttall and Warburton 1915. Neumann 1922. Bequaert 1930B. Loveridge 1936. Carmichael 1942. As H. leachii humerosoides: Theiler 1943B. Wilson 1950C). TANGANYIKA (Neumann 1907C,1910B. Neave 1912. Nuttall and Warburton 1915. Morstatt 1913. Loveridge 1923A. Bequaert 1930A. Allen and Loveridge 1933).

SOUTHERN AFRICA: ANGOLA (Neumann 1901. Gamble 1914. Nuttall and Warburton 1915. Sousa Dias 1950. Santos Dias 1950C. Theiler and Robinson 1954). MOZAMBIQUE (Howard 1908. Nuttall and Warburton 1915. De Meillon 1942. As H. leachii humerosoides: Theiler 1943B. Santos Dias 1952H,1953A,B,C,1954H,1955A. Theiler and Robinson 1953A).

NORTHERN RHODESIA (Neave 1912. Nuttall and Warburton 1915. Morris 1933,1934,1935,1936,1937,1938,1939,1940. As H. leachii humerosoides: Le Roux 1947. Theiler and Robinson 1954). SOUTHERN RHODESIA (Koch 1903. Edmonds and Bevan 1914. Nuttall and Warburton 1915. Jack 1921,1928,1937,1942). NYASALAND (Old 1909. Neave 1912. Nuttall and Warburton 1915. De Meza 1918. Wilson 1950B).

BASUTOLAND (Scarce: Theiler and Robinson 1953A). SWAZILAND (Theiler and Robinson 1953A). SOUTHWEST AFRICA (Tromsdorff 1914. Sigwart 1915. Absent in Southwest Africa: Theiler and Robinson 1953A). UNION OF SOUTH AFRICA (Neumann 1897,1911. Lounsbury 1901,1902A,1904A. Howard 1908,1909A. Galli-Valerio 1909. Speiser 1909. Dönitz 1910B. Moore 1912. Van Saceghem 1914. Nuttall and Warburton 1915. Bedford 1920,1926,1927,1931B,1932B,1936. A. Theiler 1921. Cowdry 1925C,1926A,1927. Curson 1928. Cooley 1929, 1934. Bedford and Graf 1934,1939. Pijper and Crocker 1938. J.H.S. Gear 1938. Brumpt 1938D. J. Gear 1939,1954. Gear and Douthwaite 1938. Mason and Alexander 1939. Gear and De Meillon 1939,1941. De Meillon 1942. du Toit 1942B,1947A. Theiler 1943B. Cluver 1944. Neitz and Steyn 1947. Theiler and Robinson 1953A).

OUTLYING ISLANDS: ZANZIBAR (Neave 1912. Aders 1917). Not known from Madagascan archipelago (Hoogstraal 1953E).

ARABIA: YEMEN (Sanborn and Hoogstraal 1953. Hoogstraal, ms.).

HOSTS

H. leachii leachii, in the adult stage commonly parasitizes domestic dogs. Its local incidence on dogs varies from greater to less than that of the kennel tick, R. s. sanguineus. Locally, R. simus simus is sometimes also a common parasite of dogs. On wild animals, H. l. leachii is frequently numerous on the Canidae (foxes, hunting dogs, and jackals). It is, in comparison with the subspecies muhsami, rare on the various families of smaller carnivores such as the viverrids, which are tropical Africa's most common carnivores. On larger Felidae, lions, leopards, cheetahs and the like, the subspecies leachii may occur in either larger and smaller numbers than muhsami but present data do not suggest that the large cats are hosts of preference. Records of H. l. leachii from smaller cats and from domestic cats are rare indeed.

Domestic animals, other than dogs, are parasitized only exceptionally. Under a very few local conditions cattle may be attacked. Possibly tribal customs, in which man, cattle, and dogs sleep in the same hut or compound, account for these instances.

Larvae and nymphs usually parasitize common field rodents, especially Arvicanthis and Mastomys, in their nests. They are said also to feed on domestic dogs (see BIOLOGY below). Rarely one finds a few nymphs, along with considerably larger numbers of adults, on wild canines. This would indicate that, under the influence of some yet unknown factors, nymphs have left rodent burrows to feed elsewhere, or that an apparently small proportion of the nymphal population does not feed on rodents.

Inasmuch as it is impossible to distinguish which of the two subspecies of H. leachii most authors are referring to, the only data that may be used in this section are from the present observations and those of the very few recent students who have differentiated their material. A more exact study of available data will be presented in a subsequent report.

Life Cycle

Nuttall's (1913B) and Nuttall and Warburton's (1915) summary of Nuttall's and of Lounsbury's (1901,1902A,1904A) observations on rearing H. leachii (most likely H. l. leachii) are essentially as follows: This tick requires three hosts upon which to feed during its larval, nymphal, and adult stages. About a week after molting each stage readily attaches to the host, which under experimental conditions may be a number of different animals, jackal, dog, ferret, hedgehog, goat, or rabbit. It appears to be immaterial upon which of these hosts the ticks feed. Larvae and nymphs feed for three to seven days (two to three days: Lounsbury), occasionally longer. Females attach for eight to sixteen days. Males may remain upon the host for many weeks. Air temperature, within the limits observed (9°C. to 23°C.), appears to exert little or no influence upon the time ticks remain upon the host, "the warmth from the animal being doubtless sufficient to keep the ticks active".

The time required for metamorphosis is influenced by temperature. Larvae hatch after 26 to 37 days at 20°C. or after 58 to eighty days at 12°C. to 13°C. Nymphs emerge, as a rule, after thirty to forty days. Adults emerge after fifteen or sixteen days at 24°C. to 26°C., but require up to seventy days at 14°C.

The unfed tick survives for long periods under favorable conditions. In small corked bottles maintained at about 12°C., larvae are still active after 169 days, nymphs after 52 days, and adults after about 210 days.

Males and females placed simultaneously upon the host scatter but in two or three days both sexes are found attached in close proximity to each other. Copulation occurs upon the host (HH observation). Lounsbury saw marked males detach and reattach close to females. A male may mate with more than one female.

After a replete female abandons the host, the interval before egglaying commences is markedly influenced by temperature. Females held at 23°C. begin oviposition after three to five days; at 16°C. to 21°C. after fourteen to eighteen days; at lower temperatures after 24 to 60 days. Whereas an occasional female dies as soon as oviposition is completed, others may survive for a few days or, exceptionally, for a month. One tick deposits from 2400 to 4800 eggs.

In nature, the yellow dog-tick doubtless may produce two generations a year. Lounsbury reared three generations a year in an incubator. Taking average figures for ticks raised under favorable conditions, the cycle may be completed in 123 days, as follows:

PERIOD	DAYS	
Preoviposition	4	(23°C.)
Oviposition to hatching	30	(20°C.)
Larval prefeeding period	7	
Larva feeds	5	
Premolting period	31	(17°C.)
Nymphal prefeeding period	7	
Nymph feeds	5	
Premolting period	15	(24°C.)
Adult prefeeding period	7	
Adult (female) feeds	12	
	123	

Ecology

The distribution of *H. l. leachii* has been determined for South Africa by Theiler and Robinson (1953A). The most important factor in limiting this tick's spread there is increasing aridity. Twenty inches of annual rainfall, irrespective of vegetation type, appears to be the critical level there.

However, in northern Sudan, where rainfall is absent or considerably less than ten inches annually, *H. l. leachii* is still fairly common on foxes.

In the Nile Valley of Egypt, where rainfall is nil to exceedingly low, the tick thrives. But, it should be stressed, the microhabitats of its larval and nymphal host, the grass rat, *Arvicanthis n. niloticus*, are more humid than elsewhere, situated as they are beside irrigated, cultivated fields or in dykes. We have never found these ticks in burrows in the desert, even on the Mediterranean littoral where burrows are frequently patently damp. Foxes that pick up newly-molted adult ticks, probably from vegetation near grassrat burrows when they forage in cultivated areas at night, retreat to very dry desert caves and dens to rest by day. In these situations, evaporation from the host skin may be the factor that allows the parasite's survival.

A comparative study of the survival of Northeast African and South African populations under local conditions of humidity and temperature should be of considerable interest.

Theiler and Robinson (1953A) have also found that H. l. leachii does not occur in those parts of South Africa with over sixty days of heavy frost per annum. It is generally absent from the arid Karroo except where grasses are present. Altitude does not effect the distribution of the yellow dog-tick within the limits of critical frost days noted above. Variability of incidence in various zones of South Africa is also discussed.

According to Lewis (1939A), H. leachii (probably including both subspecies - HH) occurs in all districts and altitudes of Kenya but seems to prefer the shelter of dense shrub and grassy woodlands. In some areas it is more common on dogs than is R. s. sanguineus.

Theiler and Robinson (loc. cit.) state that the immature stages of H. l. leachii may feed on dogs. Our experience in East Africa, Egypt, and Arabia indicates that nymphs are very rarely found on roaming wild carnivores such as mongooses, civets, and jackals, but that larvae and nymphs frequent rodent burrows. Onderstepoort records (Theiler, correspondence) show one hundred collections of nymphs from murid rodents, one from cattle, one from shrews, one from Felidae, one from hares, eight from elephant shrews, three from mustelids, five from springhaas, four from squirrels, three from mongooses, and one from civet. It is obvious that many factors governing the life cycle and possible variability in host preference of immature stages remain to be determined from field studies.

Roberts (1935) found larvae and nymphs in the Nairobi area common on various field rodents and in their nests. These are the same as those listed for R. s. simus (page 743). The writer's experience in other parts of Kenya in general confirms Roberts' findings. However, Roberts observed that nests of Mastomys (= Mus) coucha near the surface of the ground rather than deeper nests are preferred by H. leachii, but I do have numerous records from deeper nests of grassrats. This factor also requires further study (See R. s. simus, page 746). It is of some interest to note that all specimens that have been reared in our laboratories from nymphs from rodent nests in Kenya, the Sudan, and Egypt have been subspecies leachii.

The chalcid wasp parasite Hunterellus hookeri has been bred from nymphs in South Africa (Cooley 1929,1934). This subject is further discussed under R. s. sanguineus (page 710).

DISEASE RELATIONS

MAN: Boutonneuse fever (Rickettsia conorii).

Experimental evidence indicates efficiency as a vector of Rocky Mountain spotted fever (Rickettsia rickettsii).

MAN AND ANIMALS: Q fever (Coxiella burnetii).

DOMESTIC DOGS: Canine babesiosis (Babesia canis).

?DOMESTIC CATS: Feline babesiosis (Nuttallia felis).

?JACKALS: Canine babesiosis (B. canis).

REMARKS

A gynandromorph of H. leachii (probably subspecies leachii) has been described and illustrated by Santos Dias (1953C). The misshapen specimen of H. leachii described and illustrated by Nuttall (1914A), and widely quoted by subsequent authors, refers to the Asiatic subspecies indica Warburton, 1910. Very slightly misshapen specimens, due to injury, of both African subspecies have been described and illustrated by Santos Dias (1955A). The measurements and increase in relative size from stage to stage have been studied by Campana-Rouget (1954), apparently from data in Nuttall's Monograph.

It should be noted that some gradation appears between the two African subspecies of *H. leachii* and that a few specimens do not conform strictly to the criteria for one or the other form. The third subspecies, *indica* Warburton, 1910 of southern Asia, is more like the subspecies *muhsami* than like the subspecies *leachii*, and is distinguishable from both by minor but apparently constant and valid characters.

Dr. G. Theiler and the writer for several years have been collaborating on a morphological study of considerable series of this species from a variety of hosts and localities. The results, with complete data, will be presented in a separate report. The variety *humerosoides*, common on canines, informally proposed by Theiler (1943B) for the large, narrow, elongate form with extreme ventral projection of spurs, appears from this study to be an extreme body form of the somewhat variable *H. l. leachii* and not a separate morphological or biological subspecies. In numerous long series of specimens from single hosts, gradations from this to less extremely narrow and elongate forms occur. There are, however, suggestions that the extreme form is a reflection of particular host factors, and application of some of the more complex aspects of newer taxonomic concepts may eventually justify the name *humerosoides*.

IDENTIFICATION

Males. This long, narrow tick has tarsi II to IV gradually tapering; punctations numerous, mostly small, and discrete; palpi obtusely angled and widely triangular, widest at level of basal third, with lateral margin straight or very slightly convex but almost never concave; basally both dorsally and ventrally forming a conspicuous and usually strong spur just laterad of the point of insertion; palpal segment 3 with a retrograde spur that is long and tapering; basis capituli with lateral margins varying from almost parallel to somewhat divergent anteriorly and with cornua that are usually large and pointed; coxae always with a distinct basal spur overlapping the basal margin and with a number of long, conspicuous hairs. This combination of characters must be considered in separating males from those of other species and from the subspecies *muhsami*.

The scutum varies from about 2.3 mm. to 3.8 mm. long and from 1.2 mm. to 1.9 mm. wide; average specimens are about 2.6 mm. long by 1.3 mm. wide. This length-width ratio is important in comparing this subspecies with muhsami, though a few intergrade specimens, with respect to this feature, do occur. The punctations, always numerous and mostly comparatively small, are usually discrete; they cover the entire dorsum including lateral areas and festoons but frequently are reduced in the narrow, elongate area corresponding to the posterior median groove of rhipicephalids. The long, narrow lateral groove encloses the first one or two pairs of festoons; the closely approximated, arched cervical grooves usually extend to the anterior level of the lateral grooves. The scutal surface is more or less arched.

The palpi are notable for their wide, obtusely angled form. The lateral margin, either straight or very slightly convex in outline, distinguishes this subspecies from muhsami, but, rarely, a similar form occurs on ticks with the short, broad scutal type of muhsami. The recurved basal margin is typically broken both dorsally and ventrally by a strong spur just laterad of the point of insertion; while this spur is usually accentuated in large, narrow, elongate specimens it is surprisingly reduced in some individuals of this type. The ventral retrograde spur of palpal segment 3 notably is consistently strong, overlapping the base of segment 3, and narrow and tapering. Segment 3 is about half as long as segment 2. The basis capituli, typically, is elongate with strong, tapered cornua and with lateral margins slightly divergent anteriorly, but the length-width ratio and size and shape of the cornua is surprisingly variable, even in specimens in which the general appearance would otherwise lead one to expect that these features would be typical, and the degree of divergence of the lateral margins is also somewhat variable. The hypostome has 4/4 or 5/5 dentition.

The coxae are notable for the basal spur that overlaps the basal margin and for the presence of twelve to twenty long hairs on each (hairs may be broken or rubbed off in old or carelessly collected or preserved material). The size and position of these spurs always approximate those illustrated herein and are important in distinguishing this species from some others. In newly molted or fresh specimens, the numerous long hairs are a very characteristic feature of this species. The elongate tarsi taper gradually apically and bear a small pad and claw; the claw curves distad of the apex of the pad.

Females. This sex closely recalls the male and while it is equally as variable it appears to be less frequently confusing with the subspecies muhsami.

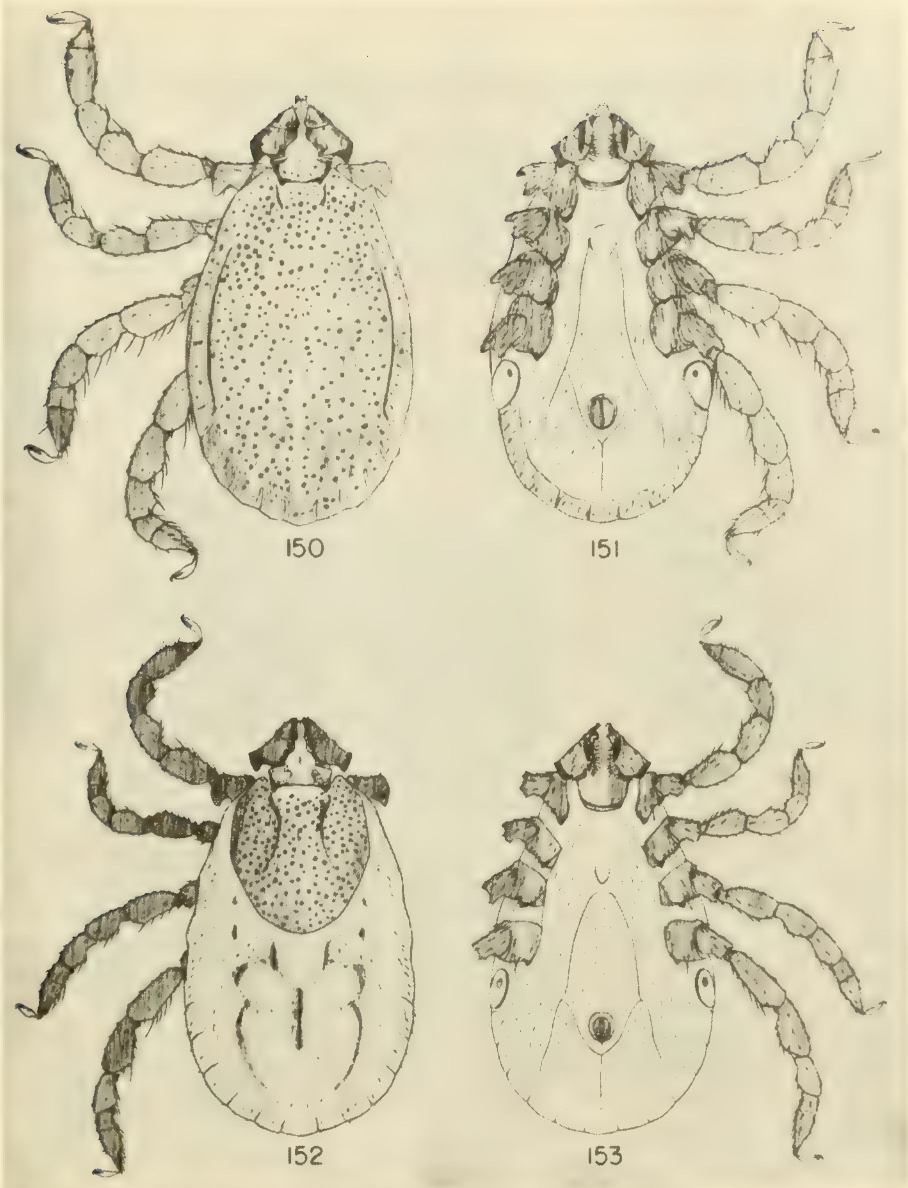
The elongate scutum, from one fourth to one third longer than wide, posteriorly tapers gradually to a more or less narrow point. Scutal punctations are much like those of the male, and while they are frequently somewhat larger and less numerous than those of the male they are distinguishable from the consistently large and sparse punctations of muhsami. The cervical grooves gradually converge to the scutal midlength and thence diverge towards the posterolateral margins but do not reach these margins.

The palpal outline is like that of the male except that it is more elongate, the length of segment 3 more nearly equalling that of segment 2 than it does in the male; and the basal spur ventrally is absent or extremely reduced in the form of a bluntly rounded projection. The lateral margin, which as in the male is typically straight or slightly convex, is actually more readily and definitely usable as a diagnostic character because of its greater length; while this margin is very slightly concave in some specimens these are unusual. The basis capituli is definitely wider and shorter than that of the male and bears shorter cornua.

Coxal and tarsal characters are like those of the male; in spite of some variation they are not likely to be confused with most specimens of the related subspecies. [In considering the female coxal spur as minute and the tarsus as "stout", Nuttall and Warburton (1915) must have been referring to specimens of muhsami.]

The body form of unengorged females is typically elongate and comparatively narrow, as in males, though the overall size is somewhat larger. Engorged females may become so large in the latter hours of feeding that superficially they resemble typical boophilid females.

The larvae and nymph of this species, but not definitely referable to this subspecies, have been described by Nuttall and Warburton (1915).



Figures 150 and 151, ♂, dorsal and ventral views
Figures 152 and 153, ♀, dorsal and ventral views

HAEMAPHYSALIS LEACHII MUHSAMI
Sudan Specimens from White-tailed Mongoose

PLATE XLV

HAEMAPHYSALIS LEACHII MUHSAMI Santos Dias, 1954(E)

(= H. LEACHII INDICA (in Africa) or

H. LEACHII near INDICA of authors).

(Figures 150 to 153)

THE YELLOW SMALL-CARNIVORE TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
			1	Torit	Crocidura nyansae toritensis	Feb	
		1		Torit	Atelerix pruneri oweni	Feb	
			2	Tarangore	Atelerix pruneri oweni	Jun	
		2	1	Torit	Mellivora capensis abyssinica	Jan	
			1	Torit	Canis mesomelas elgonae	Dec	
		3	1	Torit	Canis aureus soudanicus	Apr	(2)
		5		Obbo	Civettictis civetta congica	Apr	
		2	1	Torit	Civettictis civetta congica	Feb	
			9	Torit	Civettictis civetta congica	Jun	(2)
		4	9	Torit	Civettictis civetta congica	Jul	
		1	2	Torit	Genetta tigrina aequatorialis	Feb	
		2	15	Kapoeta	Herpestes sanguineus sanguineus	Apr	
		1	1	Torit	Ichneumia albicauda albicauda	Jan	
			15	Torit	Ichneumia albicauda albicauda	Mar	
	2	40	88	Torit	Ichneumia albicauda albicauda	Apr	(3)
	1	14	39	Yei	Ichneumia albicauda albicauda	Apr	(2)
		1		Torit	Felis libyca ugandae	Nov	
		1		Kapoeta	Lepus capensis subsp.	Apr	
		1		Ikoto	Lepus capensis crawshayi	Feb	
		1		Ikoto	Rhynchotragus guentheri smithii	Dec	
		1		Torit	Domestic dog		

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: 12♂♂, 4♀♀, black-legged mongoose, Galual-Nyang Forest, 27 May 1953, E. T. M. Reid legit. 1♂, same host and collector, Yirol, 22 January 1954. 5♂♂, Atelerix pruneri oweni, Galual-Nyang Forest, 24 February, 1953, H. Hoogstraal legit. 1♂, 1♀, *Atelerix pruneri oweni*, Majan Yom, 2 May 1953, E. T. M. Reid *legit*. 12♂♂, 6♀♀, "small rodent burrowing in termite mound", Waynjok, N. W. Gogrial, April, 1953, W. Dees *legit*. 1♀, tiang, *Damaliscus korrigum tiang*, Galual-Nyang Forest, April, 1953, E. T. M. Reid *legit*. 2♂♂, leopard, 36 miles south of Yirol, 18 January, 1953, E. T. M. Reid *legit*. 1♀, domestic cat, Galual-Nyang Forest, March 1953, and 4♀♀, same host, Wau, October, 1953, both SVS.

Blue Nile: 5♂♂, 3♀♀, "mongoose", Wad Medani, 29 November 1950, D. J. Lewis *legit* (SGC).

Khartoum: 4♂♂, "fox", Khartoum, 9 January 1918, R. Cottam *legit* (SGC).

DISTRIBUTION

The subspecies *muhsami* occurs in all areas of the Ethiopian Faunal Region, including the mountains of the Yemen in south-western Arabia. We have not seen it in Egypt. The data will be published subsequently in a series of reports on Africa haemaphysalids.

HOSTS

The subspecies *muhsami* is especially common on small carnivores such as mongooses, genets, civets, and wild cats. It seldom attacks wild or domestic canines or wild antelopes. Usually smaller numbers are found on mole rats, shrews, hedgehogs and hares; the possibility that certain of these may represent separate forms is being studied. Full data will be presented in the report mentioned under DISTRIBUTION above.

BIOLOGY

This subject requires study, especially in relation to that of the subspecies *leachii*.

DISEASE RELATIONS

Unstudied.

REMARKS

As already indicated, Theiler and the writer have been studying variation in this species for some years and the final report is nearing completion. Recent material sent by Santos Dias to Theiler for identification, and returned with the note that this was typical of what we were provisionally referring to as "H. near indica" pending completion of our studies, was utilized as the type series for the "species" muhsami. These specimens and their description and illustration correspond with what we have been considering as the "H. leachii near indica" of Theiler (1943B). Subsequent Theiler-Santos Dias correspondence, however, indicates that the latter worker considers muhsami as a separate species, separate and distinct from "near indica". Recently (November 1955) Dr. J. Bequaert has kindly sent me his paratype specimens of "H. muhsami" and study of these confirms the already mentioned Theiler viewpoint.

Santos Dias (1954C) reports a nymph of "H. muhsami" from a tchagra shrike in Mozambique. The likelihood that this is actually a specimen of H. hoodi hoodi should be considered.

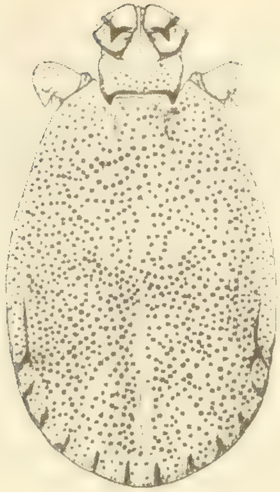
IDENTIFICATION

H. leachii muhsami in some instances intergrades with H. l. leachii and these specimens may be difficult or impossible to separate to subspecies. Criteria for separating this species from others are established in the key and under IDENTIFICATION of H. leachii and in the latter section the characters differentiating the two subspecies are also noted. Results of a long-term study of this subject will be presented subsequently. Here, only a brief resume of the characters separating H. leachii muhsami from the nominal subspecies is provided.

Males. These ticks are smaller and their scutal outline is wider than that of the subspecies leachii. Scutal punctations are only moderate in number and are generally fairly large and shallow. In outline, the palpal outlines of the two are quite similar except that the lateral margin of muhsami is slightly concave though in exceptional specimens it may be straight and even more uncommonly it may be very slightly convex. The ventral retrograde spur of palpal segment 3 notably is like that of leachii, but in _muhsami_ the basal spurs may be more reduced. The basis capituli is short and wide, with lateral margins widely diverging anteriorly, and the cornua are usually smaller and weaker than those of _leachii_. The coxal spurs are comparable with those of _leachii_, an important criterion for separating this subspecies from some other equally small, not otherwise greatly differing species in Africa.

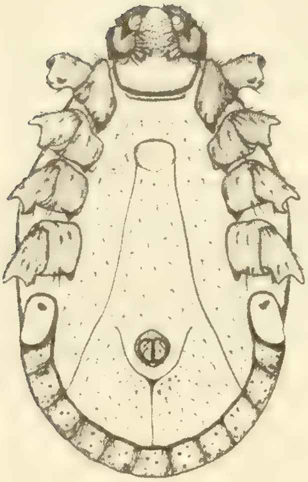
The scutal size varies from 1.3 mm. to 2.2 mm. long and from 0.8 mm. to 1.2 mm. wide. A majority of specimens fall within the lower size range and are easily recognizable. The few larger specimens may be typical or they may approach the form of the subspecies _leachii_ in shape of palpal lateral margin or in development of palpal spurs. The smaller and more compact size and shape of _muhsami_ is almost always reflected in stouter and more abruptly tapering tarsi.

Females. Like males, this sex is smaller, rounder, and more compact than females of _leachii_. The scutal length is about equal to or only very slightly greater than the width; the posterior margin is more broadly rounded; the punctations are rather large and moderate in numbers; and the cervical grooves are more concave and more distant from each other. The palpal outline usually has the lateral margin definitely concave; the ventral basal spur is absent but the dorsal basal spur is quite variable; the ventral retrograde spur of segment 3 is like that of the male and of the subspecies _leachii_. The basis capituli in all available specimens is definitely short and wide with lateral margins distinctly diverging anteriorly and the cornua are usually broadly tapered and short. Coxal spurs correspond to those of the male. Tarsi tend to be shorter, stouter, and more abruptly tapered than those of female _leachii_.

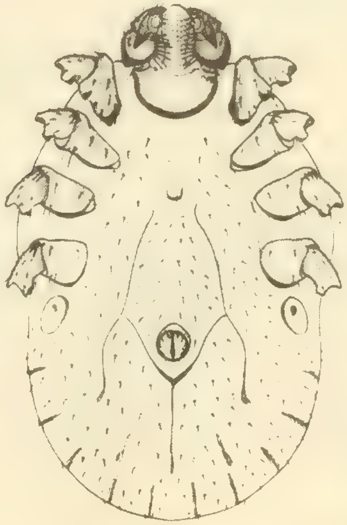


154

156



155



157

Figures 154 and 155, ♂, dorsal and ventral views
Figures 156 and 157, ♀, dorsal and ventral views

HAEMAPHYSALIS PARMATA
Rio Muni specimens

PLATE XLVI

HAEMAPHYSALIS PARMATA Neumann, 1905.

(Figures 154 to 157)

THE WEST AFRICAN ANTELOPE HAEMAPHYSALID

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		1		Noli Hills	*Cephalophus caerulus musculoides*	Mar (SGC)
		1		Nagichot	domestic cattle	Jul
		2		Gilo	domestic cattle	Dec
					BIRD	
11	16			Lotti Forest	*Guttera edouardi sethsmithi*	Apr

These localities, all in the central area of the east bank of Equatoria Province, lie between 4500 feet and 6500 feet elevation. *H. parmata* has not been found in other Provinces of the Sudan. The Noli Hills specimen is somewhat atypical, see REMARKS below.

DISTRIBUTION

H. parmata is a quite common Central and West African tick that ranges in smaller numbers into the forested highlands of eastern Africa. It is especially numerous in the Cameroons.

WEST AFRICA: GOLD COAST (Nuttall and Warburton 1915). FRENCH WEST AFRICA (Villiers 1955). SIERRA LEONE (Simpson 1913. Nuttall and Warburton 1915). NIGERIA (Ziemann 1905. Neumann 1911. Simpson 1912B. Nuttall and Warburton 1915).

CENTRAL AFRICA: CAMEROONS (Neumann 1905,1911. Ziemann 1905, 1912A. Nuttall and Warburton 1915. Rageau 1951,1953A,B. Hoogstraal 1954C). RIO MUNI (Numerous specimens in HH collection from north-central part of state; K. C. Brown *legit*; gift of Colonel R. Traub). FRENCH EQUATORIAL AFRICA (Fiasson 1943B. Rousselot 1951,1953B. Hoogstraal 1954C). BELGIAN CONGO and RUANDA-URUNDI (Nuttall and Warburton 1915,1916. Bequaert 1930A,B,1931. Schoenaers 1951A,B. Van Vaerenbergh 1954. Santos Dias 1954D. See HOSTS below).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

KENYA (Neave 1912. Anderson 1924A. Neumann 1913. Nuttall and Warburton 1915. Lewis 1931A,C. As H. calcarata: Lewis 1931B. As H. bispinosa: Lewis 1934. Loveridge 1936A. Hoogstraal 1954C). UGANDA (Nuttall and Warburton 1915. Mettam 1932. Theiler 1945C).

[SOUTHERN AFRICA: MOZAMBIQUE: Santos Dias (1954F); not typical specimens if description and illustrations are correct. UNION OF SOUTH AFRICA: Theiler (1945C) states that this species actually has not been found in the Union of South Africa, and (correspondence) that Curson's (1928) and Bedford's (1932B) records from Zululand are misidentifications.]

NOTE: Records from Sumatra (Galli-Valerio 1909B) undoubtedly are based on erroneous identification.

HOSTS

The chief hosts of adults are antelopes; any domestic animal may be attacked. Immature stages parasitize carnivores and antelopes and larvae have been recorded from forest birds.

Adults

Domestic animals: Cattle (Neumann 1905,1911, Ziemann 1905, 1912A, Nuttall and Warburton 1915,1916, Mettam 1932, Schoenaers 1951A,B, Rageau 1953B, Hoogstraal 1954B, Sudan records above). Sheep (Neumann 1905,1911, Ziemann 1905, Mettam 1932, Rageau 1953B). Goats (Neumann 1905,1911, Ziemann 1905,1912A, Mettam 1932, Rageau 1953B). Dogs (Ziemann 1912A, Mettam 1932, Rousselot 1951, Rageau 1953B). Pigs (Rageau 1953B). (?Domestic) Pigs (Neumann 1905,1911, Ziemann 1905).

Antelopes: Hartebeest (Nuttall and Warburton 1915. Mettam 1932). Bushbuck (Simpson 1913, Lewis 1931C, Nuttall and Warburton 1915, Bequaert 1931, Mettam 1932, Hoogstraal 1954C). Harnessed antelope (Nuttall and Warburton 1915). Royal antelope, black duiker, bay duiker (Villiers 1955). Bushbuck and Maxwell's duiker (Cameroons, J. Mouchet legit, HH det.). Impala and Harvey's duiker

(Hoogstraal 1954C). Blue duiker (Mettam 1932, Hoogstraal 1954B, Sudan record above). Forest or red duiker (Mettam 1932). Duiker and "forest antelopes" (Rio Muni specimens noted above). Okapi (Belgian Congo specimens, MCZ, HH identified).

Other wild animals: Water chevrotain (Bequaert 1931 and Onderstepoort collection). Buffalo (Nuttall and Warburton 1915, Mettam 1932). Bushpig (apparently from Ziemann's (1905) remarks for "pigs": Nuttall and Warburton 1915).

Immature Stages

All the following records are for nymphs unless larvae are also noted.

Antelopes: Harnessed antelope (Nuttall and Warburton 1915). "Duiker" (Fiasson 1943B, Rousselot 1951). Harvey's duiker (Hoogstraal 1954C). "Forest antelopes" (Rio Muni specimens noted above). Nymphs and larvae from bushbuck (Theiler 1945C) and from duiker (Theiler, unpublished). Larvae from "duiker" (Rio Muni specimens noted above).

Carnivores: Genet and mongoose (Hoogstraal 1954C). Domestic dog (Rio Muni specimens noted above). Civet, and larvae and nymphs from genet (Cameroons, J. Mouchet *legit*, HH det.).

Other mammals: Black and rufous elephant shrew, *Rhinonax petersi*, from Tanganyika (Theiler, unpublished).

Birds: Larvae and nymphs from forest guineafowl (Hoogstraal 1954B; Sudan record above).

BIOLOGY

Available data indicate that H. *parmata* inhabits humid, forested regions of West Africa but that more easterly populations find optimum conditions for survival chiefly in forest and uplands. Neumann's (1913) and Lewis' (1931C) Kenya reports were from areas between 1000 feet and 8000 feet altitude. In Ruanda-Urundi, this tick is found up to about 5600 feet elevation (Schoenaers 1951B).

Sudan records and several others in my collections are all from altitudes above 3000 feet. In the Sudan and frequently elsewhere, these hills are more humid than the surrounding plains.

DISEASE RELATIONS

Unstudied.

REMARKS

The only other tick recorded from Africa that has palpal characters more or less similar to those of H. parmata is H. bispinosa Neumann, 1897, an Asiatic species that is said to be found rarely on domestic animals in Kenya. Males of H. bispinosa can be distinguished by their more narrow and elongate scutum, long lateral grooves, and abrupt tapering of tarsus IV. Females of H. bispinosa have a scutal outline that is slightly longer than broad, converging cervical grooves, and a shorter, wider basis capituli. In addition, the distal tapering of tarsus IV is more abrupt. Nuttall and Warburton (1915) recorded a few specimens of H. bispinosa from Kenya, but Lewis' specimens under this name are actually H. parmata (Hoogstraal 1954C).

With respect to the tapering of tarsus IV, the Noli Hills female specimen from Equatoria Province is like H. bispinosa. In all other characters, however, it appears to equal H. parmata and it is therefore assigned to the latter species, though with some hesitation. Students of Haemaphysalis ticks believe that such tarsal characters are constant within a species, but because of the dearth of comparative material it is impossible to arrive at a satisfactory conclusion concerning this variation.

The material described by Santos Dias (1954F) from Mozambique appears to differ somewhat from that known from the rest of Africa.

In a formidable discussion, Schulze (1938A, figure 31C) has illustrated the palpi of H. parmata as data for his theories concerning generic and specific indicators resulting from pressure of the body within the developing nymph of ticks.

IDENTIFICATION

Males are easily recognized by the pointed dorsal projection from the basal margin of palpal segment 3; peculiarly shaped palpi; short and broad scutum; very short cervical grooves; lateral grooves that reach only midlength of scutum; numerous, medium size, deep scutal punctations; coxae with short but distinct basal spurs, and tarsus IV gradually tapering. Palpal characters alone are enough to quickly separate *H. parmata* from other African species. Males are very small; they measure from 1.3 mm. to 1.8 mm. long and from 0.75 mm. to 1.1 mm. wide.

Females have the same distinctive palpal features as do males. The subcircular scutum measures from 0.64 mm. to 0.70 mm. long, and from 0.75 mm. to 0.90 mm. wide; it has broad, shallow, parallel cervical grooves extending to its midlength and medium size punctations that are more shallow than those of the male. Coxa I has a rather wide, short posterior spur but other coxal spurs are replaced by broad posterior ridges. Female palpal characters are as distinctive as those of the male among the African fauna.

Theiler (1945C) has redescribed and illustrated both sexes and the immature stages of *H. parmata*. Dr. Theiler identified the larvae and nymphs from the forest guineafowl from the Sudan.

H Y A L O M M A

INTRODUCTION

The genus *Hyalomma* is a complex of a few species exhibiting an almost endless variety of facies. Its original center of dispersal was probably Iran or southern Russia. Genetic instability may in part account for the wide morphological differences found in many specimens. Environmental vicissitudes are undoubtedly important additional factors in modifying size, color, and overall appearance in this genus. These are tough, hardy ticks that survive under conditions in which all other species are uncommon or entirely absent; they may even thrive in such environs. They inhabit country where humidity is frequently low, seasonal climatic conditions are extreme, favorable niches for development away from the host are rare, smaller animals for immature-stage feeding are sparse, and larger-size hosts are frequently poorly nourished and wander widely among inhospitable situations.

Owing to their medical and economic importance and the pressing need to clarify the relationships of all presently recognized species in the genus *Hyalomma*, the plan of this section has been modified to include a key to all species and illustrations of non-Sudanese species. Further research will somewhat modify present concepts but this compilation of information will provide a firmer foundation for subsequent revision than is now available without considerable background study. The presently recognized species of continental Africa are, however, fairly well stabilized and the disconcerting prospect of further nomenclatorial changes and addition of new species applies chiefly to populations from the Near East to the Far East.

NOMENCLATORIAL BACKGROUND

HISTORY

It is hardly surprising that criteria for identification of *Hyalomma* species have long been in a chaotic state. The thirteen species described by Koch (1844), when he erected the genus, in addition to three previously described species, remained mostly unrecognized by subsequent workers. The genus was reduced to four species, including a single new one, and four subspecies by Neumann (1911). H. aegyptium was used as a "catchall" name by most persons until the 1920's. During the early twentieth century, British workers in Africa, depending on Nuttall and Warburton at Cambridge for identification of their collections, developed a group of names that are herein referred to those in contemporary usage after having studied the Nuttall collection in British Museum (Natural History).

Between 1919 and 1950, Schulze and a few of his students and followers seized upon the apparently unlimited opportunities for providing dozens of species names for variants in this genus. Scarcely a single one of the some eighty species and subspecies proposed by Schulze and colleagues has withstood the test of comparison with reared progeny from a single female tick. After having studied parts of Schulze's collection, now housed in Rocky Mountain Laboratory, one can understand, from the small series and poor labelling, how misconceptions regarding species identity developed among persons eager to tag each variation with a species name. Schulze even went so far as to name the progeny of a single female as different species (H. delpyi Schulze and Gossel, 1936) (Delpy 1946A).

RECENT REVISIONAL AND SUPPORTING STUDIES

During the last twenty years a certain amount of cosmos has begun to evolve from this nomenclatorial chaos, although it is obvious that additional modifications in species concepts and names are yet to come. The careful, tedious, and time-consuming pioneer work of Delpy, who secured specimens from many areas where hyalommas occur and reared the progeny from single females, enabled him to determine the range of variation within a single species and to show that characters proposed for many so-called species were due merely to multiformity of appearance within a few species. In a few instances, however, Delpy included species that we now know to be distinct genetic entities worthy of species rank.

Shortly afterwards, Adler and Feldman-Muhsam commenced rearing Palestinian species in the same manner as Delpy. They corroborated Delpy's species definitions but not his species names. In their 1948 paper these authors provided a potash clearing method for females by which they established constant species characters for the unmated female genital aperture. Delpy expanded this finding to mated females, thus making it of greater value for identification of field-collected material. Nevertheless, some questionable specimens inevitably crop up in routine collections.

Unfortunately, as stated above, Delpy and Adler and Feldman-Muhsam arrived at different conclusions regarding which name from the scores available should be applied to individual species. Recently Feldman-Muhsam (1954), after study of Koch's (1844) type specimens for several species in the genus, has corroborated some of Delpy's earlier decisions and proposed a few changes. Although Koch's material is badly damaged and its labels have been inexcusably tampered with, these studies probably represent the final word on these species; therefore this terminology is accepted with certain reservations as noted in the appropriate places.

Delpy's chief morphological and taxonomic contributions to Hyalomma have been his notes on the genus (1936,1946A), description of H. schulzei (1937A), description of the immature stages of H. dromedarii (1937B), generic revision by experimental methods (1947D and 1949A, especially the latter), and a synoptic list and discussion (1949B), besides studies on bovine theilerosis and tick transmission (1937C,1946B,1947A,1949C and 1950). Adler and Feldman-Muhsam presented their chief overall findings in their 1948 paper; subsequent reports by the latter author are listed in the bibliography.

Whenever possible, Delpy's (1949B) synonymy has been followed in the present work. Some changes have been necessary, however, on the basis of the kind of proof that Delpy himself advocated: rearing of progeny from single, known females. A few other changes have been necessary due to Feldman-Muhsam's study of Koch's types. It is impossible to decide whether Delpy or Pomerantzev (1950) should be followed for the synonymy of certain Russian species. Pomerantzev's ideas, whenever they differ, have been included as notes under the names indicated by Delpy.

It has been attempted herein to indicate present and previous nomenclatorial concepts of these species as clearly as possible, especially for experimental workers and reviewers. Non-taxonomists, who consider themselves "practical workers", will undoubtedly be annoyed by the remaining confusion. The end is now in sight, and within a very few years will undoubtedly be reached. A little more patience will be rewarded by better understanding of what has been an especially difficult complex of variable species in previously poorly explored parts of the world.

HYALOMMA DISTRIBUTION IN AFRICA

Two species, *H. truncatum* and *H. rufipes*, are common in drier areas throughout the Ethiopian Faunal Region (Figure 1). Two others, *H. albiparmatum* and *H. impressum*, are restricted to equatorial regions of Africa; these four species appear to have evolved in Africa from Near Eastern stock. Only *H. rufipes* extends beyond the confines of the Ethiopian Region. Two other species (*H. detritum* and *H. marginatum*) range into North Africa from the Near East and have tenuous, scattered footholds in the transitional zones just south of the great deserts along the northern periphery of the Ethiopian Region. Another Near Eastern species, *H. impeltatum*, appears to be extending its range a little more aggressively into East and West Africa. The last species known from continental Africa, *H. turanicum*, has established itself in the South African Karroo after having been introduced on sheep from the Near or Middle East.

In East Africa, the arid lowlands along the Red Sea and the Indian Ocean carry a number of Near Eastern and North African species southwards into the Somalilands and parts of Kenya towards and even slightly south of the equator. For instance, *H. dromedarii* is known from the coastal lowlands of Kenya (Walker, unpublished) and *H. impeltatum* occurs in scattered foci in Kenya and Tanganyika.

There is little question that other species do exist in nature but their identity can be established only by breeding experiments. The presence of a possibly undescribed species similar to *H. drome-*

darii in the French Somaliland fauna has also been noted (Hoogstraal 1953D).

Note the following incorrect Ethiopian Region records:

H. marginatum (= H. savignyi), reported by Rousselot (1948) from French West Africa, was not subsequently confirmed (Rousselot 1953B).

H. detritum reported from French Cameroons (Rageau 1951) was subsequently (1953) assigned to H. truncatum (= H. transiens) by the same author.

References to "H. savignyi" from Portugese Guinea (Tendeiro 1949,1952C) actually apply to H. truncatum.

In northern and central Sudan, eight species are established though seldom in a continuous range. Of these, only four are common. In most Near Eastern and North African areas about the same proportion of common and rare species occur. Yet with even so few species among which to choose the student frequently encounters difficulty in positive identification of all material in most large collections. Some specimens are so variable and intermediate that they defy assignment to a definite species. Unfortunately, previous workers have not provided pertinent details over extremes of variation among species that they have reared. Attempts to properly identify Sudan material for this report have necessitated so much study of material from other parts of the world that publication has been long delayed.

With regard to the paucity of specimens of some species collected in northern Sudan, it should be emphasized, from our experience with vertebrate and invertebrate animals in arid and semiarid areas of Africa, Arabia, and the Near East, that not infrequently small relict populations of animals are found inexplicably surviving in barely marginal habitats. This appears to be true of H. detritum, H. marginatum, H. truncatum, and H. impressum in northern Sudan.

The northcentral areas of the Sudan, by reason of their proximity and similarity to the Mediterranean subregion and their tenuous routes of entry from Arabia, West Africa, and via the Nile, are inhabited by more species of Hyalomma ticks than apparently any other area of the Ethiopian Faunal Region. The fact that some of these species appear to be represented in the Sudan only by small populations, either as a result of chance introduction or as survival or relicts, has been noted above.

The Asiatic species that do not reach the Sudan are H. hussaini of India (page 520), H. schulzei, an Iranian camel parasite that reaches the Sinai Peninsula between Asia and Africa (page 525), H. aegyptium, the tortoise parasite that extends from southern Russia westward through much of the Mediterranean basin (page 514), and H. turanicum of southern Russia and Iran that has been introduced into the South African Karroo (page 528). As stated above, the original center of distribution of hyalommas appears to have been in southern Russia or Iran.

Delpy and Adler and Feldman-Muhsam have provided few details about the geographical source and range of species that they treat, and there is still considerable question in the minds of specialists and reviewers as to the distribution of Hyalomma species. This section has therefore been given special attention in the following text. Synonyms, listed by country of origin of specimen material whenever it can be determined, are based on Delpy's (1949B) lists, which give every evidence of being carefully and judiciously assembled. These references do not include the entire literature, except I trust for Africa, but are furnished for what they are worth in elucidating the distribution of Hyalomma species and indicating the major studies of each species in different parts of the world.

HOSTS AND BIOLOGY

Biological data for Hyalomma ticks derive chiefly from veterinarians' observations on those infesting domestic animals and on laboratory experiments. From field work and from a few other sources we have gained a somewhat different impression of Hyalomma biology, especially relating to host preferences of the immature stages. In this respect, special attention is called to the HOSTS and BIOLOGY sections in the following text, especially for H. excavatum. The natural life cycle of Hyalomma ticks may be altered by the size, numbers, and density of available hosts. Further research on this subject is strongly indicated.

In the introduction to this section it has been stressed that many Hyalomma populations survive in inclement environments and are greatly affected by extremes in temperature, humidity, and condition of host nourishment, as well as by the wide wandering of their hosts over thinly populated, inhospitable xeric areas.

Much more collecting, observing, and careful identification is necessary before the ecology of most species in this genus can be adequately determined. The value of innumerable published reports on the biology of the genus is vitiated by the inaccuracies in identification.

Extraordinary survival factors play a large part in permitting these ticks to exist and even thrive where few or none others live.

The life cycle of hyalommas may be greatly lengthened in unfavorable climatic conditions, or shortened under optimum conditions. Nuttall (1915) kept adult specimens alive without food for approximately two years and observed copulation and feeding after this period of starvation. Nuttall (1920) also found the capacity for regeneration of lost appendages and injured mouthparts to be greater in Hyalomma ticks than in most others. A certain amount of hybridization is possible though curiously misformed individuals may result; these and other greatly misformed specimens that have still survived are reviewed by Pervomaisky (1950B,1954).

Special attention is called to the discussion below of the two-host, summer-feeding H. detritum, and its biological race H. scupense which is a single-host, winter-feeding form with slight morphological differences in most of its range (page

DISEASE RELATIONS

Adult Hyalomma ticks, except H. aegyptium, are today chiefly parasites of domestic animals wherever they are found, and, as such, are of considerable economic importance. Hyalommas appear to be unusually efficient vectors of a variety of disease-causing organisms. In their immature stages, they often feed on birds, rodents, and hares that are important reservoirs of pathogens, especially viruses and rickettsiae.

Few ticks have been incriminated as reservoirs and vectors of pathogenic viruses, but several species of hyalommas are known to be hosts and vectors of the viruses causing several distinctive acute infectious hemorrhagic fevers of human beings in the Soviet Union. Unpublished studies by Daubney (conversation) indicate that one of these same species may transmit in nature the virus causing a Near Eastern encephalomyelitis of equines. These same tick species occur in North Africa and northern Sudan. Other species cause paralysis of man and animals, apparently as a result of toxins injected into the host while the tick is feeding. The association of Hyalomma ticks with a number of other human and veterinary diseases is noted in the following text.

Many Hyalomma species, in our experience, attach readily to man and feed on him. The "cursorial ticks" of North African and Arabian deserts, as first described by Mann (1915), are several species of hyalommas that come rushing from beneath every shrub when persons or animals stop nearby. These are almost invariably unfed adults, of uniform size, shape, color and general appearance, that have molted from the nymphal stage in rodent burrows beneath shrubs. Although few of these highly agitated young adults actually attach to man, some do.

Confusion in nomenclature has limited the value of many earlier studies on biology and disease-transmission in this group, for it is often impossible to be certain which species the writer used in his work. Considerable study on this genus has been and is being done in Russia, and it is frequently difficult for reviewers to determine exactly the species being reported and to satisfactorily evaluate the reports.

In addition, it should be indicated that the range of Hyalomma ticks covers, in large part, a vastly undeveloped part of the world in which little serious scientific research has been accomplished. Before many years have elapsed, enough evidence probably will have been presented to indicate that Hyalomma ticks are economically among the most important of animal ectoparasites to be found anywhere in the world.

IDENTIFICATION

Use of the following key should never be attempted without reference to the section on identification for each species mentioned in the text. In the identification section, an attempt has been made to present lucidly all important characters of typical specimens and to indicate the range of variability seen in each species. I am most grateful to Mr. Makram N. Kaiser, Chief Technician in the Department of Medical Zoology at U.S. Naval Medical Research Unit, who has served as a "sounding board" and has given invaluable assistance in grouping the very large numbers of specimens that have been studied and often restudied for this section. Special acknowledgement should also be made of the services of Dr. L. P. Delpy, who initially identified many of our early collections of *Hyalomma* and of Mr. Glen Kohls who has spent several days conferring over specimens in the Schulze collection, now deposited in the Rocky Mountain Laboratory at Hamilton, Montana.

Persons attempting to identify field-collected material of *Hyalomma* should recognize that a certain proportion of specimens in many series will defy final determination of species. These had best be called "*Hyalomma* species" and sent to a capable specialist in the group or put aside for further study as additional information becomes available.

KEY TO SUDAN SPECIES OF HYALOMMA

(TYPICAL SPECIMENS ONLY)

MALES

1. Center of subanal shields characteristically exterior of the axis of the adanal shields*.......................................2

   Center of subanal shields characteristically in line with the axis of the adanal shields.......................................3

2. Medium size ticks (scutum about 3.8 x 3.0 mm.). Lateral grooves extending anteriorly at least to midlength of the scutum. Scutum largely covered by medium size punctations. (Common on cattle in central Provinces)...............H. IMPELTATUM
   Figures 170 and 171

   Large ticks (scutum about 4.5 x 3.2 mm.). Lateral grooves limited to posterior third of scutum. Scutum with few large, scattered, irregular punctations (sometimes also with small ones). (Common where camels occur in Sudan)................................H. DROMEDARII
   Figures 162 and 163

---

*In *H. excavatum*, and sometimes in other species that have engorged on large animals such as camels, and have considerably stretched their integument, the subanal shields may be laterally displaced. Such *excavatum* specimens would appear to be *H. dromedarii*, except for smaller size, fewer and smaller scutal punctations, and differences in the caudal area of the scutum. See also identification of *H. impeltatum* for superficial variation among unfed males, which may cause them to be suggestive of *H. marginatum*.

3. Lateral grooves not extending beyond the posterior third of the scutum. Scutum with few punctations except in the caudal area which is depressed between two lateral ridges and sometimes very shagreened. Small ticks, often frail, maximum overall length usually less than 5 mm. (Fairly common on cattle and especially on horses in central Provinces; also occurs in Northern Province)......................H. EXCAVATUM
Figures 166 and 167

Lateral grooves extending beyond the midlength of the scutum (may be obscured in very heavily punctate species; examine by oblique orientation)..........................4

4. Scutum smooth, bright*, with very few, large, shallow, scattered, punctations; posteromedian and paramedian grooves well marked. Legs usually not ringed. (In northcentral Provinces; rare)..................H. DETRITUM
Figures 158 and 159

Scutum densely punctate, or with dense, contiguous punctations posteriorly..............................5

5. Scutum densely, entirely, and almost always uniformly covered by punctations often obscuring the lateral grooves..6

Scutum irregularly punctate, or punctate only posteriorly...................................7

---

*Do not confuse this with H. truncatum that has a smooth, shiny scutum but also dense punctations in a rectangular field posteriorly.

6. Posterior scutal margin regularly rounded. Circumspiracular area pilose. (Widely spread in small populations throughout much of the Sudan)...H. RUFIPES
Figures 182 and 183

Scutum strongly narrowed postero-laterally to form an almost rectilinear posterior margin. Circumspiracular area not pilose. (Fairly common in central areas of the Sudan)..H. IMPRESSUM
Figures 174 and 175

7. Lateral grooves deep and wide, extending to the eyes. Scutum smooth and shiny except posteriorly where it is densely punctate; posterior margin of scutum usually rectangular. (Common in central areas and dry parts of southern areas)..................H. TRUNCATUM
Figures 186 and 187

Lateral grooves long but not well marked. Scutal punctations irregular, often more dense posteriorly, sometimes numerous anteriorly; posterior area not markedly differentiated from rest of scutum; posterior margin bluntly rounded. (Central areas of the Sudan, uncommon).......................................H. MARGINATUM
Figures 178 and 179

FEMALES

1. Scutum smooth or with few, irregularly scattered, large punctations*.......................................2

   Scutum with numerous usually discrete punctations distributed over most or entire surface.......................................4

2. Genital apron a narrowly-elongate, triangle, gradually sloping in profile. Scutum usually at least as wide as long, with ten to twenty large punctations in central field and about an equal numbers in each scapular field. Large ticks....................H. DROMEDARII
   Figures 164 and 165

   Genital apron never as narrowly elongate and otherwise variously differing from that of *H. dromedarii*. Scutum often longer than wide. Small or medium-size ticks.......................................3

---

*If small punctations are present in this group of three species, they are extremely shallow, irregular, and non-discrete. Do not confuse in this group exceptionally sparsely-punctate *H. marginatum*, which in all instances has a large, widely transverse, very strongly bulging genital apron not found in this group of species.

3. Genital apron an almost equilateral triangle; in profile gradually sloping. Medium-size tick, with dark, smooth, shiny scutum with few if any punctations; legs lighter color...H. DETRITUM
Figures 160 and 161

Genital apron circular or triangular but distinctly bulging in profile. Usually comparatively small, pale, often elongate ticks with few punctations irregularly scattered over the scutum; legs either ringed or unicolorous....................................H. EXCAVATUM
Figures 168 and 169

4. Scutum entirely covered by uniform punctations..5

Scutum more or less irregularly covered by small or medium-size, shallow to deep punctations among which some large ones may be present...6

5. Genital apron a large, wide shield, bulging in profile. Circumspiracular area unusually pilose...............................H. RUFIPES
Figures 184 and 185

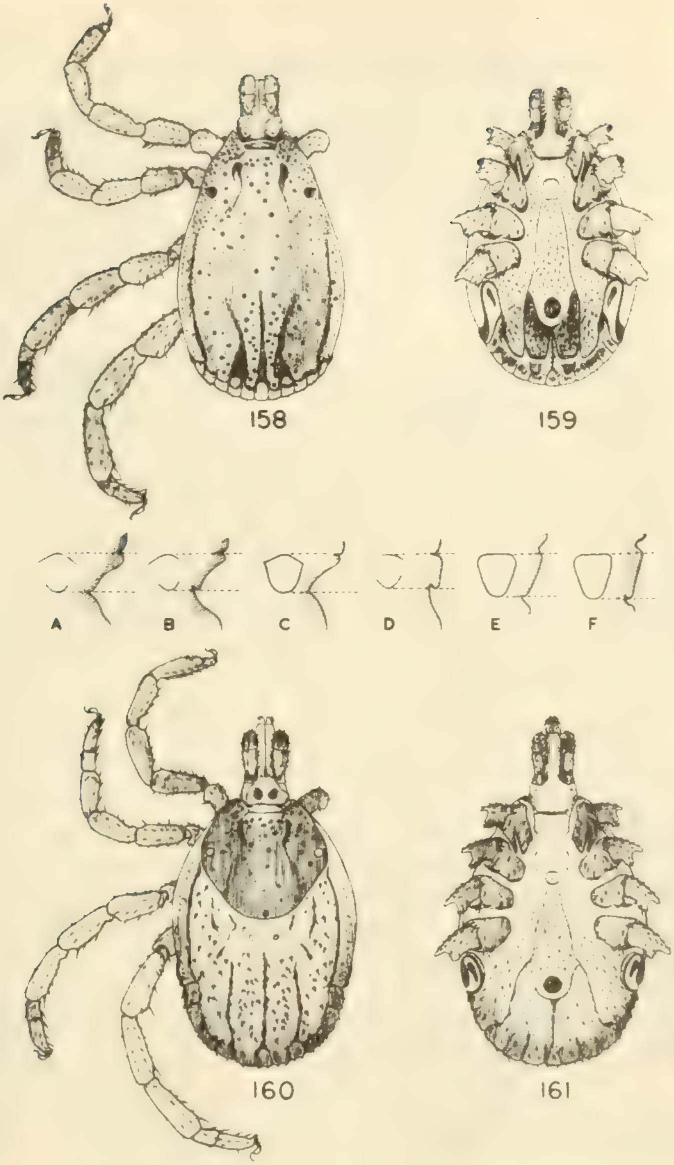
Genital apron a wide triangle with a narrow transverse anterior ridge (bulging in profile) and a posterior button (sloping or depressed in profile). Circumspiracular area not exceptionally pilose.........................H. IMPRESSUM
Figures 176 and 177

6. Genital apron a transverse oval, posteriorly deeply concave in profile. Scutal punctation usually small and regular, rarely coarse.................................H. TRUNCATUM
Figures 188 and 189

Genital apron strongly bulging (convex) in profile...7

7. Genital apron large, a widely transverse oval or triangle. Scutal punctations shallow, large ones restricted to anterior half, small ones widely scattered.................................H. MARGINATUM
Figures 180 and 181

Genital apron an elongate triangle flanked by two lobes, giving it a trilobed appearance. Scutal punctations usually numerous, regularly spaced, and medium-size posteriorly and centrally with two rows of larger and deeper punctations among them; with larger punctations anteriorly and in scapular fields........................H. IMPELTATUM
Figures 172 and 173



Figures 158 and 159, ♂, dorsal and ventral views
Figures 160 and 161, ♀, dorsal and ventral views

A to F, ♀ genital area outline and profile. A to C, partly engorged. D, fully engorged. E and F, unengorged.

HYALOMMA DETRITUM
Sudan Specimens

PLATE XLVII

HYALOMMA DETRITUM Schulze, 1919

(Including H. SCUPENSE Schulze, 1919)

(Figures 158 to 161)

THE SHINY HYALOMMA

NOTE: The some twenty synonyms of H. detritum, as presented by Delpy (1949B), are listed in the section on DISTRIBUTION below according to the political areas from which the specimens of each originate. It is impossible to believe that H. detritum had not been described as a species by some author somewhere prior to 1919, yet no contemporary specialist has come forth with a previous name for this species. Steps should be taken to stabilize the name H. detritum in order to prevent the further confusion that is bound to arise when an earlier name for this tick is inevitably discovered. Special attention is called to the "biological race", H. scupense, discussed below.

DISTRIBUTION IN THE SUDAN

H. detritum occurs rarely in northern parts of the central Provinces of the Sudan. Additional collecting is necessary to determine its exact distribution here. It would be of some interest to know whether H. detritum has invaded the Sudan from the Red Sea coast or via the Nile Valley.

Kassala: Port Sudan (cattle; SVS). It is not known whether hosts of these specimens were local or transient animals.

Kordofan: Four males have been collected from Kordofan cattle at the Khartoum Quarantine station (January and February) (HH).

[Khartoum: See Kordofan above.]

DISTRIBUTION

H. detritum is an Asiatic tick that ranges from Manchuria through China and India, much of southern Russia, southeastern Europe, and the Middle East; into Asia Minor, the Near East, the Mediterranean littoral of Africa westwards to Algeria; and into northcentral Sudan, where it occurs only in small, localized populations. It also occurs in Spain, probably having been introduced from northwestern Africa.

In Egypt and apparently in Libya, H. detritum is considerably less common than it is to the west in Algeria and in Near Eastern countries. This distributional pattern is common for animal groups that have invaded North Africa from the east.

NOTE: Specimens referred to this species by Rageau (1951) from the Cameroons were later determined by him (1953) as H. truncatum (= H. transiens).

NORTH AFRICA: *ALGERIA (All as H. mauritanicum or as H. mauritanicum annulatum: Senevet 1922B,C,1924A,1925,1928A,1929B, 1937. Senevet and Rossi 1924. Sergent, Donatien, Parrot, Lestoquard, and Plantureux 1926,1927A,B,C,D,E. Sergent, Donatien, Parrot, and Lestoquard 1928A,B,C,1931A,B,C,D,E,F,1932A,B,1933A,B, 1935A,B,1936A,B,C,1945. A. Sergent 1930. Sergent and Poncet 1937,1940,1941. Sergent, Donatien, and Parrot 1945. E. Sergent 1948. Blanc and Brunneau 1949. d'Arces 1952. As H. detritum mauritanicum: Schulze 1930. Kratz 1940).

MOROCCO (As H. mauritanicum: Desportes 1938). TUNISIA (As H. detritum: Senevet 1937. Colas-Belcour and Rageau 1951). LIBYA (As H. mauritanicum: Franchini 1927,1929A,E. Hoogstraal, ms.). EGYPT (Present but rare: Hoogstraal, ms.).

EAST AFRICA: SUDAN (As H. detritum: Hoogstraal 1954B).

Note: H. mauritanicum has been reported from Somalia, without precise locality data, by Niro (1935), but this record has not been subsequently repeated by Italian workers.

---

*Algerian specimens of H. mauritanicum, kindly presented by Dr. E. Sergent and Dr. Senevet, conform to H. detritum.

NEAR EAST: PALESTINE (All as H. detritum: Adler and Feldman Muhsam 1946,1948. Feldman Muhsam 1948. Adler 1952). SYRIA (As H. detritum damascenium: Schulze and Schlottke 1930. Schulze 1930. Kratz 1940. As H. ?mauritanicum: Pigoury 1937). TURKEY (As H. steineri steineri: Schulze 1936D. Kratz 1940. As H. detritum: Mimioglu 1954. Kurtpinar 1954. Hoogstraal, ms. As H. mauritanicum: Yasarol 1954). IRAN (As H. detritum: Delpy 1936B,1949C).

EUROPE: *BULGARIA (As H. scupense and as H. detritum dardanicum: Pavlov 1947). *YUGOSLAVIA (As either H. scupense or H. savignyi by different local workers according to Oswald 1937. As H. scupense and H. detritum dardanicum: Oswald 1937,1938A, B,C,1939A,B,1940. As H. detritum: Angelovsky 1954).

GREECE (As H. scupense: Knuth, Behn, and Schulze 1918. Schulze 1919,1930. Schulze and Schlottke 1930. Kratz 1940. Pandazis 1947. As H. detritum scupense: Delpy 1946. As H. detritum dardanicum: Schulze and Schlottke 1930. Schulze 1930. Kratz 1940. Pandazis 1947).

SPAIN (As H. steineri codinai: Schulze 1936D. Kratz 1940. As H. mauritanicum: Gil Collado 1948A. Miranda-Entrenas 1954).

RUSSIA: As H. detritum: Olenev 1929B,1931A. Pavlovsky 1940. Kurchatov 1941. Pavlovsky, Galuzo, and Lototsky 1941. Galuzo 1941,1943,1944. Lototsky and Pokrovsky 1946. Tselishcheva 1953. Viazkova and Bernadskaia 1954. Petrisheva 1955. Zhmaeva, Pchelkina, Mishchenko, and Karulin 1955.

As H. detritum detritum: Olenev 1929A,1931C. Schulze and Schlottke 1930. Schulze 1930.

As H. detritum rubrum: Schulze 1930. Olenev 1931A,C,1934. Pomerantzev 1934. Galuzo 1935. Galuzo and Bespalov 1935. Kratz 1940.

---

*The hosts of immature stages listed by authors in these countries indicate that they are quite possibly dealing with a different species of tick.

As *H. detritum pavlovskyi*: Olenev 1929A.

As *H. transcaucasicum*: Olenev 1934 (the synonymy of this name appears to have been overlooked by subsequent workers).

As both *H. detritum* and *H. scupense*: Pomerantzev 1937. Pomerantzev, Matikashvily, and Lototsky 1940. Markov, Gildenblat, Kurchatov, and Petunin 1948. *Note*: Pomerantzev 1950, in his work on Soviet ticks, considers these two as distinct species. See BIOLOGY and IDENTIFICATION below.

As *H. scupense*: Olenev 1934. Nikolsky 1948. Petunin 1948. Pomerantzev 1950. Alfeev 1951. Shatas 1952. Melnikova 1953. Rementsova 1953. Shatas and Bustrova 1954. *Note*: Pomerantzev 1950 considers *H. volgense* and *H. uralense* to be synonyms of *H. scupense*, while Delpy places them under either *H. detritum* or *H. excavatum* (see two paragraphs below). Note the references to "*H. scupense*" in the section on European distribution above. See also paragraph above and below.

H. verae Olenev, 1931B, is also placed in synonymy under *H. scupense* by Pomerantzev 1950; Delpy did not consider *H. verae* in his list of synonyms.

As *H. volgense* and/or *H. uralense*: Schulze and Schlottke 1930. Schulze 1930. Olenev 1929A, 1931A, C, 1934. Zasukhin 1932, 1935. Borzenkov and Donskov 1934. Zolotarev 1934. Galuzo 1935. Kochetkov 1935. Artjukh 1936. Kurchatov 1940B. Markov, Abramov, and Dzasokhov 1940. Enigk 1947. See paragraph on *H. scupense* above and paragraph below.

Delpy (1949B) was not certain whether *H. uralense* Schulze and Schlottke, 1930, and *H. volgense* Schulze and Schlottke, 1930, are synonyms of *H. detritum* or of *H. excavatum*, and stated that Russian workers may have included both species under these two names.

In Schulze's collection, now in Rocky Mountain Laboratory, there are 2♂♂ and 2♀♀ from Ukrainia, identified by Schulze as *H. volgense*. These are typical *H. detritum*. The same institution possesses 8♂♂ and 3♀♀ from Crimea, determined by Schulze first as *H. ?marginatum*, and later crossed out and identified by him as *H.*

uralense. The males are, all but one, H. detritum*; the exception appears to be H. marginatum; the females are in poor condition. It is reasonable to assume that what is now considered to be H. detritum (or, in part, "H. scupense") was treated by Schulze in part as H. uralense and in part as H. volgense, though, he overlooked other species in the same collection and referred to them by the same name.

As H. tunesiacum pavlovskyi: Schulze and Schlottke 1930. Described and illustrated as H. detritum pavlovskyi by Kratz 1940.

According to Galuzo 1935, the H. asiaticum of Olenev is H. detritum (= H. detritum rubrum). H. asiaticum is usually considered as a synonym of H. dromedarii.

MIDDLE EAST: INDIA (As H. aegyptium ferozedini and as H. a. isaaci: Sharif 1928. As H. sharifi: Schulze and Schlottke 1930. Schulze and Gossel 1936. Kratz 1940. As H. isaaci: Kratz 1940). PORTUGESE INDIA (As H. detritum: Santos Dias 1954J).

FAR EAST: CHINA including MONGOLIA (As H. detritum albipictum: Schulze 1919,1930. Schulze and Schlottke 1930. Yamashita 1939. Kratz 1940. As H. detritum perstrigatum: Schulze 1930. Schulze and Schlottke 1930. Hoeppli and Feng 1933. Olenev 1934. Kratz 1940).

HOSTS

Domestic cattle and horses are the most common hosts of H. detritum, all stages of which feed on the same kind of animal. Sheep and goats are sometimes attacked. For the Soviet Union, Pomerantzev (1950) lists cattle, horses, donkeys, pigs, camels, sheep, and hares; and, for nymphs, especially cattle and horses. Man is apparently commonly attacked under local conditions. [Oswald's (1939) and Pavlov's (1947) remarks for parasitism by immature stages in Yugoslavia and Bulgaria of various birds and

---

*At the time of checking this material, I did not realize the significance of "H. scupense". It cannot, therefore, be said that these specimens did not resemble the latter form.

lizards, and of hares and dogs are either incorrect or refer to a different species of tick, most probably H. marginatum.7 A. Sergent (1930) noted a nymph of H. detritum parasitizing another nymph of the same species. Hosts of specimens in British Museum (Natural History) are domestic cattle and camels (Palestine), domestic buffalo and pony (India), hare (India), and deer (Romania).

"H. scupense" attacks the same hosts as H. detritum. It has also been found on the Persian or goitred gazelle, Gazella subgutterosa, and on the red deer, Cervus elaphus bactrianus (Pomerantzev 1950). In the Crimean National Forest (Melnikova 1953), "H. scupense" is common on red deer and occurs in smaller numbers on roe deer. It is present but not common on hares but absent on squirrels and jays. Wild foxes may also be attacked. Domestic cattle are heavily infested, collections from single animals in various localities in and near the forest averaging from 78 to 756 ticks, with individual maxima ranging from 350 to 5000 ticks per animal. Domestic pigs in the same forest averaged 21 ticks per host. Zolotarev (1934) listed this tick (as H. volgense) from camels.

BIOLOGY

Introduction

Because of the interesting biological and taxonomic principles involved, separate reviews of life cycle and ecology are devoted to H. detritum and "H. scupense". H. detritum is a two-host species whose adults feed in the summer and whose nymphs undergo an extensive winter diapause; this feature is common throughout the range of H. detritum though the overwintering habits in Algeria and (usually) in Russia differ markedly; it should be determined what factors account for this variation in habits. H. scupense is confined to parts of the Soviet Union and possibly to Greece and Yugoslavia; it is said to be distinguishable from H. detritum by slight morphological differences through parts of its geographic range (see IDENTIFICATION below), and is a one-host tick whose adults feed in the winter and early spring. Pomerantzev (1950) considers "*H. scupense*" to be a "biological race" of *H. detritum*.

Life Cycle of *H. detritum*

The life cycle of *H. detritum* (= *H. mauritanicum*) in Algeria has been studied by Sergent, Donatien, Parrot, and Lestoquard (1931B and subsequent works). Larvae hatch in the late autumn and feed and molt to nymphs on the same host, remaining attached for approximately sixteen days. Nymphs hibernate for approximately eight months either in groups in cracks and crevices of farmyard walls about six feet above the ground, or under boulders. They are never found in fields without trees and boulders. Hibernation sites are generally those with a warm, sunny exposure, and those nymphs in the warmest places molt earliest in the year (June). Some days after molting, young adults start out in search of a host; they leave their hibernation place at night and travel towards stables, sometimes covering as much as thirty yards a week to reach cattle or horses.

Adults commence attaching to the host in mid June. They mate and feed there, females dropping off after ten to twelve days. Feeding females are most common in July and August; afterwards fewer are found on animals. Those that feed later do not oviposit the same season. Eggs are laid on the ground near animals and hatch in about six weeks. Females die after laying eggs. There appears to be quite a little variation from this typical life cycle.

Males remain on the host for a much longer time than females and may move from one host to the other. Nymphs sometimes move from one host to another.

Note that according to the Algerian reports mentioned above, nymphs hibernate in cracks or crevices of farmyard walls but that almost all Soviet workers, mentioned below, find nymphs alone or with larvae on cattle during the winter. This raises the question whether the Russian and Algerian ticks are actually the same species, and, if so, whether climatic or other factors modify their choice of niches for hibernating in these far-flung areas.

Galuzo (1943) made a special point of the fact that H. detritum is not found in cracks in the walls in southern Kazakstan. As stated four paragraphs below, under certain local conditions in Russia, nymphs may also overwinter off the host. No explanation for these differences in overwintering habits has been found in the Soviet literature.

In southern Kazakstan, Galuzo (1941,1944) reported H. detritum as a two-host tick with unfed nymphs hibernating on cattle during the winter. They engorge and drop from the host in the spring (end of February through April) and molt to adults anywhere from May to August, but mostly in June. Adults disappear in September. Eggs are laid in shaded places in moist meadows, waterside vegetation, or under grass. Larvae aestivate in cracks in the soil or on the surface of the ground until October. Then they ascend grass, attach to grazing cattle, feed, and molt to nymphs on the host. Few nymphs feed and drop from the host before winter.

In Tadzikistan, where H. detritum is most common in irrigated valleys, it has one generation a year (as apparently everywhere else where it occurs), and the seasonal distribution of feeding of the immature and adult stages is like that in Khazakstan (Pavlovsky, Galuzo, and Lototsky 1941).

According to Pomerantzev (1950), when H. detritum is reared in the laboratory nymphs drop from the host any time between October and April. Yet they all undergo the typical winter diapause and molt to adults from May to July, mostly in June. Thus, nymphs that begin life as larvae in October require eight and a half months to become adults, but those that commence feeding as larvae (under experimental conditions) in April require only two months to reach the adult stage. Furthermore, females may fast for six or seven months and feed, between May and August, for from seven to 27 days, average eleven days. After dropping from the host, females commence oviposition in six to 31 days. Eggs number from 5000 to 7000. Larvae appear 25 to sixty days after the eggs have been laid, and may fast for seven or eight months. They (normally) attach to the host about a week after hatching, feed for eleven days, and molt on the host about eleven days later. There is one generation a year.

Pomerantzev (1950) notes that in Middle Asia, (overwintering) nymphs may be found under cattle dung (stored for fuel), and also in the walls of stables (Pavlovsky). Metamorphosis from nymph to adult may occur in buildings and stables thus increasing the importance of the species in the spread of disease.

Life Cycle of "*H. scupense*"

Knuth, Behn, and Schulze (1918, p. 254) first noted, in their studies of tick-borne diseases in Greece, that "*H. scupense*" is a single-host tick.

According to Pomerantzev (1950), "*H. scupense*" (which occurs in the Kursk and Saratov areas, lower Volga, Ukrainia, Crimea, Caucasus, Kazakh, Tadzhik, and Yugoslavia, Central Asia, and the rayon of Kogen) is a single-host tick. Adults appear in the winter from January to April and rarely until June. Larvae feed in November, nymphs from November to March.

In the laboratory (Markov, Abramov, and Dzasokhov 1940, as *H. volgense*), females begin to oviposit from 45 to 85 days after leaving the host and continue to lay eggs for thirty days. Larvae hatch from 45 to ninety days after commencing oviposition and engorge in six or seven days. They molt to nymphs on the host, commence feeding after several days, and feed for four to six days. Nymphs molt to adults, on the same host, ten days afterwards.

In nature, unfed larvae begin to attack cattle in October and molt to the nymphal stage during the same month. The maximum number of nymphs are found in December, when young adults begin to appear. Adults move to different parts of the host and pass the winter on the host. Adults commence feeding early in March. Early in April large numbers of adults leave the hosts. Oviposition and development of the eggs occurs during the summer. [Note the long summer period of oviposition and embryological development, whereas the larval and nymphal development is rapid.] Unfed adults and fed nymphs may undergo a winter diapause. Some engorged nymphs that do not molt remain attached to the host until February. From December to March, adults wander over the host's body but do not start feeding till early spring. The cycle requires one year.

In northern Caucasus, larval "H. scupense" infest cattle in October and overwinter on the animals. Adults appear early in spring (Markov, Gildenblat, Kurchatov, and Petunin 1948). These workers confirm the single-host life cycle of this tick as does Alfeev (1951) and Melnikova (1953), in his study of the ticks of the Crimean National Forest. There, adults are found on cattle and wild ungulates from September through April but rare individuals may be collected on deer during the summer (May to June). All stages occur on deer during the winter (November-December) but in January and February only nymphs and adults are found, and by the second half of March all nymphs have molted to adults. In April and the first half of May, only males and greatly engorged females are found on wild ungulates.

Ecology of H. detritum*

In eastern Transcaucasia, H. detritum inhabits various types of desert and steppe areas, described by Pomerantzev, Matikashvily, and Lototsky (1940) (see six paragraphs below). In the Arax valley of Armenia, Pomerantzev (1934) found this tick only in saline, marshy types of grassland pasture areas, not in Artemesia semidesert areas.

It appears that H. detritum infests a selected variety of semidesert areas, and also steppe and other grassy areas, but not forest zones. It still requires to be explained why H. detritum, which seems to be ecologically more limited than "H. scupense", should have a so much more extensive geographical range than "H. scupense".

Larvae, since they attach to cattle in the cool months of October and November in Tadzhistan and eastern Uzbekistan, select those parts of the host body most exposed to the sun. Summer-feeding adults attach on the shaded undersides of the host (Galuzo 1943).

Among the enemies of these ticks are wagtails (Motacilla spp.), one of which may eat as many as a dozen engorged female ticks from a cow. This bird, and the heron, are considered of importance in the control of H. detritum in Spain (Miranda-Entrenas 1954).

---

*See also life cycle of this form above, and ecology of "H. scupense" below.

Ecology of "H. scupense"

The single-host type of life cycle, the rapid immature-stage feeding period, the long lag between female feeding and oviposition, and the long period of egg laying of this form have already been commented upon, in addition to the phenomenon of adult feeding during the late winter and early spring months.

Pomerantzev (1950) considers that the change in life cycle from a two-host to a single-host type has allowed "H. scupense" to spread further afield geographically than H. detritum. It is assumed that the remark refers to encroachment into otherwise inclement areas, for, so far as now known, the overall geographical range of H. detritum is much more extensive than that of "H. scupense".

In their work on the ixodids of Transcaucasia, Pomerantzev, Matikashvily, and Lototsky (1940) list both H. detritum and "H. scupense" as widely spread species in the southern part of the Palearctic Region. Only H. detritum is listed as a "species typical for the desert and steppe formations of eastern Transcaucasia (including salsola, and wormwood-salsola formations, gramineous-wormwood semideserts, Andropogonetum semi-steppes and the formations of highland xerophytes of southern Transcaucasia)". "H. scupense" is included under "species equally occurring both in the forest zone of highlands and in desert and steppe formations". [Several biological studies on this tick mentioned by Pomerantzev (1950) are unavailable to the writer.]

Melnikova's (1953) study of ticks of the Crimean National Forest showed "H. scupense" to be most common in populated areas adjoining the forest. It is closely associated with the grazing grounds of domestic cattle and wild deer and occurs at all altitudes except that it is much less common in mountain meadows near the peaks (1200 to 1400 meters elevation) and in coniferous forest (500 to 900 meters elevation). It is common in valleys with deciduous and mixed forest (400 to 600 meters), oak forest with many open meadows (600 to 800 meters), and beech forest with small, open fields.

REMARKS

Miscellaneous observations on H. detritum (= H. mauritanicum) by Sergent, Donatien, Parrot, and Lestoquard (1945) concern parasitism of an engorged nymph by a nymph of the same species; regeneration of appendages mutilated in the immature stages; monstrosities; progeny of intermated adults from a single egg batch; and negative results of various attempts to crossbreed this species with H. excavatum. Most of these data derive from publications listed under ALGERIA above.

Desportes (1938) described a nymph of H. detritum (= H. mauritanicum) with two anuses and a third spiracular plate. Other abnormalities have been noted by G. Senevet (1922A) and by Sergent and Poncet (1941). Abnormal specimens and gynandromorphs have been described by Pavlovsky (1940).

According to Schulze (1921), "H. scupense" may become overgrown by the host skin when it feeds on the scrotum of sheep.

In attempts to determine whether feeding by tick larvae may produce host immunity preventing the feeding of subsequent larvae on the same host, Brumpt and Chabaud (1947) found that while possibly some immunity may develop from the bites of Dermacentor pictus this does not hold when larvae of H. detritum are applied later to the same animal.

Skin lesions, a powerful salivary anticoagulin, and an egg toxin that did not, however, produce symptoms of tick paralysis have been studied by Hoeppli and Feng (1933).

Schulze (1932C) utilized males and females of H. detritum to illustrate his point that on unornamented ticks longitudinal furrows are found in constant situations; these indicate the place of attachment of the weakly transversely-striated dorsoventral muscles, etc. In the same paper, the molting of "H. scupense" from nymph to adult is discussed in relation to ornamentation of the body surface.

A condition similar to polymorphic eczema among mammals has been described and illustrated for Yugoslavian females of

"H. scupense" by Oswald (1938A). It is characterized by secretion of drops of serous liquid over the entire body surface. In one or two days, papules appear, followed by desquamation and later becoming scabby. The same author (1938B) described a toxin in the eggs of "H. scupense".

DISEASE RELATIONS

MAN: "H. scupense" (= H. volgense), harbors Pasturella pestis, the causative organism of plague, for several days after feeding on an infected animal and can transmit the bacteria by biting another animal; its feces also contains virulent organisms.

"H. scupense" appears to be of negligible importance in the sustaining of certain Soviet foci of tularemia.

H. detritum is considered by Soviet workers to be a possible vector of Uzbekistan hemorrhagic fever (virus).

In North Africa and in Uzbekistan, H. detritum is a natural reservoir of Q fever (Coxiella burnetii), and the organism is transmitted from stage to stage of the tick and through the eggs to the subsequent generation.

CATTLE: H. detritum is an important vector of theileriasis (Theileria dispar and T. annulata). "H. scupense" is also a vector of theileriasis and a carrier of brucellosis (Brucella spp.).

HORSES: H. detritum is a vector of equine piroplasmosis (Nuttallia equi) and possibly of Nuttallia minor.

IDENTIFICATION

The following remarks are based on typical specimens of H. detritum collected in Morocco, Egypt, the Sudan, Turkey, southeastern Europe, and Russia. Remarks on variations are based on Iranian specimens determined definitely as H. detritum by Delpy, and on Middle and Far Eastern specimens in the Schulze collection.

Males: Typical males have the subanal shields directly posterior of the adanal shields; the lateral grooves are clear and uniform, reaching almost to the eyes; scutal punctations are either entirely absent, or number up to twelve superficial, unobtrusive punctations either scattered or more or less localized on the scutal surface; the appearance of the scutum is bright and shiny; the posteromedian groove is narrow and long, extending from the central festoon to the scutal midlength; the paramedian grooves are distinct, wider, and somewhat deeper, either as long as or shorter than the posteromedian groove; the area in which these grooves lie is usually depressed. The size is medium to large, the typical color is intensely black; the legs are reddish or yellowish brown and may be somewhat lighter on the anterior surface. The posterior margin of the scutum is quite rectangular, the scutal surface is usually arched.

The specimen illustrated (Figure 158) indicates the maximum amount of punctation found in furrows or on the scutal surface; the punctations in the grooves of this specimen are especially numerous. A parma is either present or absent; if present it is small and inconspicuous.

Subanal shields vary in size and shape from small to moderate size.

The leg segments may have pale rings but these do not contrast greatly with the basic color of the segments.

The following variations have been seen: Lateral groove on one side not so distinct as on the other side; or indistinct on both sides beyond the posterior third (these are most confusing specimens), in which case the lateral grooves continue anteriorly as a row of contiguous punctations. Linear scutal depressions extending anteriorly from the posterior grooves frequently mar the scutal gloss. The scutal color may be various shades of brown. In greatly engorged specimens, the subanal shields are displaced from their typically posterior position to a lateral position, external of the central axis of the adanal shields; such specimens should not be confused with *H. dromedarii* or *H. impeltatum*.

Females: The genital apron is typically an almost equilateral triangle with slightly convex margins, and the posterior juncture is rounded or narrowly truncate, not narrowly pointed. In profile, it is very gradually sloping (Figure 161,E,F) when unengorged but somewhat more abruptly sloping when engorged; in greatly engorged specimens the central area protrudes (Figure 161,D) sometimes with a very slight concavity centrally. The anterior margin may be straight or slightly concave or slightly convex, and in profile the posterior slope may be more acute than it is in typical females; in these cases there may be a very narrow bulge along the anterior margin. The shieldshaped scutum is longer than wide; smooth and shiny; with from four to ten superficial, scattered punctations of large diameter; punctations may be entirely lacking or a very few, shallow, minute punctations may be present. The scutal surface in greatly engorged specimens may be slightly rugose. The cervical grooves are long and wide, and reach the posterior scutal margin.

Note: According to Pomerantzev (1950), *H. detritum* is largest in Middle Asia and gradually diminishes in size towards the west (Algeria). Color differences of various parts of the body do not support division of *H. detritum* into geographical races.

The larva and nymph of *H. detritum* have been described and compared with those of other Russian species by Bernadaskaia (1939C). Feldman-Muhsam (1948) also described these stages and compared them with those of Palestinian species.

Identification of "*H. scupense*"

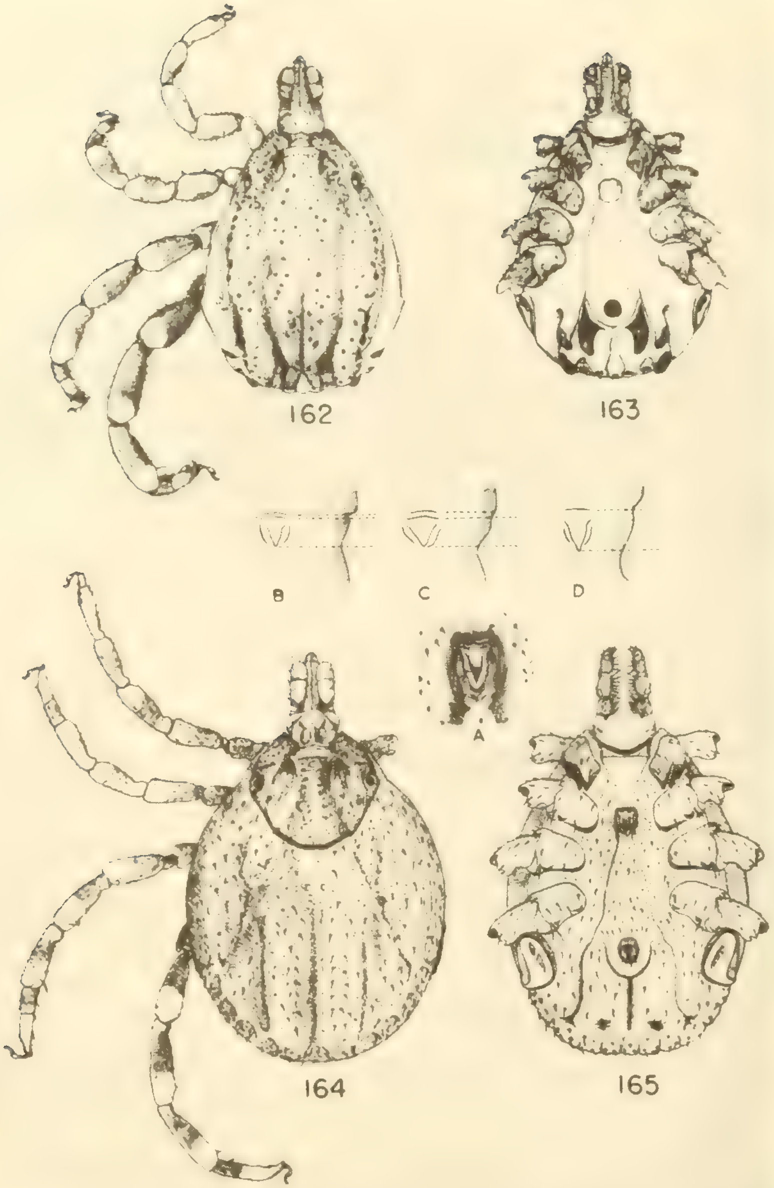
The following remarks concerning the biological race "*H. scupense*" are from Pomerantzev (1950);

H. scupense is similar to *H. detritum* and difficult to distinguish. It is smaller, has shorter legs, and has a more distinct caudal field in the male as well as greater scutal rugosity. The dorsal projection of the spiracular plate is broader and shorter. The capitulum is smaller and the porose areas of the female are more rounded than in *H. detritum*. The maximum size of the spiracular plate occurs in specimens from

Central Asia, where the species is almost indistinguishable from *H. detritum*. "It may be best to regard "*H. scupense*" as a winter, single host form of *H. detritum*".

Schulze collection material labelled *H. scupense* conforms to the above remarks but is not extensive enough to be of great value.

It is difficult to decide what taxonomic disposition should be made of biological entities with slight morphological variations, such as "*H. scupense*" appears to be. It appears that the observations on this form have been carefully done, but the biological and taxonomic principles involved are unusual if not unique in the study of ticks. Pomerantzev's approach appears to have considerable merit.



Figures 162 and 163, dorsal and ventral views
Figures 164 and 165, dorsal and ventral views

A, ♀, genital area. B to D, ♀, genital area outline and profile.
B, unengorged. C, partly engorged. D, fully engorged.

HYALOMMA DROMEDARII
Egyptian Specimens

PLATE XLVIII

HYALOMMA DROMEDARII Koch, 1844.

(Figures 162 to 165)

THE CAMEL HYALOMMA

NOTE: Numerous early literature references to "H. aegyptium" apply in whole or part to H. dromedarii, but without study of individual author's material it is impossible to state the exact species. In the pre-Delpy period, the name H. dromedarii was frequently used for Hyalomma ticks from camels, but the possibility that several species may have been included under this name indicates that caution should be exercised before it is assumed that all early references to Hyalomma ticks on camels refer to H. dromedarii. The various "subspecies" of H. dromedarii, now considered invalid, and the few known synonyms of this species are noted below in the section on distribution. No type specimens conforming to present concepts for this species are available (see Feldman-Muhsam 1954) but since species criteria are now well defined, substitute type specimens should be selected and so designated in an established collection.

DISTRIBUTION IN THE SUDAN

Hyalomma dromedarii ranges extensively north of 12°N. latitude but is entirely absent in the south of the Sudan. The camel hyalomma has not been previously recorded from the Sudan, but earlier references to H. aegyptium undoubtedly refer in part to H. dromedarii.

Localities from which specimens have been seen (all from camels unless otherwise specified) are:

Northern: Ed Damer and Shendi (camels and bulls; SVS). Berber (camels and horses; SVS). Wadi Halfa, Abu Hamed, Atbara, Ed Damer (camels and cattle; HH).

Khartoum: Khartoum and Omdurman (common on domestic animals, especially camels; SVS, SGC, HH).

Kassala: Kassala (camels and cattle; SVS). Port Sudan (cattle and horses; SVS). Tokar (donkeys; SVS).

Darfur: Nyala (SVS). Muhagariya (donkeys, camels, horses, and cattle; SVS). Zalingei (camels, goats, and horses; SVS).

Kordofan: El Obeid (camels and cattle; SVS). "Northern Kordofan" (SVS). Umm Indiraba (cattle; SVS). "Western Kordofan" (sheep; SVS).

Blue Nile: Wad Medani (cattle and camels; HH). Hassa Heissa (Kohls det., G. B. Thompson, correspondence).

DISTRIBUTION

H. dromedarii is common wherever camels occur: in southern Russia (Turkemnia, southern Tadzhikistan and Uzbekistan)*, and in the Far, Middle, and Near East. In Africa, it is found in North Africa, in the transitional belt just south of the great northern deserts, in the eastern and coastal lowlands as far south as the Somalilands, and in northeastern Kenya. Small introduced populations have been found in the Union of South Africa and in Southwest Africa, but whether they now survive is unknown. In some areas, e.g. Anatolia, the camel hyalomma feeds on other hosts since camels are now considerably less common than heretofore. The distribution of this species has been mapped by the American Geographical Society (1954). It is of interest to note that within the range of H. dromedarii, from the Eastern Desert of Egypt to Afghanistan, there exists a more localized but highly distinctive parasite of bactrian, or two-humped, camels, H. schulzei Olenev, 1931 (see page 525), which also attacks dromedaries.

---

*Pomerantzev (1950) lists the synonymous "H. asiaticum" from deserts and semideserts of southern and eastern Transcaucasia and a considerable part of Kazkhstan. In the south its distribution extends to the boundaries of the Soviet Union, embracing a considerable part of Turkmenia, Uzbekstan, and Tadzhiskstan; also Iran and central Asia.

Note: All references below are to "H. dromedarii" unless otherwise specified.

OUTLYING ISLANDS: CANARY ISLANDS (As H. d. canariensis: Schulze and Schlottke 1930. As H. d. dromedarii: Kratz 1940).

NORTH AFRICA: MOROCCO (Lavier 1923. Blanc, Bruneau, Martin, and Maurice 1948. Blanc, Martin, and Bruneau 1949). ALGERIA (As H. aegyptium dromedarii and as H. a. margaropoides: Senevet 1922B). TUNISIA (Pavesi 1884. Tonelli-Rondelli 1930A. Colas-Belcour 1931. Colas-Belcour and Rageau 1951). LIBYA (Franchini and Cadeddu 1927. Franchini 1927,1928B,1929A,B,E. Stella 1938C. Tonelli-Rondelli 1930A,1932A,C,D,1935. Gaspare 1933. As H. anatolicum zavattarii: Tonelli-Rondelli 1935. Stella 1938C. Kratz 1940). EGYPT (Koch 1844. Nagaty 1947. Taylor, Mount, Hoogstraal, and Dressler 1952. Wassif 1954).

WEST AFRICA: FRENCH WEST AFRICA (Blanc, Martin, and Bruneau 1949. Villiers 1955).

EAST AFRICA: SUDAN (Hoogstraal 1954B. The "H. dromedarii f. leptosoma" attributed to Schulze by Kratz 1940, on the basis of material from Sudanese cattle, represents weak, poorly developed individuals of H. dromedarii, H. excavatum, or H. impeltatum; it is most likely the last-named species).

ETHIOPIA (Stella 1940). ERITREA (As H. tunesiacum ganorai: Tonelli-Rondelli 1932C. Stella 1940. Kratz 1940. As H. d. dromedarii: Tonelli-Rondelli 1930A. As H. dromedarii: Niro 1935). FRENCH SOMALILAND (Hoogstraal 1953D). ITALIAN SOMALILAND (Pavesi 1884A. Paoli 1916. Tonelli-Rondelli 1926A,1935. Franchini 1929C. Niro 1935. Stella 1939A,1940). BRITISH SOMALILAND (Specimens from camels at Las Anod in BMNH collections; HH det.).

KENYA [Lewis' (1931B,1934) H. dromedarii from the Rift Valley and from the Masai Reserve are misidentifications (material checked by HH). H. dromedarii does, however, occur in the arid Northern Frontier Province (material sent to the writer by Miss J. B. Walker for determination). This species has been reported by Daubney (1937) and Mulligan (1938) without further details except that the material had been identified by Schulze.]

[TANGANYIKA specimens identified by E. A. Lewis as H. dromedarii have been reported by Cornell (1936). This improbable record should be verified by checking the material.]

[SOUTHERN AFRICA: Although southern Africa is out of the normal range of H. dromedarii. Theiler (correspondence) has material of this species from camels introduced into the Vryburg and Gordonia districts on the old camel patrol route with headquarters at Rietfontein on the border of the Union and Southwest Africa. Another collection is from the ears of a camel at Okalanga in the extreme west of Ovamboland, Southwest Africa. This material was collected between 1939 and 1942, before the discontinuance of the camel corps. Whether H. dromedarii survives in these localities is not known.]

NEAR EAST: PALESTINE (Bodenheimer 1937. Adler and Feldman-Muhsam 1946,1948. Feldman-Muhsam 1948). YEMEN (Sanborn and Hoogstraal 1953. Hoogstraal, ms.). IRAQ (Khayyat and Gilder 1947. Hoogstraal, ms.). TRANSJORDAN, SAUDI ARABIA, and ADEN (Hoogstraal, mss.). IRAN (Delpy 1936,1937B,1946A,1949A,B,C. Delpy and Gouchey 1937. Nemenz 1953. As H. yakimovi persiacum: Olenev 1931A,C. As H. yakimovi: Pospelova-Shtrom 1932. As H. delpyi: Schulze 1936D). TURKEY (Koch 1844. Kratz 1940. Kurtpinar 1954. Mimioglu 1954. Common throughout central and eastern Anatolia, even where camels have recently become scarce; rare in western Anatolia: Hoogstraal, ms.).

RUSSIA: As H. asiaticum or H. a. asiaticum: Galuzo 1935. Pomerantzev 1937. Bogoroditsky and Bernadskaia 1938. Bernadskaia 1939B,C. Chumakov, Petrova, and Sondak 1945. Pervomaisky 1947. Markov, Gildenblat, Kurchatov, and Petunin 1948. Olenev 1950. Pomerantzev 1950. Rementsova 1953. Pavlovsky, Pervomaisky, and Chagin 1954. Tselishcheva 1954. Petrisheheva 1955. Zhmaeva, Pchelkina, Mishchenko, and Karulin 1955. Serdyukova 1955.

As H. asiaticum caucasium Pomerantzev: in Pomerantzev, Matikashvily, and Lototsky 1940. Pomerantzev 1950.

As H. dromedarii: Yakimov 1923. Olenev 1929B. Pomerantzev 1934,1950. Pavlovsky and Pomerantzev 1934. Kurchatov 1941. Pomerantzev, Matikashvily, and Lototsky 1940. Pavlovsky 1940. Chumakov, Petrova, and Sondak 1945. Alfeev 1948,1951. Pervomaisky 1949.

As *H. dromedarii asiaticum*: Schulze and Schlottke 1930. Olenev 1929A,1931A,C,1934. Galuzo 1934. Pomerantzev 1950. Some of these may apply to *H. excavatum*, this is especially likely in the case of Galuzo 1934. Feldman-Muhsam 1954 does not accept Delpy's synonymy of this form under *H. dromedarii* but does not provide reasons or suggest a substitute.

As *H. aegyptium dromedarii*: Yakimov 1917,1922.

As "*H. tunesiacum amurense* Schulze": described and illustrated by Kratz 1940. Delpy 1949B attributed "*H. amurense* Olenev, 1931C" to *H. excavatum*.

As *H. pavlovskyi*: Olenev 1931C. Galuzo 1935. As *H. yakimovi*: Olenev 1931A,C. Galuzo 1935. Pospelova-Shtrom 1932.

MIDDLE EAST: AFGHANISTAN (Hoogstraal, ms.). INDIA and PAKISTAN [As *H. asiaticum citripes*: Schulze (1934X). As *H. d. citripes*: Kratz (1940). According to Delpy (1949B) these are synonyms of *H. dromedarii*. Feldman-Muhsam (1954) states, without further explanation, that they are not. Records of *H. dromedarii* by Sharif (1928) and Sen (1938) are questionable.]

FAR EAST: TIBET (and MONGOLIA): As *H. kozlovi*: Olenev 1931B. Kratz 1940. As *H. asiaticum kozlovi*: Pomerantzev 1950.

[INDOCHINA: The *H. d. indosinensis* of Toumanoff (1944) refers to *H. marginatum*.]

IMPORTED SPECIMENS: ARGENTINA (Found on camels from Dakar: Lahille 1914).

NOTE: Portugese material under this name (da Silva Leitao 1945) is assumed (HH) to be misidentified.

HOSTS

Until recently, only the hosts of adult *H. dromedarii* were known. These are chiefly camels, but also include cattle and horses and, to some extent, sheep, goats, and dogs. Man is uncommonly attacked by adults, but more frequently by larvae and nymphs. H. dromedarii is so intimately associated with camels that it does not occur outside the normal range of these animals. However in parts of Anatolia where camels are now considerably less numerous than heretofore, large numbers of adults have been found on cattle and horses, fewer on sheep and goats (Hoogstraal, ms.).

In nature, remote from large concentrations of domestic animals, larvae and nymphs feed on small burrowing mammals and hares, rarely on lizards. Adults venture forth in search of larger hosts. Nymphs appear to be more versatile, depending on local situations, and may infest camels, cattle, and horses in large numbers. Factors inducing the selection of hosts by nymphs are in need of study.

In the laboratory, Delpy and Gouchey (1937) fed larvae on hares and calves but this stage rarely engorged on camels or sheep. The same was true for nymphs. Adults attached rapidly to camels and cattle, rarely to sheep. It was often difficult to rear on a calf the F_1 generation of a female collected on a camel. Further review of Delpy and Gouchey's report is presented in BIOLOGY below.

In Yemen, Southwestern Arabia, numerous larvae and nymphs have been collected from the following hosts (Hoogstraal, ms.):

Lepus arabicus arabicus Ehrenberg
Lepus arabicus subsp.
Rattus rattus rattus Linnaeus (rare)
Gerbillus cheesmani maritimus Sanborn and Hoogstraal

In Egypt, including Sinai, nymphs have been taken from hedgehogs, hares, rodents, and lizards (identifications based on adults reared from nymphs) (Hoogstraal, ms.).

Hemiechinus auritus aegyptius Fischer (common on Mediterranean littoral)
Paraechinus aethiopicus dorsalis Anderson and De Winton (few hosts examined)

Lepus capensis sinaiticus Ehrenberg (few hosts examined)
Lepus capensis aegyptius Desmarest (common)
Gerbillus (Dipodillus) quadrimaculatus Lataste (rare)
Gerbillus g. gerbillus Olivier (fairly common)
Gerbillus p. pyramidum Geoffroy (common)
Meriones c. crassus Sundevall (common, also in burrows)
Meriones s. shawi Duvernoy (common, also in burrows)
Psammomys o. obesus Cretzschmar (common, also in burrows)
Jaculus j. jaculus Linnaeus (rare)
Acanthodactylus boskianus Daud. (Lizard) (uncommon)

According to Pomerantzev (1934) hosts of the immature stages in Armenia include reptiles and wild birds. The fatty subcutaneous layers of ground squirrels, Citellus sp., used as laboratory hosts (Pospelova-Shtrom 1932), may hinder the attachment and feeding of larval H. dromedarii (= H. yakimowi).

In Russia (Pomerantzev 1950), adult hosts are camels, horses, and sheep while nymphs feed in large numbers on cattle and camels. Hosts of adults of the synonymous H. asiaticum are camels, cattle, horses, and sheep; rarely donkeys, goats, domestic and wild pigs, hares and hedgehogs; sometimes man. Nymphs of this latter form occur on hedgehogs, in burrows of large "peschanki" and gophers, while larvae are often on hedgehogs. Both immature stages are found (?together) on hares, gophers, jerboas, "peschanki", cats and dogs, and single nymphs are found on cattle and sheep (Bogoroditsky and Bernadskaia 1938).

BIOLOGY

Life Cycle

The question of the normal number of hosts of H. dromedarii is moot. Delpy and Gouchey (1937) consider it as a three-host tick that may utilize only two hosts under unfavorable conditions; i.e. great heat, when larvae molt quickly and reattach as nymphs nearby on the same host in order to avoid desiccation. It would appear that normally, on burrowing mammals, this need would not arise since the hosts venture from their relatively cool tunnels only after the sun goes down (deserts are usually cool at night).

Alfeev (1951) reared H. _dromedarii_ as a single host tick on rabbits and noted that adults move to new positions shortly after molting and remain unattached to the host for a day or two afterwards.

Field observations suggest that this is normally a two host tick, the change in hosts usually occurring after the nymphal-adult molt, infrequently after the larval-nymphal molt (Hoogstraal, ms.). In Russia the former type appears most common (Pomerantzev 1950).

Experimentally, Pospelova-Shtrom (1932) bred H. _dromedarii_ (= H. _yakimowi_) on one, two, or three hosts. For the single host life cycle, she employed the hedgehog. [The highly artificial conditions and exceptional hosts utilized in this experiment preclude additional deductions from the results.]

During the warm season in Iran, the briefest life cycle observed by Delpy and Gouchey (1937) was 93 days. During cold weather, 280 or more days were necessary. Two generations a year may occur in nature. Variations in life cycle length are due to external or climatic factors affecting oviposition, hatching, and premolting periods; feeding times are similar at all seasons. These findings are diametrically opposed to those of Pospelova-Shtrom (_loc. cit._), who concluded, after rearing two generations under different temperature and humidity conditions, that variations in the length of different stages depends more on host body-temperature than on atmospheric differences. The Delpy-Gouchey conclusions are more in line with usual concepts concerning factors affecting tick life cycles. (See page 704)

In Egypt, some slight seasonal variation in incidence of adults on camels is noticed (Hoogstraal, ms.). Normal life cycle activity appears to continue the year around, except that it is slower during the winter. For instance, during the summer, nymphs molt to adults from seventeen to 26 days after dropping from the host while in winter this period is extended to from 27 to 48 days.

Feeding time for each stage, according to Delpy and Gouchey, is as follows:

STAGE	DAYS	EXTREMES
Larva	6	3 to 11
Nymph	7	5 to 9
Female	11	7 to 15

These authors reported individual females laying from 2000 to 8000 eggs, but Pomerantzev (1950, for the synonymous H. asiaticum) notes as many as 14000 eggs.

Males mate with unengorged or with feeding females while on the host. In the absence of males, females either detach prematurely from the host or remain fixed for an exceptionally long time - as long as two months.

In the Kazalinski district of Russia (Pomerantzev 1950), adults parasitize domestic animals from April to the end of October, but are most common from May through August while larvae and nymphs attack hedgehogs in July and August. Females that become engorged late in autumn undergo a winter diapause and do not oviposit till spring.

Ecology

Delpy and Gouchey (1937) found H. dromedarii to be very tolerant of low humidity and extremes in temperature (0°C. to 37°C.). Unfed larvae and especially unfed nymphs avoid dry atmosphere more than engorged stages and adults.

H. dromedarii is probably the most completely desert-adapted of all ixodid ticks. In remote Siwa Oasis of Egypt, it, together with R. sanguineus, is the only common ixodid tick. Italian and French observers elsewhere in North Africa and Soviet workers in Russia have made similar observations. The camel hyalomma appears to be equally at home in all desert situations where animals occur, as well as in semidesert and steppe areas. In Yemen and Eritrea, it is also common in mountainous areas to 7000 feet altitude wherever there are people and camels (Hoogstraal, ms.).

When traveling over remote parts of the African and Arabian deserts engorged females have been observed desperately crawling on sand. The opportunities for dispersal of H. dromedarii over long camel routes may easily be imagined, but a large number of ticks undoubtedly perish in either the egg or larval stage along these wide and indefinite trails through barren deserts. Blanc, Martin, and Bruneau (1949) report females on camels that had arrived, after a trek of longer than a week, across the Sahara, at Goulimine in southern Morocco from Mauritania, over a thousand kilometers away. In Egypt, similar infestations are found in the Cairo area on camels just arrived from the Sudan (these also bear other Sudanese but not Egyptian species of ticks) and in Siwa Oasis on camels from distant parts of Libya.

In Egypt, unfed adults may be taken on the desert of the Mediterranean littoral at any time of the year. Unfed adults either come rushing at any potential host, including man, from under desert shrubs or are collected in rodent burrows before they depart in search of larger hosts. Engorged, ovipositing females may be observed in rodent burrows as well as under desert shrubs, in camel yards, and under stones. On the littoral desert unfed adults are seen at any time of the day in all seasons.

REMARKS

In attempts to determine whether larvae produce an acquired immunity in the hosts, thus preventing subsequent larvae from engorging on the same animal, Brumpt and Chabaud (1947) fed this stage on rabbits with negative results.

Differences in size of each stage and sex have been presented by Campana-Rouget (1954).

A capillary tube arrangement, which has proved successful for the artificial feeding of adults of H. dromedarii for physiological and disease-transmission studies, has been described by Chabaud (1950A).

Parasitic wasps (Hymenoptera), Hunterellus hookeri, have been bred from nymphs of H. dromedarii (= H. asiaticum) in Russia by Bernadskaia (1939B).

Integumentary sense organs, which are fixed in number and location and essentially similar in all stages, though more primitive in larvae, have been described and illustrated by Dinnik and Zumpt (1949). These are the organs that Delpy (1938) had previously referred to as spiracles ("stigmates respiratoires").

Pervomaisky (1949) was unable to rear a full F_1 generation from parthenogenetic females of H. dromedarii. Abnormal specimens have been described by Pavlovsky (1940) and Alfeev (1948).

The feeding of large numbers of this tick (= H. asiaticum) induces inflammation of the host skin that hinders normal engorgement, especially of females that are likely to die as a result. When additional species compete for space, "a further antagonistic factor increases the obstacles" (Pavlovsky, Pervomaisky, and Chagin 1954).

Warburton and Nuttall (1909, page 71) produced an excellent illustration of H. dromedarii (H. aegyptium) but the legend, inferring South Africa as the source, is misleading. Apparently the only specimen from South Africa is the abnormal one (figure 18), the identity of which is uncertain.

"H. asiaticum", which Delpy considers to be a synonym of H. dromedarii, is still treated by Soviet workers (Pomerantzev 1950) as a separate species with several subspecies and with a wider geographical range than H. dromedarii. This form is less robust, smaller, and more slender, with a shorter posteromedian groove than in giant males typical of H. dromedarii. The females are more elongate than the typically robust female H. dromedarii and the length-width ratio of their palpi and of their scutum is longer. Such individuals are also encountered in African populations. Delpy (1946) first considered the short, wide palpal shape to be diagnostic but further studies indicated so much variation that "applied strictly to determination of isolated specimens, (this character) would have led to errors. (Also) the ratios that are true for a young, recently molted tick are no longer accurate when this tick has aged and become engorged". The shortness of the posteromedian groove appears concomitant with the general lack of robustness in these smaller and more slender ticks.

Feldman-Muhsam (1954) states "The type specimens of H. *dromedarii asiaticum* as well as H. *asiaticum citripes* differ from H. *dromedarii* and are not synonyms of H. *dromedarii*". Without further explanation, it is impossible to evaluate this remark.

DISEASE RELATIONS

MAN: A host and vector of Q fever (*Coxiella burnetii*).

Experimentally, this tick can be infected with the virus of Russian spring-summer encephalitis, with the virus of mosquito-borne autumn encephalitis from the Russian Maritime Province, and with the virus of a Japanese mosquito-borne encephalitis.

CATTLE: Theileriasis (*Theileria* spp.). This tick (as H. *asiaticum*) is apparently not a carrier of brucellosis (*Brucella* spp.).

CAMELS: Theileriasis (*Theileria camelensis*).

IDENTIFICATION

Males: Typical males are recognized by (1) large size (average length: 5.7 mm., range 5.2 mm. to 7.0 mm.; average width: 3.8 mm., range 3.0 mm. to 5.0 mm.), (2) distinct lateral displacement of the subanal shields, (3) short, deep lateral grooves limited to the posterior third of the scutum; and (4) few, large shallow punctations variously scattered over the surface and complete or almost complete absence of other punctations. Also distinctive is the deep, usually narrow, posteromedian groove extending from the distinct parma to the scutal midlength. This groove is bounded on either side by converging ridges; laterad of these ridges are deep, wide, often rugose paramedian grooves. The paramedian grooves are of variable length, and posteriorly delineate the two median pairs of festoons, which are often massive and which are larger than the more or less distinct three lateral pairs of festoons. Another pair of parallel ridges may be present between the paramedian grooves and the lateral grooves.

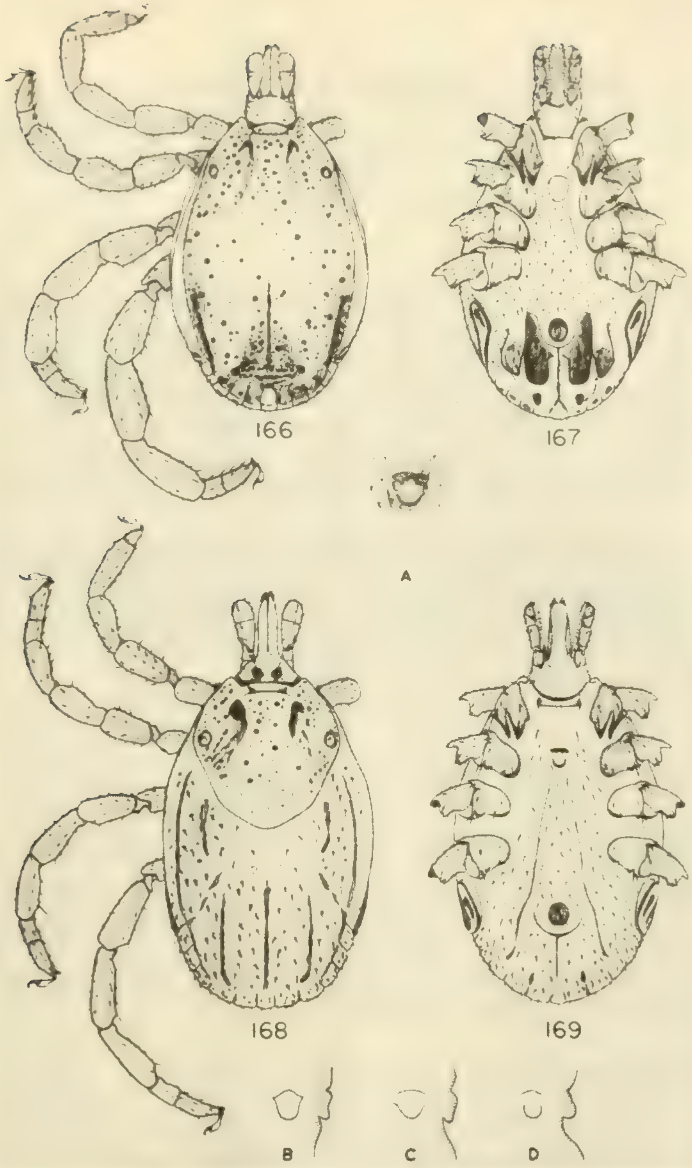
Variations of the above characters are as follows: Small punctations may be present and rarely may be obtrusive enough to suggest H. impeltatum; also a line of large punctations extending anteriorly from the apex of the lateral grooves may suggest H. impeltatum. In engorged specimens, at least, differences in the posterior area of the scutum separate such specimens. In some specimens a dense field of small punctations may be present posteriorly, suggestive of H. excavatum. The subanal shields are sometimes divided into two pairs, but very few such specimens have been seen during the present study. In unengorged males, the subanal shields are closer to the central axis of the anal shields than otherwise, but their center is still exterior of the central axis of the adanals. Color varies from yellowish brown through dark brown to brownish black. The legs are usually paler than the scutum and the segments may be ringed by a paler band.

Females: Typical females may be recognized by (1) the narrowly elongate and triangular genital aperture, which in profile slopes gradually, (2) the comparatively wide scutal outline (length-width ratio about equal, (3) few, large, scattered punctations and frequent rugosity of the scutal surface, and (4) large size. The palpi are usually twice as long as their combined width. The color varies from yellowish brown to black; the legs are usually paler than the body and may be concolorous or ringed.

The genital aperture is most distinctive and hardly variable. In newly molted females its outline is slightly concave subapically, but in engorged specimens the lateral margins are usually straight. The narrowly triangular outline is apparently never lost. A narrow, raised integumental fold surrounds the apron.

The scutal outline is widest just anterior of the eyes. The wide, deep, long cervical grooves are usually rugose as is also the scutal surface of most engorged specimens. From ten to twenty (average thirteen) large punctations are scattered over the central field and an equal number occur in each scapular field. Average newly molted specimens measure about 5.5 mm. long by 3.2 mm. wide, but engorged individuals may be 30.0 mm. long and 15.0 mm. wide. Scutal length is about 3.2 mm., width about 2.8 mm.

The *larva* and *nymph* (as *H. asiaticum*) have been described and compared with those of other species by Bernadskaia (1939C) and (as *H. dromedarii*) by Feldman-Muhsam (1948).



Figures 166 to 167, ♂, dorsal and ventral views
Figures 168 to 169, ♀, dorsal and ventral views

A, ♀ genital area. B to D, ♀ genital area outline and profile.
B, unengorged. C, partly engorged. D, fully engorged.

HYALOMMA EXCAVATUM
Egyptian Specimens

PLATE XIL

HYALOMMA EXCAVATUM Koch, 1844.

(Figures 166 to 169)

THE SMALL HYALOMMA

NOTE: Schulze and his co-workers employed the name H. savignyi (Gervais 1844) for this tick, and following their usual practice appended a variety of subspecific names to it. References to H. depressum, H. lusitanicum subspp., H. pusillus subspp., and H. rhipicephaloides also apply to H. excavatum. The name H. anatolicum, as used by Russian and French workers, applies to H. excavatum. For a list of synonyms, see Delpy (1949B, pp. 475-577).

Adler and Feldman-Muhsam (1948) and Feldman-Muhsam, following Schulze's lead, applied the name H. savignyi in studies of H. excavatum. After examining Koch's type specimens, Feldman-Muhsam (1954) agreed with Delpy that H. excavatum is the proper name for this tick. This is accepted as a final decision.

DISTRIBUTION IN THE SUDAN

H. excavatum is moderately common in northern Sudan and in the northern parts of central Sudan. No records from Darfur Province are available. The small hyalomma is generally considerably less numerous in the Sudan than in Egypt. It shows a strong predilection for horses, even in areas where other domestic animals are present in large numbers.

The following are data for material seen:

Northern: Shendi (bulls, donkeys, and horses; SVS). Wadi Halfa, Abu Hamed, Atbara, and Shendi (camels, cattle, horses, donkeys, goats, and sheep; HH).

Khartoum: Khartoum, Omdurman, and Shambat (camels, horses, donkeys, cattle, goats, sheep, and dogs, SVS; Gordon College collection; HH).

Kassala: Kassala (goats, horses, cattle, and camels; SVS). Port Sudan (cattle, donkeys, and horses; SVS). Sinkat (horses; SVS). Tokar (cattle, horses, and donkeys; SVS).

Darfur: No records.

Kordofan: El Obeid (horses and sheep; SVS).

Blue Nile: Wad Medani (camels and horses; HH). Hassa Heissa (camels; G. B. Thompson, correspondence).

DISTRIBUTION

H. excavatum is common throughout northern Africa, and ranges through the Near East, Asia Minor and southern Russia to India. It is abundant locally in southern Europe, but is particularly numerous in Egypt, Palestine, Asia Minor, and southern Russia.

In Africa, *H. excavatum* ranges along the northern and northeastern littoral, a continuous belt characterized by less than ten inches of rainfall per annum. Its southeastern limit is Somalia. The Sudan has been invaded by this parasite possibly both via the Nile from Egypt and via the Red Sea coast.

The distribution of *H. excavatum* has been mapped by the American Geographical Society (1954).

All references below are to *H. excavatum* unless otherwise noted.

ATLANTIC OCEAN: CANARY ISLANDS (Nuttall lot 3226 in BMNH; H.H. det. As *H. depressum*: Schulze 1919. As *H. lusitanicum cicatricosum*: Schulze and Schlottke 1930. Kratz 1940).

NORTH AFRICA: MOROCCO (Blanc, Bruneau, Martin, and Maurice 1948. Blanc and Bruneau 1953,1954,1955. As *H. lusitanicum*: Blanc and Bruneau 1949).

ALGERIA (As *H. l. lusitanicum*: Senevet 1922B,1925,1928A,B, 1937. Senevet and Rossi 1925. Kratz 1940. d'Arces 1952. As

H. lusitanicum berberum: Senevet 1922B. As H. lusitanicum algericum: Senevet 1928A. As H. savignyi: Sergent and Poncet 1937,1940,1943. Sergent and co-workers also employed the name H. lusitanicum at one time or another. As H. lusitanicum algericum: Schulze and Schlottke 1930. As H. aegyptium impressum: Senevet 1922B).

TUNISIA (As H. tunesiacum: Schulze and Schlottke 1930. As H. tunesiacum tunesiacum: Kratz 1940. As H. lusitanicum depressum: Schulze and Schlottke 1930. Kratz 1940. As H. lusitanicum algericum: Colas-Belcour 1931. As H. excavatum: Colas-Belcour and Rageau 1951).

LIBYA (As H. depressum: Franchini 1927,1929E. As H. tunesiacum franchinii: Tonelli-Rondelli 1932C. As H. anatolicum: Tonelli-Rondelli 1932D. As H. fezzanensis: Tonelli-Rondelli 1935. Stella 1938C. Kratz 1940. Numerous specimens in Hoogstraal collection).

EGYPT (As H. excavatum sp. nov.: Koch 1844. As H. rhipicephaloides: Neumann 1901,1911. Schulze 1919,1921,1936F. Kratz 1940. As H. pusillum alexandrinum: Schulze 1919. As H. savignyi savignyi: Kratz 1940. As H. excavatum: Daubney and Said 1951; undoubtedly in part confused with H. impeltatum. Taylor, Mount, Hoogstraal, and Dressler 1952).

EAST AFRICA: SUDAN (Taylor, Mount, Hoogstraal, and Dressler 1952. Hoogstraal 1954B).

ERITREA (Specimens from several localities in HH collection. Apparently not reported under any known synonym by Italian workers; material probably differently identified by them). FRENCH SOMALILAND (Hoogstraal 1953D). ITALIAN SOMALILAND (As H. lusitanicum: Franchini 1927,1929C,E. Niro 1935. As H. somalicum: Tonelli-Rondelli 1935. Stella 1939A,1940. Kratz 1940).

[?KENYA: H. anatolicum, a synonym of H. excavatum has been reported in various notes by Lewis, and by Daubney (1937), Mulligan (1938), and Yalvac (1939). This name derives from material identified by Schulze. Although it would not be surprising to find isolated populations in northeastern Kenya, recent workers have not encountered it and earlier specimens referred to this species are not available.]

NEAR EAST: PALESTINE (As H. anatolicum: Bodenheimer 1937. Kratz 1940. As H. rhipicephaloides Neumann 1901,1911. Schulze 1921,1936F. Kratz 1940. As H. savignyi: Bodenheimer 1937. Adler and Feldman-Muhsam 1946,1948. Feldman-Muhsam 1947,1948, 1949,1950,1951A. As H. excavatum: Feldman-Muhsam 1954. As H. tunesiacum: Bodenheimer 1937).

SYRIA and LEBANON (Hoogstraal, ms.). IRAQ (As H. aegyptium mesopotamium: Schulze 1919. Schulze and Schlottke 1930. As H. savignyi mesopotamium: Kratz 1940. As H. excavatum: Hubbard 1955. Hoogstraal, ms.). "ARABIA" (As H. pusillum: Schulze 1919). TRUCIAL OMAN, YEMEN, ADEN, SAUDI ARABIA (Hoogstraal, mss.). IRAN (Delpy 1946B,1949C,1952). AFGHANISTAN (Anastos 1954. Hoogstraal, ms.).

TURKEY (As H. pusillus: Vogel 1927. As H. excavatum: Kurtpinar 1954. Mimioglu 1954. One of the most common ticks on the Anatolian steppes: Hoogstraal, ms. As H. lusitanicum: Yasarol 1954).

CYPRUS /The H. savignyi exsul of Schulze and Schlottke (1930), attributed by Delpy (1949B) to H. marginatum (= H. savignyi of Delpy), appears rather to be H. excavatum; see pp. 534-535 of Kratz (1940)_7.

EUROPE: PORTUGAL (As H. lusitanicum: Koch 1844. Schulze 1919. Kratz 1940).

SPAIN (As H. depressum: Schulze 1919. Gil Collado 1948A. As H. excavatum: De Prada, Gay, and Llorente 1950. De Prada, Gil Collado, and Mingo Alsina 1951. As H. lusitanicum: Gil Collado 1936,1948A. Kratz 1940. As H. lusitanicum algericum: Jordano Barea 1951. NOTE: H. depressum is considered to be a synonym of H. excavatum, but the species called H. depressum by Gil Collado 1948A is one that cannot readily be determined).

FRANCE (As H. excavatum: Brumpt and Chabaud 1947. Brumpt 1949. Buttner 1949. Colas-Belcour and Rageau 1951. Chabaud and Choquet 1953). ITALY (As H. lusitanicum: Schulze 1936C. Tonelli-Rondelli 1938. Kratz 1940). GREECE (As H. anatolicum: Kratz 1940. Enigk 1947. Pandazis 1947).

RUSSIA: As *H. anatolicum*: Pomerantzev, Matikashvily, and Lototsky 1940. Galuzo 1944. Blagoveshchensky and Serdyukova 1946. Lototsky and Pokrovsky 1946. Pervomaisky 1954. Pavlovsky, Pervomaisky, and Chagin 1954. Viazkova and Bernadskaia 1954. Gajdusek 1956.

As *H. anatolicum anatolicum*: Serdyukova 1946A,B. Markov, Gildenblat, Kurchatov, and Petunin 1948. Pomerantzev 1950. Pervomaisky 1950A. Gajdusek 1953. Tselishcheva 1953.

As *H. anatolicum excavatum*: Serdyukova 1941. Pervomaisky 1949,1950A. Pomerantzev 1950. Petrisheheva 1955.

As *H. amurense*: Olenev 1931A,C.

As *H. asiaticum caucasicum*: Pomerantzev, Matikashvily, and Lototsky 1940.

As *H. excavatum*: Blagoveshchensky and Serdyukova 1946. Zhmaeva, Pchelkina, Mishchenko, and Karulin 1955.

As *H. turkmeniense*: Olenev 1931A,C. Kornienko-Koneva and Shmulreva 1944. Chumakov, Petrova, and Sondak 1945. Pomerantzev 1946. Markov, Gildenblat, Kurchatov, and Petunin 1948. As *H. tunisiacum turkmeniense*: Kratz 1940. Delpy (1949B) considered *H. turkmeniense* as questionably a synonym of *H. excavatum*; Pomerantzev (1950) synonymizes it under *H. excavatum* (= *H. anatolicum*).

[?As *H. savignyi armeniorum*: Olenev 1929A. Schulze and Schlottke 1930. Lototsky and Popov 1934. As *H. armeniorum*: Kratz 1940.]

[?As *H. savignyi*: Zolotarev 1934. Galuzo 1935,1941,1944. Bernadskaia 1939C,1943. Pavlovsky 1940. Zotova and Bolditzina 1943. Galuzo, Bolditzina, and Kaitmazova 1944. For a discussion of Delpy's remarks concerning Soviet confusion between *H. excavatum* and *H. marginatum* (= *H. savignyi*) see page 470.]

As *H. rhipicephaloides*: Yakimov 1922,1923. Olenev 1929B.

MIDDLE EAST: INDIA [As H. kumari: Sharif (1928,1930). Delpy (1949B) considers H. kumari as a synonym of H. excavatum, but it seems best to reserve judgement on this matter for the moment. Numerous specimens typical of H. excavatum are present in BMNH collections, H.H. det. As H. savignyi: Dasgupta (1955) and Dasgupta and Ray (1955); the possibility that these refer to H. marginatum should be considered]. PORTUGESE INDIA (Santos Dias 1954J).

HOSTS

H. excavatum is a parasite of cattle, horses, donkeys, camels, buffaloes, sheep, goats, and swine. It also attacks man and dogs. Hares appear to be especially important wild hosts.

Nymphs are variable in occurrence on cattle, but nymphs and larvae are often found on calves. Nymphs and larvae frequently attack rodents, and normally do so on the desert. They also feed on man, hares, lizards, and birds.

All stages of H. excavatum have been observed feeding on hares in a forest near Casablanca where other wild and domestic animals are absent (Blanc and Bruneau 1953,1954,1955). In Anatolia, numerous adults have been reared from nymphs taken from hares (Hoogstraal, ms.). A larva has been reported from a hare in Iraq (Hubbard 1955). In Yemen these animals are heavily infested by immature stages (Hoogstraal, ms.). British Museum (Natural History) collections contain specimens from Indian hares (Nuttall lot 3423; H.H. det.). Wherever hares and H. excavatum occur together the association appears to be an important one.

The complete absence of any specimens of H. excavatum on more than five hundred hedgehogs collected throughout Egypt, is noteworthy (Hoogstraal, ms.). Hedgehogs were, however, used as laboratory hosts of immature stages by Feldman-Muhsam (1948).

Delpy (1949C) considers birds, especially nestlings, important hosts of nymphs. A male in British Museum (Natural History) collections has been reared from a redstart, P. phoenicurus (= Ruticilla pluvenicurus) at Amara on the Tigris River (Nuttall lot 3240; H.H. det.).

Single instances of attack of human beings have been reported from France (Buttner 1949) and Iraq (Hubbard 1955; whether actually feeding not stated). During field work for the present study, feeding specimens of H. excavatum have been taken from personnel in Egypt, Turkey, and Yemen (Hoogstraal, ms.). In Uzbekistan, this tick (= H. anatolicum) often attaches to man (Gajdusek 1953).

Apparently the only larger wild animals yet recorded as hosts of the adult stage are gazelles in French Somaliland (Hoogstraal 1953E).

Biological observations in Egypt thus far have been confined to searching for naturally infested wild animals in the field, keeping them alive in the laboratory, and allowing ticks that drop from them to molt to the next stage. Adults reared from nymphs taken from wild animals have been from the following hosts:

Lizard	Acanthodactylus boskianus	(fairly common)
Lesser Egyptian gerbil	Gerbillus g. gerbillus	(common)
Greater Egyptian gerbil	Gerbillus p. pyramidum	(common)
Fat sandrat	Psammomys o. obesus	(fairly common)
Sundevall's jird	Meriones c. crassus	(fairly common)
Shaw's jird	Meriones s. shawi	(fairly common)
Spiny nouse	Acomys spp.	(uncommon)
Lesser Egyptian jerboa	Jaculus j. jaculus	(uncommon)
Hares	Lepus capensis subspp.	(common)

Colas-Belcour and Rageau (1951) report adults in Tunisia from burrows of gerbils, jirds, and fat sandrats and nymphs from jirds. They also found H. excavatum in burrows and on other rodents in France. Adults of H. excavatum in rodent burrows are always newly molted, remaining there before they venture forth to seek a larger host (Hoogstraal, ms.). There is no evidence to consider gerbils as common hosts of adults, as stated on the map of the American Geographical Society (1954); see also Erratum sheet).

BIOLOGY

Life Cycle

The several investigators who have reared H. excavatum in the laboratory (Delpy 1952 in Iran; Daubney and Said 1951 in Egypt;

Feldman-Muhsam 1948 in Palestine; Brumpt and Chabaud 1947 in France, and Serdyukova 1946A in Russia) confirm that this is normally a three-host species. In Tadzhikistan, however, Lototsky and Pokrovsky (1946) consider H. excavatum (= H. anatolicum) to be a two-host tick. Feldman-Muhsam observed that some larvae may remain on the host through the nymphal stage, but Delpy (1946C) stated that if they do so, they first detach and wander away, for example to the ear, and reattach only after molting. Daubney and Said observed a single larva molting while still attached. On desert rodents in Egypt nymphal H. excavatum have on several occasions been found attached to the host and partially enclosed by the larval exuvia. Possibly in these situations, where hosts are scarce, the typical life cycle is more commonly somewhat altered. On Egyptian deserts, the molt from nymphal to adult stage typically occurs in rodent burrows. Remarks that desert rodents dislodge most ticks attached to them by rubbing, shaking, or eating are contrary to frequent experience in Egypt.

The effect of a small size host on the life cycle of H. excavatum has perhaps best been described by Serdyukova (1946A, as H. anatolicum) (from abstract in Review of Applied Entomology):

> "Larvae from a single egg-batch engorged on a rabbit, which is an unusual host for this tick. Some detached after engorgement, others molted on the animal. Some of the resulting nymphs wandered on the rabbit without feeding but others engorged and then dropped off. Larvae placed on the ears of a calf all detached after engorging, and no engorged or molting larvae or larval exuvia were observed on calves in the field. Ticks collected in a calf shed included freshly engorged and molting larvae and unfed nymphs. It is concluded, therefore, that H. excavatum (= H. anatolicum) develops as a three-host tick on its normal host, but that an unusual host may alter this behavior. The cycle of ixodid development has probably altered as a result of evolutionary processes. The type of development that occurs on the usual host should be considered as normal, and deviations from it on unusual hosts as atavistic."

It is significant that the Russian worker considers the rabbit to be an atypical host of immature stages of H. excavatum. This is far from true in North Africa and Arabia, where hares and other smaller animals are frequently parasitized (rabbits do not occur here). Most probably smaller animals are also parasitized in Russia but workers there, who have been occupied chiefly with veterinary problems, have failed to investigate this possibility. Indeed, it seems that a diametrically opposed, theoretical conclusion might be drawn:

> Under primitive conditions, in areas lacking large numbers of domestic animals, H. excavatum spends part or all of its life cycle on small animals, usually no larger than hares. In these situations it undergoes a one or two-host type of life cycle. However, when herds of larger domestic animals are present in the range of this tick, the adults and sometimes the immature stages may be confined to these animals. On these larger animals, H. excavatum undergoes a three-host type of life cycle, which is an atypical one for the species, influenced as it is by the availability of hosts due to human activities.

This matter is obviously in need of further investigation.

With regard to the seasonal cycle of H. excavatum, the aforementioned authors working in Iran, Egypt, and Palestine, as well as Serdyukova (1946B) working in the semi-deserts of Tadzhikstan, agree that engorged nymphs and young adults hibernate in cracks and crevices of buildings during the winter; the Soviet observer states that larvae may also overwinter under these conditions. In Russia, hibernating ticks were taken in, among, under, and in association with wooden fixtures of animal enclosures, but not under cakes of dung plastered on loose walls. When these structures were removed the incidence of ticks found in these yards the following summer was only a fraction of what it had been the previous year. In the deserts of Egypt engorged nymphs and unfed adults overwinter in rodent burrows.

In spring, ticks that have hibernated venture forth to feed. Under experimental conditions, if they are removed to a warmer place during the winter nymphs molt and adults feed. In Egypt, wild nymphs do not normally molt until almost summertime, possibly because of cold nights during early spring. By late March, however, females begin to feed, and at this time they may oviposit very shortly after dropping from the host - as soon as seven days afterwards. The incubation period may be as short as 27 days, so that in May new larvae and last year's nymphs can be found feeding. Under the Russian conditions already mentioned, oviposition does not commence until July or August and it appears that there is only a single generation a year in those climes. In Tadzhikistan (Lototsky and Pokrovsky 1946), adults of <u>H. excavatum</u> (= <u>H. anatolicum</u>) infest cattle from the end of February to November, and larvae and nymphs from July through September; all stages are most numerous early in August.

Larvae feed for from four to six days (32°C., 75% R.H.) according to Feldman-Muhsam, but the Russian observer reported only two to four days in nature. Larvae molted six days after leaving the host (30°C.), after four or five days at 38°C., and after thirty to fifty days at 17.5°C. (after six to twelve days in Russian observations). Nymphs fed a week later and remained on the host from nine to twelve days (four to six days in Russia) but the time between dropping and molting to the adult stage varied greatly (twelve to twenty days in Russia).

At 35°C., the molt to females occurred in from eleven to 24 days and to males in from twelve to 35 days. At 30°C. both sexes appeared between eleven and 56 days after nymphs dropped from their host. The duration of one generation at 32°C. was estimated at 116 days, but it was concluded that under field conditions some of these stages may be shorter and there may be three generations a year.

Parthenogenesis in <u>H. excavatum</u> has been observed by Pervomaisky (1949) who found that a few F_1 females could be reared from eggs laid by females in the absence of males.

<u>Ecology</u>

Feldman-Muhsam (1947) observed that unfed larvae and nymphs are much more sensitive to humidity than to temperature. At any temperature survival of unfed immature stages increases with higher humidity. In laboratory tests, larval longevity varied between two and 241 days (mean 1.25 and 162.6 days), nymphal longevity between ten and 246 days (mean 6.8 and 149.2 days). The author considered that under undisturbed natural conditions survival would have been longer than in these tests in which daily counts were made.

Nymphs are less susceptible than larvae to low humidity. The length of nymphal life increases directly with humidity and inversely with temperature. Other life history and hibernation studies by Feldman-Muhsam (1949) are of interest, but since they apply to frigid Palestinian winter conditions that do not occur in the area under consideration this work is not presently pertinent.

Serdyukova (1946A) observed ticks detaching from their hosts at night; larvae and nymphs mostly between nine and eleven o'clock in the evening. A number of larvae and nymphs placed on a calf in the morning became fully engorged during the day but remained on the calf when darkness set in. This behavior, probably an adaptation to local climatic conditions, protects the ticks from exposure to the direct rays of the sun, which are fatal to them. They are apparently inactive during the hot part of the day, and attach to hosts at night as has been recorded for other Hyalomma species under desert conditions. In an isolated plot only slightly over five percent of a counted number of unfed ticks attached to calves between noon and sunset.

H. excavatum is obviously a tick of xeric regions not necessarily associated with domestic animals although populations are considerably larger where these animals occur. Experience in the comparatively lightly-vegetated desert areas of the Mediterranean littoral of Egypt, where it infests rodents in their burrows, indicate this tick's habits away from large, dense flocks of domestic animals.

In Transcaucasia, H. excavatum (= H. anatolicum) is typical of various desert, semidesert, and steppe formations, but does not occur in forested zones (Pomerantzev, Matikashvily, and Lototsky 1940). This agrees with observations in Anatolia (Hoogstraal, ms.). With respect to altitudinal distribution in Transcaucasia, these authors say H. excavatum falls in group in which the "upper limit of distribution ..... is ..... inversely proportionate to the moisture of the climate and to the amount of rainfall and directly proportionate to the height of the snow line during the summer period".

In Armenia, H. excavatum (= H. savignyi armenorium) is found in pasture at 6500 feet elevation and higher (Lototsky and Popov 1934). During the present study it has been found at similar heights in Sinai, Yemen, Anatolia, and Eritrea.

Feeding Sites and Reactions

Adults feed on cattle chiefly on the scrotum and perineum and in the inguinal and axillary areas. Nymphs generally feed on the neck, chiefly along its crest. Larvae are not commonly found on Egyptian cattle.

Note: The following section is ancillary to further remarks on the "subgenus Hyalommina" (page

In Egypt (Hoogstraal, ms.), larvae and nymphs of H. excavatum are frequently found completely overgrown by rodent host skin. This phenomenon is especially common among young jirds, Meriones shawi shawi Duvernoy, and sometimes on young fat sandrats, Psammomys o. obesus, on the Mediterranean littoral. During springtime almost every nestling jird in the vicinity of Mersa Matruh is infested in this manner. The ticks can be detected by lumps under the skin, most frequently around the neck, axillary areas, shoulders, and flanks. Some of these rodents have as many as 22 immature ticks under the skin. The host skin may partially or completely enclose the ticks*, which are almost always misshapen when removed. Some nymphs extricated from under the skin of jirds have molted to adults in our laboratories. They have invariably been tiny, weak, misshapen, poorly developed, pale specimens, which, if identified according to criteria offered by Schulze (1919), would be H. rhipicephaloides Neumann, 1901, in the subgenus Hyalommina.

---

*Nuttall (1914B) has quite accurately described this processes as an oedematous swelling of the host skin, as a result of irritation when the long mouthparts of Ixodes (and Hyalomma) ticks reach firm subcutaneous connective tissue; the oedematous swelling may gradually engulf the feeding tick.

Schulze (1921) recognized this growth phenomenon for material of "H. rhipicephaloides" from a "steinbock" (probably meaning an ibex) near the Dead Sea in Palestine, although he continued to apply a species name to these runts. Yet, Schulze and Kratz have presumed to refer to this as a "half-endoparasitic type of parasitism" by ticks. Large number of ticks were found in pale reddish cysts in the ibex's subcutaneous tissue, especially in the axillae. Holes in the host skin could not be detected.

In several instances we have found cast larval skins encasing subdermal nymphs. Young jirds raised to adulthood in the laboratory yielded dead H. excavatum in the middle of the summer when the hosts were sacrificed, and nymphal skins were found around them. We have no evidence that a Hyalomma tick overgrown by the host's skin can force its way out through the skin.

Pavlovsky, Pervomaisky, and Chagin (1954), in preliminary studies, have also indicated that when H. excavatum (= H. anatolicum) feeds in large numbers on a restricted area of the host, poorly developed specimens result. Females especially do not fully engorge and may even die due to inflammation of the host skin. When other species also compete for a restricted area of the host skin, an additional antagonistic factor increases the chances of abnormal development or death.

Prolonged infestation on rabbits by H. excavatum under laboratory conditions does not confer host immunity, preventing engorgement by subsequent larvae, against this species or against Dermacentor pictus (Chabaud 1950A, Brumpt and Chabaud 1947).

REMARKS

A capillary tube arrangement, which has proved successful for the artificial feeding of adults of H. excavatum for physiological and disease-transmission studies, has been described by Chabaud (1950A).

Schulze (1932C) illustrated the leg segments (of "H. anatolicum") to support theories of tick ornamentation. In the same work, he illustrated a cross section of the scutum (of "*H. lusitanicum*") and compared it with that of *A. cohaerens*.

Gynandromorphs and malformed specimens of this species have been described and illustrated (as *H. savignyi*: Pavlovsky 1940) by Pervomaisky (1950). A gynandromorph of *H. excavatum* (= *H. savignyi*) has been described by Feldman-Muhsam (1950) but Campana-Rouget (1950) considers this to be an "intersexue" (see also Chabaud and Choquet 1953). An abnormal male (as *H. kumari*) has been illustrated by Sharif (1940).

The rate of growth and comparative differences among those morphological parts that are either similar or different between the two sexes of this tick have been studied by Chabaud and Choquet (1953). Cuticle growth has been mentioned by Lees (1952, as *H. savignyi*).

Campaniform sense organs have been briefly described (Dasgupta 1955).

Specimens from Kenya, identified as *H. anatolicum*, were used by Yalvac (1939) to describe features of development of the adult stage in nymphs.

DISEASE RELATIONS

MAN: The virus of Uzbekistan hemorrhagic fever has been isolated from *H. excavatum* (= *H. anatolicum*) in Soviet Central Asia, where this tick appears to be at least an important natural reservoir if not a vector. Experimental work with *H. excavatum* (= *H. turkmeniense*) indicates, for the virus of Russian spring-summer encephalitis, transmission by bite and transovarial transmission, and the same for the virus of Japanese (mosquito-borne) endephalitis except that transmission by biting was not obtained. These viruses, as well as that of Russian (mosquito-borne) encephalitis, persist for many months in infected ticks.

H. excavatum is commonly found infected with the rickettsiae of Q fever (*Coxiella burnetii*) in North Africa, southern Europe, and Uzbekistan. Its importance as a vector of this disease to man requires investigation.

If, as appears likely, it is true that the "H. savignyi" of Soviet workers with ticks and brucellosis applies actually to H. excavatum, it should be noted that hereditary transmission and subsequent infection of the host by the bite of this tick is claimed.

The spirochetes of certain Russian relapsing fevers do not survive in this species (as H. anatolicum excavatum) for even a day.

CATTLE: An important vector of theileriasis (Theileria annulata).

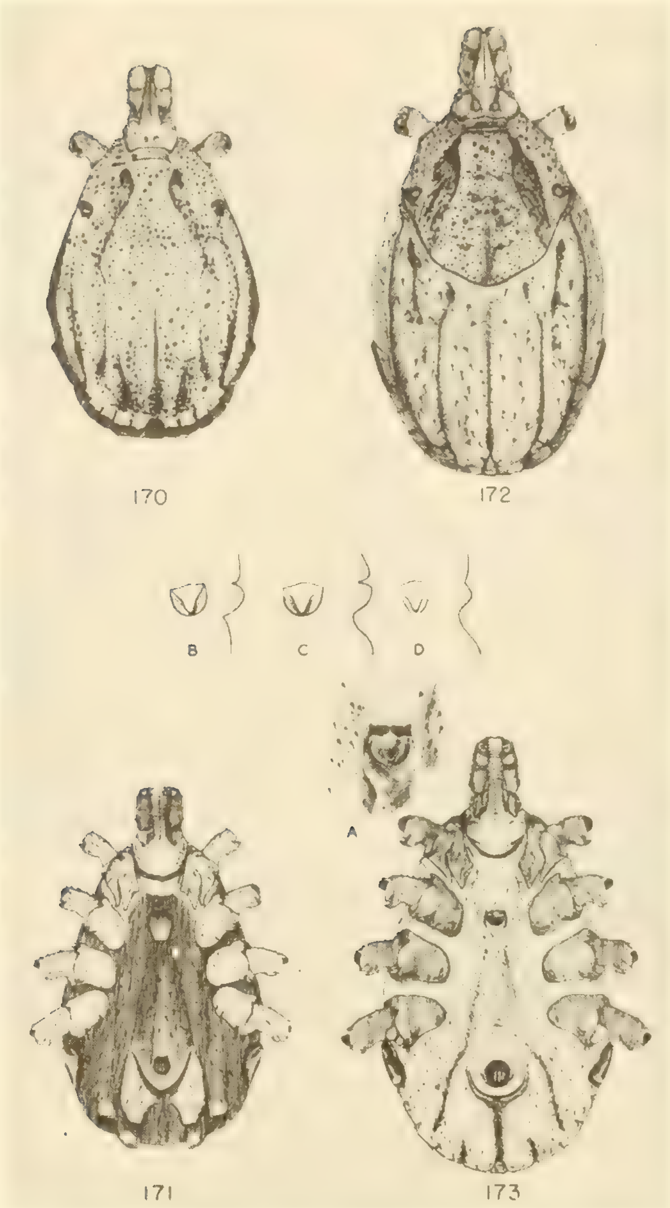
BIRDS: Benign piroplasmosis of nestlings.

IDENTIFICATION

Males: Typical males are very distinctive but in almost any field collection a large number of atypical specimens may be found. Characteristically, the center of the subanal shields is posterior of the central axis of the adanal shields. This holds true for all flat, unengorged and slightly engorged individuals. Males that have not flattened after molting and before being preserved, and engorged males, especially those that have fed on large animals such as camels, almost always have the subanal shields borne on an udder-like swelling and laterally displaced as in H. dromedarii. (The subanal shields are always small and elongate, frequently minute or even hardly distinguishable). Such specimens can be distinguished by smaller size and by the characteristic strong depression of the posterior part of the scutum between two smooth lateral ridges; this depression is almost always densely punctate. (Some atypical H. dromedarii tend towards a resemblance of this last character). The lateral grooves are very short, restricted to the posterior third of the scutum. A line of punctations frequently continues anteriorly from the lateral grooves; these may be groove-like enough to confuse keying the specimen. The scutum, away from the depressed caudal area, has rare, widely scattered, medium-size punctations, or none, but atypical very small and superficial punctations may rarely confuse this pattern. A pale parma is frequently present; the festoons are greatly variable in distinctness. The scutum is usually strongly convex, and all specimens are definitely small in size for Hyalomma ticks (scutal length no more than 4.18 mm., rarely over 3.75 mm.; width no more than 2.19 mm., rarely more than 2.19 mm.). Certain populations that key to H. excavatum but measure above the upper level of this range represent distinct species of uncertain identity (see pages 880 to 886).

Females: The knob-like genital apron is more or less (but always definitely) bulging in profile; it may be circular, elongately triangular, or widely triangular (but if so always distinctly much smaller than in H. marginatum or similar species) in outline; the circular outline is most characteristic and distinctive; the elongately triangular outline is fairly common and usually fairly distinctive; the widely triangular outline is not common but is apt to be confusing. The scutum is extremely variable in color and in length-width ratio, but it has very few large punctations scattered in the central field, a few more in the scapular areas, and sometimes some to many very fine, superficial punctations over much of its surface. The scutal surface of engorged specimens frequently becomes extremely rugose. Typical engorged females are comparatively small and narrowly elongate but quite thick dorsoventrally thus presenting a narrowly rectangular appearance.

The larva and nymph (as H. savignyi) have been described and compared with those of other species by Bernadskaia (1939C) and by Feldman-Muhsam (1948).



Figures 170 and 171, ♂, dorsal and ventral views
Figures 172 and 173, ♀, dorsal and ventral views

A, ♀ genital area. B to D, ♀ genital area, outline and profile.
A and B, unengorged. C, partly engorged. D, fully engorged.

HYALOMMA IMPELTATUM
Egyptian Specimens

PLATE L

HYALOMMA IMPELTATUM Schulze and Schlottke, 1930

(= H. BRUMPTI Delpy, 1946A).

(Figures 170 to 173)

KRATZ'S HYALOMMA

NOTE: The name *impeltatum*, proposed by Schulze and Schlottke (1930) in a brief key to *Hyalomma* ticks, was said to apply to a subspecies of *H. savignyi*. Subsequent workers were unable to recognize this tick on the basis of the brief data provided. The original material was redescribed and illustrated by Kratz (1940). Kratz also indicated that Tonelli-Rondelli's (1932C) *H. erythraeum* from Eritrea is probably a synonym. Delpy overlooked both *H. erythraeum* and Kratz's description of *impeltatum* and (1946A) described *H. brumpti* as a new species from Cameroons. It now appears that *H. brumpti* is a synonym of *H. impeltatum*. The status of *H. erythraeum* is still moot.

DISTRIBUTION IN THE SUDAN

In the Sudan, *H. impeltatum* is restricted to the drier central Provinces. It may occur locally in Northern Province, but no records are available.

Kassala: Kassala and Sinkat (cattle; SVS). Port Sudan (donkeys and cattle; SVS).

Kordofan: El Obeid and Umm Inderaba (cattle; SVS). "Northern Kordofan" (camels; SVS). See also Khartoum below.

Darfur: Sibdo (horses; SVS). Muhagariya (camels, cattle, horses, and donkeys; SVS). See also Khartoum below.

[Khartoum: A large number of specimens taken from cattle from Kordofan and Darfur Provinces at the Khartoum Quarantine Station, where they were enroute to Egypt (HH).]

Males of H. impeltatum are frequently found in rather small numbers on Sudanese cattle at the Cairo abattoir. This species is present near the Sudan frontier in the southeastern corner of Egypt (HH).

DISTRIBUTION

H. impeltatum is thus far known to range from Iran and Arabia to Egypt and Libya; into the Sudan, Eritrea, French Somaliland, and restricted areas of Kenya and Tanganyika; and westwards in localized areas of central, western, and northwestern Africa. Within this area, H. impeltatum appears to be present usually in widely scattered foci. However, it is anticipated that, as the identity of this species becomes better known, certain gaps in our knowledge of its distribution will be closed. The absence of reports of this tick by Palestinian workers causes one to wonder under which name it is being identified there.

Recent finding of small numbers of H. impeltatum on wild and domestic animals in single localities of Kenya and Tanganyika, a unique distributional pattern for a Near Eastern Hyalomma, suggests that this species is slowly extending its range into East Africa.

NEAR EAST: IRAN (As H. brumpti: Delpy 1949C). TURKEY (Specimens from Istanbul abattoir, on sheep said to be from Bedlise: Hoogstraal, ms.). IRAQ (Specimens from a number of localities in HH collections; others from Amara in BMNH; H.H. det.). PALESTINE (Material from Gaza in BMNH; H.H. det.). YEMEN (Fairly common: Hoogstraal, ms.).

NORTH AFRICA: EGYPT (As H. brumpti: Hoogstraal 1954A. One of the most numerous of local ticks; frequently taken on cattle from the Sudan at the Cairo abattoir: Hoogstraal, ms.). LIBYA (Numerous specimens from many localities in HH collection. There is a suspicion that the H. marginatum balcanicum of Tonelli-Rondelli 1930A from Tripoli and Bengasi may refer to H. impeltatum). MOROCCO (Material from Mogador in BMNH; HH det.).

WEST AFRICA: "WEST AFRICA" (As H. savignyi impeltatum: Schulze and Schlottke 1930). RIO DE ORO (SPANISH SAHARA): (As H. impeltatum: Kratz 1940). FRENCH WEST AFRICA (As H. brumpti: Rousselot 1948,1951,1953B, and Villiers 1955. Material from Mauritania in BMNH collections; H.H. det.). NIGERIA (As H. brumpti: Unsworth 1952. Material from Kano in BMNH collections; H.H. det.). IVORY COAST (As H. brumpti: Rousselot 1948. Record not repeated by Rousselot 1953B but specimens checked by Theiler).

CENTRAL AFRICA: CAMEROONS (All as H. brumpti: Delpy 1946A, 1949A,B. Rageau 1951,1953).

EAST AFRICA: SUDAN (As H. brumpti: Hoogstraal 1954B. As H. impeltatum: Feldman-Muhsam 1954).

ERITREA (Specimens from near Karkobat in HH collection. ?As H. erythraeum: Tonelli-Rondelli 1932C; Niro 1935; and Stella 1939A,1940; see NOTE above). ITALIAN SOMALILAND (?As H. erythraeum: Tonelli-Rondelli 1935 and Stella 1940; see NOTE above). FRENCH SOMALILAND (Material in HH collection).

NOTE: H. marginatum balcanicum of Tonelli-Rondelli (1930A) from Eritrea, Somalia, and Ethiopia may refer to H. impeltatum; this name was also used by Stella (1938A,1939A,1940) for material from Italian Somaliland.

KENYA (Material in BMNH from sheep at Laisamis, Northern Frontier District; H.H. det.; collected by E. A. Lewis who had determined it as H. impressum albiparmatum. Numerous specimens in BMNH collections from cattle at Magadi and Shombole).

TANGANYIKA (Miss J. B. Walker has sent a large series of typical specimens for identification; material from a rhinoceros and wildebeest at Mto-wa-Mbu, a few miles north of Lake Manyara in northeastern Tanganyika, April 1952, A. C. Brooks legit).

HOSTS

All domestic animals are attacked by adults of this tick. Available data does not indicate that among these animals *H. impeltatum* shows any marked host predilection. In Egypt a number of specimens have been taken feeding on personnel during field trips.

Wild animals known to be infested are gazelles in Egypt (HH), wild pig in Eritrea (HH), rhinoceros and wildebeest in Tanganyika (Walker records above), and caracal in French West Africa (Villiers 1955).

Hosts of immature stages are rodents, hares, birds, and man. At Amara, on the Tigris River in Iraq, Lt. R. A. Buxton reared adults from nymphs taken from hares and from a redstart, *P. phoenicurus* (= *Ruticilla pluvenicurus*) (Nuttall lots 3239 and 3240 in BMNH).

In Egypt we have reared many adults from nymphs that have dropped from both the lesser and the greater Egyptian gerbils, *Gerbillus g. gerbillus* and *G. p. pyramidum*, and fewer from the following animals: lesser Egyptian jerboa, *Jaculus j. jaculus*; fat sandrat, *Psammomys o. obesus*; Egyptian hare, *Lepus capensis aegypticus*; and man.

Although Rousselot (1948) reared this species, he furnished no data on the hosts of the immature stages either in the laboratory or in the field.

BIOLOGY

Life Cycle

Rousselot (1948) claimed that *H. impeltatum* (= *H. brumpti*) is a three-host species that in his French West Africa laboratory completed its life cycle in about three months. Results of studies in NAMRU-3 (Cairo) laboratories will be presented when completed.

Ecology

Although *H. impeltatum* is a tick of arid and semiarid regions, small populations also exist in certain African savannah areas. Biological and ecological characteristics and limitations of this species are still poorly known. As noted above, immature stages are found in common association with desert and desert-edge rodents in Egypt.

In Nigeria, where *H. impeltatum* is almost entirely confined to the more arid northern provinces, it is sometimes the most common tick collected on cattle and appears to require a drier climate than do *H. truncatum* (= *H. transiens*), *H. impressum*, and *H. rufipes* (Unsworth 1952). Adults are found around the anus and udders and in the axillary regions of their hosts.

DISEASE RELATIONS

Apparently this tick is not a vector of *Theileria annulata* of cattle. Note, from Egyptian records, that nymphs and adults are known to feed on man in nature.

REMARKS

The comparative size of each stage and sex has been noted by Campana-Rouget (1954).

The remarks below are based in part on specimens originally identified (as *H. brumpti*) by Dr. L. P. Delpy, on his remarks (correspondence) on this material, and on our further observations of additional collections consisting of some 2000 specimens.

IDENTIFICATION

Males. In TYPICAL specimens, (1) the exterior position of the comparatively large subanal shields, (2) the lateral grooves that extend anteriorly at least to the scutal midlength, and (3) the numerous, moderate size (few large), shallow, scutal punctations that are uniformly and widely distributed over most of the scutal surface, is a combination of characters easily separating males from those of all other species.

Variation in each of these characters are as follows: (1) In specimens that have fed, the subanal shields are always situated well exterior of the axis of the adanal shields; they are usually borne on a slightly rounded, elevated protrusion of the ventral integument, and usually extend posterior beyond the body margin. However, in unfed specimens, where the subanal shields are still closely appressed to the ventral integument, these shields may appear to be in line with the central axis of the adanal shields. Close observation reveals that the base of the subanal shields is in an exterior position but that the unique tilting of the subanal shields in a medially-directed position gives the first impression that they are situated directly posterior of the adanal shields. In fed males, the subanal shields are usually vertical and parallel. (2) The lateral grooves are usually well delineated and extend from the festoons in a progressively more shallow line almost to the eyes. In some specimens, they are more or less obscured, at the level of the scutal midlength and anteriorly, by scutal punctations; questionable specimens should be tilted towards the source of the light. In other individuals, the anterior extension of the lateral grooves consists chiefly of a distinct row of more or less contiguous punctations; such specimens may be confused with H. dromedarii, and, if the subanal shields are still closely appressed to the ventral integument, possibly even with H. excavatum. (3) Punctations are usually very slightly larger, deeper, and more dense posteriorly than elsewhere on the scutum. Punctations over the scutum are typically dense but not contiguous, regular, medium-size with a few scattered larger, deeper ones among them, and fairly shallow. The number and placement of these punctations is subject to considerable variation; in some specimens the central scutal area may be almost devoid of obvious punctations; this is especially true in engorged individuals.

Other characters are as follows: The area just anterior of the festoons is almost always slightly depressed and contains a long, narrow posteromedian groove, and a pair of shorter, wider, and deeper paramedian grooves. A parma, the color of which may be lighter or darker than the rest of the scutum, may be present, or may appear as a normal median festoon. Two definite pairs of festoons and two more or less fused pairs lie on either side of the parma or median festoon. Delpy states that the scutum is flat, actually it is usually more or less arched, especially in males that have fed.

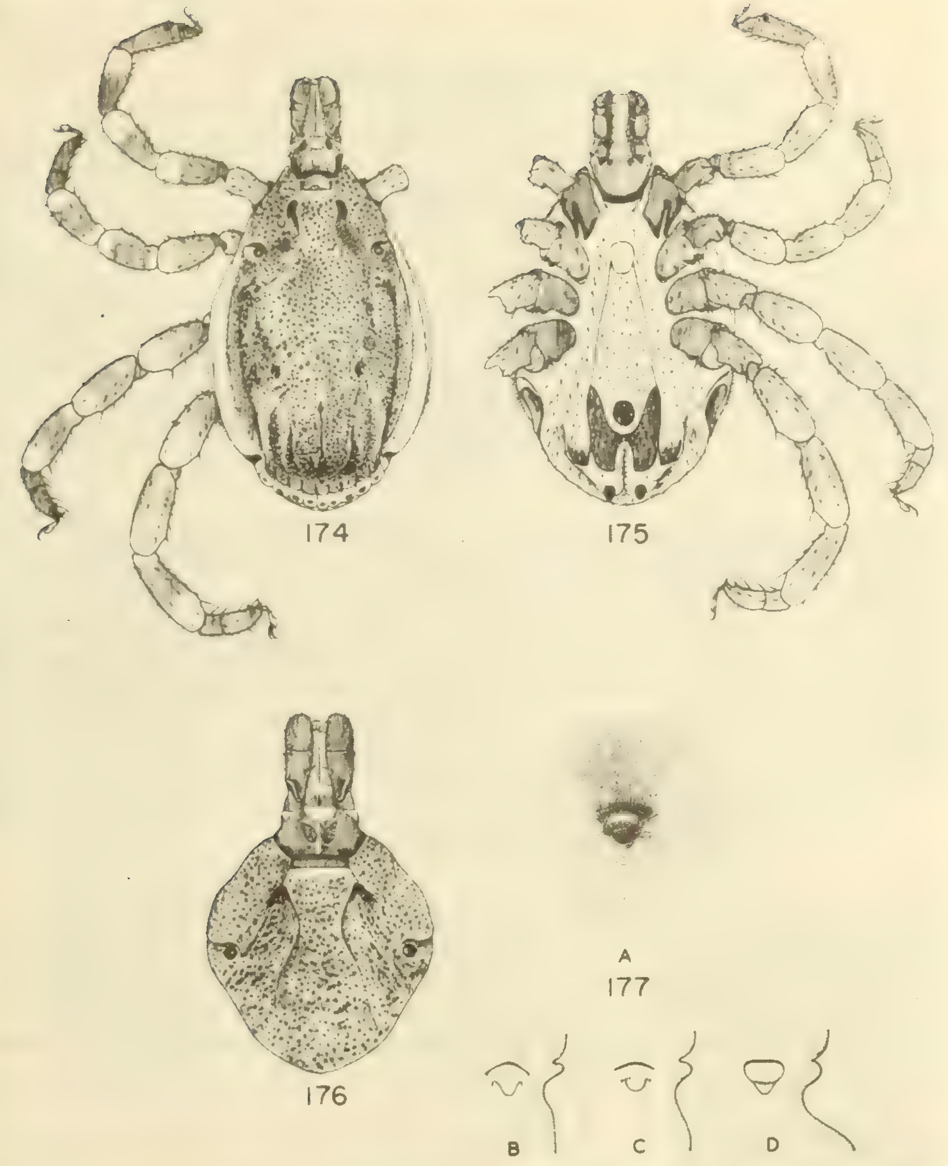
The scutal color varies from dark brown to black; exceptional specimens, usually very small ones, may be lighter. The leg segments are usually pale anteriorly and posteriorly and darker centrally, but they may be entirely pale yellowish.

Female: The scutum posteriorly and centrally has numerous rather regularly spaced, moderate size, noncontiguous punctations. Scattered among them are several larger and deeper punctations in two parallel rows centrally. The moderate size punctations are usually mostly discrete, but exceptions to this are common. Anteriorly and in the scapular areas, punctations are large and deep; in the lateral fields punctations are absent or present. The deeply depressed cervical grooves are more or less rugose, and the punctations in them are more or less contiguous. The scutum of engorged specimens frequently has less distinct punctations and grooves. The scutum is generally dark brown in color. It is definitely longer than wide, but the ratio may be reduced in some newly molted, misshapen, or greatly engorged specimens.

The genital area is distinctive. The central genital apron is an elongate triangle much like that of H. dromedarii but shorter, wider, and usually not quite so narrowly pointed apically. In profile, it definitely bulges anteriorly and is depressed posteriorly. An important principal additional feature is that, in unmated specimens and in mated but not greatly engorged specimens, this genital apron is bordered on each side by a slight bulge that gives the genital area a trilobed appearance not found in any of the other species with which H. impeltatum may be confused. This characteristic is maintained with only slightly less distinctness in greatly engorged females.

Female body size, in all except runts, is always large. The legs are like those of the male.

NOTE: Very small, rounded, globose, pale runts appear commonly with typical specimens. Their diagnostic characters are frequently modified. In field collections, such specimens are virtually impossible to identify. They should not be confused with other species or cast into the subgenus *Hyalommina*. Among collections of reared adults, gradations from typical males to atypical males closely approximating exceptionally small specimens of *H. dromedarii* are frequently seen. Such atypical specimens are obviously poorly nourished in the immature stages and show numerous indications of lack of proper development. If encountered singly, they would be most difficult or impossible to properly identify.



Figures 174 and 175, ♂, dorsal and ventral views
Figure 176, ♀, scutum and capitulum, dorsal view

Figure 177, ♀, genital area. A, partly engorged, B to D, outline and profile; B and C, partly engorged; D, fully engorged.

<u>HYALOMMA IMPRESSUM</u>
<u>Sudan Specimens</u>

PLATE LI

HYALOMMA IMPRESSUM Koch, 1844.

(Figures 174 to 177)

THE WEST AFRICAN HYALOMMA

NOTE: In literature on African ticks various subspecific designations of H. impressum apply actually to H. rufipes or to H. truncatum and are treated herein under those species. The "H. plumbeum impressum" of Soviet workers is H. rufipes. Koch's (1844) descriptions of H. impressum and of H. rufipes clearly distinguish these two species.

The H. impressum mentioned by Adler and Feldman-Muhsam (1946,1948) for Palestine resulted from mistaken identity of H. rufipes (Feldman-Muhsam 1954), as did Delpy's H. impressum (1946A,B) from Iran (Delpy 1949A,B). The H. impressum of Schulze (1918), from a single specimen collected from a horse in Macedonia, Greece, and presumed to have been carried there as a nymph on a migrating bird, is questionable; this record was repeated by Pandazis (1947).

DISTRIBUTION IN THE SUDAN

H. impressum is locally common on cattle in central Sudan west of the Nile. Numerous males and fewer greatly engorged females reach the Khartoum quarantine station on Darfur and Kordofan cattle and many males are still attached when these cattle reach the Cairo abattoir. The West African hyalomma is not known to be established east of the Nile.

Darfur: Zalingei and Sibdo (common on camels and cattle, also occurs on horses; SVS).

Kordofan: Delami (cattle; SVS). El Obeid (camels, SVS).

[Khartoum: See three paragraphs above.]

DISTRIBUTION

H. impressum is a West African tick that ranges eastward into the Sudan. It has not been found south of the equator, in the great northern deserts of Africa, or on the Mediterranean littoral.

WEST AFRICA: FRENCH WEST AFRICA (As *H. impressum* sp. nov.: Koch 1844. As *H. aegyptium impressum typica*: Schulze 1919, and Chodziesner 1924. As *H. impressum impressum*: Schulze and Schlottke 1930, and Kratz 1940. As *H. savignyi intermedia*: Girard and Rousselot 1945, and Rousselot 1946. As *H. impressum*: Rousselot 1953B). NIGERIA (As *H. impressum*: Unsworth 1952. Material in BMNH from Katagum; H. H. det.).

CENTRAL AFRICA: CAMEROONS (As *H. impressum*: Rageau 1951, 1953). FRENCH EQUATORIAL AFRICA (As *H. impressum*: Rousselot 1953B).

EAST AFRICA: SUDAN (As *H. impressum*: Hoogstraal 1954B. Feldman-Muhsam 1954).

[?UGANDA and ERITREA: As *H. impressum*: Wilson (1949B) and Tonelli-Rondelli (1930A). These may refer to *H. rufipes* or to *H. truncatum*.]

HOSTS

Domestic cattle are the chief hosts of *H. impressum*, and are mentioned by all authors. No other hosts have previously been reliably recorded. In Darfur, camels are frequently infested and horses are sometimes attacked.

BIOLOGY

Unstudied.

DISEASE RELATIONS

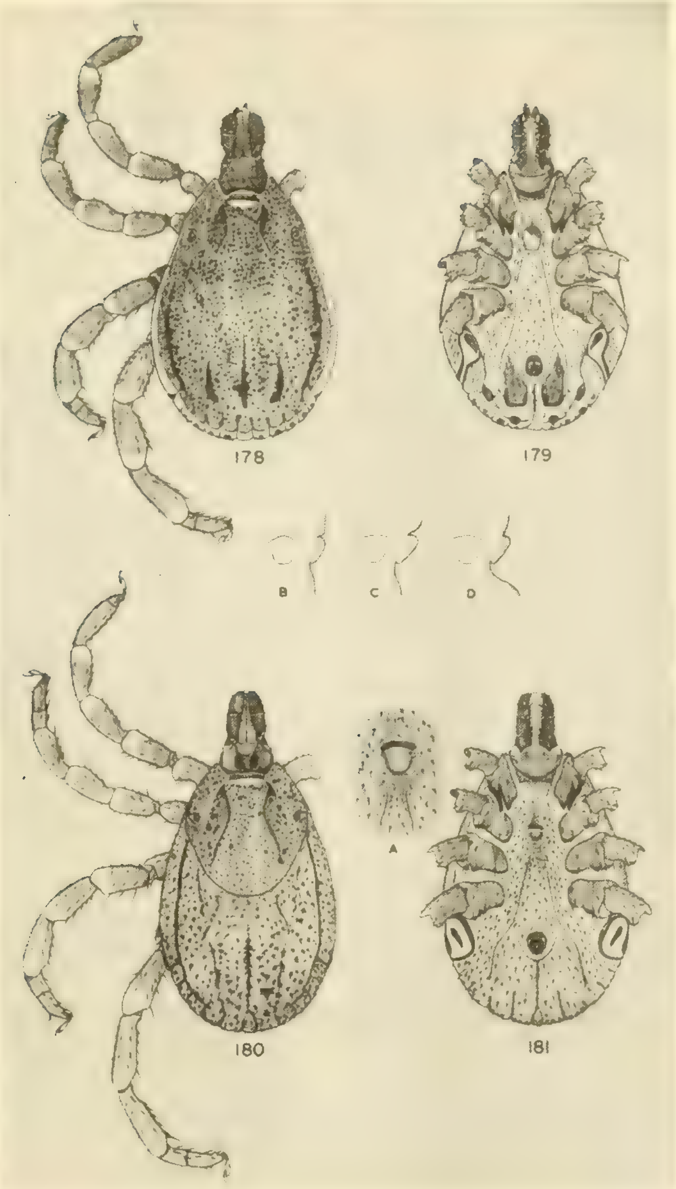
Unstudied.

IDENTIFICATION

Males: This handsome species is easily recognized and readily distinguished by the following combination of characters: (1) center of subanal shields posterior of central axis of adanal shields, (2) scutum regularly covered by deep, rather large punctations that often tend to obscure the long lateral grooves, and (3) distinctive narrowing of the scutal margin posterior of the lateral grooves, giving it a rectangular outline posteriorly.

A moderate amount of circumspiracular pilosity may in some specimens suggest H. *rufipes*. The festoons are more or less fused, but the central and two median pairs are always distinct. The scutum is dark reddish brown to black and the legs are brightly ringed. The comparatively narrow, elongate scutal shape is in contrast to the wide outline of *H. rufipes*; the rectangular posterior margin is distinctive of *H. impressum*.

Females: Numerous, regular scutal punctations, similar to those of the male, are distinctive; in some specimens they are more superficial but still numerous. The genital apron is broadly triangular in outline; it is composed of an anterior narrowly transverse (bulging) ridge and a posterior button (sloping or depressed) not so wide as the anterior ridge. [With respect to the outline and profile of the genital area of this species, no specimens observed during the present study conform to that illustrated by Delpy (1949B, page 106), which is more narrowly triangular (equilateral) and gradually sloping in profile.] A certain amount of circumspiracular pilosity is present in some females; differences in the genital aprons distinguish these specimens from females of *H. rufipes*, the scutal punctations of which may be quite similar to those of *H. impressum*.



Figures 178 and 179, ♂, dorsal and ventral views
Figures 180 and 181, ♀, dorsal and ventral views

A, ♀ genital area. B to D, ♀ genital area outline and profile.
B, unengorged. C, partly engorged. D, fully engorged.

<u>HYALOMMA MARGINATUM</u>
<u>Sudan Specimens</u>

PLATE LII

HYALOMMA MARGINATUM Koch, 1844.

(Figures 178 to 181)

THE MEDITERRANEAN HYALOMMA

NOTE: H. marginatum appears in European literature chiefly as either H. marginatum or as H. savignyi and in recent Soviet literature as H. plumbeum plumbeum. The Adler-Feldman-Muhsam (1948) school employed the name H. marginatum, the Delpy (1949) school H. savignyi (Gervais, 1844) following the lead of Schulze. The "H. savignyi" of Adler and Feldman-Muhsam (1948) and of some of their followers is H. excavatum. Recently Feldman-Muhsam (1954) concluded, from study of the Koch (1844) type material, that H. marginatum is the correct name for this species although reasons for so doing are somewhat obscure.

Pomerantzev (1950) states that the name H. plumbeum plumbeum (Panzer, 1795) refers to the present species. This point merits further investigation. Feldman-Muhsam apparently has not considered the possibility of this synonymy.

DISTRIBUTION IN THE SUDAN

H. marginatum thus far is known from only two localities in central Sudan, one in the west and one in the east. Further search will probably reveal additional populations between these two places.

Kordofan: Umm Inderaba (cattle; SVS).

Kassala: Kassala (camels; SVS).

DISTRIBUTION

H. marginatum appears to be most common in southeastern Europe and southern Russia from where it extends eastward into India and Indochina and westward throughout southern Europe, and into the

Near East including Arabia, and North Africa. Elsewhere in Africa, small populations are scattered through the drier transitional areas just south of the northern deserts from the Red Sea to the Atlantic Ocean.

Soviet workers in Transcaucasia consider this to be a "Mediterranean species" in contrast to the other hyalommas of their territory, which they classify as either "widely spread in the southern part of the Palearctic Region" or "peculiar to the zone of western deserts" (Pomerantzev, Matikashvily, and Lototsky 1940).

The mapped distribution of H. marginatum (= H. savignyi) as presented by the American Geographical Society (1954) does not correspond to the range of any recognized species in this genus.

NORTH AFRICA: "NORTH AFRICA" (As H. marginatum balcanicum: Schulze and Schlottke 1930).

EGYPT (As Cynorhaestes aegyptius: Virey 1822. As H. savignyi: Hoogstraal 1954A. Small populations exist on the Mediterranean littoral and in desert edge situations of Nile Valley and Delta; somewhat more common in Sinai: Hoogstraal, ms.).

LIBYA (Specimens from several localities in HH collection. As H. marginatum balcanicum: Stella 1938C).

TUNISIA (As H. tunesiacum: Schulze and Schlottke 1930. As H. savignyi: Colas-Belcour and Rageau 1951).

MOROCCO (As H. savignyi: Blanc, Martin, and Maurice 1946, 1947A,B. Blanc, Bruneau, Martin, and Maurice 1948. Blanc and Bruneau 1949. Blanc, Martin, and Bruneau 1949. Blanc 1951).

ALGERIA [According to Delpy (correspondence), the H. aegyptium of Senevet and subsequent French workers in Algeria, is H. marginatum (= Delpy's H. savignyi). The "H. aegyptium" life cycle studies reported by Nuttall (1913) on material from Algeria refer to H. marginatum (HH determination of Nuttall lot 1305 in British Museum Natural History). Most of the references listed for Algeria on page 405 also contain notes on H. marginatum (as H. aegyptium); this species is apparently less common there than H. detritum._7

WEST AFRICA: NIGERIA (As H. marginatum annulipes: Schulze and Schlottke 1930).

/‾Delpy (1949B) synonymized H. impressum brunneiparmatum Schulze and Schlottke, 1930 (from Togo) under H. marginatum (= H. savignyi), but this is actually a synonym of H. albiparmatum (see page). The "H. savignyi" of Tendeiro (1948, 1949A,1951F,1952A,C,D) from Portugese Guinea is shown by the same author's discussion (1949A) to be H. truncatum._7

EAST AFRICA: SUDAN (As H. savignyi: Hoogstraal 1954B).

/‾H. marginatum balcanicum, a synonym of H. marginatum, has been reported from Ethiopia and Somalia by Italian workers; these records may be correct but it is more likely that they refer to H. impeltatum._7

KENYA (A single ♂ in BMNH from a cow, Kisima, Nanyuki, May, 1932, collected after dipping by E. A. Lewis. This specimen is entirely typical of H. marginatum; H.H. det.).

/‾SOUTHERN AFRICA: Santos Dias (1950C) noted that "H. savignyi" had been reported from Angola by A. Morais in 1909, and that this probably refers to H. truncatum (= H. impressum transiens)._7

NEAR EAST: PALESTINE (As H. marginatum: Bodenheimer 1937. Adler and Feldman-Muhsam 1946,1948). SYRIA and LEBANON (As H. savignyi: Pigoury 1937). TRANSJORDAN (Hoogstraal, ms.). TURKEY (As H. marginatum balcanicum: Schulze and Schlottke 1930. As H. anatolicum: Galuzo 1944. As H. savignyi: Kurtpinar 1954 and Mimioglu 1954. As H. marginatum: Hoogstraal, ms.). CYPRUS /‾As H. cypriacum: Schulze and Schlottke 1930. Kratz 1940. The "H. savignyi exsul" of Schulze and Schlottke, 1930, attributed by Delpy (1949B) to H. savignyi marginatum (= H. savignyi of Delpy) appears rather to be H. excavatum; cf. Kratz (1940, pp. 534-535)_7. IRAN (As H. savignyi: Delpy 1946B, 1949C). IRAQ (As H. marginatum: Hoogstraal, ms. Hubbard 1955).

ARABIA: YEMEN (As H. marginatum: Hoogstraal, ms.).

EUROPE: SPAIN (As H. hispanum: Koch 1844. As H. savignyi iberum: Schulze and Schlottke 1930. As H. iberum: Kratz 1940. H. marginatum hispanum: Schulze and Schlottke 1930. Kratz 1940. As H. marginatum espanoli: Gil Collado 1936,1948A. As H. marginatum: Gil Collado 1948A. Perez Gallardo, Clavero, and Hernandez 1949,1952. As H. savignyi: Gil Collado 1948A. De Prada 1949. Parker, De Prada, Bell, and Lackman 1949. De Prada, Gil Collado, and Mingo Alsina 1951).

[PORTUGAL: It appears likely that the "H. rufipes glabrata" of Fonesca, Pinto, Colaco, Oliveira, Branco, da Gama, Soares Franco, and Lacerda (1951) may refer to H. marginatum; cf. page .]

FRANCE (As H. marginatum: Enigk 1947. As H. savignyi: Lamontellerie 1954. Specimens from Estrel Mts. in BMNH collection; H.H. det.).

ITALY (As H. marginatum: Koch 1844. Tonelli-Rondelli 1938. Enigk 1947. Cavaceppi 1950. As H. marginatum marginatum: Schulze and Schlottke 1930).

ALBANIA (As H. marginatum: Enigk 1947).

YUGOSLAVIA (As H. marginatum: Enigk 1947. As H. savignyi: Angelovsky 1954. Petrovitch 1955).

ROMANIA (As H. savignyi: Metianu 1951).

GREECE (As H. aegyptium f. brunnipes: Schulze 1919. Kratz 1940. As H. marginatum balcanicum: Schulze and Schlottke 1930. As H. marginatum: Enigk 1947. Pandazis 1947).

BULGARIA (It is possible that the "H. aegyptium" of Pavlov 1940,1942, etc., refers to H. marginatum. As H. marginatum: Enigk 1947. Pavlov and Georgiev 1950).

GERMANY (As H. marginatum marginatum: Arrives as nymphs on migrating birds according to Kratz 1940).

"INSUL BRIONI" (As H. marginatum brionicum: Schulze and Schlottke 1930. Totze 1933. Gossel 1935).

RUSSIA: NOTE: According to Delpy (1949B), Soviet authors have frequently confused H. excavatum (= H. anatolicum) under H. marginatum (= H. savignyi). Most Russian reports of "H. savignyi" appear to apply to H. excavatum (H.H.).

Most Soviet records for H. anatolicum subspp. since 1948 can be considered as applying to H. excavatum and most records for H. marginatum (and in 1950 for H. p. plumbeum) as referring to what is herein called H. marginatum. After an intensive study of all available Soviet literature on ticks and tick-borne diseases, it is concluded that Delpy's remarks in this respect apply chiefly if not entirely to reports by Galuzo (1941 and 1944) and by Galuzo, Bolditzina, and Kaitmazova (1944) on ticks of Kazakstan and control of piroplasmosis vectors in that area. Correspondence with Dr. Delpy concerning this matter has not elicited a reply. On biological grounds, it appears that Galuzo's "H. savignyi - H. anatolicum" applies to H. excavatum (= H. anatolicum of Soviet workers). It is possible that the use of the name H. savignyi by Zotova and Bolditzina (1943), who reported on work with H. marginatum and H. savignyi in relation to attempts to infect ticks with brucellosis in the laboratory, also applies to H. excavatum.

As H. marginatum: Olenev 1934. Pomerantzev 1934,1946. Pavlovsky and Pomerantzev 1934. Lototsky and Popov 1934. Galuzo 1935,1941. Galuzo and Bespalov 1935. Arginsky 1937. Bernadskaia 1939C. Kurchatov 1939A,B,1940A,B,C,D,E,F,G,1941A,B,C. Pomerantzev, Matikashvily, and Lototsky 1940. Kurchatov and Sokolov 1940. Grobov 1946. Blagoveshchensky and Serdyukova 1946. Enigk 1947. Chumakov 1948A,B. Markov, Gildenblat, Kurchatov, and Petunin 1948. Piontkovskaia 1949. Gajdusek 1953,1956. Pritulin 1954.

As H. marginatum marginatum: Serdyukova 1941. Grobov 1946. Piontkovskaia 1947,1949. Pavlovsky 1948. Korshunova and Petrova-Piontkovskaia 1949A. Pervomaisky 1949,1950. Gajdusek 1953. Tselishcheva 1953.

As both H. marginatum and H. savignyi: Zolotarev 1934. Galuzo 1935,1941,1944. Zotova and Bolditzina 1943. Galuzo, Bolditzina and Kaitmazova 1944. See two paragraphs above.

As H. marginatum balcanicum and H. marginatum olenevi: Schulze and Schlottke 1930. Olenev 1929A,1931A,C. Kratz 1940. As H. marginatum bacuense (apparently of Schulze, ms.): Olenev 1931A,C. As H. marginatum caspium (apparently of Schulze, ms.): Noted by Olenev 1931A,C, but described by Kratz 1940.

As H. plumbeum plumbeum: Pomerantzev 1950. Piontkovskaia 1951. Melnikova 1953. As H. plumbeum: Shatas 1952. Shatas and Bustrova 1954. Pavlovsky, Pervomaisky, and Chagin 1954. Arakian and Lebedev 1955. Pillipenko and Derevianchenko 1955. Petrishehevo 1955. Abramov 1955. Zhmaeva, Pchelkina, Mishchenko, and Karulin 1955.

MIDDLE EAST: INDIA (As H. aegyptium f. typica: Sharif 1928). INDOCHINA (As H. dromedarii indosinensis: Toumanoff 1944).

FAR EAST: [?CHINA: The "H. impressum rufipes" of Chodziesner (1924) is probably H. marginatum according to Kratz (1940, p. 554).]

HOSTS

The common hosts of adult H. marginatum are any domestic animals, especially cattle and horses; also goats, sheep, and camels often serve. In the Crimea, horses have been stressed as hosts by Kurchatov and Sokolov (1940). A typical female taken from a dog at Amman, Transjordan, by Dr. B. Babudieri, has been seen (Hoogstraal, ms.).

Nymphs may also attack domestic animals but are much more frequent on small wild mammals and birds, while larvae feed only on these small animals. Host preferences, especially of immature stages undoubtedly vary somewhat from locality to locality, but the impression of considerable variation between areas appears to be due to incomplete observations by various workers.

In Transcaucasia, birds are said to be the chief hosts of immature stages (Pomerantzev, Matikashvily, and Lototsky 1940). In the laboratory, chickens have been used (Zhmaeva, Pchelkina, Mishchenko, and Karulin 1955).

In Anatolia, adults have been reared from nymphs from hares, hedgehogs, and partridges (Hoogstraal, ms.). Nuttall lot 3278 in BMNH consists of adults reared from nymphs from a hare on the River Tigris, 32°N., November 1917, by Captain P. A. Buxton; H.H. det. A single nymph has been reported from a hare in Iraq (Hubbard 1955).

Hosts in Tunisia are cattle, sheep, porcupines, and hares. Adults are also found in gerbil nests (most probably newly molted, before venturing forth to find a larger host: HH). Nymphs have been taken from "Cochevis" (Galerida cristata) (Colas-Belcour and Rageau 1951). In southern Morocco, larvae and nymphs were reported from the nests of jirds, Meriones shawi (Blanc, Martin, and Maurice 1946,1947A,B), while others, presumably adults (same authors 1947B), were found on domestic animals and, at certain times of the year, on the grounds of native markets.

In Egypt, including Sinai, nymphs, which have been reared to typical adults, have been found on two kinds of hedgehogs, Hemiechinus aegyptius auritus and Paraechinus aethiopicus dorsalis, on fat sandrats, Psammomys o. obesus, and on jirds, Meriones shawi and M. crassus. Equally important here are lizards, Acanthodactylus boskianus, while lesser gerbils, Gerbillus g. gerbillus are less frequently found infested by nymphs (Hoogstraal, ms.).

In the Arax valley of Armenia, hosts of immature stages are stated to include reptiles and wild birds (Pomerantzev 1934).

Recent Soviet workers on hemorrhagic fever in Crimea report that adults attack cattle, sheep, horses, and men. Larvae and nymphs infest the European hare, Lepus europaeus transsylvanicus, in Crimea but are not found on hedgehogs, bats, rodents, dogs, or wild carnivores. Some immature specimens were taken from gray partridges, Perdix perdix, prairie larks, Melanocoripha calandria, cranes, Grus grus, and sparrows and domestic chickens (cf. Gajdusek 1953,1956).

An exceptionally interesting study of H. marginatum (= H. p. plumbeum) in the Crimean National Forest Reserve has recently been reported by Melnikova (1953), whose chart is reproduced below.

Host	No. Hosts Examined	No. Hosts with Ticks	No. Larvae	No. Nymphs	No. ♂♂	No. ♀♀	Max. No. Ticks on One Host	Mean Per Host
Red Deer	42	22	0	0	52	204	90	6.1
Roe Deer	36	1	0	0	2	0	0	0.0
Hare	32	10	31	714	0	33	309	24.0
Squirrel	38	1	0	0	1	0	1	0.0
Jay	26	20	402	225	0	0	236	24.0
Cattle	147	64	0	0	568	497	71	6.2
Pig	28	8	0	0	137	69	50	7.3
Chicken	15	15	300	25	0	0	70	21.6

As is easily seen, jays, chickens, and hares are the chief hosts of immature stages in the Crimean forest. Cattle, pigs, and red deer are important adult hosts, and hares may be of some importance. The absence of ticks on the roe deer is noteworthy.

Melnikova (loc. cit.) noted that unfed larvae enter the auditory canals of jays and chickens and molt there to nymphs and to adults; he found 118 immature ticks in the ears of a single bird. In Eastern Anatolia (Hoogstraal, ms.) partridges with larvae and nymphs of this tick similarly tightly packed in their ears have been observed. The comparative ease with which these birds were shot or even caught by hand suggested that the heavy tick infestation impaired the birds' keenness. Infested birds seemed muddled and confused and ran in staggering circles rather than flying or dashing off as did most of the flock.

BIOLOGY

Life Cycle

Life cycle studies of "H. aegyptium" reported by Nuttall (1913B) were undertaken with H. marginatum. Specimens resulting from this work are at present in the Nuttall collection at the British Museum (Natural History). Nuttall found that H. marginatum may act as a two-host or as a three-host tick; he believed that the "peculiar" two-host life cycle, when nymphs were fed on hedgehogs, was due to larvae remaining entangled among the spines. This is, however, probably the typical life cycle in nature.

Nuttall summarized his findings as follows:

PERIOD	DAYS	
Preoviposition	6	
Oviposition to hatching	35	(eggs at 18°C.)
Larval prefeeding period	7	
Larva feeds	6	
Premolting period	16	(larvae at 19°C.)
Nymphal prefeeding period	7	
Nymph feeds	6	
Premolting period	20	(nymphs at 18°C.)
Adult prefeeding period	7	
Adult (female) on host	6	
Total	116	

This period Nuttall believed to be the shortest time required for completion of the life cycle. From 4300 to 15500 eggs were laid by single females; the higher number probably approximates the more common figure in nature. Females may remain alive as long as 26 days after oviposition; males live much longer. The longevity of the various stages, presumably unfed, in these experiments was 345 days for larvae, 89 days for nymphs, and over 421 days for some adults. Hosts were hedgehogs, guinea pigs, and rams.

Subsequently, Nuttall (1915) noted that some adults were still alive 759 days after emerging. Females that had fasted for 817 days were fed on a ram, mated with males that had fasted over 210 days, and were ovipositing when the report was written. Three times as many females (253) as males (83) were counted in the progeny of a single female.

Four years later, Nuttall (1919) observed that males may remain attached to one spot of the host for as long as 122 days. More commonly, however, after preliminary feeding for periods ranging from five to 29 days, they start wandering about in search of females. After mating, when females leave the host, males do little if any wandering. If a female is placed near a male, considerable excitation is caused. A male may copulate with several females, but females apparently accept only a single male. Copulation may be very swift or may apparently extend over several days. Females do not move from their feeding site until they drop from the host.

Ecology

See also section on HOSTS above.

In Algeria, adults are rarely seen in winter but begin to appear in March and continue till October, maximum densities being reached in April, May, and June (Algerian seasons are comparable to those of southern United States). Nymphs are found mostly during the summer. With slight variation, this seasonal picture is typical for *H. marginatum* wherever it occurs.

In the Crimean forest (Melnikova 1953) adults are found during the summer, March to September, but rare individuals (?mostly males) may be seen at any time of the year. Larvae and nymphs infest hares from the end of June to the first half of September. Nymphs are most common on hares in the latter part of August; for example, a hare on 2 August yielded 100 nymphs while another on 17 August yielded 390 nymphs. In this forest reserve, *H. marginatum* (= *H. p. plumbeum*) occurs in all ecological zones and in all types of forest. In pure stands of conifers, it is, however, comparatively rare. The most favorable habitats appear to be valleys with small open fields between the mountains.

In Transcaucasia, this species occurs equally in both highland and forest zones and in desert and steppe formations and is found in every type of landscape in that area (Pomerantzev, Matikashvily, and Lototsky 1940). In Armenia, it occurs in the *Artemesia* semidesert of the Arax valley (Pomerantzev 1934) and at altitudes of 6500 feet and over (Lototsky and Popov 1934).

On the Crimean steppes, adults are most common in July (May and June according to Kurchatov 1940A). There, the greatest density of this tick is around haystacks and in fallow fields where their immature stage host, the European hare, hides and feeds. Engorged nymphs drop from hares in autumn and overwinter in that stage. They molt in the spring, and adults attack cattle, sheep, horses, and man. The devastation of the Crimea during the war, followed by a great increase in hares and their ticks, was significant epidemiologically in the outbreak of highly virulent, often fatal hemorrhagic fever at that time.

REMARKS

Gynandromorphs of H. marginatum have been described and illustrated by Pervomaisky (1950). The same author (1949) was unable to secure a complete F_1 generation from parthenogenetic females of this species.

Schulze (1932C) illustrated certain of the cuticular sense organs of two of his "subspecies" of this species, also "gynotropes", males with more dense punctations on the scutum conforming to those of the female scutum in location and distribution. This species has been utilized in a study of sensory physiology (Totze 1933).

When large numbers of ticks (as H. plumbeum) feed on a restricted area of the host, the females and sometimes also males fail to engorge completely and may die; their development is far from normal. When different species are competing for the same feeding area, this additional competitive factor often hinders their normal development (Pavlovsky, Pervomaisky, and Chagin 1954).

DISEASE RELATIONS

MAN: H. marginatum is considered to be the chief vector of the virus of Crimean hemorrhagic fever. The extensive geographic range of this tick and its large population in many areas where it occurs - factors that suggest a high potential as a medically important species - appear to be generally unappreciated outside of Crimea. This species is not involved in the transmission of Omsk hemorrhagic fever, since it does not occur in that area, so far as is presently known.

Specimens naturally infected with Q fever (*Coxiella burnetii*) have been found; this species is a vector of the organism and transmits it through all stages including the egg.

Brucellosis or undulent fever organisms, *Brucella melitensis*, survive some time in this tick, which is said by some Soviet workers to be a carrier and transmitter of this pathogen. Some Russian studies of ticks as animals sustaining natural foci of tularemia have negated the importance of *H. marginatum* (as *H. plumbeum*) in this regard, although other workers have reported the finding of naturally infected specimens.

CATTLE: Theileriasis (*Theileria* spp.).

HORSES: Theileriasis (*Theileria equi*) and piroplasmosis (*Piroplasma caballi*). Transovarial transmission of the latter organism to the seventh generation has been demonstrated.

GUINEAPIGS: Rickettsiae pathogenic to these animals and transovarially transmitted to the F_3 generation of *H. marginatum* have been reported.

IDENTIFICATION

Males: The combination of characters for recognizing typical males is: (1) the center of the subanal shields is directly posterior of the central axis of the adanal shields (which are large and broad); (2) the lateral grooves are long, reaching approximately to the eyes, but they are frequently somewhat obscured by dense punctations or by lack of discreteness, especially anteriorly; (3) the scutal punctations are dense and large in the distal and scapular fields, but variable elsewhere, being usually smaller and more shallow and less dense centrally; (4) the posteromedian groove reaches the scutal midlength, it is narrow anteriorly and wider posteriorly; the paramedian grooves are about half as long as the posteromedian groove and taper from a pointed apex to wide in the festoon area; a narrow heavily punctate ridge lies between the paramedian grooves and the lateral grooves.

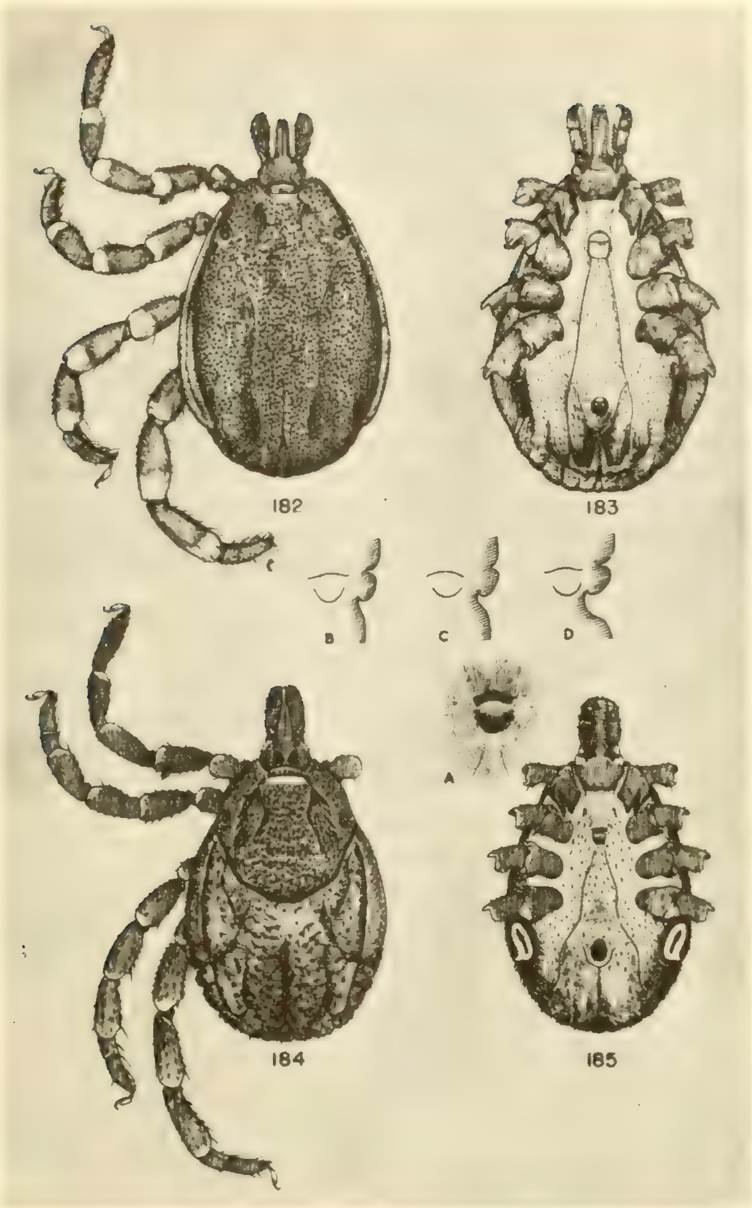
The scutum is usually comparatively narrowly elongate, measuring approximately 4.0 mm. long and 2.5 mm. wide. Its color is typically dark brown to black, but reddish specimens also occur; the legs may be entirely reddish or reddish centrally on each segment with paler anterior and posterior bands (see next paragraph). The scutal punctations may be dense enough to suggest H. rufipes, but those in the center are shallower and smaller than elsewhere, while in H. rufipes they are deep and quite uniform in size and depth. The parma may appear to be merely a median festoon and is the same color as the rest of the scutum. The subanal and adanal shields have rounded contours; the adanal shields are quite large.

Heavily punctate males, as seen among series from Libya, Algeria, Egypt, Romania, and elsewhere may suggest H. turanicum (page 531). The legs of H. marginatum, however, lack the conspicuous enamelling characteristic of those of H. turanicum.

Females: The genital apron is a large, robust widely transverse oval or triangle with a strongly bulging profile; it is most characteristic. The scutal punctation consists of numerous small, shallow, distant punctations over the entire surface (they may be almost medium size and slightly deeper and closer), and a few larger and deeper punctations scattered among them chiefly on the anterior half of the scutum. The basic punctation in some specimens is so shallow as to give scutum a rather smooth appearance, especially posteriorly. The central field between the cervical grooves is usually lighter (more reddish) than the dark lateral fields. The scutum appears to be exceptionally wide, its length-width ratio being about equal or shorter than wide.

Females of H. marginatum and H. turanicum are quite similar but the bright enamelling of the leg segments of H. turanicum distinguishes them. In most specimens of H. turanicum the genital apron is not so widely triangular and the scutal punctations are more numerous and discrete than in H. turanicum.

The larva and nymph of H. marginatum have been described and illustrated by Bernadskaia (1939C) and Feldman-Muhsam (1948).



Figures 182 and 183, ♂, dorsal and ventral views
Figures 184 and 185, ♀, dorsal and ventral views

A, ♀ genital area. B to D, ♀ genital area outline and profile.
B, unengorged. C, partly engorged. D, fully engorged.

HYALOMMA RUFIPES
Sudan Specimens

PLATE LIII

HYALOMMA RUFIPES Koch, 1844.

(Figures 182 to 185)

THE HAIRY HYALOMMA

NOTE: *H. rufipes* is a most distinctive tick although Schulze, Delpy, and Feldman-Muhsam in their earlier reports confused *H. rufipes* under the name *H. impressum*. Nuttall during the first quarter of the 1900s identified African specimens as *H. aegyptium impressum* and many British and some Italian workers of this period followed this precedent. The only other African species of wide range, *H. truncatum*, was referred to by this school as *H. aegyptium*. A few Russian synonyms are listed in the distribution section below, but contemporary Soviet usage concerning the nomenclature of this tick appears to be incorrect.

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
		1	1	Torit	*Syncerus caffer aequinoctialis*	Dec	
			3	Khor Waat (Allab)	*Syncerus caffer aequinoctialis*	-	(MCZ)
		2	17	Torit	domestic cattle	Jan	(2)
		1	3	Torit	domestic cattle	Feb	
		3	9	Torit	domestic cattle	Nov	
		1	2	Torit	domestic cattle	Dec	
		1	7	Juba	domestic cattle	Jan	
		1	2	Terakeka	domestic cattle	Mar	(SVS)
		2	4	Tali Post	domestic cattle	Mar	(SVS)
		1	5	Meridi	domestic cattle	Jan	(SVS)
		1	1	Yambio	domestic cattle	Jan	

DISTRIBUTION IN THE SUDAN

H. rufipes is widely spread in the Sudan but is numerous only in the semiarid central area. The following are localities from which specimens (all from cattle unless otherwise noted) have been seen:

Bahr El Ghazal: Galual-Nyang Forest (Very common on buffalos and giraffes; SVS, HH. The absence of this tick on the numerous tiang examined in this area is notable). Aliab (buffalos; SVS). Lau (SGC). Lake Nyubor, Boro, Khor Shammam, and near Raga (SVS). Yirol (horses; SVS).

Upper Nile: Bor, Ler, and Fangak (SVS). Malakal (HH).

Blue Nile: Common at Wad Medani (HH). Abu Zor, Hosh, near Ethiopian border, and Lake Ras Amer (camels and cattle; SGC).

Kordofan: "Western Jebels" and Umm Inderaba (SVS).

Darfur: Nyala, Zalingei, Radom, Sibdo, Muhagariya, and Sahafa (common on camels, cattle, sheep, and horses; SVS).

Kassala: Kassala (camels and cattle; SVS). Port Sudan (SVS).

Khartoum: Khartoum: Numerous specimens have been collected from sheep, goats, and horses, but few from cattle (HH). At the Khartoum quarantine station many adults are found on Darfur and Kordofan cattle. The Sudan Government collection contains a series of adults reared from nymphs from a kite, *Milvus migrans*, by H.H. King, 20 September 1922.

Northern: Shendi (camels and donkey; SVS). Wadi Halfa (camels; SGC, HH).

DISTRIBUTION

H. rufipes is widely distributed in many drier parts of Africa but it is quite localized and seldom very common in any locality. The hairy hyalomma is not known from many of the more westerly areas of Africa. It is present in the Yemen (Southwestern Arabia); and in North Africa occurs in Egypt and Libya but is not known further west on the Mediterranean littoral.

Elsewhere, *H. rufipes* occurs in Palestine, Iraq, Eastern Anatolia, and Russia (Transcaucasia, Astrakhan, Kazakhstan). Soviet workers find *H. rufipes* in such small numbers and in such scattered localities that Pomerantzev (1950) believes its presence in Russia is due to small local populations established from nymphs from migrating birds. Schulze (1918) reported a Macedonian specimen (as H. impressum) that may have been imported on a bird.

This distributional picture is indeed unique, and it may be surmised that H. rufipes is a species of the Ethiopian Faunal Region that has extended its range beyond these confines as a result of transportation by migrating birds, which are important hosts of immature stages (page 486).

Note: All records below are for H. rufipes or H. r. rufipes; other combinations are so stated.

NORTH AFRICA: EGYPT (Common on domestic animals in the Nile Valley only; also arrives at the Cairo abattoir on cattle from the Sudan and East Africa: Hoogstraal, ms. See immature HOSTS below). LIBYA (Scattered populations on Mediterranean littoral: Hoogstraal, ms.).

WEST AFRICA: NIGERIA (As H. impressum rufipes: Unsworth 1949,1952. As H. impressum subsp.: Gambles 1951. As H. rufipes: Theiler 1956. Material from Katagum and Oban in BMNH collections; H.H. det.). FRENCH WEST AFRICA (As H. savignyi impressa: Girard and Rousselot 1945. Rousselot 1946. ?As H. rufipes glabrum: Rousselot 1951 and Villiers 1955; it is assumed that these do not actually refer to H. turanicum. Rousselot 1953B. Theiler 1956).

CENTRAL AFRICA: FRENCH EQUATORIAL AFRICA (Rousselot 1953B). BELGIAN CONGO (Rare: Theiler and Robinson 1954. Theiler 1956).

EAST AFRICA: SUDAN (Hoogstraal 1954B. Feldman-Muhsam 1954. Theiler 1956).

ETHIOPIA (As H. aegyptium impressum f. typica: Stella 1939A, B,1940. As H. rufipes: Theiler 1956). ERITREA (As H. impressum impressum: Tonelli-Rondelli 1930A. As H. impressum rufipes: Niro 1935. Numerous specimens in BMNH and HH collections). FRENCH SOMALILAND (Hoogstraal 1953D). BRITISH SOMALILAND (As

H. grossum: Pocock 1900. As H. aegyptium impressum: Stella 1938A,1939A. Numerous specimens from camels in BMNH collections; H.H. det.). ITALIAN SOMALILAND (As H. aegyptium impressum: Paoli 1916. Tonelli-Rondelli 1926A. Franchini 1929C. Niro 1935. Stella 1938A,1940. As H. impressum rufipes: Tonelli-Rondelli 1935. Stella 1940. Specimens in BMNH and HH collections. See NOTE under EAST AFRICA for H. impressum, p. 463).

KENYA [Materials identified and variously reported by E. A. Lewis as H. aegyptium impressum, H. impressum albiparmatum, or H. rufipes are almost invariably a mixture of H. truncatum and H. rufipes; sometimes H. impeltatum and H. albiparmatum are included under these names in Lewis' collections now in the British Museum (Natural History) (H.H. det.). As H. rufipes: Binns (1951,1952). Theiler (1956). Note: In addition to the probability of mixed species in reports by Lewis, the synonymy of the following names is uncertain. As H. aegyptium: Brassey-Edwards (1932). As H. impressum: Daubney (1936). As H. impressum rufipes: Daubney (1937).]

UGANDA (Wilson 1953. Theiler 1956. See HOSTS below). TANGANYIKA (As H. aegyptium impressum: Cornell 1936. As H. rufipes: Theiler 1956. See HOSTS below).

SOUTHERN AFRICA: "SOUTH AFRICA" (Koch 1844. As H. impressum rufipes: Schulze and Schlottke 1930).

[ANGOLA: Absent: Sousa Dias (1950). Theiler (1956).] NORTHERN RHODESIA (Matthysse 1954. Theiler and Robinson 1954. Theiler 1956). SOUTHERN RHODESIA (As H. aegyptium impressum: Jack 1921,1928,1937,1942. As H. rufipes: Theiler 1956). NYASALAND (No available records). MOZAMBIQUE (As H. impressum rufipes: Theiler 1943B. Santos Dias 1952D,1953A,1954H. Tendeiro 1955. As H. rufipes: Theiler 1956). BECHUANALAND (Specimens from Ghanzi in BMNH collections; H.H. det. Theiler 1956). SWAZILAND (Uncommon: Theiler 1956). SOUTHWEST AFRICA (As H. impressum rufipes: Schulze 1936A. As H. impressum: Schulze 1940. As H. rufipes: Theiler 1956. See HOSTS below).

UNION OF SOUTH AFRICA (The H. aegyptium of Dönitz 1910B and of Cooley 1934 apparently includes both H. truncatum and

H. rufipes. As H. aegyptium impressum: Howard 1908. Bedford 1932B,1934,1936. Alexander, Mason, and Neitz 1939. McIntyre 1939. du Toit 1942,1947. du Toit and Mönnig 1942. As H. aegyptium: Clark 1933. As H. impressum rufipes: Theiler 1943B. As H. rufipes: Thorburn 1952. Neitz 1954. Theiler 1956).

ISLAND GROUPS: MADAGASCAR (Hoogstraal 1953E. Theiler 1956). COMORES (Kratz 1940; cf. immature HOSTS below).

NEAR EAST: TURKEY (Rare in eastern Anatolia: Hoogstraal, ms.). PALESTINE (As H. impressum, rare: Bodenheimer 1937. Adler and Feldman-Muhsam 1946,1948). YEMEN and IRAQ (Common: Hoogstraal, ms.).

RUSSIA: (As H. aequipunctatum: Olenev 1931A,C. Galuzo and Bespalov 1935. As H. impressum: Pomerantzev, Matikashvily, and Lototsky 1940. As H. marginatum impressum: Pomerantzev 1946. Tselishcheva 1953. As H. plumbeum impressum: Pomerantzev 1950).

NOTE: The record of H. impressum rufipes from China (Chodziesner 1924) probably refers to a heavily punctate H. marginatum (Kratz 1940). H. rufipes has been stated to occur in Portugal by Kaplan and Hulse (1953) in their review of prevalence of Q fever in Europe; this apparent error derives from the report by Fonesca, Pinto, Colacao, Oliveira, Branco, da Gama, Franco, and Lacerda (1951) that "H. rufipes glabrum" is associated with Q fever there. This is assumed to refer to H. marginatum.

HOSTS

Domestic cattle appear to be the most common hosts of this tick. They are mentioned by practically every author and are the most frequent hosts of specimens in museum collections. Other common domestic hosts are horses, sheep, and goats. Bedford (1932B) states that dogs and cats are also infested; specimens from these hosts are present in British Museum (Natural History) and HH collections. In semidesert areas, camels are frequently parasitized (Sudan records; HH mss.; numerous Somaliland specimens in BMNH collections; Hoogstraal 1953D). Among wild animals, the buffalo and giraffe are common hosts, as is the rhinoceros. Antelopes and certain birds are less common hosts of adults, and a variety of small mammals are occasionally infested.

Immature stages feed on a large variety of birds and also on hares.

Adults

Domestic animals: See two paragraphs above.

Man: Howard (1908). Bedford (1932B). J. B. Walker (correspondence; ♀ tick from Tanganyika).

Wild animals: Rhinoceros (Two collections in BMNH from Kenya). Buffalo (Santos Dias 1952D,1953B. Onderstepoort collection from Northern Rhodesia. BMNH collection from Kenya. Sudan records above). Eland (Schulze 1936A. Two collections in BMNH from Southwest Africa. HH collection from Tanganyika. Onderstepoort collection from South Africa and Tanganyika). Bushbuck (MCZ collection from Tanganyika). Duiker (*Sylvicapra grimmi*) (Bedford 1932B). Sable antelope (Santos Dias 1953A). Gemsbok (Onderstepoort collection from Southwest Africa). Giraffe (Santos Dias 1952D,1953B. Onderstepoort collection from northern Kenya and Southwest Africa. Sudan records above). Jackal (*Canis mesomelas schmidti*) (Stella 1939B). Zebra (Santos Dias 1952D. BMNH collection from Tanganyika). Hare (Howard 1908. Onderstepoort collection from South Africa).

"Fowls" (Howard 1908). Ostrich (Howard 1908. Bedford 1932B. ♂ in HH collection, from "west of Afmadu", Somalia, 1952, Col. D. Davis *legit*). Guinea fowl (Santos Dias 1953B).

Adults from the following birds are present in the Onderstepoort collection (Theiler, correspondence): ostrich (Southwest Africa), swallow (Southern Rhodesia), Cape dikkop (*Burhinops c. capensis* from South Africa), and mocking chat (*Thamnolaea c. cinnamomeiventris* from South Africa).

Immature Stages

Hosts of the immature stages noted by Bedford (1932B,1936) are not listed here since it is questionable that larvae and nymphs of H. rufipes and of H. truncatum (= H. transiens) could be differentiated at that time. Nymphs have been reported from a hare (Alexander, Mason, and Neitz 1939), and from a kite (Sudan records above); the former workers induced five of the twelve nymphs to reattach to a guinea pig.

Kratz (1940) records the finding of a nymph, which molted into a male rufipes, on a female comorant caught on the high seas between the northern trip of Madagascar and the Comores Archipelago.

The Onderstepoort collection (Theiler, correspondence) has larvae (L) and/or nymphs (N) from the following South African birds:

N Namaqua thrush, Afrocichla smithi
LN Cape thrush, Afrocichla o. olivacea (2 collections)
N White-throated seed-eater, Crithagra a. albogularis
LN Mocking chat, Thamnolaea c. cinnamomeiventris (3 collections)
N Red-winged starling, Amydrus m. morio
N Starling (Southwest Africa)
N Boubou shrike, Lanjarius f. ferrugineus
N Gray tit, Parus afer
N Fiscal flycatcher, Sigelus silens
N Cape barn owl, Tyto alba affinis

The same collection contains nymphs from a hare and a rock hare (Pronolagus randensis) in South Africa and from a hare in Uganda.

In Egypt, nymphs (reared to adults in the laboratory) have been found only on birds (Hoogstraal, ms.) although adults are locally common on domestic animals. The hosts have been:

Wheatear (European form), Oenanthe o. oenanthe
Blackeared wheatear (Eastern form), Oenanthe hispanica melanoleuca

The former bird breeds throughout most of Europe east to Central and northern Asia and to northern Alaska; it winters in Arabia and tropical Africa, also in Asia to India. The latter "breeds in the Crimea, Bulgaria, and almost throughout the Balkan peninsula, Asia Minor, Palestine, and western Persia, etc.; winters in Egypt and Sinai to the Sudan, Ethiopia, the Red Sea coast, and has straggled to the southern Sahara, British Islands, Malta, and northwest Africa" (Meinertzagen 1930). Possibilities for the wide dispersal of this tick are easily recognized.

BIOLOGY

Life Cycle

Under laboratory conditions, H. rufipes is a two host tick although it possibly may also undergo a three host type of life cycle. Theiler (1943B and 1955 correspondence) has summarized the developmental stages as follows:

PERIOD	DAYS (1943B)	DAYS (1955)
Preoviposition	4 to 12	4 to 19
Oviposition period	37 to 59	
Oviposition to hatching	34 to 66	28 to 66
Larval prefeeding period	?	
Larva feeds	5 to 7	
Premolting period	2 to 15	
Nymphal prefeeding period	?	
Nymph feeds	7 to 10	
Premolting period	14 to 95	
(Larvae and nymphs on host)	13 to 45	average 14
Adult prefeeding period	?	
Adult (female) feeds	5 to 6	5 to 12

It appears that the minimum time for completing the life cycle is between four and five months but double this period may be required under local conditions.

"The life cycle of H. aegyptium (= ?H. rufipes, possibly mixed with H. truncatum: HH) is of particular value in that it illustrates the influence of vermin in the distribution of the species. On sheep, cattle, and domestic fowl it behaves as a three host tick, requiring a separate host for the larval, nymphal, and adult stages. On the hare, H. aegyptium will feed as a larva, become engorged, molt as a nymph without leaving the host, feed as a nymph on the same individual host, and then drop off the host for molting. Thus on the hare the life cycle requires only two hosts" (Brassey-Edwards 1932). This interesting phenomenon should be reinvestigated.

The long oviposition period is especially noteworthy. Unfed larvae may survive a year, unfed nymphs three months, and unfed adults for longer than a year (Theiler 1943B). Enigk (1953) observed unfed adults surviving up to two years.

Howard (1908) considered H. rufipes as a two-host tick with one generation a year in South Africa. He described, illustrated, and discussed the immature stages but did not differentiate them from those of H. truncatum which he apparently did not rear. Jack (1928) noted a two-host and a three-host type of life cycle for this tick.

Ecology

Thorburn (1952) states that on cattle the chief site of infestation of this tick is in the tail region. Specimens in the present collection are from the flanks, genitalia, udders, and perianal regions. The anal area is mentioned by Matthysse (1954). Nymphs are always, in our experience, on the crown of the head of their avian hosts.

du Toit and Mönnig (1942) record the finding of a male attached to the hard palate of the mouth of a cow, and indicated that on the farm where this occurred this phenomenon had been observed on several occasions.

H. rufipes ranges through the more arid areas of tropical and southern Africa but only localized populations maintain themselves in the severely arid conditions of northern Africa. It exists where annual rainfall is from ten to thirty inches a year. It may also thrive in irrigated areas with diminished rainfall or where a long, severe dry season occurs between an annual rainy season of approximately forty inches. In the Sudan, it is more common in the drier savannah and semiarid central areas than in the southern forest and savannah areas; it occurs in the Nile Valley, but is not known in extreme desert conditions. In Egypt,

H. *rufipes* is found only in the Nile Valley, never in extreme desert areas.

The hairy hyalomma is included in Wilson's (1953) *Amblyomma gemma* - *R. pravus* (= *R. neavi*) association (see page), which is found in areas where rainfall rarely exceeds 25 inches annually.

The only ecological survey of this tick is that of Theiler (1956) who lists the areas of its occurrence and absence in southern Africa. It occurs in all desert and semidesert areas with rainfall up to thirty inches annually, but at higher altitudes or in semitropical conditions, where the relative humidity is higher, it is absent even though annual rainfall is little or no greater than in some of the hotter, drier areas. It does not occur in winter rainfall areas, where rain falls throughout the year, or in coastal areas with high relative humidity as a result of proximity to the sea. Temperature appears to be a limiting factor of lesser importance since H. *rufipes* ranges from hot deserts into areas with up to 120 days of frost annually. Increase in temperature associated with increase in relative humidity restricts the tick's range. Other factors being equal, the hairy hyalomma occurs in most vegetational types except forested areas of central Africa. In many regions it is active the year around, but in others more so in summer than in winter.

In Russia, *H. rufipes* has been reported (as *H. impressum*) from the western deserts of Transcaucasia (Pomerantzev, Matikashvily, and Lototsky 1940) and, in western Tadzhikistan, from mountain pastures but not in the valleys (as *H. aequipunctatum*) (Galuzo and Bespalov 1935).

DISEASE RELATIONS

MAN: Nymphs infected with boutonneuse fever (*Rickettsia conorii*) have been taken from a hare in South Africa.

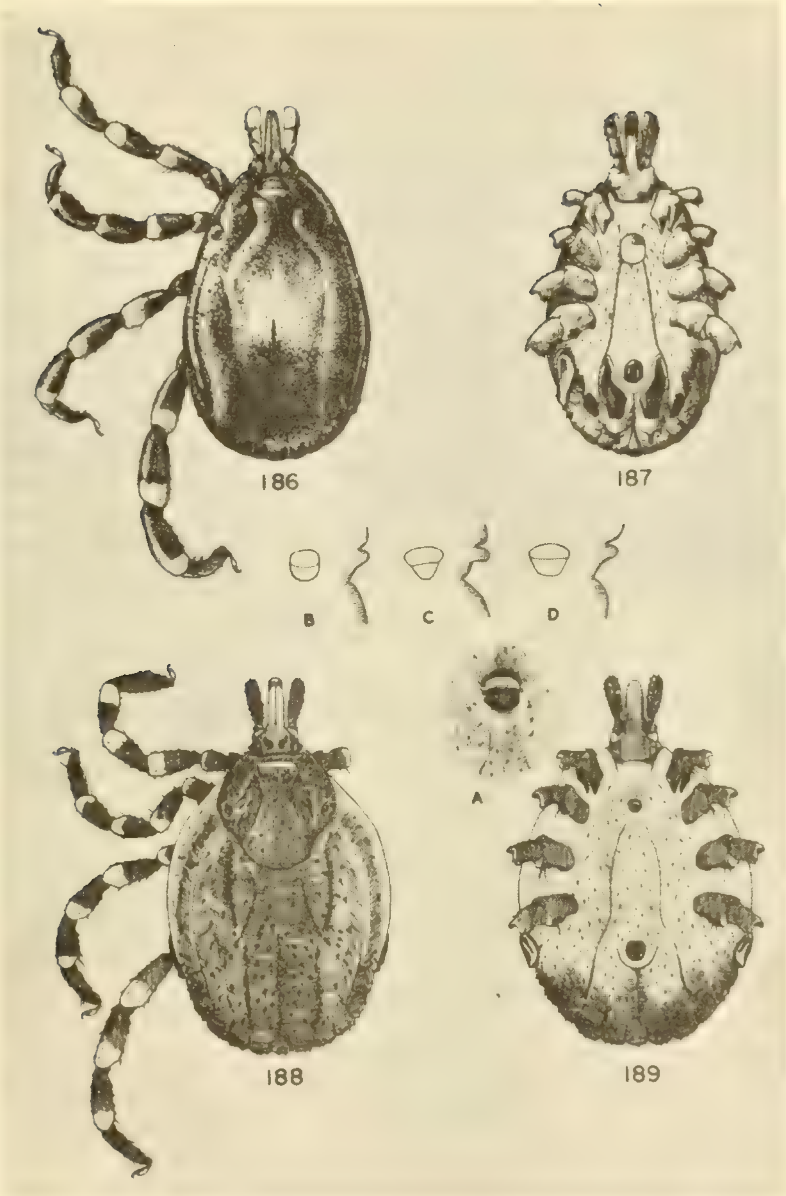
CATTLE: *H. rufipes* causes abscesses and sloughing of the host skin. These areas often serve as points of penetration of the screwworm *Chrysomia bezziana* Villem. This tick may also be associated with footrot of sheep, a secondary infection by bacteria, and lesions from its bites may also lead to lameness in sheep. The possibility that the hairy tick may be a vector of sweating sickness (virus) of cattle has been mentioned.

IDENTIFICATION

Male: H. rufipes, almost without exception, is a large, robust, shiny black tick with a comparatively broad body outline. Its scutum is densely and rather uniformly punctate, so much so that the lateral grooves are obscured. The punctations are close together and while they give the impression of being rather uniform, they usually grade imperceptibly from large posteriorly to smaller anteriorly. There is little differentiation of the caudal area. Ventrally, the subanal shields are directly posterior of the adanals and the circumspiracular area is more or less hirsute, but a fair to dense accumulation of hairs always occurs in this area. The ventral integument is usually somewhat more hirsute than in other species. The legs are reddish brown with bright, paler rings. The posterior body margin is typically broadly rounded but not infrequently may be somewhat constricted and thus tend to approach the form of that in H. impressum. Newly molted specimens are reddish brown and rare preserved individuals show this color. The body shape of some specimens is more narrowly elongate than is typical for this species, but such individuals always appear to be rather weak and poorly nourished.

Females: This sex often reaches considerable size. Circumspiracular pilosity and color are like those of the male; scutal punctations are like those of the anterior part of the male scutum. The genital apron is a wide shield that bulges strongly from a deep anterior and posterior indentation. The outline of the apron is much like that of H. marginatum and H. impressum; however the division of the apron of the latter species into an anterior ridge and a posterior button readily separates this from H. rufipes.

The larva has been sketched by Bedford (1934) and Theiler (1943B).



Figures 186 and 187, ♂, dorsal and ventral views
Figures 188 and 189, ♀, dorsal and ventral views

A, ♀, genital area. B to D, ♀, genital area outline and profile.
B, unengorged. C, partly engorged. D, fully engorged.

HYALOMMA TRUNCATUM
Sudan Specimens

PLATE LIV

HYALOMMA TRUNCATUM Koch, 1844.

(Figures 186 to 189)

THE AFRICAN HYALOMMA

NOTE: The Nuttall school referred to *H. truncatum* as *H. aegyptium*. During the past five years, most authors have called this species *H. transiens*, the authority for which has been attributed to Schulze (1919) or to Delpy (1946A). Feldman-Muhsam's (1954) studies of Koch's type specimens leave no doubt that this species is Koch's (1844) *H. truncatum*. Feldman-Muhsam (op. cit.) has also compared the type specimens of several of Schulze's African "species" and found them to be identical with *H. truncatum*. These are noted below in the distribution section.

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
		1		Lugurren	*Phacochoerus aethiopicus bufo*	Jan	
			1	Torit	*Sus scrofa sennaarensis*	Mar	
		1	1	Kajo Kaji	*Syncerus caffer aequinoctialis*	-	(SVS)
		1	1	Kapoeta	domestic cattle	Jul	(SVS)
		1	1	Torit	domestic cattle	Jul	
	1	5	9	Torit	domestic cattle	Dec	(2)
		1		Lalanga	domestic cattle	Dec	(SVS)
		2	2	Iliu	domestic cattle	Dec	
		12	4	Tombe	domestic cattle	Jan	(SVS)
		4	8	Kapoeta	domestic cattle	Dec	
			2	Loronyo	domestic goats	Jan	
			2	Torit	domestic goats	Jan	
					Tortoise		
		1	1	Juba	*Kinixys belliana*	Dec	

DISTRIBUTION IN THE SUDAN

The following material has been studied:

Bahr El Ghazal: Galual-Nyang Forest (Large numbers of adults from several giraffes in March, May, and June; SVS. Moderate numbers of adults from forest buffalos from February through April; SVS, HH. Small numbers of adults from tiang, roan antelope, domestic horse, and on ground from February to April; SVS, HH). Fanjak (Small numbers of adults from cattle, February and March; SVS, HH). Wau (roan antelope; SGC). Yirol (cattle; SVS).

Note: The following records consist of one to ten adult specimens per collection unless otherwise mentioned.

Upper Nile: Makier (cattle; SVS).

Blue Nile: Lake Ras Amer (camel; SGC). Hassa Heissa (camel; G. Kohls det., G. B. Thompson, correspondence). Wad Medani (cattle and camels; HH).

Darfur: Nyala (camel; SVS). Muhagariya (horses, donkeys, cattle, and camels; SVS). Zalingei (camels, cattle, horses, donkeys, and goats; SVS). Kulme (no host record; BMNH). Radom (cattle; SVS).

Kordofan: Talodi and Heiban (cattle; SVS).

[Khartoum: Apparently not established in this Province but arrives in fairly large numbers on Kordofan and Darfur cattle for export to foreign markets; HH.]

Kassala: Kassala (goats; SVS). See EGYPT below.

Northern: Rare in this Province but arrives at the Wadi Halfa Quarantine on cattle en route to Egypt. Known only from report by Chodziesner (1924) from Delgo.

DISTRIBUTION

H. truncatum is the sole endemic representative of this genus that is widely spread throughout the Ethiopian Faunal Region (Figure 1) and nowhere else. It commonly occurs in the drier parts of this Region but appears to increase in numbers towards and north of the equator. It is rare or absent in forests of western Africa.

ATLANTIC OCEAN: CANARY ISLANDS (Specimens from dogs, Tenerife, 1906, in BMNH collections; HH det.).

NORTH AFRICA: EGYPT (Occurs only in Gebel Elba area of extreme Southeastern Egypt adjacent to Sudan frontier (Kassala Province); numerous males arrive at the Cairo abattoir on cattle from the Sudan and East Africa but this species has not established itself as a result of these introductions: Hoogstraal, ms.).

WEST AFRICA: FRENCH WEST AFRICA (As H. truncatum sp. nov.; Koch 1844. As H. aegyptium impressum transiens: Schulze 1919. As H. transiens: Rousselot 1951,1953B). GAMBIA (Numerous specimens in single lot from cattle in BMNH collections; HH det.).

PORTUGESE GUINEA (As H. savignyi: Tendeiro 1948,1949A, 1951F,1952A,C,D. From Tendeiro's 1949A discussion it is evident that he is referring to H. truncatum (= H. transiens) but prefers to call it H. savignyi. It is likely that one to three other Hyalomma species occur in Portugese Guinea).

NIGERIA (As H. aegyptium: Simpson 1912A,B. As H. impressum transiens: Unsworth 1949. As H. impressum subsp.: Gambles 1951. As H. transiens: Unsworth 1952. See HOSTS below). GOLD COAST (As H. aegyptium: Simpson 1914). TOGO (Feldman-Muhsam 1954 states that H. impressum brunneiparmatum Schulze and Schlottke, 1930, is a synonym of H. truncatum; however, from examination of Miss J. B. Walker's Kenya-reared material of H. albiparmatum, in which the parma varies in size and color, it is evident that H. brunneiparmatum is a synonym of H. albiparmatum).

CENTRAL AFRICA: CAMEROONS (As H. aegyptium impressum transiens: Chodziesner 1924. As H. transiens: Rageau 1951,1953. Rousselot 1951,1953B. Unsworth 1952). FRENCH EQUATORIAL AFRICA (As H. nitidum from "New Cameroons": Schulze 1919. Chodziesner 1924. As H. impressum nitidum: Schulze and Schlottke 1930. Kratz 1940. See also Feldman-Muhsam 1954. As H. aegyptium impressum transiens: Chodziesner 1924. As H. transiens: Rousselot 1951, 1953B). BELGIAN CONGO (As H. transiens: Theiler and Robinson 1954).

EAST AFRICA: "EAST AFRICA" (As H. planum and H. zambesianum: Schulze and Schlottke 1930).

SUDAN (As H. aegyptium impressum transiens: Chodziesner 1924. Kratz 1940. As H. impressum luteipes: Schulze and Schlottke 1930. As H. transiens: Hoogstraal 1954B).

ETHIOPIA (As H. impressum transiens and H. impressum nitida: Stella 1939B,1940. As H. aegyptium impressum transiens: Chodziesner 1924). ERITREA (As H. impressum transiens: Tonelli-Rondelli 1930A,1932C. Niro 1935. Stella 1939A,1940. Common in many parts of Eritrea: HH). FRENCH SOMALILAND (As H. transiens: Hoogstraal 1953D). BRITISH SOMALILAND (Numerous specimens from camels in BMNH collections; HH det.). ITALIAN SOMALILAND (As H. aegyptium impressum: Paoli 1916. As H. aegyptium impressum form transiens: Tonelli-Rondelli 1926A,1935. Stella 1940. See HOSTS below).

KENYA [As H. impressum transiens: Daubney (1937). As H. transiens: Binns (1951,1952). As H. impressum near planum: Fotheringham and Lewis (1937). As H. truncatum: Feldman-Muhsam (1954). Hoogstraal (1954C). See also H. albiparmatum, p. See HOSTS below.

H. lewisi Schulze (1936E) is a synonym of H. truncatum and not of H. excavatum as stated by Delpy (1949E); it is also not a "Hyalommina" as stated by Schulze (1936E). Schulze-identified material of "H. lewisi" consists of small, stunted, misshapen H. truncatum (seen by HH); in this Feldman-Muhsam (1954) is in agreement. Kratz (1940) also referred to H. lewisi from Kenya. See page

Lewis (see bibliography) mentions Hyalomma ticks under a variety of names. Most specimens in his large collections now in British Museum (Natural History) are H. truncatum among which H. rufipes is frequently mixed and other species are sometimes included. The H. truncatum specimens had been identified by Lewis as H. impressum, H. dromedarii, and H. aegyptium; this confusion is understandable due to the unsatisfactory information available in literature at that time.]

UGANDA (As H. impressum transiens: Wilson 1950C. As H. transiens: Wilson 1953. Common in many Uganda collections studied by Theiler and by HH).

TANGANYIKA [As H. *planum* and H. *aegyptium albiparmatum*: Schulze (1919). As H. *aegyptium impressum transiens*: Chodziesner (1924). As H. *impressum transiens* and as H. *lewisi*: Schulze (1936E). Kratz (1940). See KENYA above. As H. *aegyptium*: Cornell 1936. ?As H. *impressum planum* f. *rhinocerotis*: Schulze and Schlottke (1930) and Kratz (1940); the synonymy of this name is uncertain but it is suspected to apply to H. *truncatum*. See HOSTS below.]

SOUTHERN AFRICA: ANGOLA (As H. *impressum transiens*: Sousa Dias 1950. Santos Dias 1950C. As H. *transiens*: Theiler and Robinson 1954. Santos Dias 1950C noted that "H. *savignyi*" had been reported from Angola by A. Morais in 1909, and that this may refer to H. *truncatum* (= H. *impressum transiens*), MOZAMBIQUE (As H. *impressum transiens*: Theiler 1943B. Santos Dias 1947B, 1953B,H,1954H. Tendeiro 1955. As H. *truncatum*: Theiler 1956).

NORTHERN RHODESIA (As H. *transiens*: Theiler and Robinson 1954. Matthysse 1954. See HOSTS below. SOUTHERN RHODESIA (As H. *aegyptium impressum transiens*: Chodziesner 1924. As H. *aegyptium*: Lawrence 1939. As H. a. *aegyptium*: Jack 1942. As H. *truncatum*: Theiler 1956. See HOSTS below). NYASALAND (As H. *impressum transiens*: Wilson 1943,1946. As H. *impressum*: Wilson 1950B).

SOUTHWEST AFRICA (As H. *aegyptium impressum transiens*: Chodziesner 1924. As H. *impressum transiens*: Kratz 1940. As H. *aegyptium aegyptium*: Bedford 1932B. As H. *transiens*: Fiedler 1953. See HOSTS below). SWAZILAND (As H. a. *aegyptium*: Bedford 1932B. As H. *truncatum*: Theiler 1956). BECHUANALAND (As H. *aegyptium impressum transiens*: Chodziesner 1924. As H. *truncatum*: Theiler 1956). [BASUTOLAND: Absent; Theiler (1956).]

UNION OF SOUTH AFRICA (The "H. *aegyptium*" of Dönitz 1910B and of Cooley 1934 apparently includes both H. *rufipes* and H. *truncatum*. As H. a. *aegyptium*: Lounsbury 1904C. A. Theiler 1905B,1906. Howard 1908. Bedford 1920,1926,1927,1932B,1936. Nieschulz and du Toit 1937. P. J. du Toit 1931. Finlayson, Grobler, and Smithers 1940. R. du Toit 1942A,B,1947A. As H. *impressum impressum*: Theiler 1943B. As H. *transiens*: Erasmus 1952. Thorburn 1952. Neitz 1954. As H. *truncatum*: Feldman-

Muhsam 1954. Theiler 1956. As H. aegypticum (sic): Gear 1954. See HOSTS below).

"SHORES OF THE ZAMBESI" (As H. zambesiacum: Schulze and Schlottke 1930. Kratz 1940).

ARABIA: YEMEN (Hoogstraal, ms.).

OUTLYING ISLANDS: MADAGASCAR (Recently introduced: Hoogstraal 1953E. Theiler 1956). SEYCHELLES (Desai 1941; not stated whether introduced or established). ZANZIBAR (As H. aegyptium: Aders 1917).

HOSTS

Domestic cattle and goats are the most common hosts of H. truncatum but other large wild or domestic mammals may be infested. Wild carnivores are seldom recorded as hosts. Rarely, small mammals, birds, or tortoises are also attacked. Immature stages are definitely known from birds and hares but most published remarks concerning these stages should be accepted with reservation because of questionable identity.

Adults

Domestic animals: Cattle (Bedford 1932B, Schulze 1936C, Fotheringham and Lewis 1937, Sousa Dias 1950, Wilson 1943,1946, 1950B, Rousselot 1951, Rageau 1951,1953, Santos Dias 1953B. Sudan records above. Numerous specimens in various collections examined for the present study). Goats (Bedford 1932B, Rousselot 1951, Hoogstraal 1953D,E. Numerous BMNH specimens. Sudan records above). Sheep (Bedford 1932B, Wilson 1950B, Sousa Dias 1950, Rousselot 1951, Hoogstraal 1953D. BMNH specimens. Sudan records above). Camels (Aders 1917, Rousselot 1951. Numerous BMNH specimens from British Somaliland. Hoogstraal, Yemen ms. Sudan records above). Horses (Bedford 1932B, Sousa Dias 1950, Rageau 1953. Sudan records above). Donkeys (Bedford 1932B, Rousselot 1951).

Mules, dogs, and rarely cats (Bedford 1932B). Dog (BMNH specimens from Canary Islands, Eritrea, and Transvaal).

Wild antelopes: Tiang (Sudan records above). Roan antelope (Bedford 1932B, Cooley 1934, Tonelli-Rondelli 1930A. BMNH specimens from Nigeria. Sudan records above). "*Ozanna grandicornis*" (Santos Dias 1952D). Wildebeest (Matthysse 1954. Onderstepoort specimens from South Africa). Nyasa wildebeest (J. B. Walker specimens from Tanganyika). Lichtenstein's hartebeest (Santos Dias 1952D,1953B). Brindled gnu or blue hartebeest (Bedford 1932B, Santos Dias 1953B). Sassaby or bastard hartebeest (BMNH specimens from South Africa). Eland (Chodziesner 1924, Bedford 1932B, Wilson 1950B, Santos Dias 1953B. BMNH specimens from Southern Rhodesia and Southwest Africa. Onderstepoort specimens from South Africa). Greater kudu (Santos Dias 1953B). Bushbuck (MCZ specimens from South Africa). Western defassa waterbuck (Rageau 1953). Gemsbok (Onderstepoort specimens from South Africa).

Other wild animals: Hedgehog (Bedford 1936). Hares (BMNH specimens from Kenya and Nigeria). Bushpig (Santos Dias 1953B. HH specimens from Eritrea. Sudan records above). Warthog (Santos Dias 1953B, Bedford 1932B, Rageau 1953. Numerous BMNH specimens from Kenya and Nigeria. Sudan records above). White or square-lipped rhinoceros, southern race (MCZ specimens). Black or narrow-lipped rhinoceros (Schulze 1919, Schulze and Schlottke 1930. BMNH specimens from Kenya). Buffalo (Schulze 1919, Wilson 1950B, Santos Dias 1952D,H,1953B. MCZ and BMNH specimens from Kenya. J. B. Walker specimens from Tanganyika. Sudan records above). Dwarf buffalo (Rageau 1953). Giraffe (Chodziesner 1924. MCZ specimens from Kenya. BMNH specimens from Tanganyika. Onderstepoort specimens from Transvaal and Southwest Africa. Numerous Sudan specimens recorded above). Burchell's zebra (Santos Dias 1952D,1953B). Zebra (Matthysse 1954. BMNH specimens from Kenya. Onderstepoort specimens from Northern Rhodesia). Lion and antbear (Wilson 1950B). Leopard (BMNH specimens from Kenya. Onderstepoort specimens from Southern Rhodesia). Jackal and African porcupine (Matthysse 1954. Onderstepoort specimens from Northern Rhodesia).

Reptiles: Tortoise (Sudan records above).

Birds: Cape thick-knee, *Burhinops capensis* (Bedford 1932B). Ostrich (1♂ and 1♀ in HH collection, from "west of Afmadu", Somalia, 1952, Col. D. Davis *legit*. Ostriches in Southwest Africa (Theiler, correspondence).

Man: Several specimens from Kataguna and Katagum, Nigeria, and from Kenya in BMNH collections (HH det.).

Immature Stages

Nymphs on dogs and hedgehogs (Rousselot 1951). Larvae and nymphs sometimes on cattle, sheep, and goats (Fotheringham and Lewis 1937). Nymphs on hares (Wilson 1946,1950B, Sousa Dias 1950. Fiedler 1953). Larvae from a hornbill, *Tokus flavirostris leucomelas* (Santos Dias 1952D). "Immatures" from a pied crow, *Corvus albus albus* in Transvaal (Theiler, correspondence).

BIOLOGY

Life Cycle

Unstudied. Wilson (1946) was unable to rear this species in Nyasaland.

Ecology

The African hyalomma, another xerophilic member of this genus, obviously differs somewhat from *H. rufipes* in ecological requirements but the limiting factors are not yet recognized clearly enough for proper elucidation. As stated above, the distribution of *H. truncatum* is strictly limited to the Ethiopian Faunal Region and its range is widespread and fairly continuous within these confines except in heavily forested and high rainfall areas. Wilson (1953) includes *H. truncatum* in the *A. gemma* - *R. pravus* (= *R. neavi*) association (see page) that occurs where annual rainfall seldom exceeds 25 inches.

In southern Africa (Theiler 1956), the range of *H. truncatum* differs from that of *H. rufipes* in that the former is absent at higher elevations with high rainfall but present in cooler lowland winter rainfall areas. In regions with 25 inches of annual rainfall populations are rare and isolated. In Equatorial Africa, however, the African hyalomma does tolerate this and a slightly higher range of rainfall (HH). Here a combination of factors including higher temperatures, long dry seasons, and lower average relative humidity probably modify this tick's ecological thresholds (HH).

In southern Africa, low temperature and high altitude do not in themselves limit the range of H. truncatum. It occurs in all types of South African vegetation except in short grass of the highveld, a mountainous zone associated with high rainfall, and is rare or absent where snow falls.

From the size and variety of collections examined, it appears that in comparison with H. rufipes, H. truncatum may be somewhat less numerous and more widely ranging in southern Africa but that the reverse is true towards and beyond the equator. This matter, however, requires more careful study. H. truncatum is rare or never present in the forests of western Africa.

This species was not collected in high rainfall areas of the Cameroons (Unsworth 1952), and is unusual if not entirely absent on the humid west bank of Equatoria Province in the Sudan.

In Northern Province of Nyasaland, where H. truncatum is the only species of this genus that is found, females engorge on cattle chiefly during the dry season (March, April, May) but also in small numbers during other months of the dry season. Nymphs were found on hares early in the rainy season (October) and also in December (Wilson 1946).

Adults attach in the brush of hair at the tip of the tail, between the hooves, in the inguinal and perianal areas, and on the scrotum and udders.

A hymenopteran parasite, Hunterellus theilerae, has recently been described from nymphs of H. truncatum of Southwest Africa and from nymphs of Rhipicephalus oculatus from Transvaal (Fiedler 1953). Cooley (1934) reared Hunterellus hookeri from nymphs of "H. aegyptium" in South Africa, but it appears that he included both H. truncatum and H. rufipes under this name.

DISEASE RELATIONS

MAN: Tick paralysis (toxin or venom). Q fever (*Coxiella burnetii*).

CATTLE: Sweating sickness (virus). Lameness and paralysis in calves (toxin or venom).

SHEEP: This tick may be associated with footrot of sheep, a secondary infection by bacteria, and lesions from its bites may lead to lameness.

HORSES: Not a vector of horsesickness (virus).

NOTE: This species should be considered as strongly suspect in the transmission of rickettsial organisms among domestic and wild animals.

REMARKS

A somewhat deformed specimen of *H. truncatum* has been described and sketched by Santos Dias (1947B) and another (as *H. savignyi*) by Tendeiro (1951F).

In various papers by E. A. Lewis on work in Kenya, based largely on *H. truncatum* (cf. Hoogstraal 1954C), the author refers to rearing experiments by Nuttall (1913) and Patton and Cragg (1913) as being accomplished with the same species. Since Nuttall's material originated in Algeria and Patton and Cragg's in India, these workers obviously utilized different species. The material used by Nuttall, now in British Museum (Natural History) collections, reported as *H. aegyptium*, is *H. marginatum*.

The 4500 specimens of *H. truncatum* from throughout Africa that have been examined for the present study are highly distinctive and show considerably less variation than encountered among most other species in this genus. This observation is diametrically opposed to Feldman-Muhsam's (1954) remarks: "Examination of laboratory-bred material ....

showed an enormous range of variation between the offspring of one female". As much caution must be employed in evaluating laboratory-reared specimens as in evaluating field-collected material. Under abnormal, artificial conditions, some individuals that would not survive in the field may be protected enough to maintain the life they would otherwise lose under inclement conditions. Artificial conditions in themselves obviously induce morphological modifications. At any rate, extremely few atypical specimens are found in field collections.

IDENTIFICATION

Males: The scutum is black or reddish-black and measures approximately 3.3 mm. long and 2.3 mm. wide. It is characterized by long, deep, distinct, cleanly cut lateral grooves; smooth, glossy, impunctate surface except caudally, where there is a dense patch of large, contiguous punctations. The scutum is narrowed posterior of the spiracular plate, but the posterior margin is usually not so squarely truncate as in H. impressum. The festoons number seven and the central one is not morphologically differentiated, as compared with H. albiparmatum in which the central festoon forms a parma resembling a miniature celluloid watch cover, variable in size, shape, and color. Ventrally, the small rectangular subanal shields lie posterior of the axis of the larger, rectangular adanal shields. The legs are reddish brown with bright paler rings.

Variable field collected males may be small and stunted and lack the subanal shields. Such specimens are the basis of Schulze's so called "H. lewisi" in the "subgenus Hyalommina" (page 521). Collections from a few areas show somewhat more than ordinary scutal punctation. The long, clear, cleanly cut lateral grooves indicate that such specimens are H. truncatum and not lightly punctate H. impressum, as does also the comparatively more rounded posterior margin of the body.

Although H. marginatum occurs with H. truncatum only in rare localities at the northern periphery of the range of the latter, it may be well to add that the scutum of H. truncatum is characterized by fewer scapular and central punctations;

longer and cleaner lateral grooves; glossier surface; often somewhat smaller size; obsolescence of posteromedian and paramedian grooves in the caudal field of dense punctations; and narrowed posterior margin. Field collected specimens of these two species that might be confused have not been observed during the present study; Feldman-Muhsam (1954), however, states that laboratory-bred series might be confused.

Females are easily recognized if only by the genital apron, the character of which is accentuated rather than decreased by enormous engorgement. The apron is a transversely elongate oval of somewhat variable shape; in profile it is surmounted anteriorly by a narrow, bulging lip; centrally it is deeply depressed (or concave); posteriorly it is bounded by a more or less distinct lip that never protrudes as much as the anterior lip. Feldman-Muhsam's (1954) figure 2F of this apron is a surprisingly unsatisfactory representation of its actual appearance and supports the assumption that this species did not prosper during the laboratory study devoted to it.

The scutum of practically every field collected female is blackish and with few punctations among which a few fine ones may be scattered. The scutum of a few specimens bears larger, superficial punctations scattered about its surface; that of greatly engorged specimens, as usual in this genus, is rugose. In the few specimens with a more punctate scutum, the genital apron is nevertheless highly distinctive and the glossy scutal appearance is retained.

Note that no known characters distinguish the females of H. truncatum from those of the less common and more restricted H. albiparmatum.

NON-SUDANESE SPECIES OF HYALOMMA

(Figures 190 to 211)

In order to better understand this group, illustrations and selected data for all species presently-recognized in the genus *Hyalomma* have been assembled in this section.

KEY TO ALL PRESENTLY RECOGNIZED

SPECIES OF THE GENUS HYALOMMA

MALES

1. Without subanal shields. Festoons not fused. Adanal shields unusually large and wide. Scutum with few large, scattered punctations and long, clear lateral grooves. (India). (Subgenus *Hyalommina*)*....................................H. HUSSAINI
Figures 198 and 199

With subanal shields (exceptional, deformed runts may lack subanal shields)..2

---

*The status of *H. kumari* Sharif, 1928, which falls into this classification, is uncertain.

2. Coxa I simple, with two wide, short spurs from posterior margin. Scutum smooth, shiny with few, scattered, large punctations; festoons unfused; lacking lateral grooves and caudal depression. Adanal shields large, much like those of H. hussaini; subanal shields minute. (Tortoise parasite; Mediterranean and Black Sea areas, southern Russia to western Middle East). (Subgenus Hyalommasta)............H. AEGYPTIUM
Figures 190 and 191

Coxa I deeply divided into narrow external branch and wider internal branch. Festoons partly fused. With short or long lateral grooves. Adanal shields not so large and wide as above. Subanal shields typically larger than above (frequently though abnormally as small as above). (Palearctic, Oriental, and Ethiopian Faunal Regions). (Subgenus Hyalomma)..3

3. Center of subanal shields characteristically exterior of the axis of the adanal shields..4

Center of subanal shields characteristically in line with the axis of the adanal shields (frequently laterally displaced when greatly engorged)............................6

4. Spiracular plates of female type, with short, blunt "tail". (Camel parasite, Iran to Egypt; large size, up to 8 mm. long)...............................H. SCHULZEI
Figures 202 and 203

Spiracular plates of normal male type, with long "tail"...................................5

5. Lateral grooves reaching scutal midlength; scutum largely covered by small and medium-size punctations. (Medium-size; Near East; North, West, and coastal East Africa) .... H. IMPELTATUM
Figures 170 and 171

Lateral grooves confined to posterior third of scutum; scutum smooth with few, scattered, usually large punctations; posterior grooves characteristically marked. (Large ticks of camels wherever these animals now or recently occurred) .... H. DROMEDARII
Figures 162 and 163

6. Lateral grooves confined to posterior third of scutum; scutum almost impunctate except in caudal depressed area. (Usually small ticks; Mediterranean Basin, Near and Middle East; East African coastal areas and northern Sudan) .... H. EXCAVATUM
Figures 166 and 167

Lateral grooves reaching at least scutal midlength (if specimen is heavily punctate, grooves may be obscure) 7

7. Scutum smooth, shiny with rare, scattered large punctations; lateral grooves long and usually very distinct; posterior grooves well marked; legs usually not ringed .... H. DETRITUM*
Figures 160 and 161

---

*A closely related "form" of uncertain taxonomic status, "H. scupense", with some biological and morphological characters differing from those of typical H. marginatum, occurs in parts of the Soviet Union and southeastern Europe.

Scutum either densely punctate, irregularly punctate, or lightly punctate except in caudal area where punctations are dense 8

8. Scutum densely, entirely, and almost always uniformly covered by punctations often obscuring the lateral grooves 9

Scutum lightly or irregularly punctate, or densely punctate only posteriorly 11

9. Scutum strongly narrowed posterolaterally to form an almost rectilinear posterior margin. (West Africa) .... H. IMPRESSUM
Figures 174 and 175

Scutum bluntly rounded posteriorly 10

10. Circumspiracular area glabrous. Scutum brownish, punctations not so dense as in *H. rufipes*. Legs with dorsal enamelling on middle segments of two hind pairs. (Russia, Middle East, and South African Karroo) .... H. TURANICUM
Figures 204 and 205

Circumspiracular area hirsute. Scutum black, punctations usually very dense. Leg segments usually distinctly annulated but lacking dorsal enamelling. (Near East, Arabia, Northeast Africa, tropical and South Africa) .... H. RUFIPES
Figures 182 and 183

11. Lateral grooves long but often not well marked. Scutum irregularly punctate, posterior area not strikingly differentiated, posterior margin bluntly rounded. (Far, Middle, and Near East, Arabia, Northwest Africa, rare in Northeast Africa)....................................H. MARGINATUM
Figures 178 and 179

Lateral grooves long, distinct, deeply and cleanly delineated. Scutum smooth and shiny except posteriorly where it is densely punctate, posterior margin usually rectangular. (Strictly African, not including North Africa)..............................12

12. Central festoon undifferentiated. (Throughout Ethiopian Faunal Region)..H. TRUNCATUM
Figures 186 and 187

Central festoon forming a whitish or brownish parma. (East and West Africa)..H. ALBIPARMATUM
Figures 194 and 195

FEMALES

1. Genital apron divided into two lateral fields by a vertical median depression extending from posterior margin to mid-length of apron. Scutum smooth. (Subgenus Hyalommina)..............................H. HUSSAINI
Figures 200 and 201

Genital apron not divided by a vertical median groove..2

2. Coxa I simple, with two wide, short spurs from posterior margin. Scutum shiny, smooth, with few scattered, large, deep punctations. Genital apron a flat, widely triangular shield that becomes greatly depressed posteriorly upon engorgement. (Subgenus Hyalommasta)...................H. AEGYPTIUM
Figures 192 and 193

Coxa I deeply divided into a narrow external branch and a wide internal branch. (Subgenus Hyalomma)..............................3

3. Scutum regularly and completely covered by rather uniform, discrete punctations of moderate or large size*...4

Scutum with few to moderate number of irregular punctations...................................6

---

*Exceptional specimens of H. turanicum may lack this aspect. Others of H. marginatum and H. impeltatum may approach this aspect.

4. Genital apron a wide triangle composed of a protruding anterior ridge and a deeply, abruptly depressed, narrower posterior button.................................H. IMPRESSUM
Figures 176 and 177

Genital apron a wide shield with a broad posterior margin and not divided as above..5

5. Circumspiracular area hirsute. Middle segments of two pairs of hind legs lacking dorsal enamelling..H. RUFIPES
Figures 184 and 185

Circumspiracular area glabrous, or with few hairs. Middle segments of two pairs of hind legs enamelled dorsally..H. TURANICUM
Figures 206 and 207

6. Genital apron an elongate triangle or circular...7

Genital apron distinctly wider than long, a transverse oval, triangle, or shield..10

7. Genital apron a narrowly pointed triangle with lateral margins definitely longer than dorsal margin; gradually depressed in profile. Scutum usually as wide as or wider than long; with few, scattered large punctations; uncommonly with scattering of smaller punctations; surface frequently rugose. Usually large ticks..................................H. DROMEDARII
Figures 164 and 165

Genital apron circular or a less narrowly pointed triangle with lateral margins approximating dorsal margin in length. Scutum usually somewhat longer than wide; punctations variable; usually less rugose. Size moderate (except H. schulzei) to small...8

8. Genital apron a triangle bounded on each side by a lobe; greatly bulging in profile. Scutum usually with sinuous posterior margin, numerous small punctations, and two irregular, submedian rows of large, deep punctations. Usually moderate size.................................H. IMPELTATUM
Figures 172 and 173

Genital apron circular or triangular but lacking lateral lobes; greatly bulging or gradually depressed in profile. Scutum usually with very few punctations..9

9. Genital apron triangular; gradually depressed except when greatly engorged but never convex in profile. Scutum smooth and shiny with very few, scattered punctations of large size; uncommonly with superficial small punctations. Usually moderate size...H. DETRITUM
Figures 160 and 161

Genital apron small, triangular or circular, convex or bulging in profile. Scutum usually lacking smooth, shiny appearance of H. detritum; few, scattered punctations, those present small or moderate size; almost never large. Usually small size and narrow shape..H. EXCAVATUM
Figures 168 and 169

10. Genital apron a transverse oval, in profile deeply concave posteriorly and with a narrow, bulging lip anteriorly. Scutum usually smooth and shiny with few scattered punctations, with or without inconspicuous interstitial punctations. (Ethiopian Faunal Region only)............................11

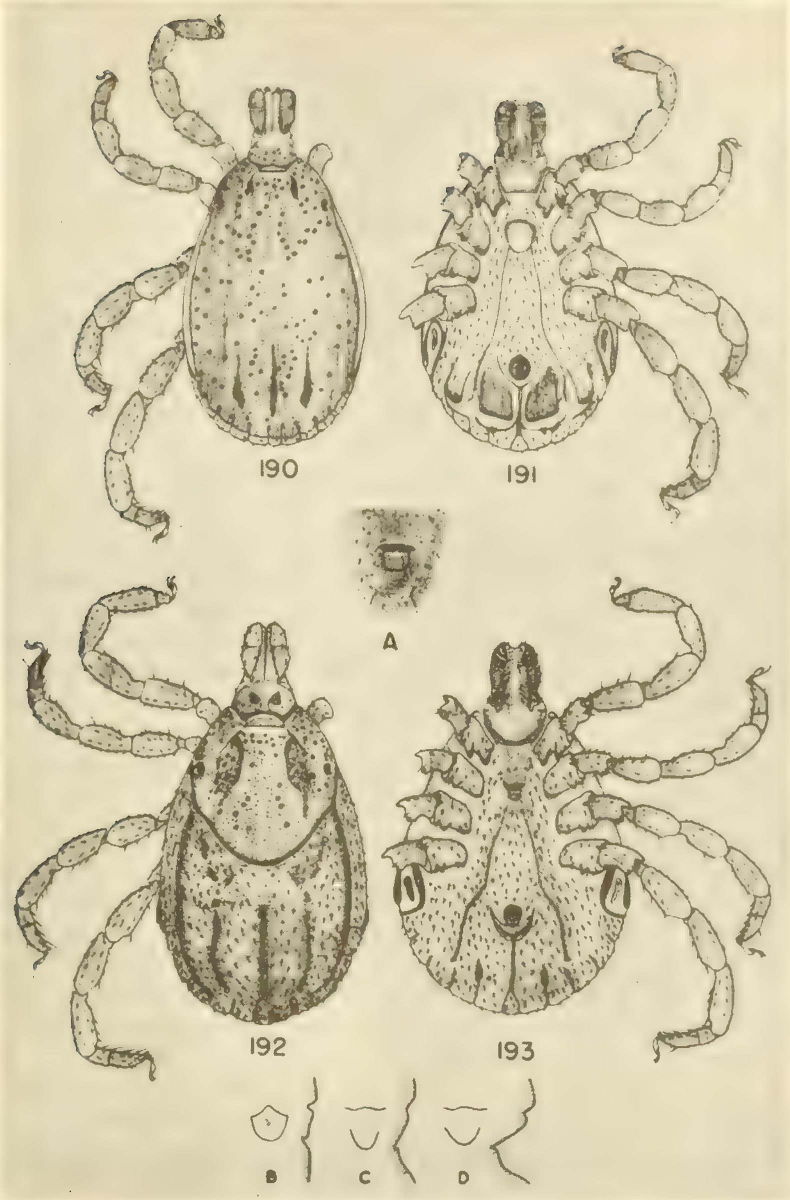
Genital apron not deeply concave in profile. (Absent or exceptional and only peripherally in Ethiopian Faunal Region)..12

11. Common, widely ranging species throughout Ethiopian Faunal Region...............*H. TRUNCATUM*
Figures 188 and 189

Uncommon species, known by small populations only from Kenya, Tanganyika, and Togo. Differentiated only by association with male.................*H. ALBIPARMATUM*
Figures 186 and 187

12. Genital apron a large, transverse oval; flat, somewhat protruding, or convex in profile. Circumspiracular area usually markedly pilose. Usually large size. (Palearctic Faunal Region only)...*H. SCHULZEI*
Figures ___ and ___

Genital apron a large robust shield; transversely oval or widely triangular in outline; strongly bulging in profile; scutum with moderate to numerous punctations of variable size...................*H. MARGINATUM*
Figures 180 and 181



Figures 190 and 191, ♂, dorsal and ventral views
Figures 192 and 193, ♀, dorsal and ventral views

A, ♀, genital area. B to D, genital apron, outline and profile.
B, unengorged. C, partly engorged. D, fully engorged.

HYALOMMA AEGYPTIUM
Specimens from Land Tortoise, Eastern Anatolia
Hoogstraal Collection

PLATE LV

HYALOMMA AEGYPTIUM (Linne, 1758).

(Figures 190 to 193)

THE TORTOISE HYALOMMA

The much mooted name *H. aegyptium* has been frequently used as a "catchall" by workers in many countries for a number of species. Consequently much literature referring to *Hyalomma* ticks has been hopelessly confused, even to the present day.

King (1926) lumped all Sudan species under the name *H. aegyptium**, as did most other workers on African and Near Eastern ticks of his time. *H. aegyptium* (Linne, 1758) is now recognized as a distinct parasite of tortoises in the Mediterranean area and Near East. In Russia it is confined to Crimea, Georgia, Armenia, the Caucasus, Azerbaijan, Turkmen, Uzbek, and Tadzhik (Pomerantzev 1950). It is common in many parts of Asia Minor (Hoogstraal, ms.) and occurs in Afghanistan (Anastos 1954).

The tortoise hyalomma does not occur in the Sudan, elsewhere in tropical or southern Africa, or in Europe away from the Mediterranean and Black Sea areas. Although originally described from Egypt, where tortoises are said to have been numerous on the Mediterranean littoral, *H. aegyptium* apparently is now extinct here. In present-day Egypt, tortoises occur only a few miles east of the Libyan border - extremely rarely as far as seventy miles east of Libya - and in Sinai a few miles west of Palestine. No ticks have been found on recent Egyptian tortoises, except on specimens from Palestine in Cairo pet-shops.

Tortoises are the hosts of predilection of adult *H. aegyptium*. Exceptionally, lizards, hares, and hedgehogs are attacked. While other mammals may be infested rarely, long lists of various hosts for this tick are all erroneous, based as they are on old records in which all species were lumped under the name *H. aegyptium*. In

---

*With reference to reports of "*H. aegyptium*" from the Sudan, it should be noted that the actual tick species with which O'Farrell (1913A,B), did his interesting work on an entomogenus trypanosome, *Crithidia* (?*Herpetomonas*) *hyalommae*, cannot now be determined.

Anatolia, however, when rearing larvae and nymphs from tick-infested animals, it was found that these stages commonly attack tortoises, lizards (Agama), partridges, man, hares, hedgehogs, and a wide variety of rodents (Hoogstraal, ms.). A number of Russian host records were presented by Olenev (1928B).

The life cycle of "H. aegyptium" described by Nuttall (1915) applies to H. marginatum. Nuttall's lot 1305a in British Museum (Natural History) was used for this study. No material for his lot X (from Rome) can now be located. It appears that the study of the external morphology of each stage and of the bionomics of "H. aegyptium" in India (Sharif 1924) applies actually to H. excavatum, but this is not certain.

A popular article concerning the actual H. aegyptium has recently appeared in the Illustrated London News (Browning 1950). Based on living ticks arriving in the British Isles on pet-shop tortoises from southern Europe, this account should interest persons who frequently encounter this name promiscuously used in the literature. Distribution data in the Browning paper are from literature references under H. aegyptium, and, therefore, far more extensive than the actual geographic range of this species in nature.

Contemporary published reports on disease transmission by ticks unfortunately continue to perpetuate the early confusion in identification of species in this genus. The tortoise parasite, H. aegyptium, has never been incriminated as a vector or reservoir of pathogenic organisms of man, other mammals, or birds.

H. aegyptium does, however, transmit two sporozoa to land tortoises in northwestern Africa and in the Near East. These are Haemogragarina mauritanica and H. stepanovi (cf. Sergent and Sergent 1904, Laveran and Negre 1905, Nicolle and Comte 1905, Laveran and Pettit 1910, Brumpt 1938C; and Laveran 1901, Marzinowsky 1927, Popovici-Baznosano 1901,1906,1907, and Reichenow 1910). Another parasite from this tick Coelomoplasma hyalommae, has been briefly described by Brumpt (1938D) without further classification as to group (see also Brumpt 1938E). Further studies on these parasites have not been encountered.

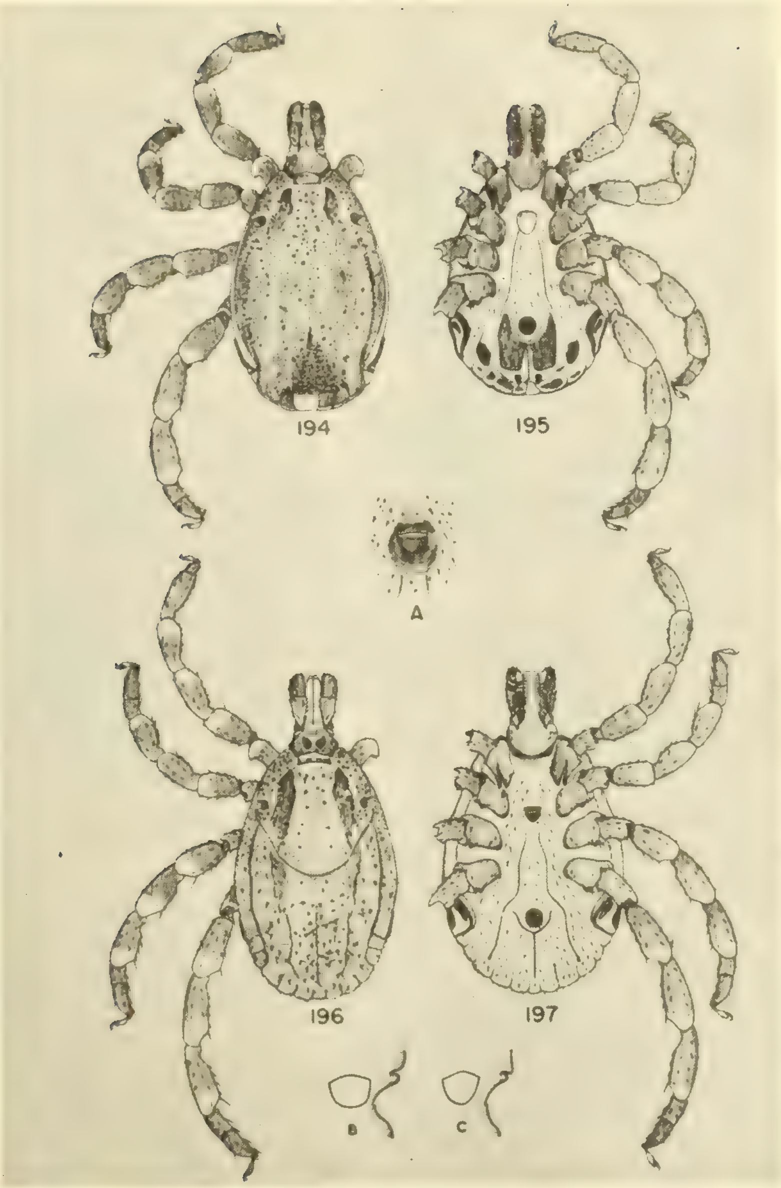
Certain unusual morphological characters of this easily recognized species cause the tortoise hyalomma to be considered in a separate subgenus, *Hyalommasta* Schulze, 1930.

H. aegyptium punctata Schulze, 1919 (see also Kratz 1940), a name proposed for a single specimen from Malta and subsequently overlooked by even Schulze himself, is undoubtedly a synonym of *H. aegyptium*.

Pomerantzev (1950) considers *Dermacentor rosmari* Ass (1935), described from nymphs from walrus in the Kara (White) Sea and said to be the northernmost ticks on record, as a synonym of *H. aegyptium*. On the basis of the original description and illustrations of *D. rosmari*, its systematic position is uncertain but this synonymy is hardly convincing.

The synonymous name *H. syriacum* Koch, 1844, has frequently been used for the actual *H. aegyptium*. So far as has been determined, *H. syriacum* has been confused with no other species.

Both sexes can be readily distinguished from key characters provided herein.



Figures 194 and 195, ♂, dorsal and ventral views
Figures 196 and 197, ♀, dorsal and ventral views

A, ♀, genital area. B and C, ♀, genital area, outline and profile, unengorged.

HYALOMMA ALBIPARMATUM
Specimens from cattle, Kenya; from Nuttall lot 3773, exchange, British Museum (Natural History). Hoogstraal collection.

PLATE LVI

HYALOMMA ALBIPARMATUM Schulze and Schlottke, 1930

(= H. BRUNNEIPARMATUM S. and S., 1930).

(Figures 194 to 197)

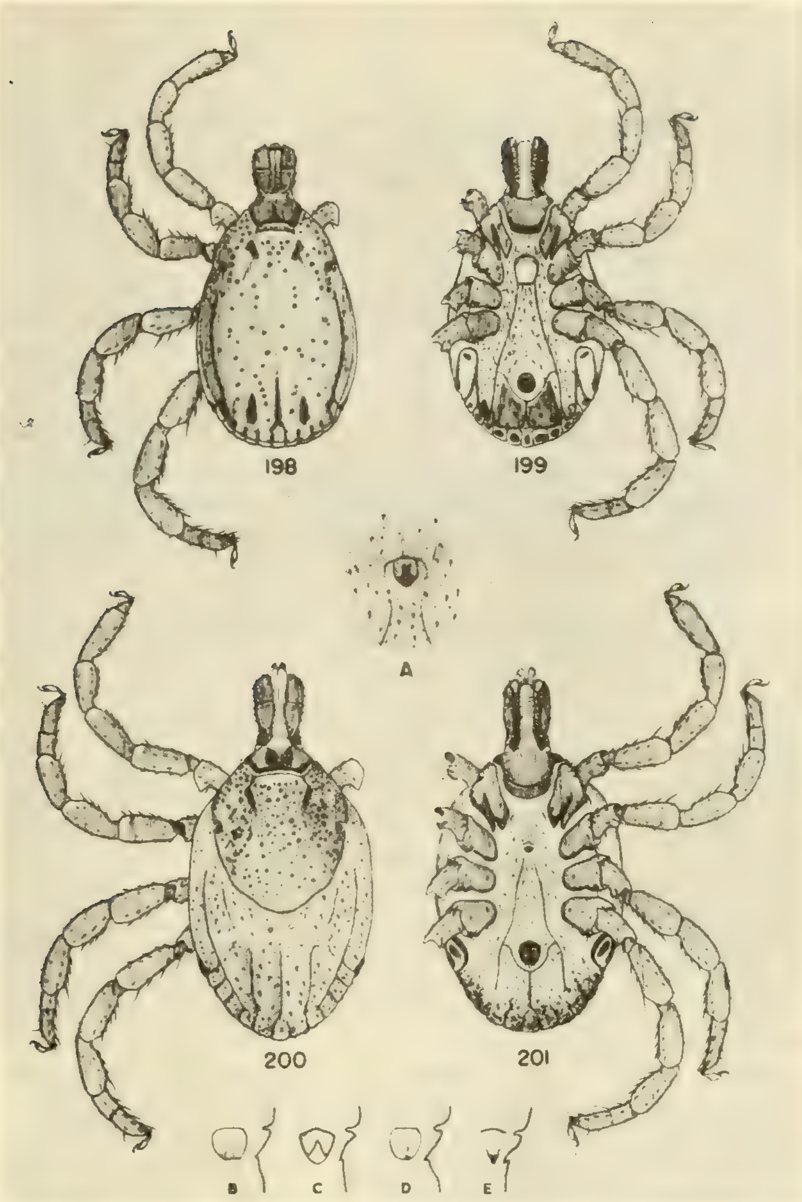
THE PARMATED AFRICAN HYALOMMA

H. albiparmatum, presently known only from Kenya, Tanganyika, and Togo, is similar to *H. truncatum* except that the central festoon is differentiated as a parma in the form of a celluloidlike cover of variable size, shape, and color. No constant characters have been discovered for differentiating females of these two species.

Delpy (1949B) considered *H. impressum albiparmatum* Schulze and Schlottke, 1930, from East Africa, as a synonym of *H. marginatum* (= *H. savignyi*) or questionably of *H. truncatum* (= *H. transiens*); he considered *H. brunneiparmatum* of Schulze and Schlottke (1930) to be a synonym of *H. marginatum* (= *H. savignyi*).

Feldman-Muhsam (1954) stated, after examining Kenya laboratory-reared material of *H. albiparmatum* submitted by J. B. Walker that *H. albiparmatum* is a synonym of *H. truncatum*. Dr. Theiler and the writer, after examination of the same material, are convinced that Walker's *H. albiparmatum* is a distinct genetic entity worthy of full species rank. It is also apparent from Walker's material and from other series in British Museum (Natural History) collections that *H. impressum brunneiparmatum* Schulze and Schlottke, 1930, from Togo is a synonym of *H. albiparmatum* and not of *H. truncatum* as stated by Feldman-Muhsam 1954. Miss Walker is preparing a report on this species for publication in Parasitology. Hosts of the parmated African hyalomma appear to be the same as those of *H. truncatum*.

British Museum (Natural History) collections contain material from cattle and from a rhinoceros from Zatta Plains, Kajiado, Namanga, and the Masai Reserve, Kenya (HH det.). J. B. Walker (correspondence) has seen specimens from a rhinoceros from Iringa District, Tanganyika, and from a warthog in Chunya District, Tanganyika.



Figures 198 and 199, ♂, dorsal and ventral views
Figures 200 and 201, ♀, dorsal and ventral views

A, ♀, genital area. B to E, ♀, genital apron, outline and profile; all unengorged; E dried, contracted specimen.

HYALOMMA HUSSAINI
Specimens from Bihar, India (det. Sharif)
(Rocky Mountain Laboratory collection).

PLATE LVII

MARINE BIOLOGICAL LABORATORY
WOODS HOLE
LIBRARY
MASS.

HYALOMMA HUSSAINI Sharif, 1928.

(Figures 198 to 201)

HUSSAIN'S INDIAN HYALOMMA

AND REMARKS ON THE SUBGENUS HYALOMMINA

Special note should be made of the subgenus *Hyalommina*, established by Schulze (1919) for the new species *H. rhipicephaloides* from the Red Sea area. Subsequently, Schulze (1936) placed *H. lewisi* from Tanganyika (and Kenya) in this subgenus and Sharif (1928 and 1936) included *H. kumari* and *H. hussaini* from India. These are discussed below.

The criterion proposed by Schulze for this subgenus is the absence of subanal shields.

With regard to the so-called "*H. rhipicephaloides*", it has been our experience during field collecting and study of *Hyalomma* material from the Near East, Asia Minor, Arabia, North Africa, and tropical Africa, that weak, poorly developed, apparently undernourished, runts of any *Hyalomma* species frequently lack subanal shields. Such individuals may be part of a series in which some are typical of a common species (such as *H. excavatum*) and others, usually smaller and weaker, conform to the same species in morphological characters, except that they lack subanal shields. It has also been noted from personal field experience and from series in British Museum (Natural History) collections, especially those of the late Professor Buxton from Iraq and Palestine, that when nymphs are removed from a bird, lizard, or small mammal and placed in a vial to molt, the resultant adults, obviously affected by abnormal, artificial conditions, are frequently frail and lack subanal shields. This feature is the rule rather than the exception among adults reared from nymphs that have become overgrown by the host skin (see below and page 447).

Schulze (1932C) referred to "*Hyalomma* (*Hyalommina*) *rhipicephaloides*" as a "half endoparasite" (and compared it with

Amblyomma nymphs to support a morphological theory). The conception of a separate species with unique "half-endoparasitic" habits is not supported by field and laboratory observations. In several *Hyalomma* species observed in Egypt, long-feeding immature stages become overgrown by the host skin. Poorly developed adult "*Hyalomminas*" result from these nymphs. If removed early enough, such nymphs may molt into typical though frail adults of recognized species with or without subanal shields. Other larvae and nymphs that attach to the ears, which do not react to the engorging ticks by producing a large amount of tissue, usually develop normally.

On the basis of many such variants among specimens of *H. excavatum* examined for the present study it is apparent that Delpy's (1949B) synonymy of *H. rhipicephaloides* under *H. excavatum* is correct.

H. lewisi Schulze, 1936, from tropical Africa is the result of similar misinterpretation of *H. truncatum* by Schulze and his students.

In the present collection, a few specimens of *H. truncatum* are poorly developed and lack subanal shields. These are similar to specimens (in the Rocky Mountain Laboratory) determined by Schulze as *H. lewisi* from Kenya and Tanganyika. There is no question but that *H. lewisi* is a synonym of *H. truncatum*. Delpy (1949B), probably inadvertently, listed *H. lewisi* as a synonym of *H. excavatum*. Kratz (1940) retained *H. lewisi* in the "subgenus *Hyalommina*" even though he noted that "some specimens retained subanal shields while others lacked them".

With regard to *H. hussaini* Sharif, 1928, the Rocky Mountain Laboratory collections contain enough constant specimens of this species (described below) from India to indicate beyond a doubt that *H. hussaini* is a valid species. It is coincidental that this species conforms to the criteria proposed for the subgenus *Hyalommina*; *H. hussaini* rather than *H. rhipicephaloides* might, therefore, be considered as the type species of this subgenus. The absence of subanal shields apparently has become a genetically-established character in Indian populations. As stated below, other constant male and female characters also validate this species. Thus, recognition of the subgenus Hyalommina would be justified. It is, however, likely that the absence of subanal shields is not a genetic character in Hyalomma populations of Africa and the Near East.

Conclusions on the subgenus Hyalommina may be summarized as follows: Such an entity apparently does exist, but criteria proposed for it apply to a species (H. hussaini and possibly H. kumari) different from that originally proposed as the type for this subgenus (H. rhipicephaloides), this latter species being merely a morphological variant of H. excavatum.

These conclusions are based on study of series of preserved specimens, on field rearing of specimens, and on laboratory observations of wild-caught subdermal specimens from rodents. More formal laboratory studies on the phenomenon of loss of subanal shields among other species are indicated.

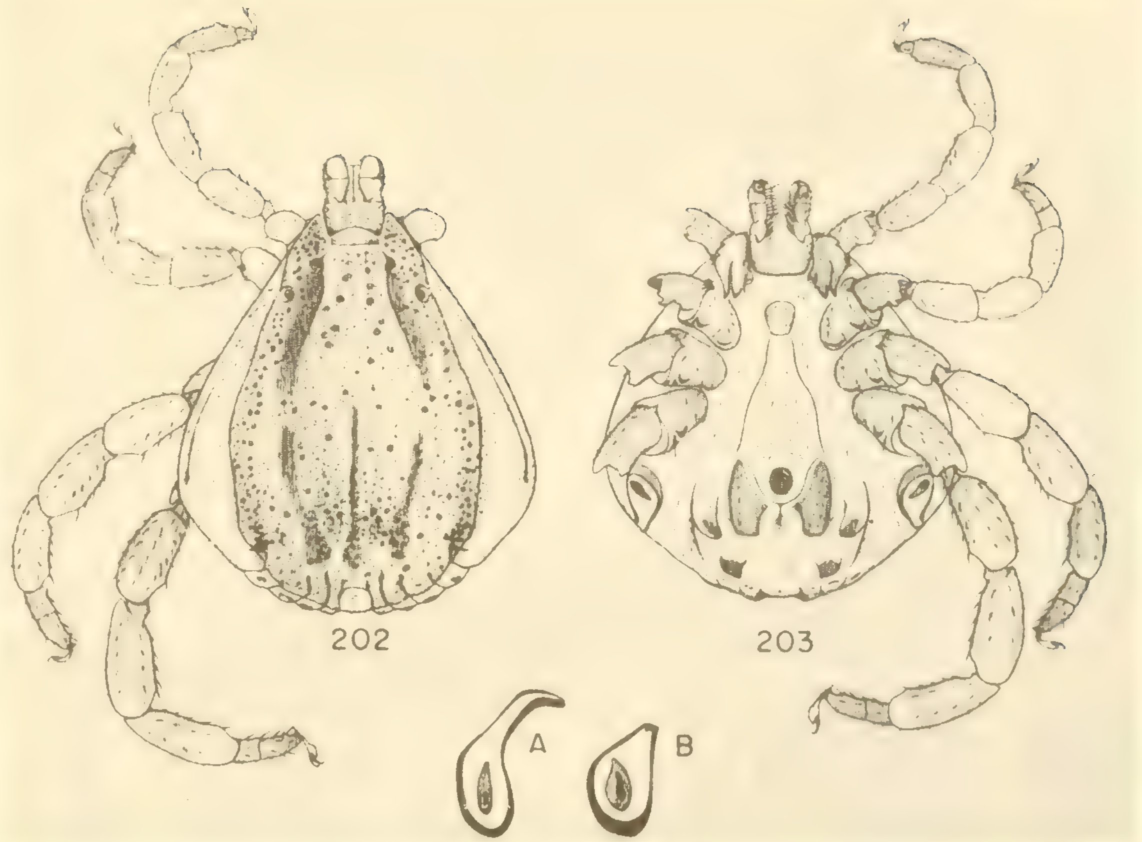
Sharif (1928) also described H. hussaini brevipunctata and H. kumari from Indian populations on the basis of slight differences in color, lateral grooves and tarsi. No specimens of these forms have been available for the present study.

Sharif (1928) lists specimens of H. hussaini from the following India areas: Bihar, Orissa, Central Provinces and Madras and Bombay Presidencies. The subspecies brevipunctata is listed from the same areas as well as from Bengal. H. kumari is also known from the first localities and Assam and Punjab. Hosts are cattle, buffalos, horses, goats, sheep, dogs, tiger, and various kinds of deer.

Sharif (1930) illustrated a specimen of H. hussaini with unequal adanal shields. Material from Portugese India has been reported (Santos Dias 1954J).

Both sexes of H. hussaini have such unique morphological characters that it is difficult to comprehend why Delpy (1949B) placed this species in synonymy under H. excavatum. Sharif's (1928) original description is excellent as are the illustrations of the male. This sex is characterized by large, broad adanal shields, absence of subanal shields; bright, shiny scutum with long, pronounced lateral grooves; long, narrow posteromedian grooves, shorter and wider paramedian grooves; rarity of punctations that are widely scattered over scutal surface but usually arranged in lines bordering the posterior grooves, and small size (less than 3.00 mm. long and 2.00 mm. wide).

The female also has a smooth, shiny scutum with few punctations, those present are similar to those of the male. Porose areas of the females at hand are notably large and distinct. The genital apron is unique in that it is divided by a medioposterior depression that is either a narrow, median, posterior groove or expanded posteriorly to include the posterior periphery. In outline the genital apron is subrectangular to subtriangular, in profile it is more or less gradually depressed posteriorly. The female size unengorged is only slightly greater than that of the male.



Figures 202 and 203, ♂, dorsal and ventral views
A, spiracular plate, H. dromedarii. B, spiracular plate, H. schulzei.

HYALOMMA SCHULZEI

Specimen from camel, Central Iraq.
Hoogstraal Collection from Dr. G. H. Hall.
For ♀ illustrations, see PLATE XVIIC

PLATE LVIII

HYALOMMA SCHULZEI Olenev, 1931(B).

(Figures 202 and 203,337 and 338)

THE NEAR EASTERN CAMEL HYALOMMA

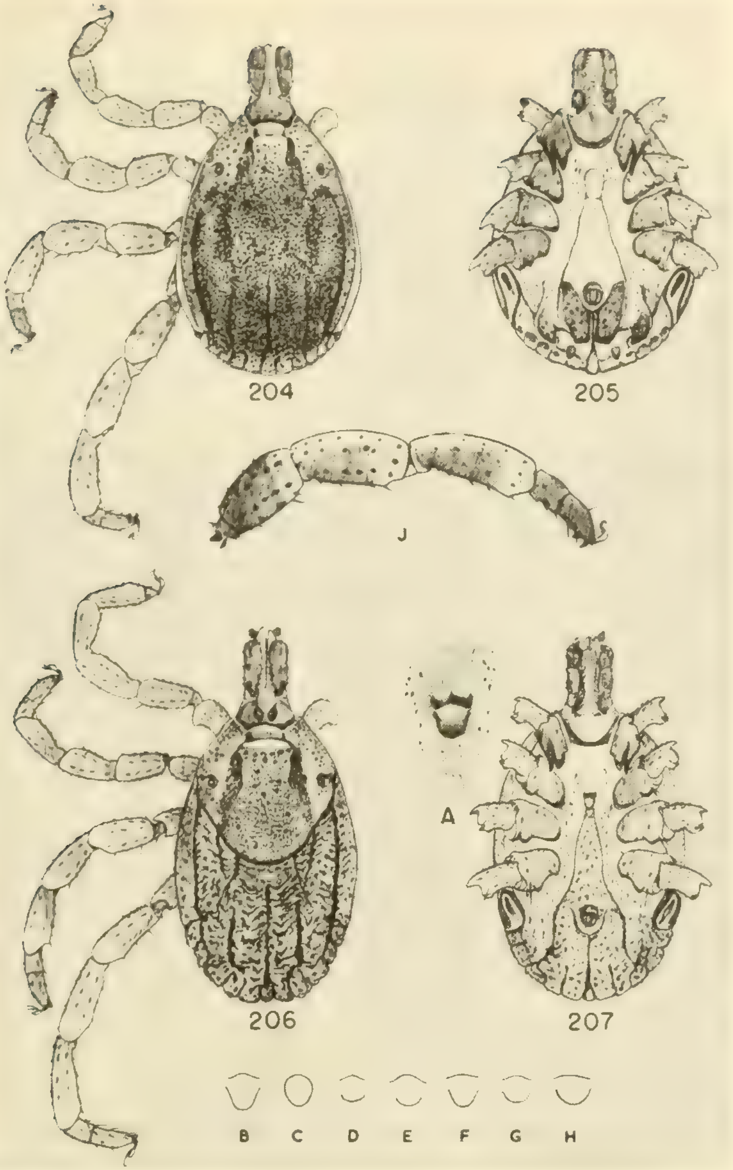
H. schulzei a hyalomma of restricted geographical range, appears from male characters to be a giant relative of H. dromedarii. The female genital apron, however, differs so greatly from that of H. dromedarii that the relationship of these two species does not appear to be actually so close as previously considered. It is also likely that females associated by Olenev with males of H. schulzei in the original description of the species included some specimens of H. dromedarii.

The geographic range of H. schulzei extends from Iran (Olenev 1931A,B, Delpy 1937) and Afghanistan (Anastos 1954), through Iraq (Hoogstraal, ms.), and Palestine (Schulze 1936C; Kratz 1940, Adler and Feldman-Muhsam 1946,1948) into Sinai and the Eastern and Western Deserts of Egypt some 200 miles west of Alexandria (Hoogstraal, ms.). It is absent in Russia (Pomerantzev 1950) and is not represented in the present collections from Libya, Yemen, coastal East Africa, or Turkey.

Hosts of adults mentioned by all authors and represented in our collections are camels, and Pomerantzev (1950) adds cattle. Hosts of immature stages have not previously been determined. In Sinai and Egypt (Hoogstraal, ms.), nymphs (reared to adults) have been found on hares, Lepus capensis subsp., and fat sandrats, Psammomys o. obesus. Unfed, newly molted adults have been taken from burrows of jirds, Meriones c. crassus.

The male is large and when engorged measures up to 8.00 mm. in length and 7.00 mm. in width. The extreme width is due to considerable lateral stretching of the integument during feeding; unengorged specimens are approximately 4.00 mm. wide. The scutum of specimens at hand and previously described has parallel lateral margins while those of H. dromedarii are usually convexly arched. The palpi of available specimens are notably short and robust; the parma is subrectangular; in H. dromedarii it is typically triangular. The most notable distinction between the two species is the short, almost tailless, female-type spiracular plate of the male H. schulzei that is usually surrounded by numerous hairs. This type of spiracular plate is found in the male of no other species in the genus. [An approach to this spiracular form occurs in "H. scupense"; see page 418.] In other characters, these two species are similar.

Females of these two species are also superficially similar but the genital apron of H. schulzei is considerably different and the scutum (of available specimens) is slightly more elongate than that of H. dromedarii. The genital apron is subrectangular with slightly convex anterior and posterior margins and rounded junctures; this convexity is increased with extreme engorgement. In profile, the apron is flat when unengorged but after feeding it protrudes and is markedly depressed posteriorly. The female is illustrated herein in the APPENDIX (PLATE XIXC) inasmuch as distinguishing features were recognized only near the termination of the present study after other illustrations had been numbered. Delpy and Adler and Feldman-Muhsam did not describe the female genital apron of the meagre amount of material available to them. The short, wide scutal outline with a bluntly rounded posterior margin, as illustrated, is similar in all available specimens and corresponds to that delineated by Pomerantzev (1950). Other workers however, have shown it as more elongate and with the posterior margin gradually converging to a fairly narrow point.



Figures 204 and 205, ♂, dorsal and ventral views
Figures 206 and 207, ♀, dorsal and ventral views

A, ♀, genital area, unengorged. B to H, ♀, genital apron, outline. B and C, unengorged. D and E, slightly engorged. F to H, moderately engorged. J, ♂, Leg III, dorsolateral view to show enamelling.

HYALOMMA TURANICUM
South African Karroo Specimens Reared by Dr. G. Theiler

PLATE LIX

HYALOMMA TURANICUM Pomerantzev, 1946

(= H. RUFIPES GLABRUM Delpy, 1949)

NEW NAME COMBINATION

(Figures 204 to 207)

THE ENAMEL-LEGGED HYALOMMA

H. turanicum, is considered by South African and French workers as a subspecies of *H. rufipes* and by Russian workers as a subspecies of *H. marginatum* (= *H. plumbeum* of Pomerantzev).

The specific entity of *H. glabrum* has been demonstrated in laboratory rearings by Theiler, who has kindly provided material for the present study and has provided a manuscript (Theiler 1956) on distribution and ecology in South Africa for use herein in advance of her own publication.

H. turanicum (= *H. glabrum*) appears to have been introduced into the arid South African Karroo on Persian sheep. It is unknown elsewhere in Africa. Persian sheep were originally introduced into South Africa in 1872, having been purchased from a ship from the Mediterranean then anchored in Table Bay (Lounsbury 1904E). Subsequently others were imported from Aden. The exact locality from whence any of these importations originated does not appear definitely to be known. A number of flocks were scattered about South Africa at the time (1904) Lounsbury reported their high degree of immunity to heartwater.

H. rufipes glabrum was briefly described by Delpy (1949A) from material reared from females from Karroo sheep sent to him by Theiler. The source of this material has been identified in correspondence with Dr. Delpy and Dr. Theiler; it is not found in the literature. Subsequently, Delpy (1949C,1952) indicated that *H. rufipes glabrum* is a poorly known, two host tick, that it also occurs in Iran, and that it is not of considerable importance in the transmission of bovine theileriasis, *Theileria annulata*. This species occurs in southern Russia (Pomerantzev

1950; as H. plumbeum turanicum) and a single specimen has been collected in Afghanistan (Anastos 1954; as H. rufipes glabrum).

H. marginatum turanicum Pomerantzev, 1946 /subsequently (1950) considered as a subspecies of H. plumbeum by the same author 7 is obviously the same tick as H. rufipes glabrum Delpy, 1949. It is necessary, therefore, to give the Soviet name priority. There is no biological reason or taxonomic utility for considering H. turanicum as a subspecies of any species. Theiler (1956) continues to apply the name H. glabrum to South African populations of this species.

Rousselot (1951) reported H. rufipes glabrum from French West Africa but omitted it from his 1953B work, apparently after having reconsidered the identification of pertinent material. Villiers (1955) also used this name for material from the same area. It is assumed that these data refer actually to H. rufipes.

Fonesca, Pinto, Colaco, Oliveira, Branco, da Gama, Soares Franco, and Lacerda (1951) reported "H. rufipes glabrata" from Portugal, but Theiler, who has seen their material, states (correspondence) that it is an entirely different species, probably H. marginatum.

According to Pomerantzev (1950) the biology of H. turanicum was reported in 1945 by Lototsky, pp. 69-130, but it has been impossible to secure further details for the present study. The distribution of this tick is stated to be southern Khazakstan, Middle Asia, and Iran. To this range, the South African Karroo and Afghanistan should be added.

Where it occurs in the Soviet area, H. turanicum ranges through a number of altitudinal zones. It lives in tugai meadows, in semidesert, and in low areas of fields at the base of hills and on mountain slopes to the wooded belts. Adult hosts are "large and small horn-bearing animals", especially cattle, and also horses. A single Afghanistan male was taken from a camel (Anastos 1954). Immature stages attack birds; these hosts are listed below and those most commonly infested are preceded by an asterisk.

Alectoris kakelik kakelik (?= *A. graeca falki*), Chukar partridge
Phasianus chrysomelas bianchii (= *P. colchicus bianchii*), Ring-neck pheasant
Columba livia neglecta, Rock dove
Columba eversmanni, Eastern stock pigeon
Streptopelia turtur arenicola, Turtle dove
Neophron percnopterus, Egyptian vulture
Coracias garrulus, Roller
Merops persicus, Iranian beeater
Upupa epops, Hoopoe
Sturnus vulgaris dresseri, Starling
Pastor roseus, Rosy starling
Carduelis carduelis subcaniceps, Goldfinch
Passer domesticus bactrianus, House sparrow
**Passer montanus zaissanensis*, Tree sparrow
Miliaria calandra buturlini (= *Emberiza c. buturlini*), Corn bunting
Emberiza stewarti, White-capped bunting
**Emberiza buchanani huttoni*, Grey-necked bunting
Emberiza icterica, Red-headed bunting
**Melanocorypha calandra*, Calandra lark
Calandrella acutirostris, Oriental short-toed lark
**Alauda gulgula inconspicua*, Oriental sky lark
Anthus campestris griseus, Tawny pipit
Sitta tephronota, Rock nuthatch
Lanius minor, Lesser grey shrike
Lanius collurio isabellinus, Red-backed shrike
Phylloscopus nitidus viridanus, Greenish willow warbler
Sylvia curruca, Lesser whitethroat
Sylvia althaea, Hume's lesser whitethroat
Saxicola torquata, Stone chat
Oenanthe capistrata, White-headed chat
Oenanthe opistoleuca, Strickland's chat
Phoenicurus ochruras phoenicuroides, Black redstart

Russian adults feed during the warm period of the year, commencing late in March in the valleys and at the end of April or early in May in the mountains. Maximum infestations occur during the warm summer period. The duration of the life cycle, period of most active attack by larvae, and seasonal dynamics are not completely known. The overwintering period is seven months. Lototsky's experimental observations are as follows: The female remains quiescent for 28 days between terminating feeding and commencing oviposition. Eggs hatch after 36 days; larvae and nymphs each feed for eight days. Twenty-four days after feeding, nymphs molt to adults. (See also Tselishcheva 1953).

The ecology and distribution of H. turanicum (= H. glabrum) in southern Africa are described by Theiler (1956). It is present only in the Karroo areas of the eastern Cape, western and southwestern Cape, the Cape midlands, and the Brokenveld of southern Orange Free State, but absent elsewhere in the Union and in Basutoland, Namaqualand, Bushmanland, Bechuanaland, and Southwest Africa. Although this tick exists in areas with as little as 0.5 inches of annual rainfall, it is more common where five to ten inches of rain falls annually. It is absent in areas with over fifteen inches of annual rainfall, in winter rainfall areas, and, with a single exception, where rain is distributed throughout the year. South African cold and heat do not appear to restrict the range of H. turanicum inasmuch as it is found in areas with up to 150 days of frost per year. This is the only Hyalomma in localities where snow occurs in South Africa. Karroo type vegetation areas including those mixed with Mesembrianthemum, sourveld grass, and, to a lesser extent, sweetveld grass support H. turanicum. It is absent in all forests, parklands, grasslands, and other desert thorn, succulent, and grass areas. Adults are active during the summer and in some localities during the entire year.

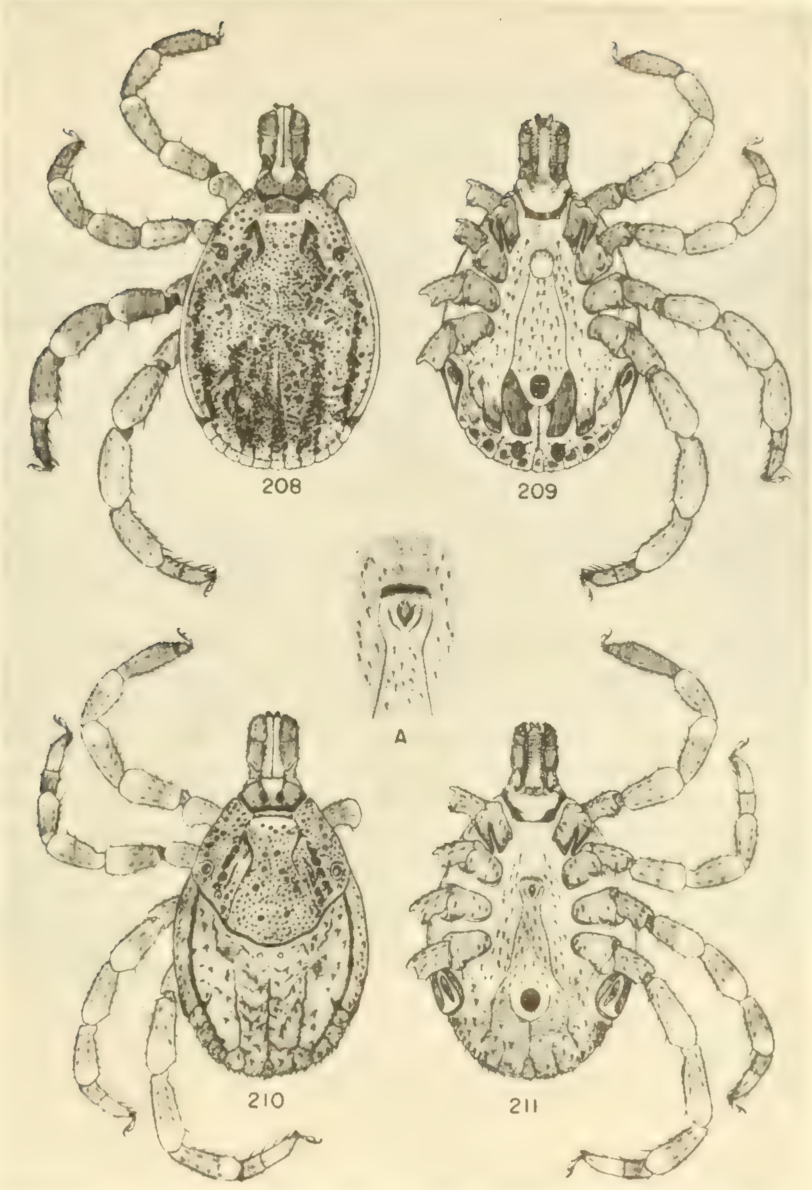
Pervomaisky (1949) unsuccessfully attempted the rearing of a full F_1 generation from parthenogenetic females of H. turanicum.

Neitz (1954) was unable to achieve transmission of the virus of sweating sickness of cattle in South Africa by means of H. turanicum (= H. rufipes glabrum). As already noted, Delpy (1952) indicated that this tick is "not of considerable importance" in transmission of bovine theileriasis, Theileria annulata, in Iran.

The vertical rings of the leg segments of both sexes of H. turanicum are usually not so contrasty as they are in H. rufipes but the middle segments of the two pairs of hind legs show a dorsal enamelling not found in H. rufipes; this is especially distinct in dry specimens. The circumspiracular area of neither sex is pilose and the scutal punctations are not so dense as in H. *rufipes*, except in the scapular area. There is some variation in density of scutal punctations and both sexes may resemble exceptionally heavily punctate individuals of H. *marginatum*; leg characters, however, readily distinguish them. The scutum is usually more leathery and not so black as in H. *rufipes*. The female genital aperture, although unusually variable, is much like that of H. *marginatum* (page 478) and considerably different from that of H. *rufipes*. The various outlines of the genital apron in available material are illustrated in Figure 207 A to H.

These notes are made from material reared and presented by Dr. G. Theiler and from a small number of field collected specimens from Iran. A more extensive comparative study of larger amounts of reared and field collected specimens is indicated.

Theiler's laboratory rearings show the specific entity of this species. Consideration of H. *turanicum* as more closely related to H. *marginatum* than to H. *rufipes* appears justified.



Figures 208 and 209, ♂, dorsal and ventral views
Figures 210 and 211, ♀, dorsal and ventral views

A, ♀, genital area.

<u>HYALOMMA</u> ?SPECIES
French Somaliland Specimens
Hoogstraal Collection

PLATE LX

HYALOMMA ?SPECIES

(Figures 208 to 211)

The exact status of this form is uncertain. Since first mentioned from French Somaliland (Hoogstraal 1953D), a small amount of additional material, all from camels in the Somali biotope, from British Somaliland and Gebel Elba of southeastern Egypt, has been seen. An attempt will be made to obtain living material for rearing studies in order to define the morphological characters and taxonomic position of this form, both sexes of which resemble extreme variations among other species. The consistency with which males and females of this form are found together throughout coastal eastern Africa north of the equator arouses suspicion that this is a distinct genetic entity.

The male subanal shields lie directly posterior of the central axis of the adanal shields; the scutum has characters in common both with heavily punctate *H. marginatum* and *H. impeltatum*. The female scutum is also similar to that of both of these species but the genital apron is like that of *H. dromedarii* although more depressed posteriorly. The outline of this apron in the specimen illustrated (Figure 211) represents the maximum width of this structure observed among available material; in other specimens it is more narrowly and elongately triangular, as in *H. dromedarii*. The apron is not flanked by two lobes as in *H. impeltatum*, and its profile differs greatly from that of *H. impeltatum*.

IXODES

INTRODUCTION

Ixodes ticks are highly specialized in their habits. They frequently parasitize small or seldom-examined hosts and are so small themselves that they are easily overlooked. Of some twenty-five species in Africa, six occur in the Sudan. Only sixteen specimens of the whole genus have been collected in the Sudan, all but three of these by the writer. This paucity of material is in striking contrast to Kenya, Cameroons, and Nigeria, where careful collecting is fairly productive for several species.

Phylogenetically, *Ixodes* ticks occupy a solitary position as a unique, highly specialized branch from proixodoidea stock. Several exceptional morphological characters may be seen easily by comparison of *Ixodes* illustrations with those of other genera. The absence of eyes in this genus is believed by some to be a primitive character and the sexual dimorphism of the mouthparts is unparalleled in other ixodid ticks.

Intraspecific variation in the African *Ixodes* fauna is still poorly understood because only small amounts of material from many localities are available and probably also because these variations do not conform to those typically expected in ticks. Dr. D. R. Arthur of King's College, University of London, is presently undertaking an exhaustive study of this subject.

Biologically, ticks of this genus offer a wide field for research; their habits differ from all others. To elucidate this, Nuttall (1911A) erected the following biological criteria for *Ixodes* ticks:

I. Species in which both male and female occur on the host.

  (a) Species in which the sexes are found *in copula* on the host (usually on wandering hosts).

  (b) Species in which the sexes are found near each other on the host (on either wandering or fixed habitat hosts).

II. Species in which only females are found on the hosts, and in which males may or may not be known.

Although the males of species confined to the Ethiopian Faunal Region (except Ixodes nairobiensis Nuttall, 1916 and I. hoogstraali Arthur, 1955) are known, their habits are still obscure.

The genus Ixodes has been reviewed by Nuttall and Warburton (1911), to which important additions have been made by Nuttall (1913C,1916). The African representatives of this genus are reviewed by Arthur (ms.), who also proposes a number of new species.

Careful examination of rodents and other small animals, and of dogs and other domestic animals will probably reveal other species in the Sudan, especially on the west bank of Equatoria Province. Search in rodent nests, animal lairs, and bat caves and retreats should prove fruitful.

No African Ixodes has been reported to transmit human diseases, but at least Ixodes cavipalpus and I. rasus are known to bite man. In southern Africa, I. rubicundus is an important cause of tick paralysis of sheep. I. pilosus, to which this condition is most commonly attributed in literature, plays no known rôle in this affliction; early misidentification was the cause of this frequently quoted misstatement (Theiler, correspondence).

KEY TO SUDAN SPECIES OF IXODES

MALES*

1. Legs longer than body. (From bat habitats).................................I. VESPERTILIONIS
Figures 232 and 233

Legs not longer than body. (Not from bats)..2

*The males of I. nairobiensis and of I. s. simplex are not known.

2. Palpal base forming a lateral projection from basis capituli, palpi converging anteriorly. Scutum sharply narrowed posteriorly. (Shrew parasite, uncommonly on other insectivores and rodents)..................I. ALLUAUDI
Figures 339 and 340

Palpi normal, arising from anterior of basis capituli and parallel. Scutum gradually or bluntly rounded posteriorly...3

3. Anal grooves united..........................I. RASUS SUBSP.
Figures 222 and 223

Anal grooves not united posteriorly.........................4

4. Scutum with faint, shallow punctations....................................I. CAVIPALPUS
Figures 216 and 217

Scutum with numerous large, uneven punctations. (Monkey parasite)...............I. SCHILLINGSI
Figures 226 and 227

FEMALES

1. Legs longer than body. (Bat parasite)...................................I. VESPERTILIONIS
Figures 234 and 235

Legs not longer than body.................................2

2. Palpi arising laterally from basis capituli. Scutum abruptly converging posteriorly, with few medium punctations; cervical grooves lacking; lateral grooves fine.....................I. ALLUAUDI
Figure 341

Palpi normal, arising from anterior margin of basis capituli.................................3

3. Anal grooves horseshoe shaped or elliptical, not united posteriorly........................4

Anal grooves either united posteriorly or parallel or divergent posteriorly...5

4. Scutum at least 1.5 times as long as wide; punctations few and fine; lateral ridges distinct......................I. NAIROBIENSIS
Figures 220 and 221

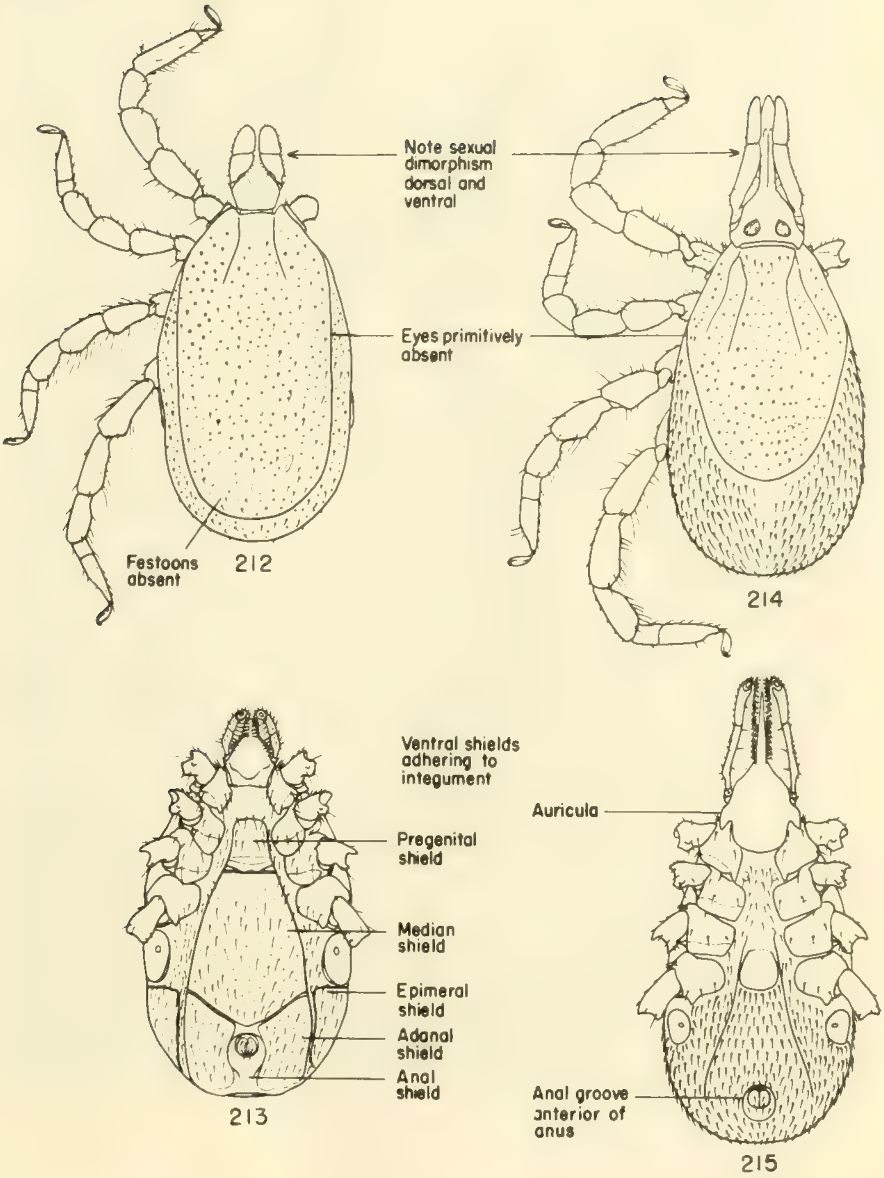
Scutum only slightly longer than wide; punctations large, distinct, deep; lateral ridges absent...................I. SCHILLINGSI
Figures 228 and 229

5. Anal groove closed posteriorly...............I. RASUS SUBSP.
Figures 224 and 225

Anal grooves not closed posteriorly..6

6. Anal grooves short, divergent posteriorly. Basis capituli without cornua or auriculae. Scutal punctations fine.................................I. S. SIMPLEX
Figures 230 and 231

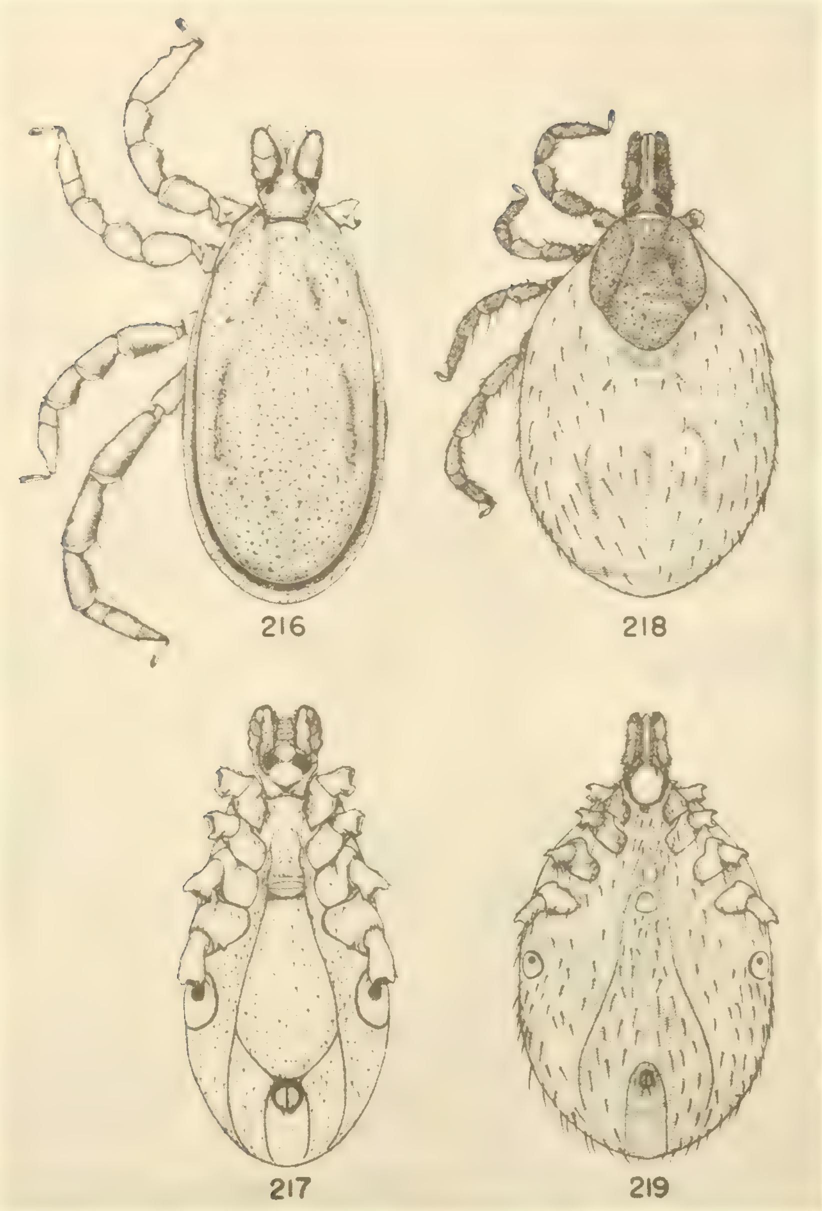
Anal grooves long, parallel posteriorly. Basis capituli with cornua; auriculae lacking. Scutal punctations large.................................I. CAVIPALPUS
Figures 218 and 219



Figures 212 and 213, ♂, dorsal and ventral views
Figures 214 and 215, ♀, dorsal and ventral views

SPECIAL MORPHOLOGICAL FEATURES, IXODES TICKS

PLATE LXI



Figures 216 and 217, ♂, dorsal and ventral views
Figures 218 and 219, ♀, dorsal and ventral views

<u>IXODES CAVIPALPUS</u>
Sudan specimens

PLATE LXII

IXODES CAVIPALPUS Nuttall and Warburton, 1908 (not 1907).

(Figures 216 to 219)

THE ANGOLAN RUSSET TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
		1	1	Obbo	Civettictis civetta congica	Apr

This is the only record of this species from the Sudan.

DISTRIBUTION

I. cavipalpus is probably more generally distributed in Africa than the following meagre records for central, eastern, and southern Africa indicate. Theiler (correspondence) states that in her experience, Angolan records are the most numerous.

CENTRAL AFRICA: BELGIAN CONGO (As I. rubicundus limbatus: Neumann 1908B. Schwetz 1927C. Bequaert 1930A,B,1931. Theiler and Robinson 1954. Arthur, ms.).

EAST AFRICA: SUDAN (Hoogstraal 1954B. Arthur, ms.).

KENYA (Lewis 1931B,C). UGANDA (Specimens from Lugaga, Ankole, 5000 ft. elev., in BMNH).

SOUTHERN AFRICA: ANGOLA (Nuttall and Warburton 1908,1911. Sousa Dias 1950. Santos Dias 1950C). NORTHERN RHODESIA (Massey 1908. Nuttall and Warburton 1908,1911. Matthysse 1954. Theiler and Robinson 1954. Arthur, ms.). NYASALAND (Nuttall 1916).

HOSTS

Domestic animals: Cattle (Nuttall 1916, Schwetz 1927C, Matthysse 1954, Theiler and Robinson 1954), goats (Neumann 1908B, Lewis 1931B), and sheep (Neumann 1908B). "Various domestic animals" (Sousa Dias 1950).

Man (Nuttall and Warburton 1908).

Wild animals: Baboon (Nuttall and Warburton 1908, Massey 1908). Hare (Lewis 1931C). Waterbuck, steinbuck, and hare (Lewis 1931B). Duiker (Massey 1908, Schwetz 1927C, Bequaert 1931). Congo civet (Sudan record above). Damalisus korrigum ugandae (Uganda material noted above).

BIOLOGY

I. cavipalpus belongs to the group within the genus Ixodes in which males and females are usually found together, not necessarily in copula, on either a "wandering" or a "fixed habitat" host (Nuttall and Warburton 1911). The immature stages are not known. In Angola, Sousa Dias (1950) collected "several females but only a single male". Massey's specimens from a baboon consisted of two males and seven females. In Northern Rhodesia, Matthysse (1954) obtained a few collections of adults from cattle only in October and November. We obviously know very little about the biology of I. cavipalpus.

It appears likely that this species inhabits forested or wooded savannah areas rather than open savannah country.

DISEASE RELATIONS

Ixodes cavipalpus has been taken feeding on a human child but is not known to transmit pathogenic organisms.

REMARKS

Nuttall and Warburton's (1911) key to Ixodes is confusing at couplet 10 (male) in that to reach I. cavipalpus one must consider coxa I as having no spur. A small spur is, however, indicated on coxa I in Nuttall and Warburton's descriptions of this species, is present in our Sudan specimens, and, according to Theiler (correspondence) and Arthur (ms.), occurs on East African specimens in their collections. It also occurs in material from the Belgian Congo in our collection.

A small external spur is also present on coxa IV of Theiler's and some of the present material; on one specimen no spur or sign of a spur is present. Nuttall and Warburton describe this as "a very slight tubercle" in their specimens. The presence and size of a spur on coxa IV is quite possibly subject to some variation.

Previously it has been difficult to differentiate between _Ixodes cavipalpus_ and _I. rubicundus_ Neumann, 1904. It is probable that numerous published remarks about East African and Congo _I. rubicundus_ apply actually to _I. cavipalpus_, as is true for all such material seen by Arthur (ms.), who presents a more complete description with adequate criteria for each species. _I. rubicundus limbatus_ Neumann, 1908, is considered a synonym of _I. cavipalpus_ on the basis of examination of type material.

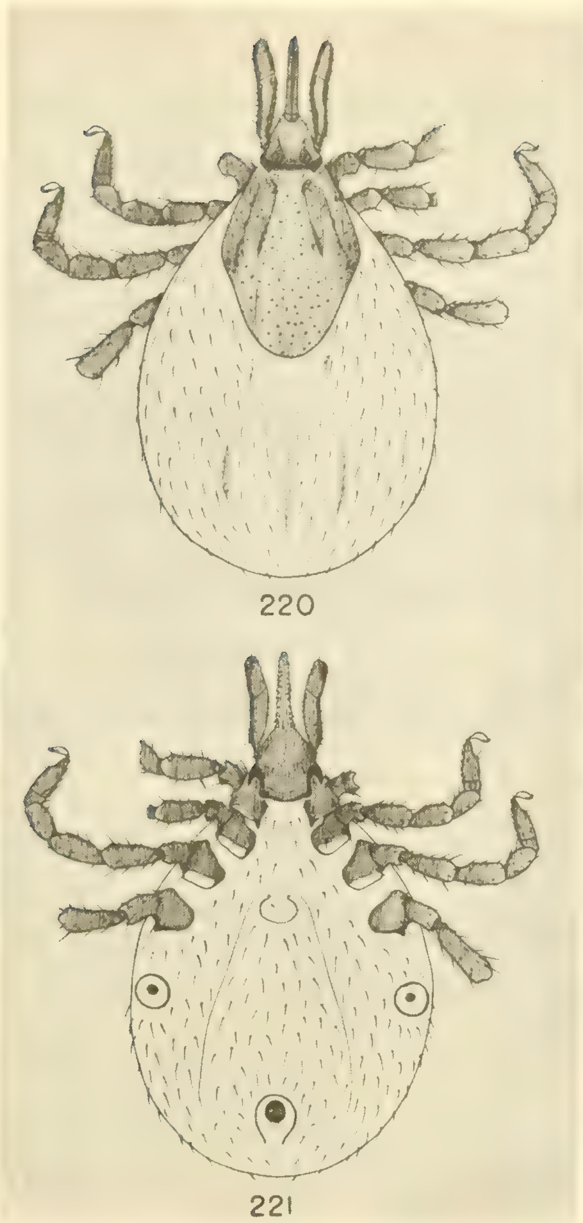
Although Nuttall and Warburton in subsequent reports stated the date of authorship of _I. cavipalpus_ as 1907, the actual date of issue of number 4 of volume 14 of the Proceedings of the Cambridge Philosophical Society, in which the original name and description was published, was 10 March 1908. Massey (1908) mentioned: "_Ixodes cavipalpus_, Nutt. & Warb. (sp. nov.)," without further reference except that the material came from a baboon. This obviously referred to specimens that he had sent to Nuttall and Warburton who used them as type specimens for the description of this species. The date of publication of number 5 of volume 12 of the Journal of Tropical Medicine and Hygiene, in which Massey's paper appeared, is 2 March 1908. Massey's usage of this name therefore comprises a _nomen nudum_.

IDENTIFICATION

Males fall in the group in which anal grooves are slightly divergent posteriorly; the degree of divergence may be so slight that the grooves are almost parallel. The long, ovate scutum is widest at midlength and has only faint, shallow punctations and short, divergent cervical grooves; lateral grooves are absent and the marginal fold gradually widens posteriorly; the scutal surface is glossy and bears short, fine hairs. Ventrally, the basis capituli has a wide V-shaped point medially near its posterior border. Coxa I has a slight posteromedian spur, and coxa IV has either a slight external tubercle, a small external spur, or no tubercle or spur; the other coxae are unarmed.

Females have anal grooves similar to those of males. The scutum is very slightly longer than wide; has a slightly sinuous posterior margin; dark brown color; long but shallow cervical grooves; no lateral grooves; and numerous, fine punctations. The basis capituli has distinct cornua dorsally and no auriculae (lateral spurs) ventrally, in place of the latter is a rounded or acutely angled bulge. Coxae I and IV have a faint tubercle, that of I situated at the posteromedian point, of IV externally near the posterior margin.

Fuller descriptions of both sexes are presented by Arthur (ms.). The immature stages are unknown.



Figures 220 and 221, ♀, engorged, dorsal and ventral views

IXODES NAIROBIENSIS
Specimen from Er Renk, Upper Nile Province, Sudan (SGC),
in poor condition.

PLATE LXIII

IXODES NAIROBIENSIS Nuttall, 1916.

(Figures 220 and 221)

THE RODENT RUSSET TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	7			Torit	*Mastomys natalensis ismailiae*	Dec
	1			Lotti Forest	*Mastomys natalensis ismailiae*	Mar

The Lotti Forest specimen was taken at 4500 feet elevation.

DISTRIBUTION IN THE SUDAN

Upper Nile: Er Renk, a single female from a dog, H. H. King *legit*, 2 July 1909. King (1926) had referred to this specimen as "*Ixodes rasus*". See OTHER SUDAN NOTES under *Ixodes rasus* ?subspecies.

DISTRIBUTION

Ixodes nairobiensis is a seldom collected tick of East Africa that ranges as far south as Southern Rhodesia and Angola.

EAST AFRICA: SUDAN (Hoogstraal 1954B).

KENYA (Nuttall 1916. Bedford 1932B). UGANDA (Theiler, unpublished).

SOUTHERN AFRICA: ANGOLA (CNHM collection, from near Dundo, Lunda). SOUTHERN RHODESIA (Theiler, unpublished).

HOSTS

The strange assortment of hosts listed below indicates that there is much to learn about this tick and that some records may be due to misidentification.

Females

Domestic dogs (Nuttall 1916. Sudan record above). Warthog and multimammate mouse (*Mastomys*) (Bedford 1932B). Shrew, civet, and the following rodents: rat (*Rattus rattus*); creek rat, *Pelomys fallax concolor*; rock rats, *Aethomys* spp.; and groove-toothed rat, *Otomys tropicalis pretoriae* (Theiler, unpublished), and striped grassmouse, *Lemniscomys s. striatus* (Angola specimen mentioned above).

Immature Stages

Nymphs from multimammate mice (Equatoria Province records above), and *Aethomys* spp. (Theiler, unpublished). Larvae from *Otomys tropicalis pretoriae* (Theiler, unpublished). Unstated stage from kusu or grass rat, *Arvicanthis abyssinicus* (Theiler, unpublished).

BIOLOGY

The male is unknown. It either takes no blood or feeds for only short periods, and should be searched for especially in rodent nests. Immature stages have been collected from nest-inhabiting rodents and probably also feed on insectivores as well. Females parasitize carnivores and the warthog. It is noteworthy that Roberts (1935) did not obtain this tick in his survey of rodent-nest inhabiting ticks in the Nairobi area. See HOSTS above.

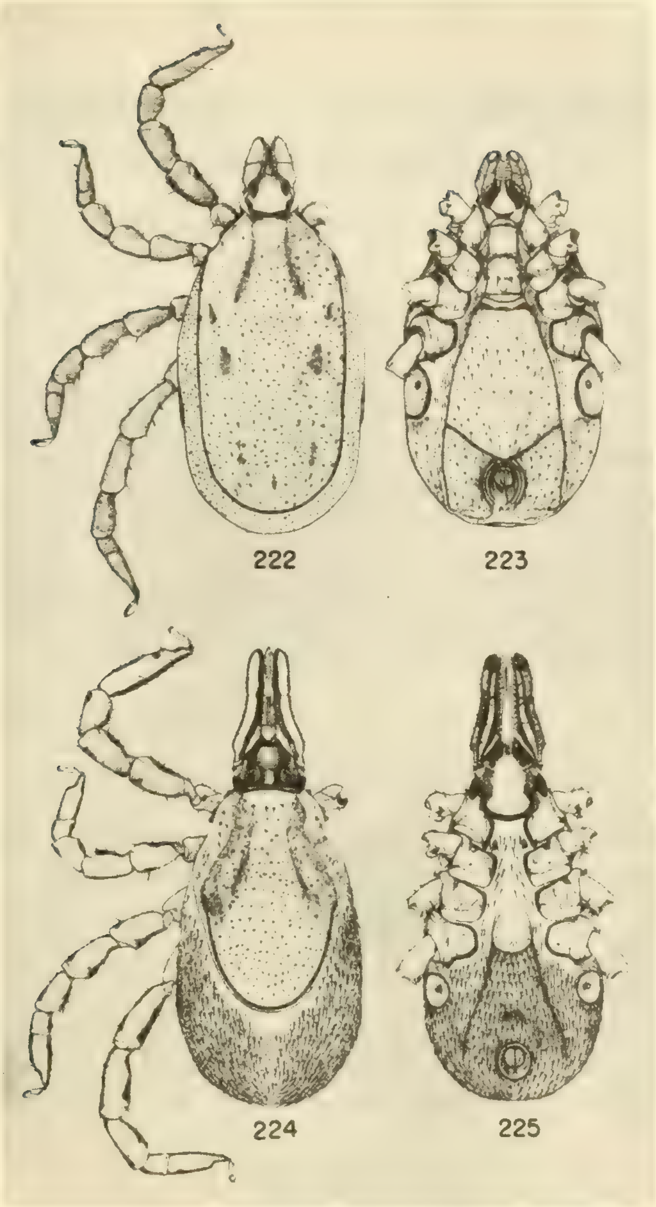
DISEASE RELATIONS

Unstudied.

IDENTIFICATION

The *female* is readily identified. The anal grooves are horseshoe shaped. The scutum is 1.5 times as long as wide or even longer, widest just anterior of the midlength; it has a moderate number of mostly fine and a few moderate size punctations many of which give rise to a pale hair, distinct lateral ridges, and a depressed cervical area; its color is chestnut brown. Coxae are without internal spurs except on I, but each has a small basoexternal spur. The auriculae (i.e. lateral spurs) of the ventral basis capituli are long and retrograde.

The immature stages have not yet been described and the male is unknown.



222 223 224 225

Figures 222 and 223, ♂, dorsal and ventral views
Figures 224 and 225, ♀, dorsal and ventral views

<u>IXODES RASUS</u> SUBSP.
Kenya specimens
For comment on these specimens, see REMARKS under *Ixodes rasus*.

PLATE LXIV

IXODES RASUS Neumann, 1899 (?SUBSPECIES)

(Figures 222 to 225)

THE CENTRAL AFRICAN RUSSET TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
			1	Torit	*Lepus victoriae microtis*	Mar

This specimen, which cannot be assigned to any described subspecies, is the only one of *Ixodes rasus* actually known from the Sudan.

King (1926) believed that two other ticks that had engorged on him, one within the nostril the other behind the knee, while he was in the Yei River area of Equatoria Province might have been *Ixodes rasus*.

OTHER SUDAN NOTES

King (1926) listed *Ixodes rasus* from Er Renk and Kaka, Upper Nile Province. The Er Renk specimen, now in Sudan Government collections, is a female of *Ixodes nairobiensis*. It was taken from a domestic dog on 2 July 1909, by H. H. King. Nuttall evidently saw the specimen some time before he described *Ixodes nairobiensis* (1916) because the label with this specimen reads "Ixodes rasus. Nuttall's note: Agrees with *cavipalpus*, but scutum longer". The Kaka specimen is a poorly preserved nymph that appears to be *I. rasus* but cannot definitely be assigned to this species.

DISTRIBUTION

The actual range (and identity) of subspecies of *Ixodes rasus* is unknown (see REMARKS below). The species is especially numerous in many parts of West and Central Africa and locally common in East Africa. Material on which the few records of South African specimens are based should be restudied.

WEST AFRICA: NIGERIA (Pearse 1929). FRENCH WEST AFRICA (Neumann 1899,1901,1911. Rousselot 1951,1953B. Villiers 1955). GOLD COAST (Nuttall and Warburton 1911. Nuttall 1916. Stewart 1936).

CENTRAL AFRICA: FERNANDO PO (Schulze 1943A). CAMEROONS (Neumann 1899,1901,1911. Ziemann 1912A. Nuttall 1916. Jojot 1921. Rageau 1953. Schulze 1943A. Rageau 1951,1953. Dezest 1953. See HOSTS below). FRENCH EQUATORIAL AFRICA (Bequaert 1931 refers the type locality to French Equatorial Africa, not to Belgian Congo. Fiasson 1943B. Rousselot 1951,1953B). RIO MUNI (Nuttall 1916. Schulze 1943A). BELGIAN CONGO (See French Equatorial Africa above. Neumann 1899,1901,1911. Nuttall 1916. Nuttall and Warburton 1916. Schwetz 1927C,1932. Schouteden 1927. Bequaert 1930A,B,1931. Schoenaers 1951A. Rousselot 1951,1953B. Theiler and Robinson 1954).

EAST AFRICA: SUDAN (King 1926. Hoogstraal 1954B).

ETHIOPIA (Nuttall 1916).

KENYA (Neave 1912. Nuttall 1916. Anderson 1924A. Lewis 1931A,B,C,1939A. See HOSTS below). UGANDA (Nuttall and Warburton 1911. Mettam 1932,1933. See HOSTS below). TANGANYIKA (Neumann 1899,1901,1907C,1910B,1911. Morstatt 1913. Bequaert 1930A. Reichenow 1941B. Schulze 1943A).

SOUTHERN AFRICA: SOUTHERN RHODESIA (Nuttall 1916). [?UNION OF SOUTH AFRICA (Bedford 1929A,1932B. Cooley 1934. Some or all of this material refers actually to Ixodes pilosus: Arthur, correspondence.]

HOSTS

The range of hosts of adult Ixodes rasus includes a large variety of animals from mice and elephant shrews (small insectivores) to leopards, large antelopes, and domestic dogs. It is difficult to determine whether this tick displays predilection for any group of mammals. The picture for immature-stage host preferences is equally uncertain. Whether individual "subspecies" have characteristic preferences differing from each other remains to be demonstrated.

Published reports of adults and immature stages found together on a single host are categorized below by associated stage and sex for what they may be worth in eventually answering questions of host preferences and biology of this species.

Stage or sex not specified: Domestic cattle from Uganda, leopard and domestic dog from Gold Coast (Nuttall and Warburton 1911). Domestic sheep from Kenya (Lewis 1931B).

Cricetomys emini (giant forest rat), Crocidura sp. (shrew), Crocidura manni, Hybomys univittatus (back-striped mouse), Leggada musculoides (pygmy mouse), Lemniscomys striatus (striped grass-mouse), Rattus rattus (house rat), Taterillus gracilus angelus (gerbil), Thyronomys swinderianus (cane rat) (Pearse 1929, from Nigeria).

Buffalo, blue duiker, forest or red duiker, and domestic cattle (Mettam 1932, from Uganda). Black duiker (Villiers 1955, from Ivory Coast). Warthog (Ziemann 1912A, from Cameroons). Cane-rat (Schwetz 1927C, from Belgian Congo). Okapi (Schouteden 1927, from Belgian Congo). Impala (Bedford 1932B and Cooley 1934, from South Africa). Tree hyrax, Dendrohyrax (Schoenaers 1951A, from Belgian Congo).

Larvae alone: Common on small and large birds in Kenya (statement should be checked for accuracy) (Lewis 1939A).

Nymphs alone: Bdeogale mongoose (Schulze 1943A, from Tanganyika). Man (Nuttall 1916, from Ethiopia). "Antilope brune" (Bequaert 1931, from Belgian Congo).

Females with larvae: Okapi (Schwetz 1927C, from Belgian Congo).

Females with larvae and nymphs: Akeley's suni or dwarf antelope, Nesotragus moschatus akeleyi, (from Kenya; this female tick corresponds more closely to the description of Ixodes rasus cumulatimpunctatus than any other specimens that I have seen). Mole rat, Tachyoryctes sp. (HH legit at Njoro, Kenya).

Females with nymphs: Water chevrotain, giant elephant shrew, giant forest rat, wild pig, mongoose, and domestic dog (Schulze 1943A, from Tanganyika and Cameroons). Hyrax (Procavia sp.) (Bedford 1929A,1932B, from South Africa). "White mongoose" (specimens seen by HH, from Cameroons).

Females alone: Domestic dog (Schulze 1943A, from Tanganyika; Rageau 1951, from Cameroons; Nuttall 1916, from Gold Coast). Domestic cattle (Nuttall and Warburton 1911, from Uganda*). Domestic goat (Nuttall 1916, from Belgian Congo).

Tree hyrax, Dendrohyrax arboreus (Bequaert 1931, from Belgian Congo). Hyrax (?Procavia) (Schwetz 1927C, from Belgian Congo). Giant forest rat (Cricetomys) (Schulze 1943A, from Rio Muni; others seen by HH, from Uganda). Grass rat (Arvicanthis abyssinicus nubilans) and groove-toothed rat (Otomys tropicalis elgonis) (specimens from the latter host closely correspond to description of Ixodes rasus cumulatimpunctatus (HH legit at Njoro, Kenya). Duiker (Bequaert 1930A, from Tanganyika). Serval from Kenya, pangolin and bush pigs from Cameroons (Nuttall 1916). Leopard (Nuttall et al 1911, from Cameroons*). Large gray mongoose (Herpestes caffer) and slender mongoose (Myonax cauui) (Bedford 1932B, from South Africa).

Females and males: "Man and domestic dog" (Nuttall et al, from Gold Coast*). Hyrax (Neumann 1899, from French Equatorial Africa - not Belgian Congo according to Bequaert 1931); bush pig (Schulze 1943A, from Tanganyika); leopard (Nuttall 1916, from Southern Rhodesia; others seen by HH, from Kenya). Pangolin (Specimens seen by HH, from Uganda).

Males alone: Hare (Sudan record above). Caged chimpanzee (Specimens seen by HH, from Cameroons).

---

*Stages or sex not reported in literature cited, but determined from Nuttall collection in British Museum (Natural History).

BIOLOGY

After having collected numerous specimens of *Ixodes rasus* from many small mammals in Kenya, from sea level to 8000 feet elevation, it was surprising to find this species so rare in the Sudan. From Pearse's (1929) report on Nigerian ectoparasites, *I. rasus* appears to be common on small mammals there. The reasons for these considerable differences in local populations remain to be explained.

Nuttall (1911) categorized *I. rasus* in the biological group within the genus *Ixodes* in which males and females are usually found together on a host that either wanders or does not travel far and in the subgroup in which the sexes are often found *in copula* on the host. Present evidence partially supports the inclusion of *Ixodes rasus* in the last subgroup and careful collecting may subsequently prove that this species should be so considered.

Systematic search probably will show *Ixodes rasus* to be a common tick in many parts of tropical Africa. Examination of rodents in certain areas should prove fruitful. Seeking for every tick on a variety of animals will undoubtedly reveal a few, small inconspicuous, well-hidden *Ixodes* ticks along with more apparent, more numerous, larger, and more colorful ticks of other genera.

Questions concerning the biology of *Ixodes rasus* in its various forms (i.e. subspecies) offer a challenge in one of the most fascinating zoological areas of the world.

DISEASE RELATIONS

Unstudied.

REMARKS

Schulze (1941) noted certain features of the haller's organ of *I. rasus* (cf. also K. W. Neumann 1943). A comparison of this organ with that of other Ixodes species is presented in table form by Arthur (1956B).

Remarks on morphology of this species are contained in papers by K. W. Neumann. These have not yet been seen and complete references are not available except for: (1942) Z. Morph. Ökol. Tiere, 38(2):358, 362. (Morphology of subcoxa of subspecies cumulatimpunctatus); and (1945) Zool. Jb. (Anat.), 69(2):286, fig. 8. Jakob (1924B) included this species in his review of the relationship of tick genera from the standpoint of comparative morphology.

Both sexes are readily distinguished by their completely closed, usually circular anal grooves, an easily observed character in all specimens except some greatly engorged females in which the anal area is depressed and the associated grooves are difficult to discern. Only one other African species, Ixodes ugandanus Neumann, 1906 (with which Ixodes ampullaceus Warburton, 1933, from Uganda is quite possibly synonymous), is known to have closed anal grooves; these are not circular but characteristically oval and unite in a slight posterior elongation. I. ugandanus has not yet been found in the Sudan.

Schulze (1943A) indicated that circular anal grooves are characteristic of this species but that some specimens in which these grooves are expanded to a broad oval outline are merely atypical individuals of the same species. According to Schulze, the anal grooves of I. rasus may even be narrowed posteriorly.

Schulze (1943A) differentiated three subspecies of I. rasus and one "related species" as follows:

I. rasus rasus: Short, broad palpi and hypostome; retrograde auriculae (lateral spurs of ventral basis capituli); pronounced single punctations on scutum. (From Cameroons).

I. rasus cumulatimpunctatus: Long, narrow palpi and hypostome; perpendicular auriculae; and small scutal punctations, some of which appear to be formed of a small group of smaller, contiguous punctations. (Tanganyika to Fernando Po).

I. rasus eidmanni: The same characters as given above for I. rasus rasus, but "more strongly chitinized and darker", and denticles of hypostome with a small apical "hook", proximity of sensory organs in the integument, and absence of a definite "peripheral zone" of the integument. (Rio Muni, or Spanish Guinea).

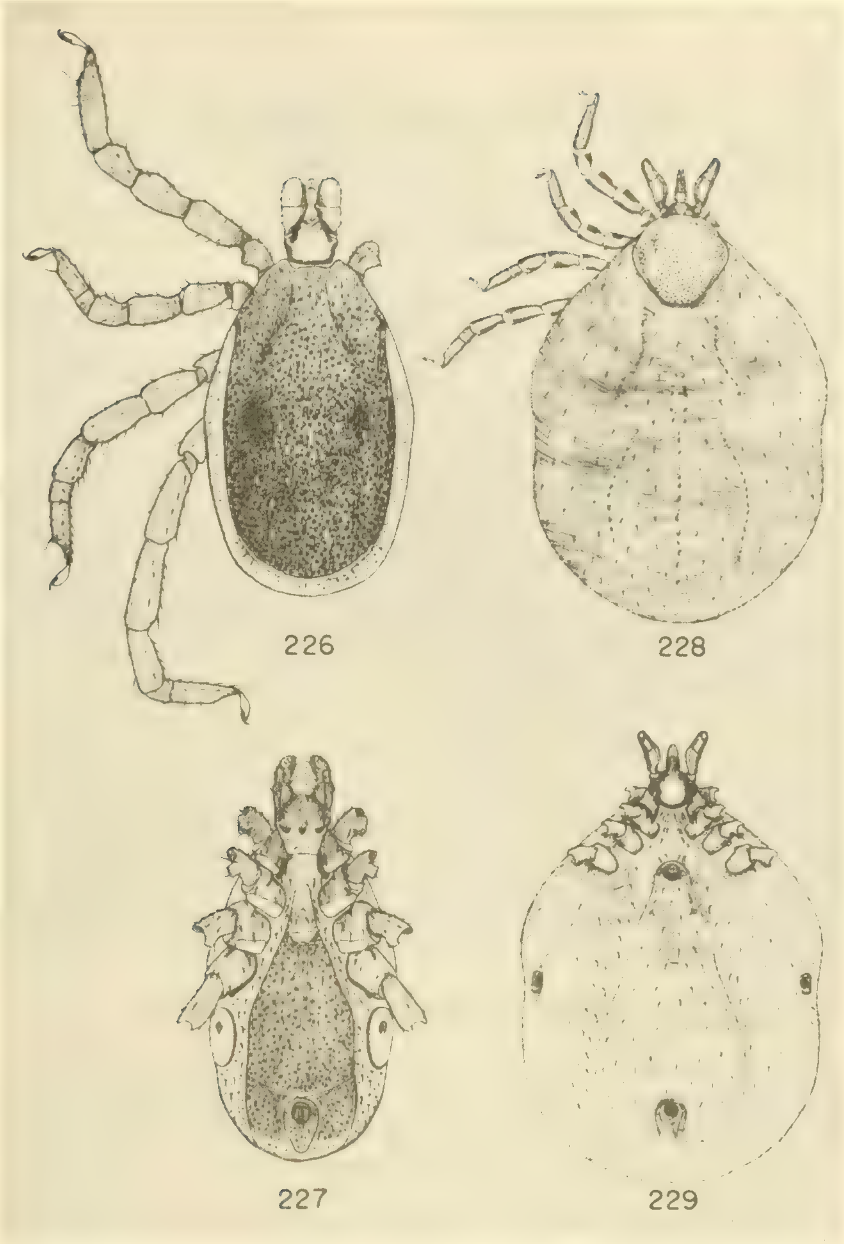
I. vanidicus: Similar to I. rasus but with anal grooves horseshoe shaped or circular but not closed posteriorly. (Tanganyika to Cameroons).

IDENTIFICATION

Males are characterized by circular anal grooves (see REMARKS above), narrow marginal fold beside the scutum, fairly many to numerous fine scutal punctations, and short palpi with segments 2 and 3 of about equal length. This reddish brown species is about 2.8 mm. long and 1.8 mm. wide and has a broadly rounded posterior margin. The tarsi are usually humped but in some specimens which otherwise conform to this description they are tapering.

Females also have closed anal grooves. Their scutal punctations are similar to those of males. The hypostome and palpi are long and narrow and the basis capituli ventrally has a large spur (auricula) arising from each lateral margin. The tarsi are either tapering or somewhat humped.

Note: As presently considered, any African Ixodes male or female with circular, closed anal grooves is I. rasus. Within the large amount of material seen in various collections there is considerable variation in most other characters, the significance of which await to be determined by Dr. Arthur.



Figures 226 and 227, ♂, dorsal and ventral views
Figures 228 and 229, ♀, dorsal and ventral views

IXODES SCHILLINGSI
♀ Sudan specimen
♂ Kenya specimen

PLATE LXV

IXODES SCHILLINGSI Neumann, 1901.

(Figures 226 to 229)

THE COLOBUS RUSSET TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
		1		Lotti Forest	Colobus polykomos dodingae	Apr

Lotti Forest is at 4500 feet elevation. This is the only record of this species from the Sudan. About a dozen monkeys of the same species examined in Lotti Forest and at other places at different altitudes in the same forest were free of ticks. An equal number of monkeys, Cercopithecus mitis stuhlmanni, from Lotti Forest were tickless, as were numerous specimens of other monkeys (Setzer 1956) examined elsewhere in the Sudan.

DISTRIBUTION

I. schillingsi, a parasite of East African Colobus monkeys, does not appear to range outside of wooded savannah and forested areas. It is the sole described African representative of a complex of species occurring in Asia, Madagascar, Australia, and Europe.

EAST AFRICA: SUDAN (Hoogstraal 1953E,1954B. Arthur, ms.).

KENYA (Nuttall 1916. Lumsden 1955. Arthur, ms. See HOSTS below). TANGANYIKA (Neumann 1901,1907C,1910B,1911. Nuttall and Warburton 1911. Morstatt 1913. Arthur, ms.). ZANZIBAR (Arthur, ms.).

SOUTHERN AFRICA: MOZAMBIQUE (Neumann 1919A,1911. Nuttall and Warburton 1911. Santos Dias 1953B).

HOSTS

Man is parasitized by I. s. schillingsi according to a single record for a female tick of this species from Njoro, Kenya (Lumsden

1955). Aside from this, Colobus monkeys, also known as guereza or leaf-eating monkeys, are the only known hosts. As stated below, all other records from different mammals, including man and monkeys other than Colobus refer to undescribed Ixodes species or subspecies.

Colobus polykomos caudatus (Neumann 1901,1907C,1910B. Nuttall and Warburton 1911). C. polykomos dodingae (Sudan record above). Colobus sp. (Nuttall 1916).

Anderson (1924B) recorded Rattus rattus kijabius as a host in Kenya. Specimens of this tick species collected by Anderson in Kenya, now in British Museum (Natural History) collections, are labelled as from Colobus monkeys and others bear no host data (Arthur, ms.). The rodent host is believed to be an error.

Lewis (1931C) listed this tick from a duiker, bushbuck, and domestic cattle in Kenya. These four collections, two from bushbucks and one each from the other hosts have been examined at British Museum (Natural History) and found to refer to an entirely different species. They were then referred to Dr. Arthur, who considers them to be an undescribed subspecies of Ixodes pilosus (Arthur, ms.).

Rageau (1953B) reported specimens from man and from another kind of monkey, Cercopithecus (= Lasiopyga) cephus cephus. These represent an undescribed species related to Ixodes schillingsi (Arthur, ms.).

BIOLOGY

This species is a parasite of Colobus monkeys and uncommonly of man. It is said to prefer young hosts and attaches exclusively to the eye according to collecting notes furnished Neumann (1901). Females have been taken from around the eyes and ears and in the axillae of adult Colobus monkeys in Kenya and on the eyelid of a Colobus monkey in the Sudan.

The male has been found only in copula on the host (and once alone on a tree trunk) and its feeding habits are not known. Larvae, nymphs and both sexes of adults may occur on the same host (Arthur, ms.).

Extremely few ticks of any genus attack primates as hosts of predilection (Hoogstraal 1953E). Ixodes schillingsi appears to be one of these few.

Monkeys, lemurs, and other primates usually groom themselves and each other so meticulously that external parasites have little chance of surviving on them. Certain exceptions should, however, be noted. When wishing to examine baboons for ectoparasites, one should choose large, lone males who wander separate from the group. Individual baboon hobos have yielded as many as 350 ticks (Rhipicephalus simus simus) while others living in groups in the same areas have been free of ticks or have been infested by only one or two specimens. The striking rarity with which one observes easily-visible groups of Colobus monkeys grooming each other immediately suggests that because this practice is so infrequently indulged, I. schillingsi has managed to survive on this genus of monkeys but not among others.

REMARKS

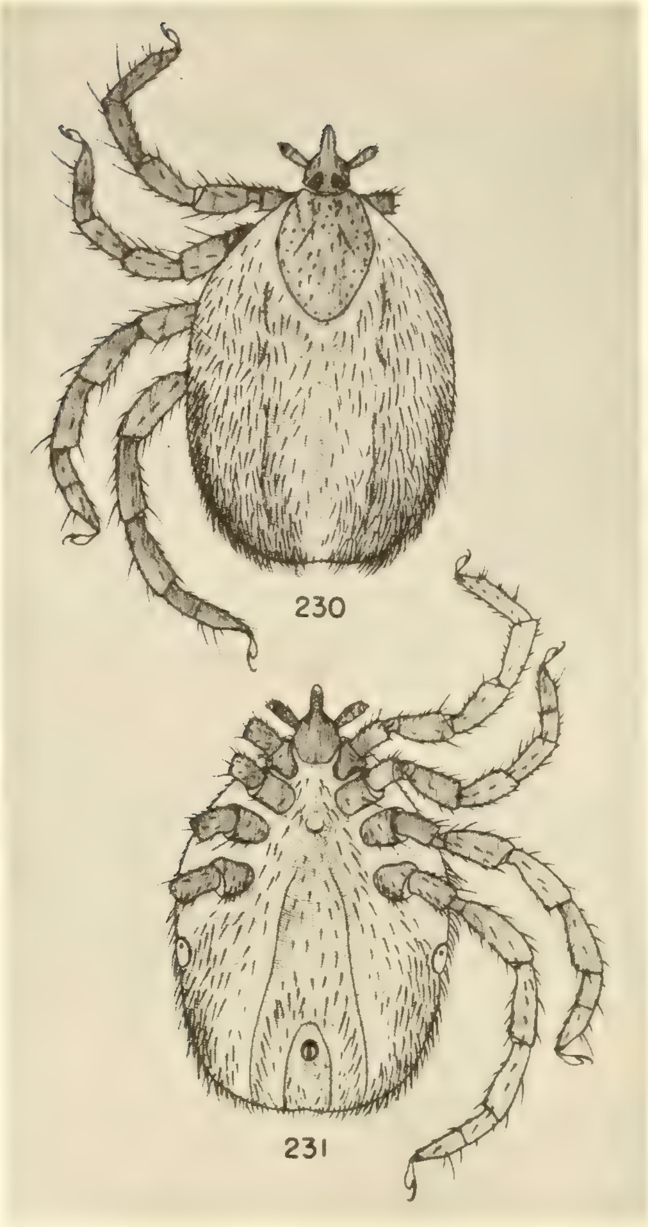
The close relation of Ixodes schillingsi to Ixodes lunatus Neumann, 1907, a Madagascan parasite of rodents that also infests insectivores (Hoogstraal 1953E), has been described by Colas-Belcour and Grenier (1942) who consider that these two ticks might be regarded as related subspecies. The features of the haller's organ of I. schillingsi are listed in a table by Arthur (1956B).

IDENTIFICATION

Males are easily recognized among the African Ixodes fauna by the following characters: Anal grooves racket-shaped (anteriorly slightly wider than "horseshoe shaped"), not closed. Legs normal length, but fourth pair comparatively long, coxae with first three pairs bearing a small internal spur posteriorly, coxa IV with a small external spur. Scutum with one lateral fold, convex, with many large, subequal punctations. Basis capituli with a sharp, pointed posteromedian spur ventrally. Measures about 2.3 mm. long and 1.4 mm. wide.

Females have elliptical, open anal grooves. Coxa I has a concave posterior border prolonged internally to a long spine and externally to a shorter spine. The scutum is longer than broad, broadest at anterior third; it lacks lateral grooves, has numerous deep, uniform punctations, and its cervical grooves diverge from the anterior third and are deeper posteriorly than they are anteriorly. The basis capituli ventrally has pointed, retrograde spurs (auriculae). Total length of gorged specimens may reach 7.0 mm.

The nymph has been described and figured by Nuttall and Warburton (1911). The larva is described by Arthur (ms.), who also redescribes the nymph and both sexes of adults.



Figures 230 and 231, ♀, dorsal and ventral views

IXODES SIMPLEX SIMPLEX

Kenya specimen

PLATE LXVI

IXODES SIMPLEX SIMPLEX Neumann, 1906.

(Figures 230 and 231)

THE SHORT-LEGGED BAT-RUSSET-TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
	1			Katire	Rhinolophus clivosus zambesiensis	May (CNHM)

Katire is at 3500 feet elevation in the Imatong Mountains. The tick noted above was sent for identification after having been removed at Chicago Natural History Museum from a host collected by Mr. John Owen. This is the only record of this species from the Sudan.

DISTRIBUTION

The subspecies simplex has a wide distribution throughout the warmer parts of the Old World. In Africa, it is thus far known only from the Sudan, Kenya [where the only other subspecies, africanus Arthur, 1956(A), also occurs], and the Union of South Africa. Elsewhere, it is found in the Near East, southern Europe, and Asia from Shanghai to Japan. A larger, closely related South African form has been noted by Arthur (1956A) as Ixodes sp. incertae.

Africa

[CENTRAL AFRICA: BELGIAN CONGO. The subspecies mentioned by Bequaert (1930B,1931) is not now certain. Records from French Equatorial Africa (Neumann 1906,1911, and Nuttall and Warburton 1911), refer actually to material from Kashmir or a neighboring country in southern Asia; cf. Arthur (1956A).]

EAST AFRICA: SUDAN (As I. simplex: Hoogstraal 1954B. As I. simplex simplex: Arthur 1956A).

KENYA [Arthur 1956A. Note: I. simplex was listed by Loveridge (1936A) from Kenya; his specimens, from Mt. Elgon, are not available for subspecies determination. Material from the crater of Mt. Menengai (HH _legit_) recently has been described by Arthur (1956A) as _I. simplex africanus_ 7.

SOUTHERN AFRICA: UNION OF SOUTH AFRICA [Arthur (1956A). _Note_: According to Bedford (1932B), the record of _I. pilosus howardi_ from a bat, reported by Howard (1908), may be _I. simplex_, but the material is not now available and the subspecies or species cannot be determined. The specimens referred to as _I. simplex_ by Zumpt (1950B) have not been reexamined. A closely related species or subspecies, of uncertain taxonomic status, is noted by Arthur (1956A) from the Irene caves near Pretoria 7.

[?_NORTH AFRICA_: Specimen with this designation noted by Arthur (1956A)./

Near East

PALESTINE (Arthur 1956A).

Europe

GREECE (Schulze 1937B. Pandazis 1947. Arthur 1956A). FRANCE (Arthur 1956A).

Asia

"KASHMIR OR A NEIGHBORING COUNTRY" [Type locality according to Arthur (1956A) 7. CHINA (Neumann 1906,1911. Arthur 1956A). JAPAN (Kishida 1930. Arthur 1956A).

HOSTS

Bats known to be hosts of _I. simplex simplex_ or of "_I. simplex_" are those of the genus _Rhinolophus_, family Rhinolophidae, the horseshoe bats; _Miniopterus_, long-fingered bats (all previously unreported); and _Myotis_, mouse-eared bats. Both latter genera are in the family Vespertilionidae and both families are in the suborder Microchiroptera (insectivorous bats).

Rhinolophus ferrum-equinum (Neumann 1906). Rhinolophus eloquens (Loveridge 1936A). Rhinolophus clivosus auger (= geoffroyi auger*) (Zumpt 1950B). R. sp. of Howard (1908) equals R. clivosus auger (= geoffroyi auger*) according to Bedford (1932B). Rhinolophus clivosus zambesiensis (Sudan record above).

Myotis (= Vespertilio) sp. (Neumann 1906). Myotis tricolor (Bedford 1932B), and Irene caves material mentioned under SOUTH AFRICA above. Myotis macrodactylus (Arthur 1956A).

Miniopterus natalensis arenarius and Miniopterus schreibersi (subsp. probably japoniae*) from Japan, M. schreibersi and M. s. schreibersi (Arthur 1956A).

BIOLOGY

Aside from the fact that larvae, nymphs, and females are taken on bats, nothing is known concerning the biology of I. simplex. Males either do not take blood or feed very rapidly and quickly secrete themselves thereafter; they should be searched for in retreats frequented by bats. Ixodes simplex is widely spread through the tropics and temperate climates of the world and must be an uncommonly adaptable tick. Its hosts' ability to fly undoubtedly accounts in part for the great range of this species.

DISEASE RELATIONS

Unknown.

REMARKS

The haller's organ of both subspecies of I. simplex is like that of I. vespertilionis (Arthur 1956B).

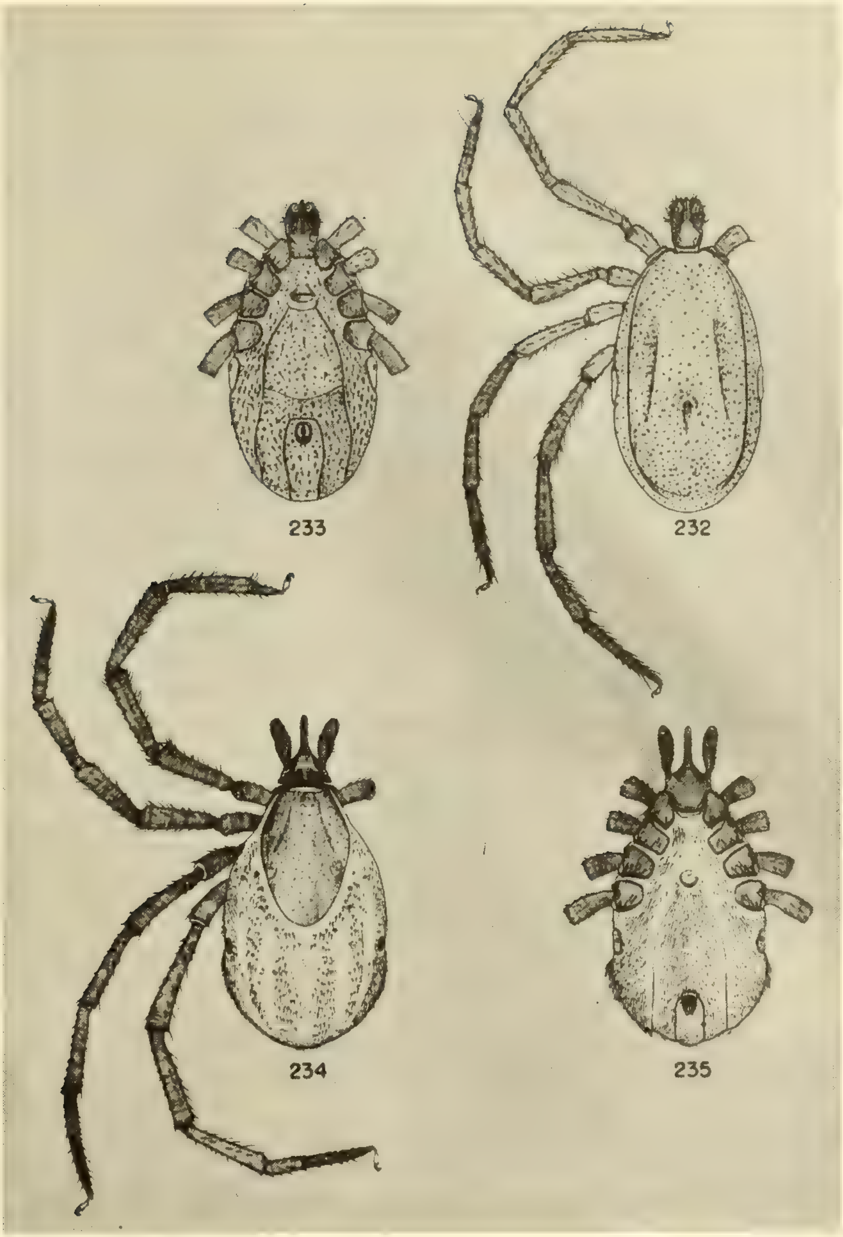
---

*I am indebted to C. C. Sanborn, Curator of Mammals at Chicago Natural History Museum, and an outstanding authority on bats, for checking the bat host names in this section.

IDENTIFICATION

Females are readily separated from those of the only other known bat-infesting species of this genus, *I. vespertilionis* by the fact that *I. simplex* has normal-length legs, although the last pair is longer than usual (all pairs of legs of *I. vespertilionis* are exceedingly long). Anal grooves are short and divergent. The scutum is slightly longer than broad, has gently curved postero-lateral margins, and converging anterolateral margins; widely scattered, subequal punctations, shallow cervical grooves, no lateral grooves; its color is brownish, reddish, or yellowish. The basis capituli is triangular, without cornua or auriculae. Coxae are flat and without spurs. For a fuller description, see Arthur (1956A).

Males are unknown. Immature stages are described by Arthur (1956A).



Figures 232 and 233, ♂, dorsal and ventral views
Figures 234 and 235, ♀, dorsal and ventral views

<u>IXODES VESPERTILIONIS</u>
English specimens. ♂ loaned by British Museum
(Natural History). ♀ loaned by Dr. D.R. Arthur

PLATE LXVII

IXODES VESPERTILIONIS Koch, 1844.

(Figures 232 to 235)

THE LONG-LEGGED BAT-RUSSET TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
	1			Torit	Bat, unidentified	Feb

This is the only specimen of *I. vespertilionis* known from the Sudan.

DISTRIBUTION

I. vespertilionis is widely distributed in the Old World and is known from scattered areas in Africa where search will probably reveal numerous new locality records.

The distribution of I. *vespertilionis* was first summarized by Nuttall and Warburton (1911) and later, more extensively, by Neumann (1916). The present distributional summary is based on the latter paper, with only subsequent reports added. More recently, Arthur (1956A) has brought these records up to date.

Africa

NORTH AFRICA: ALGERIA (Neumann 1916. Hirst 1916. Nuttall 1916. Senevet 1937). MOROCCO (Arthur 1956A).

EAST AFRICA: SUDAN (Hoogstraal 1954B. Arthur 1956A).

UGANDA (Arthur 1956A). KENYA (HH collecting in crater of Mt. Menengai).

SOUTHERN AFRICA: UNION OF SOUTH AFRICA (Arthur 1956A. See NOTE five paragraphs below.

Europe

GIBRALTAR (Neumann 1916). PORTUGAL (Hirst 1916). SPAIN (Neumann 1916. Schulze 1927. Gil Collado 1936,1938,1948). FRANCE (Neumann 1916. Hirst 1916. Jeannel 1926. Schulze 1927. Senevet 1937. Cooreman 1954A,B. Lamontellerie 1954. Arthur 1956A). GERMANY (Neumann 1916. Schulze 1923B,1944B. Schulze and Schlottke 1929). SWITZERLAND (Arthur 1956A). AUSTRIA (Neumann 1916. Nuttall 1916). BRITISH ISLES (Neumann 1916. Nuttall 1916. Hirst 1916. MacLeod 1939. Arthur 1948,1953A,1956A). BELGIUM (Bequaert 1913. Schmitz and Bequaert 1914. Leruth 1939B. Cooreman 1951). LUXEMBURG (Leruth 1939B). NETHERLANDS (van Eyndhoven 1939,1953). ITALY (Neumann 1916. Tonelli-Rondelli 1930A). SARDINIA (Kohls, correspondence). GREECE (Schulze 1936. Pandazis 1947. Arthur 1956A). HUNGARY (Neumann 1916. Hirst 1916. Kotlan 1921A,B). CZECHOSLOVAKIA (Neumann 1910C. Rosicky 1953). BULGARIA (Schulze 1927). YUGOSLAVIA (Neumann 1916. Oswald 1939). ROMANIA (Leruth 1939A. Cooreman 1951). CRETE (Hirst 1916).

[NOTE: Schulze (1927) listed a nymph from *Rhinolophus hipposiderus* (sic) (?*ferrum-equinum*) at "Zelebor" (?Europe).]

Near East

TURKEY (Arthur 1956A). PALESTINE (Arthur 1956A). IRAN (Olenev 1927,1931. Pomerantzev 1937,1950). RUSSIA (Olenev 1927, 1929,1931. Pomerantzev 1937,1950. Karpov and Popov 1944).

Far East

JAPAN (From Sawada, Myiagi, Honshu, A. J. Nicholson *legit*: Kohls, correspondence).

NOTE: *I. vespertilionis* has been reported from Australia by Nuttall and Warburton (1911) and quoted by Neumann (1916), Ferguson (1925), and Leruth (1939B), but not subsequently verified. The host was listed as *Vesperugo tricolor*. The only vespertilionid bat known to have the specific name *tricolor* is *Myotis tricolor** of East and South Africa. The collecting locality for

---

*I am indebted to C. C. Sanborn, Curator of Mammals at Chicago Natural History Museum, and an outstanding authority on bats, for checking the bat host names in this section.

the tick is Kingwilliamstown. There is a city of this name in Cape Province, South Africa but, so far as known, none in Australia. The specimen came from the Rothschild collection, a frequent source of South African material for Nuttall in the early 1900s. With little hesitation, therefore, this may be considered to be a South African record. Fielding (1926) recorded I. vespertilionis from North Queensland bats, but this appears to be merely a repetition of the earlier literature statement. Taylor and Murray (1946, p. 41) state that this species is "doubtfully Australian" and the "original specimen is unfortunately lost".

HOSTS

All authors list bats except for the probably adventitious Hungarian record from a domestic dog (Kotlan 1921A,B). Immature stages and females are usually found on bats; males only in caves inhabited by bats.

The host of only one of the few specimens originating in Africa has been reported. Nuttall's (1916) Algerian specimen came from Pipistrellus (= Vespertilio) kuhlii. The host number of the specimen collected in Torit was inadvertently not included in the vial. The nymphs taken in Kenya (HH) were found, together with the holotype female of Ixodes simplex africanus, on Miniopterus natalensis arenarius. So far as known, there are no other records of both I. vespertilionis and I. simplex subspp. from a single collection. Myotis tricolor of South Africa has been discussed in the NOTE above. Hipposideros caffer is also a host in South Africa (Arthur 1956A).

Genera of European bats reported by Neumann (1916) are Rhinolophus, Plecotus, Pipistrellus, and Myotis. The most commonly listed hosts are R. ferrum-equinum and R. hipposideros; the former species is also the host of the Japanese specimen reported by Kohls (correspondence). A few other Rhinolophus species are also mentioned by various authors.

BIOLOGY

Judging from its considerable geographical range, this species is able to adjust to marked climatic variations only partially modified by protected cave environment.

I. vespertilionis is rare on bats in Equatoria Province east of the Nile. Over a thousand bats, representing almost every species in Eastern Equatoria, have been carefully searched without finding more than the single specimen listed above. There has been little opportunity to examine carefully many caves.

Males have been collected only from caves and other retreats in which bats assemble. No males have been found on bats. Nuttall and Warburton (1911) postulated that males may either feed very rapidly and then leave the host or that they may not feed at all Neumann (1916) believed that the various degrees of engorgement in which male specimens are found might not necessarily prove that males do feed but rather may be an indication of degree of nymphal feeding. This conclusion is based on the atrophy of the male hypostome in comparison with its robust development in females and in immature stages.

Neumann (loc. cit.) mentioned the preponderance of numbers of males in relation to females and immature stages in collections and surmised that this may be due to the conspicuousness of the male's vagabond search for females. Females secrete themselves between stones of the caves to digest their blood meals. They probably oviposit in these niches, though this is not certain. Engorged nymphs are sometimes found in similar situations.

When females are found on the host, immature stages are frequently found with them. Feeding is probably comparatively rapid, otherwise it is logical to assume that females and nymphs would have been more frequently reported from bats.

Arthur's (1956A) comparison of data from Switzerland and from Macedonia leads him to believe that, because there is a reasonably high catch of partially and fully engorged ticks between October and January and a number of unfed nymphs and females during the summer, feeding is accomplished mainly during the winter months. This picture, possibly modified by the host's seasonal breeding cycle and activity, requires further observation.

REMARKS

The exceptionally long legs of this species is a character shared by many chiropteran parasites, notably the Streblidae and Nycteribidae (Diptera) and *Argas boueti* (cf. Figures 33 and 34). This feature is, however, not shared by all bat parasites, especially those which are strongly appressed laterally, as fleas, or appressed dorsoventrally as bugs of the families Cimicidae and Polyctenidae. Except for *Argas boueti*, all the known chiropteran-infesting *Argas* species have normal-length legs, and indeed some, as for instance *Argas transgariepinus* White, 1846 (cf. Hoogstraal 1952A), have comparatively short legs.

Certain morphological peculiarities of adults and immature stages have been briefly mentioned by Arthur (1953A). The haller's organ is described by Arthur (1956B); it is like that of *I. simplex* subspp.

Schulze (1938A, figure 28) has utilized this species to illustrate the thesis of morphological indicators due to pressure within the developing nymph.

The subgeneric position of this species has been discussed by Neumann (1916), but this is moot; Arthur (1956A), the outstanding contemporary specialist on this genus, disregards it until further study can be undertaken.

IDENTIFICATION

Both sexes and the immature stages of *I. vespertilionis* are unique in the extreme elongation of the legs. The long anal grooves of both sexes are open; those of the male slightly converge posteriorly, but female anal grooves are parallel. The male scutum has a few large punctations in three rows and numerous fine, scattered punctations; the female scutum has numerous small, shallow punctations.

The larva and nymph were partially illustrated and briefly described by Nuttall and Warburton (1911) but Arthur (1956A) provides complete descriptions of both sexes and of the immature stages.

MARGAROPUS

INTRODUCTION

The genus Margaropus, closely related to Boophilus and confined to Africa and Madagascar, consists of only two species, M. winthemi Karsch, 1879, of southern Africa and Madagascar, and M. reidi sp. nov. of the Sudan. Earlier assertions that M. winthemi is a South American tick apparently are erroneous.

Usual remarks in the introductory sections for each genus treated in the present work are, in the case of Margaropus, incorporated into the text below and do not require repetition here.

Illustrations of nymphal M. reidi sp. nov. and of M. winthemi, together with a review of the latter species, are given in the APPENDIX, pages 896 to 905. The unexpected circumstance of the very recent acquisition of the new species necessitates this treatment.

KEY TO THE GENUS MARGAROPUS*

MALES

Six pairs of hair tufts and ventral hook on posterior body margin; a caudal projection present when engorged. Adanal shields sharply pointed distally, accessory shields absent. Scutal outline convex laterally and bluntly rounded posteriorly. Free segments of leg IV as wide as long. (South African winter horse tick)...M. WINTHEMI

Figures 359 and 360, 363 to 367

---

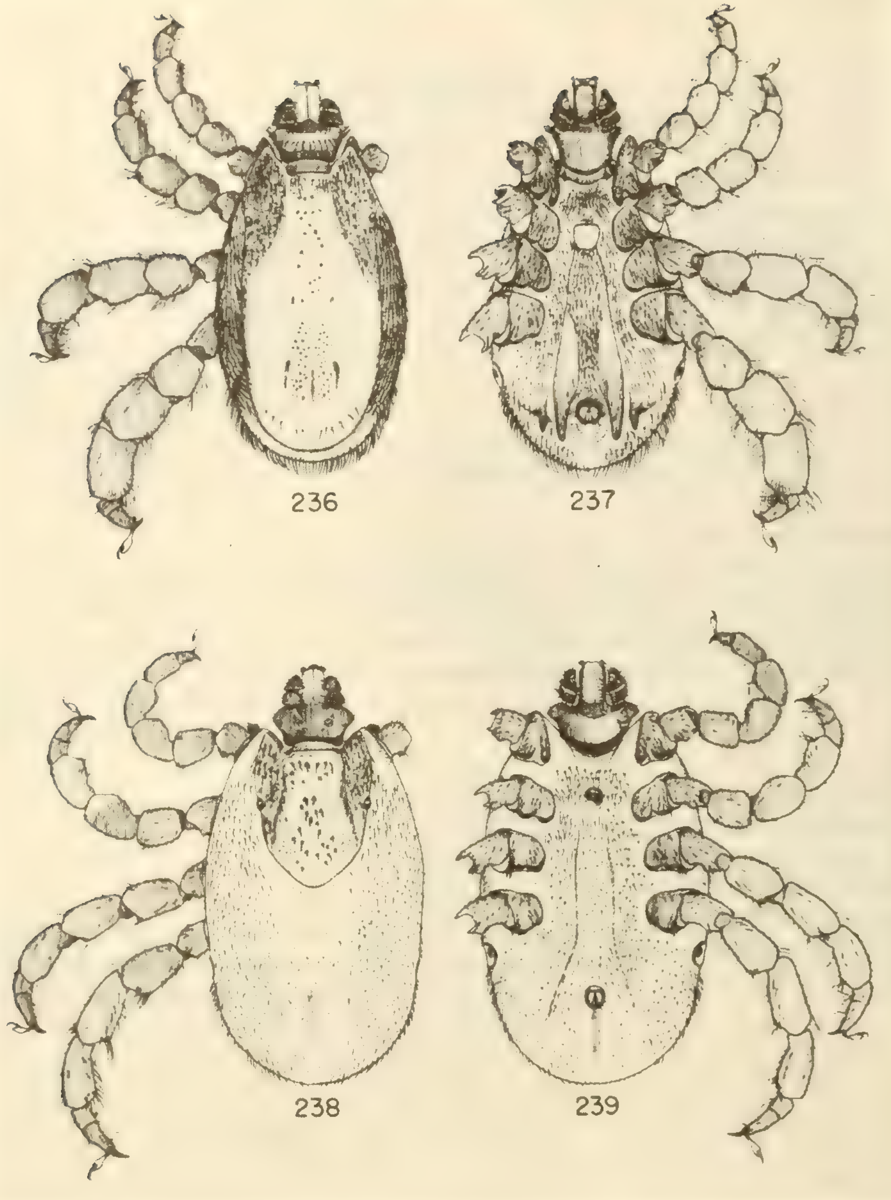
*The characters provided in the key, together with those in the generic key, are sufficient to comprise an adequate diagnosis for each species in this genus.

Dense row of scattered hairs on posterior body margin; hook lacking; caudal projection not known to be present. Adanal shields bluntly pointed distally; accessory shields present. Scutal outline parallel laterally and gradually rounded posteriorly. Intermediate segments of leg IV slightly longer than wide. (Sudanese giraffe tick).................................M. REIDI
Figures 236 and 237

FEMALES

Palpal segments 2 and 3 not separated by a slight constriction; basis capituli dorsally three times as wide as long; porose areas transversely oval. Scutum widest at level of eyes, rounded posteriorly.....................................M. WINTHEMI
Figures 361 and 362
368 to 372

Palpal segments 2 and 3 separated by a slight constriction; basis capituli dorsally twice as wide as long, porose areas vertically subtriangular. Scutum widest midway between scapulae and eye level, bluntly pointed posteriorly........................M. REIDI
Figures 238 and 239



Figures 236 and 237, ♂, dorsal and ventral views
Figures 238 and 239, ♀, dorsal and ventral views

MARGAROPUS REIDI SP. NOV.
Holotype and Allotype

PLATE LXVIII

MARGAROPUS REIDI SP. NOV.

(Figures 236 to 239, and 342 to 358)

THE SUDANESE BEADY-LEGGED TICK

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: All from Giraffa camelopardalis subsp., E. T. M. Reid legit: Liednhom (south bank of Jur River); 14♂♂, 19♀♀, from muzzle, March 1955. One nymph, same locality, 8 March 1955. Twenty-four nymphs, Guar, Galual-Nyang Forest, 15 May 1953.

DISTRIBUTION

M. reidi sp. nov. is known only by the above specimens from the Sudan. It is related to the South African winter horse tick, M. winthemi, the range of which is charted by Theiler and Salisbury (1956). The small males may easily have been overlooked by earlier collectors and the larger females may previously have been quickly identified as Boophilus by nonspecialists. More careful search should reveal the wider distribution of this interesting tick in the Sudan and possibly elsewhere in Africa. See M. winthemi (page 900).

HOSTS

The only known hosts are three specimens of the western Sudanese form of giraffe, Giraffa camelopardalis subsp., the actual subspecific identity of which is considered by Setzer (1956) to be a moot subject that cannot presently be decided. See M. winthemi (page 900).

BIOLOGY

Unstudied. See M. winthemi (page 900).

DISEASE RELATIONS

Unstudied.

REMARKS

M. winthemi and M. reidi sp. nov. are readily distinguished by key characters (pages 574 and 575).

The HOLOTYPE ♂ is deposited in the United States National Museum, number 2225. The ALLOTYPE ♀ is deposited in the same institution, together with one of the PARATYPE nymphs collected on 15 May 1953. The data for these specimens are presented above. A single ♂, ♀, and nymph (15 May 1953) PARATYPE are deposited in the Onderstepoort collection (Dr. G. Theiler), East African Veterinary Research Organization (Miss J. B. Walker), British Museum (Natural History), Rocky Mountain Laboratory, and Chicago Natural History Museum. The remainder of the PARATYPE material is in the writer's collection.

See M. winthemi (pages 899 to 905).

DESCRIPTION

MALE (Figures 236, 237, 342 to 346): Length overall approximately 3.0 mm., width approximately 1.4 mm. Color (dry) dark reddish brown, legs yellowish; integument white, yellowish, or dark brown. Outline oval with integument bulging beyond scutum laterally and posteriorly, but lacking caudal protrusion (available specimens are moderately engorged).

Capitulum: Basis capituli twice as wide as long; lateral margins markedly diverging anteriorly, basal margin slightly concave; dorsal surface bearing a horizontal row of twenty hairs at level of midlength; ventrally more elongate, length and width equal, lateral margins slightly concave, basal margin convex. Palpi comparatively short; overall length and width of each palpus approximately equal; segment 1 forming a short, wide pedicle for segment 2. Segment 2 subquadrate, approximately twice as wide as long; outer margin slightly expanded basally, inner margin straight or slightly convex; anterior and posterior margins straight, parallel. Segment 3 triangular, outer margin approximately twice as long as inner margin. Palpi ventrally with segments 2 and 3 of almost equal length, segment 3 bearing a small triangular retrograde spur extending just beyond the apex of segment 2; segment 4 small, inserted in pit of segment 3; segment 1 forming a slight pedicle for palpi and bearing at its inner basal margin a slight knob with at least one bristle. Hypostome twice as long as wide, apical margin broadly rounded and notched medially; a dense corona present; dentition 5/5, with nine to eleven denticles in each file, files of equal length.

Scutum: Outline narrowly elongate with lateral margins parallel, posterior margin bluntly rounded; lateral margins widening slightly over scapulae; anterior emargination deep. Posteromedian and paramedian grooves shallow, narrow, short, and indistinct, situated at level of spiracular plates. Cervical grooves shallow but distinctly divergent to lateral margin posterior of eyes. Eyes on lateral margin at level of coxa 2; small but distinct, rounded and slightly raised. Surface of scutum smooth and shiny, with a narrow median field of few scattered punctations extending the full length of the scutum; a single row of twelve hairs along posterior margin and a few hairs among posterior grooves; area between cervical grooves and lateral margins punctate and bearing scattered fine, long, white hairs; a row of hairs also situated on anterior margin between cervical grooves. Integument bulging around scutum from level of eyes posteriorly; furnished with regularly scattered, dense, long, white, conspicuous hairs bordering scutum to level of spiracular plates; thence these hairs more confined to narrow lateral surface of integument around posterior margin of scutum, few or no hairs on dorsal surface in this area.

Spiracular plate subcircular, with one and a half rows of large goblets surrounding aperture. Genital aperture situated at midlevel of coxa II, anterior and posterior margins parallel, lateral margins slightly converging posteriorly. Genital grooves extending from genital aperture to level of anus, slightly divergent. Adanal shields commencing at anterior level of coxa IV and extending beyond level of anus almost to posterior margin of body (depending on degree of integumental stretching due to feeding), narrowly elongate, slightly expanded just anterior of anus, tapering and bluntly rounded distally; divided from each other by narrow area of integument; unattached to integument posterior of anus; surface bearing a few scattered hairs distally. Accessory shields extending from level of anus to approximately same level as apex of adanal shields, tapering, bluntly rounded apically; narrower than adanal shields. Hairs on ventral surface fairly dense and evenly distributed but shorter than those on lateral surfaces.

Legs with free segments appearing beaded due to width and constriction between several segments; length-width ratio of segments variable but width of none equalling length of same segment; free segments with numerous long, fine hairs dorsally and ventrally. Tarsi apically extended into a downward projecting, spurlike point; IV also with a short ventral subapical spur; outline narrowly elongate; claws and pads arising from dorsal surface at apex; claws long, narrow, recurved at some distance beyond pads. Coxa I narrowly, elongately subtriangular and extending anteriorly almost to anterior margin of basis capituli, visible from dorsal view; posteriorly deeply cleft to form a widely triangular outer spur and a narrower, tapered inner spur; other coxae subrectangular with rounded margins; posterior margins slightly cleft; all coxae with numerous hairs.

FEMALE (Figures 238, 239, 347 to 351): Unengorged specimens are very slightly larger than males; engorged specimens measure up to 6.2 mm. long but retain the linear, podshape appearance of boophilid females due to the severely parallel lateral margins of the body. Female characters recall those of the male but the leg segments are less expanded and the palpi are more elongate with a slight constriction between the second and third segments.

Capitulum: Basis capituli from one and a half to twice as wide as long; basal margin moderately concave and joined to lateral margins by slight expansions suggestive of cornua; lateral margins concave to widest point at anterior third, thence recurved to anterior margin; porose areas small, shallow, and indistinct, subtriangular or pear shaped; bearing four or five hairs laterally on dorsal surface. Palpi more elongate than those of male, segments 2 and 3 separated by a pediclelike constriction and of approximately equal length; segment 2 arising from pedicle, with straight outer margin, convex inner margin, and subparallel anterior and posterior margins; segment 3 with lateral margins slightly converging to bluntly rounded anterior margin, posterior margin straight though forming a slight, more or less downcurved projection at juncture with inner margin; segment 3 ventrally with short, broad spur reaching basal margin; segment 1 narrow, pediclelike, not observed to bear a ventral knob as in male; palpi with hairs as illustrated. Hypostome larger but otherwise similar to that of male.

Scutum three-fourths as wide as long; outline slightly convex anterior of eyes, slightly converging from eyes to juncture of cervical grooves, abruptly converging posteriorly; anterior emargination deep. Cervical grooves reaching lateral margins as in male and delimiting an anterolateral area that is hirsute and somewhat punctate as in male. Surface otherwise smooth except for a transverse row of hairs bordering anterior margin between cervical grooves and a few scattered hairs arising from punctations in central field. Eyes on lateral margins at scutal midlength, slightly convex.

Spiracular plate of similar construction to that of male but differing slightly in outline. Genital apron a wide oval at level of coxae II. Genital grooves subparallel to level of spiracular plates, thence divergent to level of posterior margin of anus.

Integument with numerous fairly regular rows of short hairs on both dorsal and ventral surfaces; hairs more dense on posterior margin between spiracular plates.

Legs similar to those of male except that the free segments are narrower and tarsi more elongate; tarsus IV lacking ventral subapical spur; anterior projection of coxa I variable, as distinctly produced as that of male or more truncate.

NYMPH (Figures 352 to 358): Capitulum. Basis capituli three times as wide as long, with straight basal margin, rounded junctures, and divergent lateral margins. Palpi four times as long as wide; segment 1 forming a slight pedicle; segments 2 and 3 of approximately equal length and subrectangular; apex more or less bluntly rounded; segment 3 ventrally with a short, wide spur not reaching basal margin of segment. Hypostome similar to that of adults but with smaller corona and 3/3 dentition in files of eight denticles.

Scutum with length-width ratio approximately equal; outline gradually diverging from scapulae to midlength, thence abruptly converging to narrow, bluntly rounded posterior margin. Surface lightly shagreened and with a few scattered hairs; cervical grooves as in adults (not visible in all specimens); eyes small, indistinct or invisible.

Spiracular plate subcircular, with six large goblets in a circle. Integument with long hairs.

Legs with length-width ratio of free segments intermediate between those of male and females sexes; coxa I not so deeply cleft and truncate anteriorly; tarsi short, robust, not tapered downwards as in adults; dorsal margin gradually tapering; claws and pads as in adults.

LARVA: Unknown.

RHIPICEPHALUS

INTRODUCTION

It appears well established that continental Africa is the place of origin and center of distribution of Rhipicephalus ticks. Of the 46 rhipicephalid species and subspecies that Zumpt (1950A) recognized in his preliminary generic revision, 39 (including the now cosmopolitan R. s. sanguineus) are endemic in the Ethiopian Faunal Region; two are Oriental; and five range from southern Europe and northern Africa into Russia.

The genus Rhipicephalus comprises almost a third of the known Sudan tick fauna and contains more than twice as many endemic African species as any other ixodid genus in the Ethiopian Faunal Region.

King (1926) listed five forms of Rhipicephalus from the Sudan. In addition, R. capensis has been apparently erroneously referred to the Sudan (Zumpt 1942B). During the present study, seventeen species and two additional subspecies, or nineteen different forms, have been discovered in the Sudan.

Zumpt's (1950A) major contribution in bringing together the basic taxonomic data for this difficult genus will facilitate greatly the final revision of rhipicephalid species. Earlier, Theiler (1947,1949B,1950A,B) had commenced study of individual species, an effort that is still underway (Theiler and Robinson 1953B, Theiler, Walker, and Wiley 1956). Very careful and thorough studies are also in progress by Walker (1956), who has several further reports completed or in an advanced stage of preparation. Since Zumpt's classic preliminary work, Wilson (1954) described a new species, R. hurti, from Kenya and Santos Dias has provided a number of new names, the validity of which are uncertain. Obviously, new criteria must be sought to separate many rhipicephalid species and subspecies. In an attempt to apply characters surrounding the female genital aperture, Feldman-Muhsam (1952A) has distinguished another species, R. secundus, among populations appearing to be R. s. sanguineus. However, problems of morphological and biological criteria for this genus are not likely to be solved until more exhaustive field research and patient laboratory investigation have been devoted to them.

Study of comparative morphology in the genus Rhipicephalus and of chaetotaxy in the family Ixodidae led Pomerantzev (1936) to reconstruct radially generic concepts of this family. This approach merits further investigation; however, the pitfalls of hasty conclusions based on worn or poorly-preserved field collected specimens, in which the chaetotaxic picture is imperfect, may result in additional confusion of species concepts (Hoogstraal 1955C).

Rhipicephalids tend to considerable variation in appearance and morphological details owing to crowding on the host, welfare of immature stages, and availability of suitable hosts, factors that play a part in the determination of size, robustness, and even certain physical characteristics. Distinguishing characters in many specimens tend to become so generalized that diagnosis is difficult. This is especially true for females. The question of biological races remains to be explored; many data suggest this phenomenon to be operable in certain groups of rhipicephalids. The genus is divided into clearly defined species and species variable enough to cause confusion. It contains extremely common as well as rare species.

Host predilections within this genus are fairly wide among several groups of available animals, although the lack of interest in other animals easily available in the same area is conspicuous by rarity of records of their infestation. A few species, such as R. pravus, have an exceedingly wide host range, being commonly taken on man and all domestic and many feral animals, such as carnivores, antelopes, hares, birds, elephant shrews, elephants, buffalos, and others. Other species, such as R. distinctus from hyraxes, are known only from a single kind of host. It is significant that immatures and adults of most rhipicephalid species do not attack birds and reptiles.

The life cycle is either the two host or the three host type and hosts of immature stages may be either the same as those parasitized by adults or smaller and different animals. In some species, records of larvae from both cattle and rodents are so common as to confuse the picture of the preferred hosts of this stage. R. appendiculatus is an interesting example in point. In R. s. simus there is so much data indicating immature stage predilection for burrowing rodents that it is disconcerting to find that in certain areas where this tick is common larvae are frequently found on other animals. Reasons for these differences are beyond our present ability to explain.

Immature stages of many rhipicephalid species remain undescribed and distinguishing criteria for a number of those that are known are insufficient for identification of field collected material.

Ecological stratification is quite restricted, various species being confined to forests, highlands, semidesert areas, or certain rainfall conditions. The degree and distribution of relative humidity appear to be the most critical of limiting factors. Vegetation types associated with this factor and influenced by the length of the rainy season or proximity to moisture laden air beside the seas can often be associated with rhipicephalid distribution.

Economically, many species are of considerable importance as reservoirs and vectors of a variety of animal and some human pathogens. The kennel tick, R. s. sanguineus, has been shown to have a particularly wide spectrum of actual or potential relationships as a vector of diseases.

KEY TO SUDAN SPECIES OF RHIPICEPHALUS

MALES

1. Eyes convex or hemispherical, distinctly furrowed laterally or protruding from a depression ("orbited"). Coxa I with distinct dorsal projection....................................2

   Eyes flat or slightly rounded, not convex, hemispherical, furrowed, or orbited. Coxa I with or without dorsal projection...3

2. Eyes hemispherical, in a depression (orbited). Adanal shields large, enormously widened posterolaterally. Scutum dark with dense medium and large size punctations; color contrasting with reddish body integument and saffron legs. Frequently large (about 5.0 mm. long). (Common through much of Sudan)..................................R. E. EVERTSI
   Figures 265 and 266

   Eyes convex, with an encircling furrow. Adanal shields mildly rounded laterally, not exceptionally large. Color overall brownish. Scutum with moderately numerous fine and medium size punctations. Fairly small (about 3.5 mm. long). (Southeastern Sudan)................R. PRAVUS
   Figures 285 and 286

3. Coxa I with distinctly pointed dorsal projection*. (Localized areas in southern Sudan)..4

   Coxa I without a distinctly pointed projection though a smaller, rounded hump may be visible in its place. (More or less widely distributed)..........................11

---

*R. simpsoni (R. simus group), a small parasite of canerats only, typically bears this projection but this projection is so small and frequently so reduced that it is not considered distinct enough to include in this section.

4. Lateral grooves faint, absent, or indicated only by a row of punctations. (Rare species)*....................5

Lateral grooves distinct as such*....................8

5. Scutal punctations in more or less definite rows of R. simus type, interstitials variable but always insignificant in comparison with primary punctations....................6

Scutal punctations scattered, not in rows, fairly numerous....................7

6. Posteromedian and paramedian grooves absent. Adanal shields with inner margin in a straight line centrally and with a peculiar protrusion at juncture of inner and posterior margins....................R. LONGICOXATUS
Figures 273 and 274

Posteromedian groove long, narrow, paramedian grooves shorter, wider, less well defined. Adanal shields with inner margin concave centrally and its juncture with posterior margin rounded....................R. BEQUAERTI
Figures 249 and 250

7. Basis capituli sharply angled laterally and with long cornua. Scutal punctations large, unequal, unevenly distributed, small laterally, larger anteriorly....................R. ARNOLDI
Figure 245

Basis capituli slightly convex laterally and with brief cornua. Scutal punctations medium size, superficial, dense, fine laterally....................R. MÜHLENSI
Figures 281 and 282

---

*R. distinctus atypically may have apparently shallow lateral grooves due to the size and depth of the row of large punctations in its bed.

8. Scutal punctations few, in four irregular rows (simus type). Posteromedian and paramedian grooves present but sometimes much reduced...9

Scutal punctations scattered, not in rows...10

9. Lateral grooves containing prominent, large punctations. Adanal shields with rounded or angular posterior marginal junctures but these not produced into spurlike points.....................................R. DISTINCTUS
Figures 261 and 262

Lateral grooves without prominent punctations. Adanal shields with both posterior marginal junctures extended, the outer juncture spurlike, the inner rounded or spurlike; accessory shields distinct and pointed.....................................R. TRICUSPIS
Figures 317 and 318

10. Scutal punctations moderate size, rather few and well spaced centrally, even fewer or none laterally. Cervical fields moderately or non-reticulate. (Common only in Yei District)..................................R. APPENDICULATUS
Figures 240 to 242

Scutal punctations large, dense, partly confluent. Cervical fields markedly reticulate. (Always rare)............R. SUPERTRITUS
Figures 313 and 314

11. Scutal punctations either excessively rare or in a pattern of four more or less linear rows (sometimes with one or two partial additional rows); among these interstitial or secondary punctations are present or absent, if present they are smaller and more superficial*....................12

Scutal punctations not in these patterns, rather dense, not separated into primary and interstitial punctations but uniform or mixed. (Uncommon southern species)....................16

12. Scutum impunctate or with excessively few, shallow punctations. Adanal shields typically tending towards sickleshape but quite variable in series from single hosts. Posteromedian and paramedian grooves present or absent. Lateral grooves distinct or indicated only by a row of punctations. Coxa I with a small dorsal projection which may be much reduced. (Small, rare, pearshaped, variable species, confined to cane rats)....................................R. SIMPSONI
Figures 297 and 298

Scutum with more, larger, and deeper punctations. Other combinations of characters differing....................................13

---

*The linear punctation pattern of heavily punctate specimens of R. s. sanguineus in southern Sudan may be somewhat obscured by dense, moderately large interstitial punctations, but can be discerned by turning the specimen obliquely to the source of the light.

13. Posteromedian and paramedian grooves pronounced, deep, and wide*. Interstitial punctations varying from faint to large and numerous enough to somewhat obscure basic pattern of four rows of larger punctations. (Common, widely distributed in Sudan)........................<u>R. S. SANGUINEUS</u>
Figures 289 and 290, 293 and 294.

Posteromedian and paramedian grooves indistinct, shallow, or absent..............................14

14. Adanal shields elongately triangular with rounded marginal junctures. Only middle festoon protrudes. Posterior grooves absent, rarely very faintly indicated (but never distinct). Scutum arched; interstitial punctations usually absent or insignificant, rarely more definite but never confusing basic pattern. (Common, widely distributed in Sudan)....................................<u>R. S. SIMUS</u>
Figures 301 and 302

Adanal shields either distinctly sickle-shaped or with peculiar inner or outer posterior protrusion. (More localized in southern Sudan and less common)..........................15

*This character is constant in this variable species in all but a very few individuals obviously misformed in several characters.

15. Adanal shields sickleshaped. Three middle festoons may protrude. Posteromedian groove shallow but usually discernible. Punctations slightly more dense bordering posteromedian groove. Interstitial punctations varying from absent to fairly numerous but not obscuring basic pattern. (Specimens may integrade with R. s. simus)............R. S. SENEGALENSIS
Figures 305 and 306

Adanal shields unusually wide, with rounded outer and posterior margins but with an elongated point at the juncture of the posterior and the concave inner margin, this point reaches the festoons. Scutum exceptionally flat and broad..............................R. CUSPIDATUS
Figures 257 and 258

16. Lateral grooves replaced by a line of almost contiguous punctations. Posterior grooves merely faint, shagreened lines. Punctations numerous, close or contiguous, mixed large and small. (A mountain-inhabiting species)....................R. KOCHI
Figures 269 and 270

Lateral grooves present. Other characters various...17

17. Posteromedian and paramedian grooves wide and deep (like those of R. s. sanguineus). Adanal shields typically broadly triangular (like those of R. s. sanguineus) but may be reduced to a pseudosickleshape. Punctations deep, dense, medium to large, some confluent; fewer laterally........................R. SULCATUS
Figures 309 and 310

Posteromedian and paramedian grooves long and very narrow or vague or obsolete...18

18. Scutal punctations uniformly shallow, small or medium size, dense and close everywhere except in scapular areas, on festoons, outside lateral margins, and in narrow area just inside lateral margins. Posteromedian and paramedian grooves vague or obsolete. Adanal shields typically sickleshape (reduced in small specimens)...............................R. LONGUS
Figures 277 and 278

Scutal punctations uniformly large, deep, dense but not contiguous in central area, variable in size in cervical area, fewer laterally. Posteromedian and paramedian grooves long and narrow. Adanal shields broadly triangular but with rounded margins, inner margin slightly concave and more or less pointed at juncture with posterior margin, other junctures rounded........................R. COMPOSITUS
Figures 253 and 254

FEMALES

1. Eyes convex or hemispherical, distinctly furrowed or in a depression....................................2

Eyes flat or slightly rounded....................................3

2. Eyes small, hemispherical, in a depression ("orbited"). Scutum with broadly rounded posterior margin; punctations dense, large and medium size, extending to lateral margins. Body reddish, legs saffron, scutum dark..............................R. E. EVERTSI
Figures 267 and 268

Eyes moderate, convex, with an encircling furrow. Scutum with posterior margin sinuous, strongly converging posteriorly; moderate numbers of mostly medium size punctations extending to lateral margins only anteriorly......................R. PRAVUS
Figures 287 and 288

3. Palpi markedly conical in outline. Scutum longer than wide; lateral grooves absent; lateral margin elevated; cervical grooves pronounced; punctations large and small mixed, fairly numerous.............R. ARNOLDI
Figure 246

Palpi not converging; normally subrectangular..4

4. Scutum with great density of moderate size to large, contiguous or closely adjacent punctations size and depth of which do not markedly differ....................................5

Scutum with few to moderate numbers of uniform or mixed, noncontiguous punctations..9

5. Punctations exceptionally rugose, dense; cervical fields markedly reticulate..................................R. SUPERTRITUS
Figures 315 and 316

Punctations not exceptionally rugose; cervical fields mildly or nonreticulate....................6

6. Lateral grooves lacking; scutum slightly wider than long; numerous moderate size punctations onto lateral ridges.................R. KOCHI
Figures 271 and 272

Lateral grooves present and distinct.........................7

7. Scutum no longer than or not so long as wide; posterior margin bluntly rounded; numerous large punctations; lateral ridges extending to posterior margin, raised, wide, glossy, mostly impunctate..................................R. COMPOSITUS
Figures 255 and 256

Scutum longer than wide; lateral ridges not markedly raised or glossy; with some punctations on lateral ridges..8

8. Scutal punctations fairly large, deep, and uniform, dense, evenly distributed between lateral ridges, fewer on lateral ridges and beside lateral grooves; posterior margin gradually rounded, nonsinuous. Large tick...............................R. LONGUS
Figures 279 and 280

Scutal punctations mixed medium to large size; unevenly but densely distributed and extending onto lateral ridges; posterior margin tapering and sinuous. Medium size tick.................................R. SULCATUS
Figures 311 and 312

9. Punctations inconspicuous, obsolete or rare, small, interstitials obsolete or inconspicuous. Scutum generally but not always longer than wide. Small parasite of cane rats........................R. SIMPSONI
Figures 299 and 300

Punctations conspicuous, rare to moderate numbers. Moderate to fairly large size species.....................................10

10. Scutum with notably few, moderate or large, scattered punctations in central field..11

Scutum with moderate to large number of small, medium size, or large punctations...................16

11. Lateral grooves typically long and distinct (frequently reduced in R. s. simus, see page 752)....................................12

Lateral grooves absent or typically so short and indistinct as to be questionable, frequently replaced by several large, deep, punctations............................13

12. This and the following subspecies cannot be distinguished with certainty. Size moderate. Scutal posterior margin usually somewhat sinuous; punctations restricted to few of moderate size but deep, distinct, and widely scattered; interstitials normally few, rare, inconspicuous, sometimes fairly numerous but small and superficial.......................R. SIMUS SIMUS
Figures 303 and 304

Size fairly large. Other characters as above, although punctations are often somewhat larger than in subspecies simus. Differentiated with certainty only by association with male...........R. SIMUS SENEGALENSIS
Figures 307 and 308

13. Coxa I with two robust posterior spurs widely but not deeply divided. Scutum distinctly wider than long; margin abruptly converging posterior of eyes; lateral grooves replaced by four very large, deep punctations; central field with only four to seven large, deep punctations; cervical grooves shallow but almost reaching posterior margin.................................R. CUSPIDATUS
Figures 259 and 260

Coxa I deeply divided.......................................14

14. Scutum with very short lateral groove containing four to six closely adjacent punctations; several moderate size punctations in central field; outline typically shieldshape; cervical grooves narrow, deep, and converging. A fairly small, variable species...............................R. TRICUSPIS
Figures 319 and 320

Lateral grooves absent or very slightly indicated posteriorly; scutal outline not shieldshape. Moderately large tick...15

15. Scutum with lateral grooves absent or faintly indicated posteriorly; punctations few, moderate size or fine; interstitials rare or obsolete; width lightly greater than length..................R. LONGICOXATUS
Figures 275 and 276

Scutum lacking lateral grooves; with three to seven large punctations in place of each groove and with an equal number of same size in the central field. Hyrax parasite. Other characters uncertain; see pages 638 to 640.........R. ?DISTINCTUS
Figures 263 and 264

16. Scutum with variable background of irregularly scattered fine to medium size punctations among which fewer larger punctations are more or less distinct; lateral grooves pronounced, long; outline distinctly longer than wide and with characteristically sinuous posterior margin.......................R. S. SANGUINEUS
Figures 291 and 292
and 295 and 296

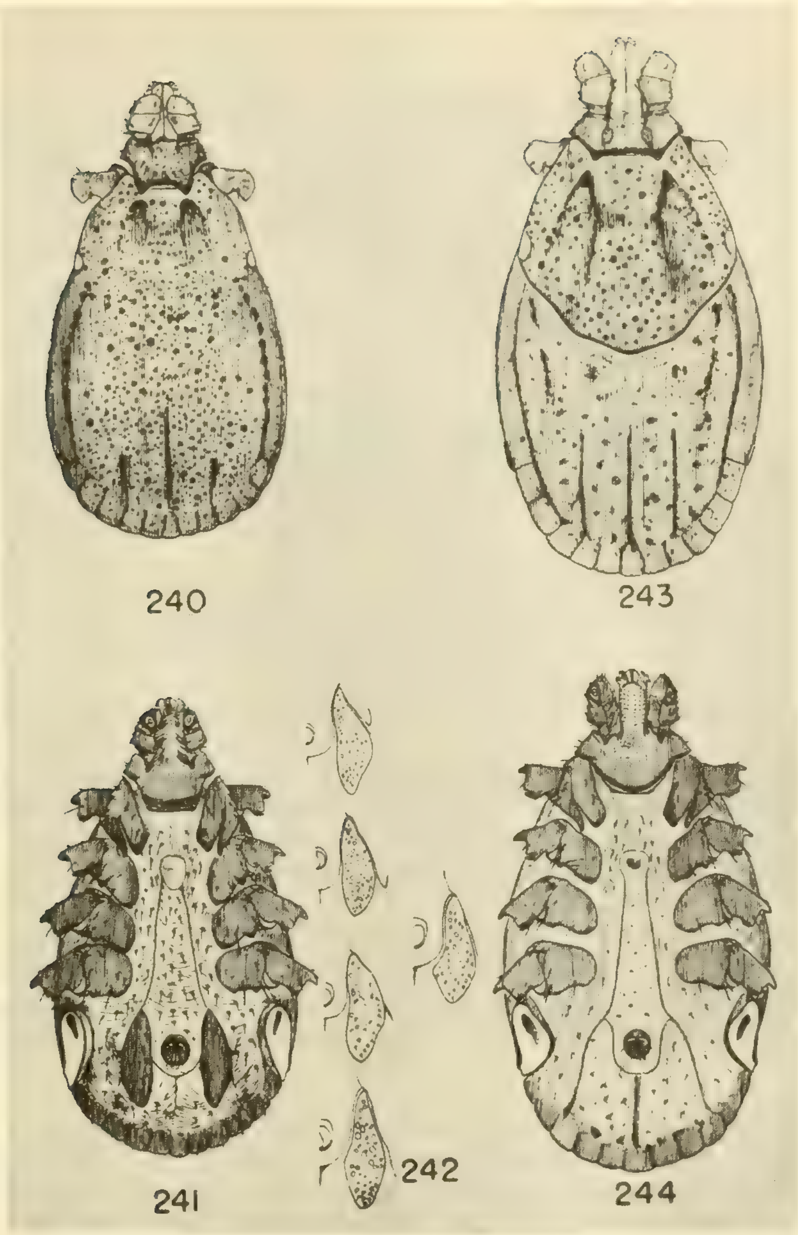
Scutum with scattered punctations not as above; lateral grooves short, poorly developed, or absent, never rectilinear or deep......................................17

17. Porose areas large, circular or subcircular; interval between these areas no greater than their diameter. Scutum with widely scattered fairly large punctations and moderate number of superficial interstitials of variable size; outline somewhat wider than long or length-width ratio approximately equal; lateral grooves short or indistinct; cervical grooves shallow, indistinct, may extend to posterior margin. (Rare)..R. BEQUAERTI
Figures 251 and 252

Porose areas small or moderate, interval separating them greater than their own diameter..18

18. Scutum lacking lateral grooves; punctations dense but superficial, medium size with finer interstitials, rare laterally anterior of eyes and on scapulae; posterior margin typically gradually rounded. (Rare)........................R. <u>MÜHLENSI</u>
Figures <u>283 and 284</u>

Scutal characters frequently modified by crowding; lateral grooves superficial, short to long; lateral ridges more or less elevated; punctations widely spaced, fewer laterally, small to moderate size, interstitials rare or absent; posterior margin abruptly rounded or slightly tapering. (Common in restricted areas only)....................................R. <u>APPENDICULATUS</u>
Figures <u>243 and 244</u>



Figures 240 and 241, ♂, dorsal and ventral views
Figure 242, ♂, variation in adanal shields
Figures 243 and 244, ♀, dorsal and ventral views

RHIPICEPHALUS APPENDICULATUS
Sudan Specimens

PLATE LXIX

RHIPICEPHALUS APPENDICULATUS Neumann, 1901

(Figures 240 to 244)

THE BROWN EAR-TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
	1			Torit	Man (engorged on)	Dec
			1	Ngangala	Hippotragus equinus bakeri	May (SVS)
		1	1	Katire	domestic cattle	Jan
	31	245	622	Kajo Kaji	domestic cattle	Dec (3)
		21	32	Kajo Kaji	domestic cattle	Jan
	12	131	148	Yei	domestic cattle	Dec (2)
		1	13	Yei	domestic cattle	Jan
			5	Yei	domestic sheep	Jan
	6	1	2	Yei	domestic sheep	Dec
		5	14	Kajo Kaji	domestic sheep	Dec
		14	48	Kajo Kaji	domestic goats	Dec

In the Sudan, R. appendiculatus is known only from Kajo Kaji and Yei on the west bank of Equatoria Province and from Katire (3500 feet elevation) and Ngangala (± 1700 feet elevation) on the east bank of Equatoria Province (Hoogstraal 1954B).

The engorged nymph removed at Torit from the leg of one of our party who had just come almost three hundred miles from Kajo Kaji is a good example of how an important tick species may easily be spread far from its present range by modern, fast, transportation.

There appears to be little reason why R. appendiculatus should not be able to maintain itself east of the Nile in certain scattered areas of Torit District, though as yet it has been found only at Katire, which is cooler and more forested than are the plains. To the east and north of Torit District, conditions are most likely too arid for the brown tick. Most of the west bank of Equatoria Province is probably suitable for this tick.

The first Sudanese specimens of R. appendiculatus were collected by Mr. H. Luxmoore at Kajo Kaji and Yei in 1950 in connection with the first definitely known outbreak of East Coast fever in the Sudan* (Evans 1952). Mr. Luxmoore sent these specimens to the writer for determination, and their identity was later corroborated by Dr. G. Theiler. A restriction was then placed on the movement of cattle from Uganda into Kajo Kaji and out of Kajo Kaji and Yei District.

---

*If East Coast fever, of which R. appendiculatus is the chief vector, had been a significant problem in the Sudan earlier, it seems most likely that the hard-working Sudan Veterinary Service would have recognized it.

Without presenting data, Schwetz (1934) accused the Anglo-Egyptian Sudan as being the source of an epizootic of East Coast fever in Stanleyville, Belgian Congo.

In Egypt (Mason 1920), 32 cases of this disease were diagnosed in Sudan cattle at the Cairo abattoir in 1917. Mason (1922) further reported that East Coast fever had been demonstrated in Sudan cattle arriving at Egyptian quarantine as early as 1913. So far as it has been able to determine, the bulk of Egyptian cattle imports from the Sudan has always been from Kordofan and Darfur Provinces. The occurrence of this tick and of this disease in these two Provinces would be surprising indeed. It seems unlikely that (1) the disease is unrecognized in Kordofan and Darfur, (2) the brown ear-tick occurs in these commercially important cattle-raising areas of the Sudan, and (3) a secondary vector plays an important rôle in Provinces from which cattle are exported.

Possibly, early Egyptian veterinarians lumped animals imported from Ethiopia, Kenya, and Tanganyika under the designation "Sudanese", as is still the practice. In the course of surveying the ticks arriving in Egypt on "Sudanese cattle", numerous specimens of Amblyomma gemma have been obtained. This species is not represented in available Sudan collections. Investigation has revealed the present practice of referring to all cattle imported into Egypt from Africa as "Sudanese". In connection with Brumpt's (1920) reference to East Coast fever in Egypt and the possibility of its transmission by R. simus and R. bursa, see DISTRIBUTION of R. s. simus (page

During the 1951-52 visit for the present study in the Sudan, R. appendiculatus was found to be still extremely numerous on almost all cattle in the Kajo Kaji area, and surprisingly common on the Yei dairy herd in spite of a gammexane spray program in effect there. In December of 1952, we also collected many specimens on cattle at Yei. A careful watch for this tick in southern Sudan is indicated, especially since a program for restocking areas from which cattle have earlier been eradicated by the tsetse fly has recently been undertaken. It is conceivable that this tick, if unchecked, could spread to the point where the value of the entire program on the west bank of Equatoria Province might be severely jeopardized.

DISTRIBUTION

The brown ear-tick reaches its northern limit in southern Sudan and somewhere in Ethiopia. From this level it extends to South Africa, where, south of about Pretoria, it occurs only on the coastal strip. Within this range, it is absent in deserts and in areas without shrub cover. It is common in the Congo but most probably absent or almost entirely absent in West Africa.

The range of R. appendiculatus has been mapped by the American Geographical Society (1954; see also ERRATUM sheet).

/WEST AFRICA: NIGERIA: Simpson (1912A). Mettam's (1940) remark apparently refers to Simpson's report. GOLD COAST: Stewart's (1933) statement that this tick is common here requires substantiation./

CENTRAL AFRICA: /CAMEROONS: Neumann (1911). Rageau (1951, 1953A,B) did not find this species in the Cameroons and it is possible that Neumann's record is in error. FRENCH EQUATORIAL AFRICA: Fiasson (1943B). Rousselot (1951) noted a single collection from Oubangui-Chari but did not again report this record (1953B)./

BELGIAN CONGO and RUANDA-URUNDI (As R. nitens: Newstead, Dutton, and Todd 1907. Nuttall and Warburton 1916. Marcq 1924. Seydel 1925. Schwetz 1927A,B,C,1932,1933A,1934. Schwetz and

Collart 1929. Bequaert 1930A,1931. Bouvier 1945. Schoenaers 1951A,B. Rousselot 1951,1953B. Theiler and Robinson 1954. Santos Dias 1954. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (Evans 1952. Hoogstraal 1954B).

ETHIOPIA (Stella 1938A,1939A,B,1940. Roetti 1939). ERITREA (Carpano 1912. Stella 1939B,1940. Sforza 1937. Ferro-Luzzi 1948). BRITISH SOMALILAND (Neumann 1922. Stella 1938A,1939A,1940). [ITALIAN SOMALILAND: Paoli (1916). Franchini (1927,1929C,E). Niro (1935). Stella (1938A,1939A,B,1940). Pellegrini (1950) says *R. appendiculatus* is absent on sheep with Nairobi sheep disease, and Tonelli-Rondelli does not list it in any of her papers. FRENCH SOMALILAND: Probably absent; HH observation.]

KENYA (Neumann 1912. Neave 1912. A. Theiler 1912B. Montgomery 1913,1917A,B,1919. Stordy 1914. Neumann 1922. Anderson 1924A,B. Harrison 1928. Walker 1928,1931,1932. Cowdry and Ham 1930,1932. Lewis 1931A,B,C,1932A,B,1934,1939A,B,1943,1946,1950, 1952. Brassey-Edwards 1932,1933. Cowdry and Danks 1933. Daubney 1933,1934,1936A,B,1937,1939. Daubney and Hudson 1931A,B,1933, 1934. Fotheringham and Lewis 1937. Reichenow 1937,1940. Mulligan 1938. Lewis and Fotheringham 1941. Lewis, Piercy and Wiley 1946. Dick and Lewis 1947. Beaumont 1949. White 1949. Binns 1950,1951, 1952. Worsley 1950. van Someren 1951. Wilson 1953. Wiley 1953, 195).

UGANDA (A. Theiler 1910A,1911A,1912B. Bruce *et al* 1911. Neave 1912. Warburton 1913. Hutchins 1917,1924. Neumann 1922. Richardson 1926,1930. Mettam 1932,1933. Mettam and Carmichael 1936. Laws 1948. Wilson 1948A,B,C,1949,1950A,C,D,E,1951A,B,1953. Taylor 1954. Taylor and McAnulty 1951. Wiley 1953. Clifford 1954. Lucas 1954).

TANGANYIKA (A. Theiler 1910A. Neumann 1907C,1910B,1911. Dönitz 1905, probably with excellent reason, stated that the *R. sanguineus* of Koch 1903 is a mistake in identity of *R. appendiculatus*. A. Theiler 1912B. Morstatt 1913. Loveridge 1928. Bequaert 1930A. Allen and Loveridge 1933. Moreau 1933. Cornell 1936. Reichenow 1937,1940,1941A,B. Zumpt 1942B. Lowe 1944. Beakbane and Wilde 1949. Wilson 1953).

SOUTHERN AFRICA: ANGOLA (Manetti 1920. Sousa Dias 1950. Santos Dias 1950B). MOZAMBIQUE (Howard 1908,1911. Bedford 1932B. Theiler 1943B. Santos Dias 1950B,1951B,1952D,H,1953B. Wilson 1953).

NORTHERN RHODESIA (Neave 1912. Le Roux 1934,1937,1947. Matthysse 1954. Theiler and Robinson 1954). SOUTHERN RHODESIA (Robertson 1904B. Bevan 1910,1915,1920,1927. Edmonds and Bevan 1914. Sinclair 1916,1920. Jack 1921,1928,1936,1942. Lawrence 1935,1937,1938A,1942). NYASALAND (Old 1909. Garden 1912. Neave 1912. De Meza 1918A. Lamborn 1929. Wilson 1943,1944,1945,1946, 1950B. Beakbane and Wilde 1949. Binns 1951).

SOUTHWEST AFRICA (Neumann 1901. Tromsdorff 1914). BECHUANALAND (Eastern part; Theiler, unpublished).

UNION OF SOUTH AFRICA (Neumann 1901,1911. A. Theiler 1903, 1905B,1906,1909A,B,C,1910A,1911B,1912B,1921. As R. nitens: Neumann 1904. A. Theiler and Stockman 1904. Lounsbury 1904A, B,C,1905A. Howard 1908. A. Theiler and Christy 1910. Dönitz 1910B. Moore 1912. Nuttall 1914A. Van Saceghem 1914. Dixon 1914. Borthwick 1918. Bedford 1920,1929B. Cowdry 1925B,C, 1926A,1927. A. Theiler and du Toit 1926,1928. Sergent, Donatien, Parrot, Lestoquard, and Plantureux 1927B. P. J. du Toit 1928, 1931,1947. Curson 1928. P. J. du Toit and Viljoen 1929. Bedford 1932B,1934. Alexander and Neitz 1933,1935. Bedford and Graf 1934,1935,1939. Cooley 1934. Pijper 1934. Pijper and Dau 1934. M.D. 1936. J. H. S. Gear and Bevan 1936. Nieschulz and du Toit 1937. Pijper and Crocker 1938. Neitz and du Toit 1938. J. H. S. Gear 1938. Neitz 1939,1948,1950,1953. Neitz, Alexander, and Mason 1941. R. du Toit, Graf, and Bekker 1941. R. du Toit 1942B,C,1947. Thorburn 1947. Bekker, Graf, Malan and Van der Merwe 1949. Graf and Bekker 1949. Whitnall and Bradford 1949. Theiler 1949B,C,1952A,B. Jansen 1952. Meeser 1953. J. Gear 1954).

Note: The South African "aberrant strain" which was considered possibly an arid-adapted strain (Theiler 1949B, p. 283) is actually R. pravus according to Theiler and Robinson (1953). The range of this tick in South Africa, as mapped by the American Geographical Society (1954), was modified on their Erratum Sheet.

OUTLYING ISLANDS: ZANZIBAR (Neave 1912. Aders 1917).

HOSTS*

Most prominently listed as hosts of all stages of R. appendiculatus by most authors are cattle, but domestic goats, sheep, horses, mules, donkeys, and dogs are also commonly listed. The comparative incidence on these animals has seldom been carefully observed. The brown ear-tick appears to feed more readily on cattle than it does on sheep, according to Worsley (1950). A single male has been reported from a domestic chicken (Lucas 1954).

Wild antelopes and buffalo are frequently reported, and numerous other animals are infested on occasion. Wild carnivores appear to be parasitized only rarely.

Larvae and sometimes nymphs feed on medium-small animals such as hares and cane rats, and may also attack man. Mostly, however, they are known from the same larger size hosts as adults. The question of why some larvae and nymphs choose smaller hosts deserves further investigation.

In connection with the account of noninfestation of young antelopes (below), it is of interest that Binns (1951) has reported that calves tied to trees in the Lela District of Kenya were attacked within two days after birth. Although these calves harbored only one or two ticks during the first week, four to ten ticks infested them after a fortnight. At the end of the month, over twenty brown ear-ticks were feeding on some calves. Afterwards, the count fluctuated considerably but averaged weekly 12.9 adult ticks per animal for six calves for three months. This was a lower average than for freely grazing older animals (but "adequate to provide a reasonable exposure to East Coast fever").

Adult Hosts (only wild animals listed)

Antelopes: Death of waterbuck due to heavy infestation (Hutchins 1917). Most of the following antelope hosts have been reported by several authors. Uganda kob (Warburton 1913). Nyala, kudu (Bedford 1932B, Santos Dias 1952D). Impala (Bedford 1932B. Santos Dias 1952D. Meeser 1952). Bushbuck, waterbuck (Bedford 1932B). Sable antelope, Livingstone's suni, steenbuck, klipspringer (Jack 1942).

---

*The matter of domestic animal hosts will be treated in the forthcoming volume on disease relations of African ticks. Numerous additional host records are provided in the APPENDIX.

White-bearded gnu (Loveridge 1928). Dik-dik (Loveridge 1928, Stella 1939B). Kobus ellipsiprymus and Adenota vardoni (Schwetz and Collart 1929). Hippotragus niger roosevelti (Santos Dias 1952D). Hartebeest and lechwe (Matthysse 1954).

Mettam (1933) reported the interesting observation that newly-born kob, duiker, bushbuck, and reedbuck in an Entebbe paddock heavily infested with R. appendiculatus and R. evertsi were in no instance affected by these ticks.

Buffalo: (Howard 1908, Richardson 1930, Lewis 1931C,1943, Walker 1932, Jack 1942, Santos Dias 1950B,1952D).

Carnivores: Hunting dog (Lycaon sp.) (Howard 1908). Lion (Zumpt 1942B, Santos Dias 1953H, Matthysse 1954). Felis capensis hindei (Allen and Loveridge 1933). Jackal (Santos Dias 1952D, 1953B). Leopard (Santos Dias 1952H,1953B, Matthysse 1954).

Man: (Howard 1908).

Miscellaneous: "All game animals in Kenya" (Lewis 1939A) but "rare on game in Masai Reserve" (Lewis 1934). Warthog and elephant (Zumpt 1942B). Zebra (Lewis 1931,1932, Santos Dias 1952D, Matthysse 1954). Giraffe (Santos Dias 1953B).

Stage of Tick Questionable

Squirrel (Bedford 1932B). Hares (Schwetz 1927A, Jack 1942).

Nymphal Hosts

Hares and rock rabbits (Pronolagus sp.) (Theiler, unpublished). Large cane rat (Wilson 1950B). Bush squirrel (Santos Dias 1952D). Duiker (Lewis 1931C). Zebra, hartebeest, lechwe, kudu, hares (large numbers), and jackals (Matthysse 1954). Man (Equatoria Province record above. Pijper and Dau 1934).

Tick identification "probable": elephant-shrews (Rhinonax chrysopygus and Petrodromus s. sultani) and Peter's gazelle (Lumsden 1955). Parasitism of elephant shrews by nymphs of this species is probably rare or questionable.

Larval Hosts

Hares (Lewis 1934). Man (Pijper and Dau 1934). See APPENDIX.

BIOLOGY

R. appendiculatus is a three host tick. In Nyasaland, where there is a single rainy season each year, the brown ear-tick produces one generation a year (Wilson 1946,1950B) but in South Africa it may produce one or two generations a year (Lounsbury 1904). In Kenya and Uganda, where two rainy seasons occur each year, multiplication is faster and two or three generations breed within a twelve months' period (Wilson 1953). As stated in the section on HOSTS above, adults feed on large animals, nymphs attack large or medium size hosts, and larvae appear to prefer small to medium size animals above the size of usual rodents. Variation in size and structure of this species, as influenced by hosts and environment, are discussed under REMARKS below.

Life Cycle

In Nyasaland, Wilson (1950B) found that under optimum conditions of high humidity, from 110 to 129 days are necessary to complete the life cycle. In South Africa, Lounsbury reared the brown ear-tick through its life cycle in from 61 to 146 days depending on the season. Nuttall (1913B), working in an English laboratory, reared this species in a minimum of 115 days, from preoviposition to preoviposition period, when maintained at between 17°C. and 20°C.

Nuttall (1913B) summarized his life cycle studies about as follows: *R. appendiculatus* requires three hosts upon which to feed in its larval, nymphal, and adult stages. Larvae usually remain on the host for from three days to a week; when they remain considerably longer they either do not imbibe blood freely or they may not actually attach on the day on which placed on the host. Engorged larvae drop off up to fifteen days after having been placed on the host. Nymphs remain on the host for five to eleven days. Fertilized, replete females abandon the host after six to fourteen days. Males attach to the animal for longer periods, and unfertilized females may remain on the host up to 24 days.

The temperature at which the host is maintained, within the limits observed, exerts no apparent influence on the time that different stages remain attached. Postfeeding metamorphosis requires the following time: from egg to larva, 32 to 65 days at 17°C. to 19°C.; from larva to nymph, four to six days at 30°C., or 21 to 41 days at 15°C. to 17°C., or 60 to 75 days at 13°C. to 14°C.; from nymph to adult, ten days at 37°C., or 21 to 38 days at 20°C., or 64 days at 14°C. Away from the host, therefore, temperature markedly influences the rate of development.

Once the female abandons the host, oviposition commences after six to 23 days at 17°C. to 19°C., or after fifty to sixty days at 12°C. Oviposition continues for from fifteen to 56 days, during which period the female lays from 3000 to 5770 eggs.

Nuttall's average minimum times and Theiler's minimum and maximum times for various periods of the life cycle are summarized as follows:

PERIOD	DAYS	
	Nuttall (1913B)	Theiler (1943B)
Preoviposition	6	5-40
Oviposition to hatching	32 (17-19°C.)	*28
Larval prefeeding period	7	-
Larva feeds	3	3-7
Premolting period	21 (17°C.)	10-49
Nymphal prefeeding period	7	-
Nymph feeds	5	3-7
Premolting period	21 (20°C.)	10-61
Adult prefeeding period	7	-
Female feeds	6	4-10
Total	115	63-202

Field observation indicates the extreme importance of knowing not only the temperature but also relative humidity at which all rearing experiments such as these are accomplished.

*Eggs require three months for hatching in wintertime, South Africa.

Life cycle figures published by Wilson (1950B) for Nyasaland fall well within the above limits. Lewis (1939B) in Kenya found that larvae and nymphs remain on their host for several days longer than the above periods.

Females in Nyasaland engorge and oviposit only during the wet season when the relative humidity is above 75%. Adults, especially engorged females, are rare at other times of the year. Unengorged larvae die in large numbers during the cool, dry months of the year, but nymphs are common at this season. Under optimum conditions of high humidity, 110 to 129 days are necessary to produce adults of the F_1 generation in Nyasaland (Wilson 1944,1946,1950B).

The life cycle in Northern Rhodesia is much like that of *A. variegatum* (Matthysse 1954), although adult brown ear-ticks are more severely restricted to the wet season. No adults appear until November, when they reach a high peak of abundance, but their numbers drop rapidly in the dry season, late March and early April, and until October adults are rare. In some areas, however, a few adults persist through the dry season. Larvae are not found until late in the rainy season, late February, and are abundant from March through August. Larval and nymphal incidence overlaps from early April through August, but nymphs rapidly disappear with September's hot weather and are completely absent by early November. Incidentally, adults of *R. compositus* (= *R. ayeri*) preceed those of *R. appendiculatus*, being abundant in September and October and present in some numbers in July, August, and November. This may have some significance in maintaining and transmitting East Coast fever in cattle when adult brown ear-ticks are absent.

In laboratory studies on the effect of artificial climates (Mulligan 1938), engorged females proceeded to oviposit when returned to a temperature of 24°C. to 27°C. after having been exposed to 1°C. to 4°C. for eight or nine days. Many of the resulting eggs shriveled and died; some larvae that hatched did survive but many others succumbed. Eggs hatched after having been exposed to the same low temperature range for six hours. About half of the engorged larvae subjected to the low temperature failed to molt and died.

The survival of ticks, whether fed or unfed, is of practical importance. Lewis (1939B), working in Kenya, has recorded the longest survival time for unfed stages of R. appendiculatus: larvae about nine and a half months, nymphs about twenty months, and adults about two and a half years. In South Africa, du Toit (1928B) noted the same survival time for adults in the laboratory and also that unfed adults remained in the field for fourteen months. Nuttall (1913B) was able to keep unfed larvae alive for eleven months (slightly longer than Lewis' observations) but survival periods for other stages were shorter than those of Lewis. Wilson (1946) could not maintain unfed larvae in his Nyasaland laboratory for more than a week or so.

Ecology

As many as 1000 individuals of this species may be found on single host, most commonly on the ear, on the inner, concave, surface and especially along the anterior margin. When the infestation is heavy, fewer numbers also attack around the base of the horns, eyelids, cheek, neck, tail switch, udders, scrotum, vulva, anus, and flanks (Wilson 1948B,1949, Beakbane and Wilde 1949). Immature stages are mostly on the ears but not deep in them, as is true of immature R. evertsi. Immature B. decoloratus are frequently associated with R. appendiculatus along the edge of the ear. If the host is heavily infested, immature brown ear-ticks may be found on many parts of the animal's head. Unengorged larvae and nymphs are so small that they are difficult to detect on the host (Wilson 1948C).

Heavy infestations of brown ear-ticks and of nymphs of R. evertsi on and in the ears of cattle frequently leads to a severe bacterial otitis, caused by Corynebacterium pyogenes, and sloughing of the external ear (Clifford 1954). Dr. J. I. Taylor, recently Director of the Uganda Veterinary Service, states (conversation) that the tympanic membrane is frequently ruptured by heavy infestations and a severe lymphangitis occurs in the head and neck regions.

In order to assess the degree of infestation of cattle in the Lela district of Kenya, an area with about 58 inches of well distributed annual rainfall and with a high average temperature and humidity, the East African Veterinary Research Organization (Binns 1951) removed a single animal out of each local herd at fortnightly intervals and collected the ticks from its ears.

Over a period of seven months the weekly count per animal averaged only 27.3 adult brown ear-ticks, varying from sixteen to 41 on each. Higher counts had been anticipated in view of the apparently favorable conditions for these ticks in the area and because of the presence of East Coast fever. The same report gives average counts from other areas, correlated with rainfall, vegetation, and incidence of disease.

The distribution of the brown ear-tick in South Africa, briefly summarized from Theiler's (1949) detailed study, is as follows: It is present in areas with annual rainfall above fifteen inches, provided that bush and shrub coverage is adequate. With proper dipping practices and restriction of wild game movement this tick can be eradicated*. Theiler's report should be consulted by anyone seriously concerned with this parasite.

In Kenya, where temperatures are higher than in South Africa, an average rainfall of twenty inches or more appears necessary for R. appendiculatus to maintain itself (Wiley 1953). Because various workers have so intimately associated their studies on the life cycle and their observations on the seasonal incidence of the brown ear-tick, this subject has been discussed under Life Cycle above. Other climatic factors are presented below.

Lewis' (1939A) findings in Kenya corroborate Theiler's statements for South Africa. There, the tick is absent from the plains, desert, and high plateau areas, but common, especially between 4,800 feet and 7,000 feet elevation, where vegetation provides enough shade to meet its requirements. [It is of interest to interpolate here that Kajo Kaji, Yei, and Katire, from where these specimens were taken in the Sudan, are at about 3000 feet elevation; these areas are more forested than most of Torit District]. Lewis concluded that R. appendiculatus is active at all times of the year but more so during the rainy season, and that it thrives best when the mean maximum temperature is between 60°F. and 80°F., and the mean minimum between 50°F. and 60°F. Lewis' 1931 and 1932 papers give other details of the presence or absence of R. appendiculatus in Kenya.

---

*A number of veterinarians believe that under most African conditions complete eradication is impossible and while control to prevent otitis and lymphangitis should be practiced, restricted populations should be allowed to remain to induce East Coast fever immunity in calves.

In Uganda, after a series of dry years, the numbers of R. appendiculatus decrease to the point where East Coast fever is not maintained in cattle in endemic form. When the disease is introduced during the great increase of the species in abnormally wet years, the mortality of the now-susceptible cattle may be serious (Wilson 1948A). It has been suggested that this tick should not be entirely eradicated in order to maintain its hosts' immunity to East Coast fever.

By way of summing up the ecology and distribution of the brown ear-tick, Wilson (1953) has designated the "R. appendiculatus - A. variegatum association" of East and Central Africa. This interesting and important contribution is reviewed herein under A. variegatum (cf. page 274; also R. pravus, page) and should by all means be consulted by anyone concerned with the biology of the brown ear-tick. Reichenow (1941A,B), from his own observations in Tanganyika, has also stressed the practical importance of knowing the ecology and distribution of this parasite.

The red-billed oxpecker, or tickbird, Buphagus erythrorhynchus (Stanley), which attends all the larger herbivores except the elephant and the hippopotamus, has been shown by Moreau (1933) to be a predator of some importance on R. appendiculatus and on other economically important ticks. Of the 58 tickbirds examined in Tanganyika, almost 500 brown ear-ticks were found in the stomach of thirty. The number of brown ear-ticks per stomach ranged from one to 96.

In Kenya, van Someren (1951) removed 59 adult and nymphal brown ear-ticks from the stomachs of eight of the same birds that he examined; none were found in four others of the same kind. He found 112 nymphs and adults in stomachs of all seven specimens of B. a. africanus that he examined in Kenya.

A further discussion of birds feeding on ticks is presented under biology of A. variegatum, page 275.

The chalcid wasp parasite Hunterellus hookeri Howard, 1908, has been found infesting nymphal brown ear-ticks removed from hares, Lepus capensis subsp., in South Africa (Cooley 1934). Cooley did not find this wasp in ticks in Kenya (Price 1948) but Philip (1954) has found it in nymphal kennel ticks there. For a brief discussion of this wasp, see biology of R. s. sanguineus, pages 710 to 712.

DISEASE RELATIONS

MAN: Boutonneuse fever (Rickettsia conorii).

The virus of Rift Valley fever of man and animals survives only until the tick molts and is transmissible only experimentally.

CATTLE: The common, important vector of East Coast fever (Theileria parva); experimental work with the "turning sickness" form also reported. Pseudo East Coast fever (T. mutans). Redwater (Babesia bigemina). Louping-ill (virus) (experimental). Not a vector of bovine infectious petechial fever (Ondiri disease) (virus).

SHEEP: Nairobi sheep disease, and (experimentally) louping-ill (both virus).

GOATS: Nairobi sheep disease (virus).

HORSES: Louping-ill (virus) (experimental). Not a vector of horsesickness; virus is not transmitted to the progeny of ticks from fatally-infected hosts.

REMARKS

Integumentary sense organs, which are fixed in number and location, and which are essentially similar in all stages of the tick, though more primitive in larvae, have been described and illustrated by Dinnik and Zumpt (1949).

A misformed specimen has been described and illustrated by Nuttall (1914A) (repeated by most subsequent workers on the subject) and a gynandromorph has been reported by Santos Dias (1952E).

Schulze's work on the brown ear-tick has included certain aspects of the larval gut (1943B), of the larval haller's organ (1941), and of the external body structure of males (1932C).

Copulation has been observed by Dönitz (1905) and discussed by Christophers (1906); the same remarks as for R. e. evertsi (page 652) apply to the brown ear-tick.

That the wide range of adult size and appearance (scutal smoothness, degree of punctation, depth of lateral grooves, presence of hairs on basis capituli, presence of dorsal concavity of palpi, shape of adanal shields, presence of accessory shields, size and shape of tarsi and of porose areas, etc.) is due to variation in fullness of feeding of the immature stages has been convincingly presented by Nuttall (1913).

It appears, however, that no matter how variable this species may be, it is seldom difficult to distinguish from other species.

When making the rather sizeable collections of R. appendiculatus at Kajo Kaji and Yei, in December of 1951, it was noted that specimens from the ears of cattle were consistently of rather uniform size and similar in structure and appearance. But specimens from sheep and goats varied considerably in size and structure, and many were malformed. Upon returning to Yei in December of 1952, additional specimens were obtained from cattle. Many of these were as variable and misshapen as the previous year's collections from goats and sheep. The factors behind these differences are too complex to allow conjecture over the reason, interesting as it might be to do so. It is suggested, however, that other reasons, besides immature stage nutrition, may dramatically influence the parasite's well-being and should be investigated.

IDENTIFICATION

Males vary in overall length from 1.8 mm. to 4.4 mm.; "normal" males are 3.0 mm. or above in length. They are usually brownish or reddish-brown, but may be very dark; the legs are always reddish-brown. The clearly-defined dorsal process of coxa I restricts this species to a rather small group among which it can be distinguished by the deep, long lateral grooves, peculiar scutal punctation, shape and rounded posterior margins of adanal shields, flat eyes, etc. Scutal punctations of moderate size are evenly spaced in the central area of the scutum but almost or entirely disappear in the lateral fields and outside of the lateral grooves. Posteromedian and paramedian grooves are narrow but distinct and the cervical fields are more or less reticulate, especially in large specimens. A caudal process is sometimes present. The characteristic elongate shape of the adanal shields with their slightly rounded angles is most distinctive after some series have been examined. Variation in shape of the adanal shields is illustrated (Figure 242). The basis capituli is somewhat variable in that the lateral margins may be more or less angled, depending largely on the size of the individual.

Females are similar to males in color and quality of punctations. The scutum has a distinctive outline (Figure 243) that may be slightly more narrowly rounded posteriorly than the specimen herein illustrated; it is as wide as or slightly wider than long. The lateral grooves are frequently short or poorly defined; the transition to the raised lateral border of the scutum may be gradual or abrupt; the lateral grooves are often picked out by a row of medium size punctations. The long cervical grooves that extend, albeit shallow, to the posterior margin of the scutum demarcate oval fields beside the central field, a characteristic aspect of this species; combined with it is the moderate density of small to moderate size punctations scattered over the scutum. In small females, the punctations are frequently less numerous and the scutal surface is not so markedly divided into a central and two oval fields within a raised lateral border. The porose areas vary with the size of the individual.

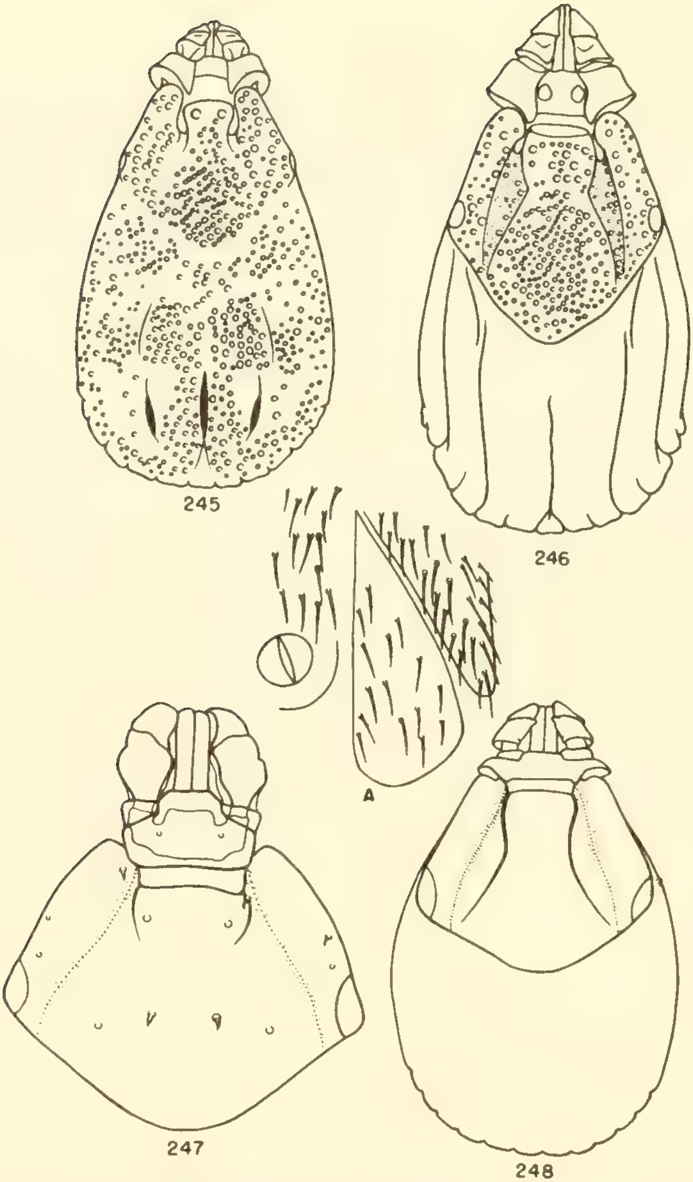


Figure 245, ♂, dorsal view. Figure A, adanal shield.
Figure 246, ♀, dorsal view. Figure 247, larva, dorsal view.
Figure 248, nymph, dorsal view.

<u>RHIPICEPHALUS</u> <u>ARNOLDI</u>

[After Theiler and Zumpt (1950) in Zumpt (1950A)]

PLATE LXX

RHIPICEPHALUS ARNOLDI Theiler and Zumpt, 1950*.

(Figures 245 to 248)

ARNOLD'S BROWN TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		10		Ikoto	*Lepus capensis crawshayi*	Feb
1				Lotti Forest	*Praomys tullbergi sudanensis*	Apr

These are the only records of this species aside from the original collections from Transvaal and Cape Province, South Africa. Dr. Theiler's identification of the larval specimen noted above is tentative.

DISTRIBUTION

The actual distributional picture of *R. arnoldi*, presently known only from the Union of South Africa and the Sudan, remains to be ascertained.

EAST AFRICA: SUDAN (Hoogstraal 1954B).

SOUTHERN AFRICA: UNION OF SOUTH AFRICA (Theiler and Zumpt, in Zumpt 1950A).

HOSTS

Hare, *Lepus* sp., and rock hare, *Pronolagus* sp. (Theiler and Zumpt in Zumpt 1950A). *Lepus capensis crawshayi* and larva on *Praomys tullbergi sudanensis* (Equatoria Province records above).

BIOLOGY

Unstudied.

---

*Described in Zumpt (1950A).

DISEASE RELATIONS

Unstudied.

REMARKS

The Sudan material was identified by Dr. G. Theiler. Santos Dias (1952H) has compared this species with _R. serranoi_.

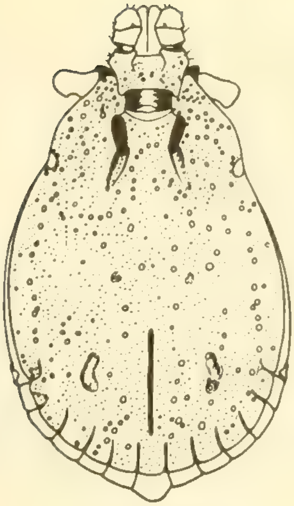
IDENTIFICATION

The following diagnosis is taken from the original description of this species.

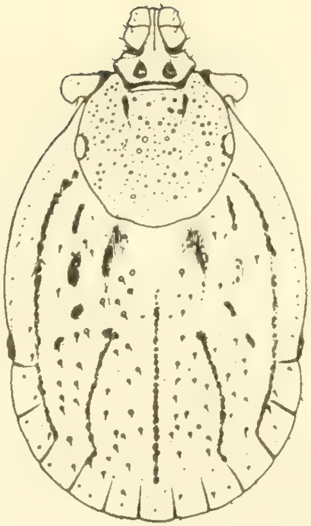
Males are like those of _R. mühlensi_ in that they possess a well developed dorsal projection of coxa I and have lateral grooves indicated only by punctations. They differ from _R. mühlensi_ in that the scutal punctations are larger, the basis capituli is broader and has more acute lateral angles, the palpi are more compressed, and the adanal shields and spiracular plates are different. The middle festoons do not protrude; the posteromedian groove is narrow and long, the paramedian grooves are elongate-oval, and all the grooves are reticulate. Size is 2.25 mm. to 3.00 mm. long and 1.66 mm. wide; color light to dark brown; shape convex.

Female palpi are unusually triangular in combined appearance when the mouthparts are tilted downwards. The basis capituli, about twice as wide as long, converges strongly anteriorly in an extension of the same angle as the lateral margins of the palpi. The scutum is slightly longer than wide and posterior of the eyes is sharply narrowed to a comparatively long, narrowly pointed, posteromedian angle. No lateral grooves are present but the scutal periphery is raised and the cervical fields depressed; the cervical grooves converge from the deep anterior pits to the anterior third of the scutum and thence diverge as shallow grooves extending almost to the posterior margin. Scutal punctations are mixed, irregular, larger and denser than those of the male in the central area but fewer in lateral raised areas.

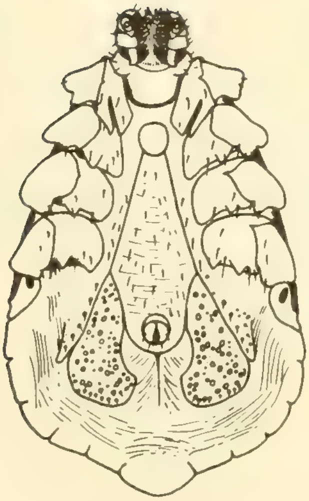
Theiler and Zumpt (_loc. cit._) also described and illustrated the immature stages.



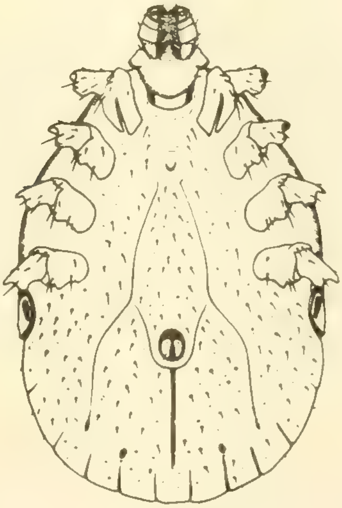
249



251



250



252

Figures 249 and 250, ♂, dorsal and ventral views
Figures 251 and 252, ♀, dorsal and ventral views

RHIPICEPHALUS BEQUAERTI
♂, Central African Specimen (after Zumpt)
♀, Sudan Specimen

PLATE LXXI

RHIPICEPHALUS BEQUAERTI Zumpt, 1950.

(Figures 249 to 252)

BEQUAERT'S BROWN TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
		1		Nagichot	domestic goat	Dec

Nagichot is at 6500 feet elevation in the Didinga Mountains of Eastern District. R. bequaerti is known from the Sudan by only this single specimen.

DISTRIBUTION

R. bequaerti appears to be a rare, mountain-inhabiting tick of Central Africa and nearby mountains of the Sudan.

CENTRAL AFRICA: "Central Africa, Lissenji" (Zumpt 1950A). Dr. Theiler and I cannot locate "Lissenji" but believe that it may be a misspelling for Kisenyi, which is in Ruanda Urundi. RUANDA-URUNDI ("Ljenda; 2500 meters altitude," Rousselot 1951,1953B. This material has been checked by Dr. G. Theiler).

EAST AFRICA: SUDAN (Hoogstraal 1954E).

HOSTS

Buffalo (Zumpt 1950A). Domestic goat (Sudan data). Cattle (Rousselot 1951,1953B).

BIOLOGY

Unknown. This tick should be searched for especially at high altitudes.

DISEASE RELATIONS

Unknown.

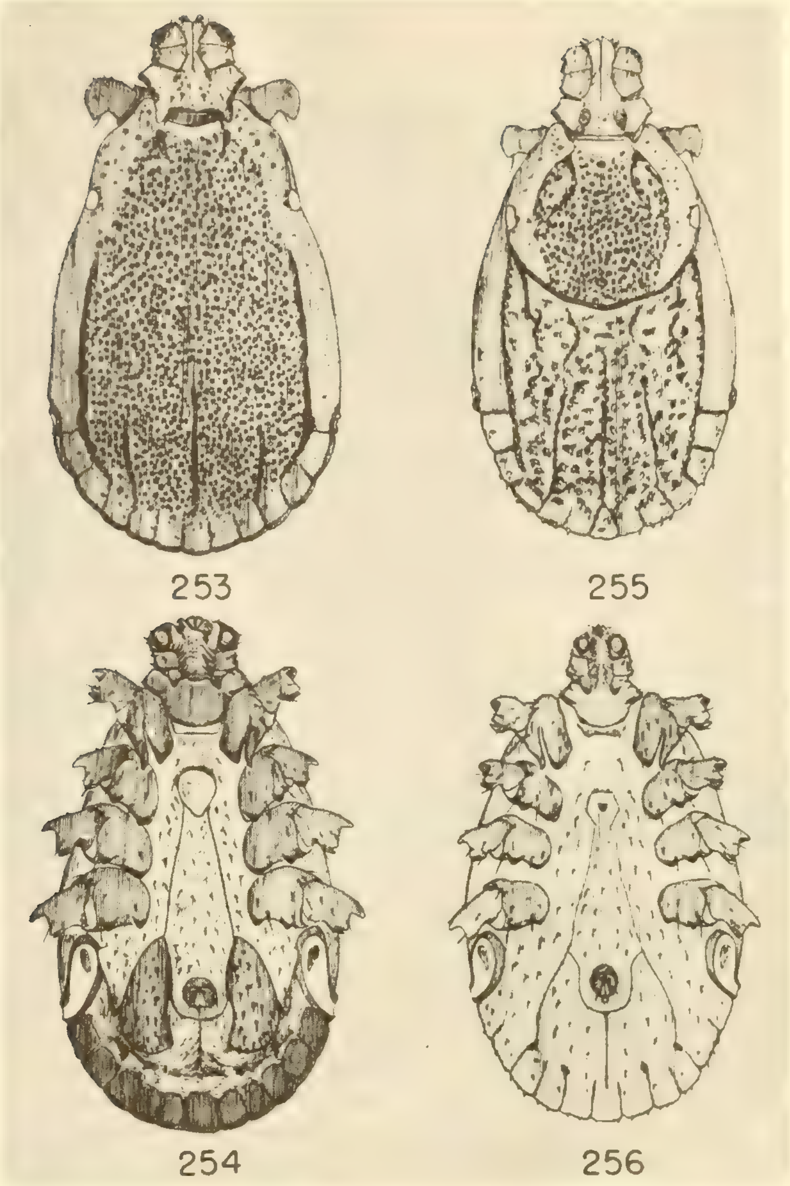
IDENTIFICATION

With so few specimens extant, the variability of *R. bequaerti* cannot be determined.

Males. This sex is easily recognizable by complete absence of *lateral* grooves that are replaced by a line of large punctations bounding the raised lateral ridge. Medium-size scutal punctations are arranged linearly like those of *R. simus* but are interspersed with numerous fine interstitial *punctations*. The posteromedian groove is long and narrow, the paramedian grooves are curved and wider. The cervical pits are short, deep, and punctiform. The adanal shields are L shaped with a heavy, broad base, convex internoanterior margin, and other margins straight with rounded junctures. Coxa I has a small but distinct dorsal projection. The original description states that the spurs of coxa I are "strikingly short" but the illustration accompanying the description hardly verifies this statement. Color is reddish-brown.

Females. The scutum is approximately as wide as long and its *posterior* margin is abruptly rounded. Lateral grooves are greatly reduced, being restricted to the anterior half of the scutum; bordering these grooves the lateral ridges rise sharply. Cervical pits are wide and deep; cervical grooves reach almost to the posterior scutal margin. Punctations are large and widely scattered, interstitial punctations are stronger than in the male. The basis capituli is twice as wide as long, with rightangled lateral angles and short, rounded cornua; large porose areas are circular or subcircular and spaced apart from each other by less than their own diameter (in *R. s. simus*, these are small, circular, and spaced far apart).

A small dorsal process of coxa I is present on the Sudan specimen, though this process is stated to be absent on the type female. Eyes of the Sudan specimen are situated on the scutal margin, dark amber color, elongately oval, very slightly convex, and delimited by a shallow groove along the internal border. The Sudan specimen was identified by Dr. G. Theiler.



Figures 253 and 254, ♂, dorsal and ventral views
Figures 255 and 256, ♀, dorsal and ventral views

RHIPICEPHALUS COMPOSITUS
Sudan Specimens

PLATE LXXII

RHIPICEPHALUS COMPOSITUS Neumann, 1897

(= *R. AYERI* Lewis, 1933).

(Figures 253 to 256)

THE EAST AFRICAN HIGHLAND BROWN TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
		2	1	Nimule	*Syncerus caffer aequinoctialis*	Dec	
		3	2	Kheirallah	*Syncerus caffer aequinoctialis*	-	(SGC)

These specimens, from the east and west banks of Equatoria Province, are the first of *R. compositus* from known localities in the Sudan. Although the Kheirallah (spelled Hierallah on the label) specimens were collected in 1911 by H. H. King, they had remained unidentified in Sudan Government collections. For further comments on these specimens, see BIOLOGY below.

DISTRIBUTION IN THE SUDAN

The type locality given by Neumann (1897) for *R. compositus* is Khartoum. It is obviously impossible that this tick has been established in this desert environment in recent times. Unfortunately, the source of specimens provided Neumann was frequently incorrect and his acceptance of collectors' information has subsequently led to numerous misconceptions before knowledge of the species concerned became detailed enough to recognize these errors. It is hardly likely, in the troubled and harassed times when the type specimens were reputed to have been collected at Khartoum, that cattle were being imported there in any numbers from areas where this tick is likely to occur. It is possible, but not very probable, that the collector merely lumped the vast poorly-explored northeastern African area of his day under the heading Khartoum. The normal occurrence of *R. compositus* outside of Equatoria Province in the Sudan is hardly to be expected, and even in this Province it is probably restricted to the rather few highland outcrops and their vicinity.

DISTRIBUTION

R. compositus, as shown by Theiler, Walker, and Wiley (1956), is a locally common East African highland parasite with scattered populations in the highlands of Central Africa and of eastern West Africa. Literature before 1933 refers to it as R. compositus, from 1933 onwards mostly as R. ayeri. See REMARKS below and Theiler, Walker, and Wiley (1956).

WEST AFRICA: NIGERIA (Mettam 1950. Unsworth 1949,1952. Gambles 1951. Theiler, Walker, and Wiley 1956).

CENTRAL AFRICA: CAMEROONS (Unsworth 1952. Theiler, Walker, and Wiley 1956). BELGIAN CONGO and RUANDA-URUNDI (Bequaert 1930A, B,1931. Theiler remarks in Santos Dias 1949D, p. 170. Hoogstraal 1954C. Theiler and Robinson 1954. Van Vaerenbergh 1954. Theiler, Walker, and Wiley 1956. It seems likely that the "R. capensis" of Schoenaers 1951A,B, refers to R. compositus).

EAST AFRICA: SUDAN (Neumann 1897, see DISTRIBUTION IN THE SUDAN above. Hoogstraal 1954B. Theiler, Walker, and Wiley 1956).

KENYA (Lewis 1933,1934. Theiler, Walker, and Wiley 1956). UGANDA (Wilson 1948,1950A,1952,1953. Theiler, Walker, and Wiley 1956). TANGANYIKA (Dönitz 1905. Neumann 1911. Theiler, Walker, and Wiley 1956. J. B. Walker, unpublished; see HOSTS below).

SOUTHERN AFRICA: NORTHERN RHODESIA (Le Roux 1947. Theiler remarks in Santos Dias 1949D, p. 170. Matthysse 1954. Theiler, and Robinson 1954. Theiler, Walker, and Wiley 1956). NYASALAND (Theiler remarks in Santos Dias 1949D. Wilson 1950B. Theiler, Walker, and Wiley 1956). MOZAMBIQUE (Santos Dias 1949A,E,F, 1952H,1953B,1954A. Theiler, Walker, and Wiley 1956).

HOSTS

The buffalo appears to be the preferred host of R. compositus and other larger game animals to be second choice. In some areas, this tick transfers to cattle but, as shown by Theiler, Walker, and Wiley (1956), it is not known to do so in Kenya. In Northern

Rhodesia, Matthysse (1954), however, recorded this tick only from cattle. A single incidence of parasitism on man has been reported. Hosts of the immature stages in nature are unknown.

Man (Hoogstraal 1954C).

Domestic animals: Cattle (Neumann 1904,1911, Wilson 1948, 1950A,B, Santos Dias 1949A,F,1953B. Matthysse 1954. Van Vaerenbergh 1954, Theiler, Walker, and Wiley 1956). Dog (Dönitz 1905, Theiler, Walker, and Wiley 1956).

Wild animals: Buffalo (Lewis 1933, Wilson 1948,1950B, Santos Dias 1953B, Theiler, Walker, and Wiley 1956). Rhinoceros (Lewis 1933, Theiler, Walker, and Wiley 1956). Roan antelope (Lewis 1934). Eland (Theiler, Walker, and Wiley 1956). Lichtenstein's hartebeest (Santos Dias 1952H,1953B). Sitatunga (J. B. Walker, Tanganyika; unpublished). Lion (Lewis 1933, Wilson 1950B, Theiler, Walker, and Wiley 1956). Cheetah (Wilson 1950B). "Game" (Wilson 1950A). Bushpig (Santos Dias 1953B). Warthog (Bequaert 1930A,1931, Santos Dias 1953B).

BIOLOGY

Life History

Details of the life history under laboratory conditions will be presented by Theiler, Walker, and Wiley (1956). Observations on the seasonal occurrence of various stages are presented below.

Ecology

R. compositus (= R. ayeri) is included in the ecological zone referred to as the R. appendiculatus - A. variegatum association (cf. page 274), but restricted to highland forests where it may occur locally together with R. kochi (= R. jeanneli).

It is likely that R. compositus and R. kochi were once more isolated than they presently are and that they now occupy in part the same unique ecological zones due to movements of wild hosts or of domestic hosts. They are sympatric species in which hybridization is not known to occur.

The highland range of R. compositus is confirmed by the careful study of numerous records by Theiler, Walker, and Wiley (1956).

Sudan specimens from a buffalo near Nimule, which is a savannah area at the level of the Nile River, 2,059 feet elevation, might appear to be exceptions to the highland concept of this species. They were, however, collected in December, shortly after the end of the rainy season, when there is a tremendous movement of outlying animal populations towards the river. It seems probable that the buffalo from which these ticks were taken had recently come to the river from the nearby Acholi mountains, where he had acquired these parasites.

In Nyasaland, adults were collected only in December and January (middle rainy season), when adults of the closely related R. capensis were absent (Wilson 1950B).

Matthysse (1954), working in Northern Rhodesia, considers it noteworthy that adults of R. compositus preceed those of R. appendiculatus, being found abundantly before the rains, in September and October, and also being present in July, August, and November. Rains commence in November. This factor may be of importance in the transmission of East Coast fever during the absence of adult brown ticks. "Cattle examinations during the latter part of the dry season and during the early rains will show many brown ticks on the undersides of the body, in the tail brush, and on the feet, but not in the ears. These ticks are largely R. compositus" (= R. ayeri) (Matthysse 1954). The same author lists a single collection from the ears of cattle.

DISEASE RELATIONS

CATTLE: A vector of East Coast fever (Theileria parva).

REMARKS

The confusion regarding the taxonomic position of this species is reviewed in detail by Theiler, Walker, and Wiley (1956) in a report so easily available to all specialists who might be concerned with this matter that it is not abstracted here.

These authors, with admirable conservatism, persist in referring to that tick herein called *R. compositus* by the name *R. ayeri*. However, their various rearing and distributional studies show *R. ayeri* to include all morphological and ecological features of *R. capensis compositus* and to be a valid species and taxonomic entity, separate and distinct from *R. capensis*, which they have also reared through the F_1 generation. They say: "As to whether *R. ayeri* is *R. compositus* or not, we are inclined to think that it is, but we are at the moment not in a position to commit ourselves". In their summary, it is stated that: "(*R. ayeri*) is shown to be a valid species and is in all probability synonymous with Neumann's 1897 *R. compositus*".

While there is some possibility that eventually *R. compositus* and *R. ayeri* will be shown to be separate species, this at present appears so unlikely that I, more rashly than my friends, am calling this material *R. compositus*.

Santos Dias (1948A) attributed a slightly misshapen specimen to *R. ayeri*.

The Sudan material has been checked by Dr. Theiler.

IDENTIFICATION

Males: Size medium to large (4.00 mm. to 7.75 mm. long). Scutal punctations are numerous, very closely spaced, but mostly noncontiguous, uniformly large in central area (in *R. capensis*, large punctations are scattered among numerous smaller punctations in central area), fewer or absent bordering at least the anterior half of the lateral grooves. The cervical area may have somewhat more variable punctations within lateral grooves (few in *R. capensis*). Cervical pits are short and deep; cervical grooves are shallow, diverging (frequently indistinct) (deep and long in R. capensis). The body margin is regularly rounded or slightly bulging posterior of the eyes*. Lateral grooves are deep, extending from usually clearly-marked pseudoscutum to margin between second and third festoon. The posteromedian groove is long and narrow (possibly wider and sometimes shorter in R. capensis); paramedian grooves are narrow. A small dorsal hump of coxa I is visible. The basis capituli is nearly twice as wide as long; lateral angles are at the basal third and acute. The color is dark brown (usually light brown in R. capensis) to black. Adanal shields are of the widely triangular type with rounded junctures and margins and a slightly emarginate inner margin.

The wide, glossy scutal periphery and the numerous, regular scutal punctations are striking.

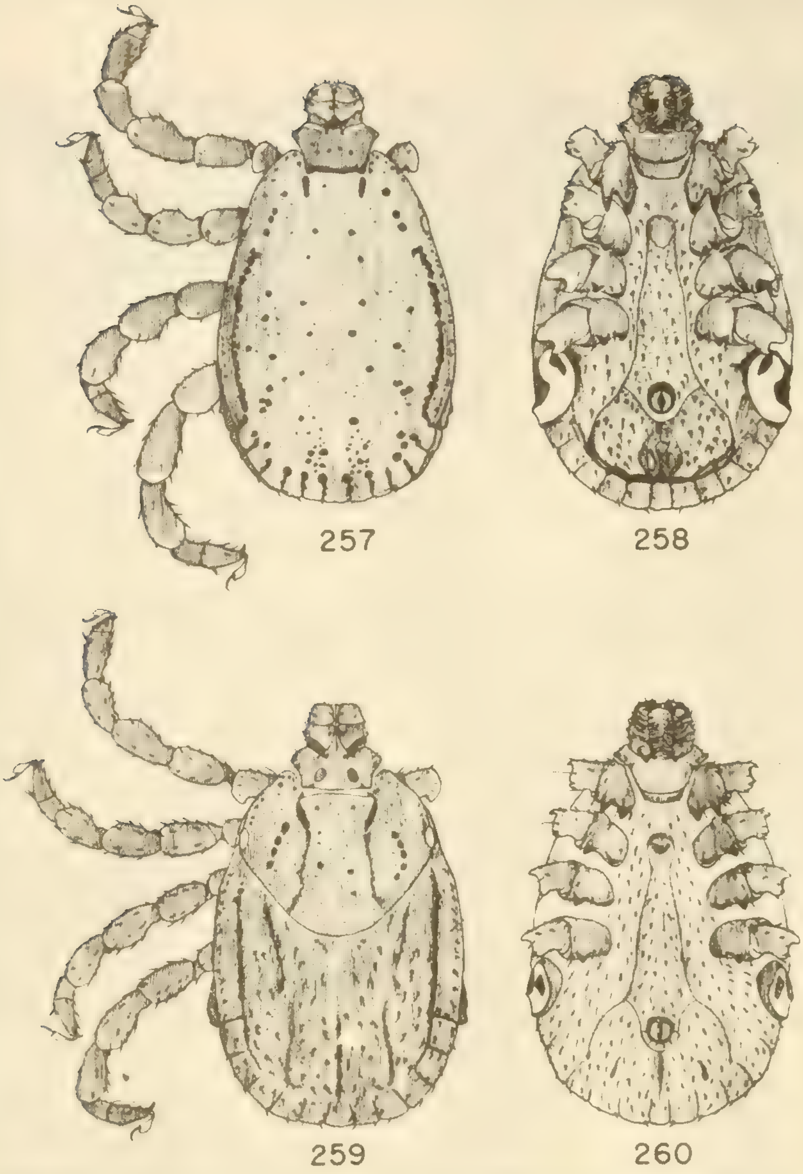
Females: This sex has a similarly wide, glossy border of the dark brown or black scutum, with but few, small punctations outside the definite lateral grooves, which extend the full length of the scutum. The scutum is, therefore, quite distinctive. This feature, together with the rounded scutal margin (sometimes slightly indented posterior of the eye), numerous, uniformly large punctations in the central field and a few small punctations anteriorly, and scutal length (only slightly wider than long) rather easily separates R. compositus from the female of R. capensis (which has punctations reaching the lateral scutal margin, slightly greater scutal width, and numerous small punctations irregularly scattered among fewer large punctations). Cervical grooves are short and deep. Females are about 7.5 mm. long and 5.0 mm. wide, scutum about 2.2 mm. long, and 2.3 mm. wide.

Note: In the Sudan tick fauna there should be little difficulty in determining R. compositus. The criteria separating this species from R. capensis have been included above because of the

---

*According to Santos Dias (1949F) the body outline of R. capensis bulges more than in R. compositus (= R. ayeri) just posterior of the eyes. This is not necessarily true in nonrobust specimens.

possibility that this important species may some day be introduced into the Sudan. This is the only Sudanese species in which the male scutal punctations are large, deep, dense and noncontiguous centrally, the margins are wide and glossy, and the posterior grooves are narrow. The dense, uniform female scutal punctation, the glossy, smooth scutal periphery, and the wide, regular scutal outline easily distinguishes this sex in the Sudan fauna.



Figures 257 and 258, ♂, dorsal and ventral views
Figures 259 and 260, ♀, dorsal and ventral views

RHIPICEPHALUS CUSPIDATUS
Sudan Specimens

PLATE LXXIII

RHIPICEPHALUS CUSPIDATUS Neumann, 1906

(Not R. CUSPIDATUS sensu Zumpt, 1950A)*

(Figures 257 to 260)

THE WEST AFRICAN WARTHOG BROWN TICK

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: Galual-Nyang Forest, 15♂♂ and 31♀♀ from two warthogs, *Phacochoerus aethiopicus* subsp., and 1♂ from ground, 21 and 23 February 1953, H. H. *legit*; 2♂♂, 6♀♀, same locality and host species, 7 June 1953, E. T. M. Reid *legit*. These are the only specimens of this interesting West African tick from the Sudan.

DISTRIBUTION

This West African warthog and aard-vark parasite ranges eastward as far as the western part of southern Sudan.

WEST AFRICA: FRENCH WEST AFRICA (Neumann 1905,1911. Theiler 1947. Rousselot 1951,1953B. Specimens from Fort Foureau and French Sudan, collected by Rageau and Rousselot, are present in the Theiler collection. It seems likely that the "*R. complanatus*" reported by Fiasson (1943B) from wild pigs refers actually to *R. cuspidatus*. PORTUGESE GUINEA (As R. sp.: Tendeiro 1948. As *R. cuspidatus*: Tendeiro 1951A,E,1952C,1953,1954).

CENTRAL AFRICA: CAMEROONS (Rageau 1953A,B).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

Note: Stella (1940) listed *R. cuspidatus* from the Harrar area of Ethiopia. Pending further investigation, this record is considered questionable.

---

*See REMARKS, page 632.

HOSTS

Warthogs, *Phacochoerus aethiopicus* subsp. (Neumann 1906,1911, and Sudan records above). Aard-vark, *Orycteropus afer senegalensis* (Rousselot 1951,1953B, Tendeiro 1952C).

BIOLOGY

It seems strange that this large tick from much-hunted warthogs should not have been more often reported from West Africa, though misidentification of specimens may account for this situation.

DISEASE RELATIONS

Ten of the above-mentioned Sudanese female specimens were inoculated into mice and guineapigs in the Cairo laboratories of Naval Medical Research Unit No. 3, for attempted isolation of viruses or rickettsiae. The host animals produced no sign of infection.

It is claimed that specimens naturally infected with Q fever (*Coxiella burnetii*) occur in Portugese Guinea.

REMARKS

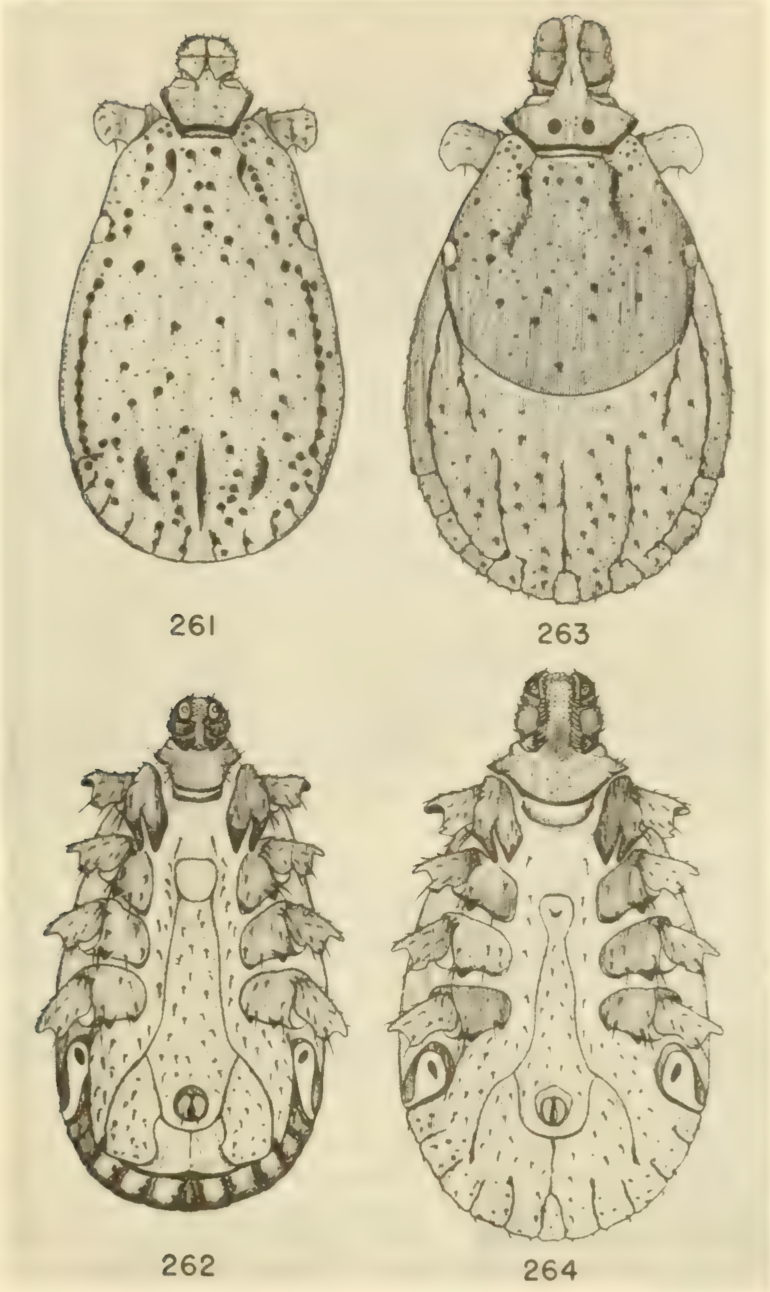
It was impossible to identify with certainty the Sudan specimens and some were sent to Dr. Theiler. She had received similar material from French West Africa (noted above) and found that it corresponded to Neumann's (1906) description of *R. cuspidatus* but differed markedly from Zumpt's (1950A) interpretation of this species. Thereupon she sent the French West Africa specimens to Dr. D. R. Arthur for comparison with the *R. cuspidatus* type specimens in the British Museum (Natural History). He found these to be the same. What the tick reported by Zumpt (*loc. cit.*) as *R. cuspidatus* should be called is not known.

R. cuspidatus falls into the subgenus Rhipicephalus (sensu strictu) of Zumpt (1950A) and not in Rhipicephalus in which he placed the species attributed by him to this name.

IDENTIFICATION

Males are readily recognized by the unique internoposterior curved or straight, pointed projection of the adanal shields, which reach to the festoons. (Slight variations in these projections have been illustrated by Tendeiro 1951E). The width of the adanal shields, which is almost half as great (at the posterior two-thirds) as the total length, is also distinctive as is the broadly triangular shape of the anterior two-thirds, the acutely rounded and posteriorly sloping posterior margin, and the concave emargination of the posterior half of the inner border. Accessory shields are absent. Dorsally, a small rounded (not pointed) dorsal projection of coxa I is visible. The scutum is remarkably flat and broad, three-fourths as wide as its length from scapulae to posterior margin; its surface is smooth except for twelve to twenty widely scattered, large, deep punctations, six or eight small, deep ones, and two short, posterior rows of three or four adjacent, large, and deep punctations. Many specimens have one, two or three mild longitudinal depressions at one place or another on the scutal surface; these are obviously due to injury, crowding, malnutrition, or molting conditions. The deep lateral grooves, which are marked by a row of large, adjacent punctations, begin at the first festoon and extend to the level of coxa III; thence they continue anteriorly as a curved row of four equidistantly spaced, large, deep punctations. The very deep cervical grooves are parallel or slightly convergent and short, reaching only the level of trochanter II. The impunctate basis capituli is three times as wide at its anterior third as its total width. Unfed specimens are reddish brown, engorged individuals are an intense black with reddish-brown legs. Overall length varies from 3.50 mm. to 4.90 mm.; width from 1.98 mm. to 2.54 mm.

Females unengorged average 4.40 mm. in overall length and 2.70 mm. in width; our largest engorged specimen is 11.00 mm. long and 6.30 mm. wide. The scutum is distinctly wider than long; lateral margins diverge gradually to the midlength of the scutum from whence they rather abruptly converge as a straight or slightly sinuous posterior margin merging with the narrowly blunt posterior margin. The cervical grooves are very deep and convergent, and reach the midlength of the scutum; thence they continue as very shallow, divergent grooves extending to or almost to the posterior margin. Lateral grooves as such are absent; their place is marked by three to seven very large, deep punctations that may be either free or in a shallow depression; the lateral field beyond these grooves is more or less abruptly raised. The scutum is slightly depressed between the lateral punctations and the shallow extensions of the cervical grooves, but its intense black surface is otherwise marked by only four to seven large, deep, scattered punctations. The basis capituli is three times as wide as long and widest at its midlength; the porose areas are oval, vertical (not tilted), about twice as long as wide, deep, separated by a distance of one and a half times their own length, and extend from almost the posterior margin to just past the midlength of the basis capituli. Ventrally, it is important to note that coxa I is not deeply divided but that its posterior margin bears two robust spurs; the broadly triangular internal spur is not quite so long as the more narrowly triangular external spur and the division between these two spurs is equitriangular with the internal spur.



Figures 261 and 262, ♂, dorsal and ventral views
Figures 263 and 264, ♀, dorsal and ventral views

RHIPICEPHALUS ?DISTINCTUS
♂ Sudan specimen
♀ Southwest Africa specimen
(See comments on ♀ specimen, see REMARKS, page 638)

PLATE LXXIV

RHIPICEPHALUS ?DISTINCTUS Bedford, 1932(B)*

(= R. PUNCTATUS Bedford, 1929A).

(Figures 261 to 264)

THE HYRAX GLOSSY TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
			1	Rejaf Hill	Procavia habessinica slatini	May

No other specimens of this species have been found in the Sudan. See HOSTS and REMARKS below.

DISTRIBUTION

The hyrax glossy tick ranges from southern Sudan to Southwest Africa. Its distribution is probably more continuous than present records indicate. Possibly two species are represented in the material quoted below.

EAST AFRICA: SUDAN (Not previously reported).

UGANDA (A. J. Haddow, correspondence; common at Kaabong, Karamoja). TANGANYIKA (Theiler 1947).

SOUTHERN AFRICA: SOUTHERN RHODESIA (Bulawayo specimens; Theiler, unpublished). MOZAMBIQUE (Santos Dias 1953C).

SOUTHWEST AFRICA (Bedford 1929A,1932B. Zumpt 1943A. Theiler 1947. BMNH collections contain numerous specimens from Bellrode, Naukluft, and Otjosongombe; K. Jordan legit, H. H. det.). UNION OF SOUTH AFRICA (Cooley 1934. Theiler 1947. Note: Occurs in Cape Province, Orange Free State, and Transvaal. Earlier records appear to be based on misidentification; see HOSTS below).

*The possibility that the single specimen available from the Sudan represents an undescribed species should be considered. See REMARKS and IDENTIFICATION (pages 638 and 639).

HOSTS

Hyraxes, or dassies, both rock and arboreal kinds, are the chief host of this tick. Procavia coombsi (Bedford 1929,1932B). P. capensis meneliki (Uganda material noted above). P. habessinica slatini (Sudan record above). P. johnstoni matschiei and Heterohyrax welwitschi volkmanni (Theiler 1947). Procavia waterbergensis (Southwest Africa; Theiler, unpublished). Dendrohyrax a. arboreus (Santos Dias 1953C). Procavia sp. and Heterohyrax sp. (All other records.

Although other animals have been reported as hosts, Theiler (correspondence) now believes these records to be based on incorrect identification. Bedford (1934) and Theiler (1947) referred to domestic sheep in Cape Province of South Africa; and A. J. Haddow (correspondence) to the long-snouted dikdik in Karamoja, Uganda.

It is of some interest that we found only a single specimen of this tick on the numerous rock hyraxes taken in Torit and Juba Districts in Equatoria Province. Few of these mammals were taken at Rejaf, where the tick was found, but good series were obtained and carefully examined in a number of other localities.

It is of equal interest to note that while 21 rhipicephalid larvae and nymphs were found on two hyraxes (Heterohyrax brucei hoogstraali) in Torit District, these represent, according to Theiler (correspondence), an unidentifiable species, not R. distinctus. Inasmuch as hyrax parasites are most distinctive and host-specific, it is probable that these larvae and nymphs represent the same species as the single Sudanese male, which differs from Southwest African specimens of R. distinctus, and that these represent an undescribed species.

BIOLOGY

Nymphs and adults are found on rock hyraxes. Nothing else is known about the biology of this species.

DISEASE RELATIONS

Unstudied.

REMARKS

This species is a member of the R. simus group (Zumpt 1942A). On superficial examination, males might be confused with either R. s. sanguineus or R. s. simus, or, as noted below, they may easily be miskeyed. Once the basic characters are learned, the worker recognizes this as a most distinct species, the female of which is even more unique than the male. This note applies to material from both southwestern and eastern Africa.

The single Sudanese male agrees with numerous specimens from Southwest Africa in all respects except the width and shape of the externoposterior juncture of the adanal shields (see below). Should further Sudanese specimens be consistent in this respect, it is likely that they represent a subspecies or species differing from R. distinctus of Southwest Africa. In this respect, the Mozambique specimen illustrated by Santos Dias (1953C, figure 3) is like the Sudanese specimen. The female accompanying Santos Dias' male has a much longer scutum than those from Southwest Africa and a much more narrowly pointed posterior margin. This fact may support the premise that populations from Mozambique to the Sudan represent an undescribed species. Note that the female herein illustrated (Figures 263 and 264) is from Southwest Africa and possibly not representative of Sudanese populations. Presumably, also, the immature specimens referred to as Rhipicephalus sp. (page 778), which differ from R. distinctus, may be associated with the single available Sudanese male.

It is unfortunate that more time could not have been devoted to determining the actual status of the Sudanese male during the course of the present study. Although we collected this specimen in 1948, it had been separated from the rest of the collection by another member of the party and eventually sent to the Museum of Comparative Zoology. Just as the present work was being completed, Dr. J. Bequaert noted this specimen and kindly returned it to our collection.

IDENTIFICATION

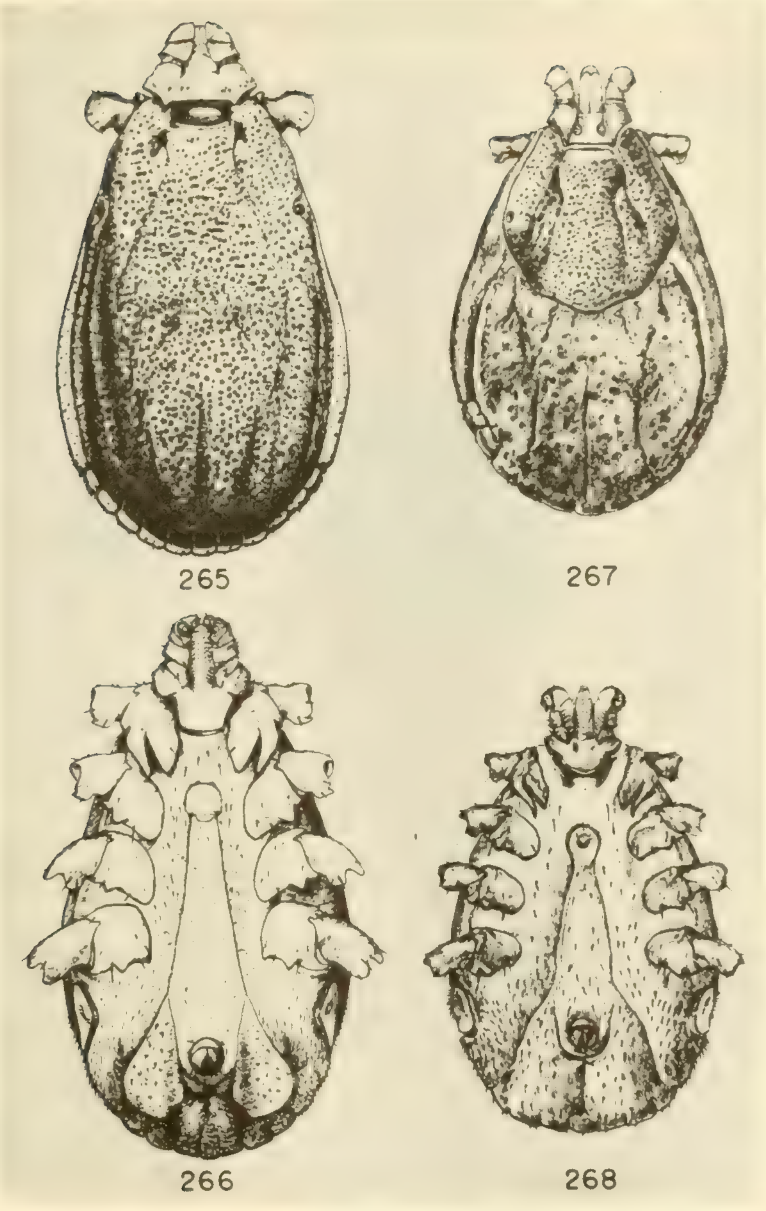
This is a member of the *R. simus* group (page 751).

Males: Males are characterized by a combination of characters including few, large scutal punctations arranged in four irregular longitudinal rows that form an especially distinctive pattern posteriorly (as in *R. simus senegalensis*); lateral grooves varying from deep to shallow (narrow and shallow in Sudanese specimen) but containing a row of large, deep, almost adjacent punctations extending from the first or second festoon to the eyes (this row of punctations also extending from the eyes to the scapulae but more widely spaced and not in a groove; coxa I with a dorsal projection that is small but definitely pointed; posteromedian groove and paramedian grooves more or less marked, indicated by narrow, shallow depressions (uncommonly all but obsolete; distinct in Sudanese specimen). The adanal shields of material from southern Africa are narrowly elongate, subovate, with rounded external margin, pointed anterior and posterior junctures, and slightly recurved inner margin posteriorly; those of the single available Sudanese specimen (Figure 262) are broader posteriorly and the externoposterior juncture forms almost a right angle (see REMARKS above). Accessory shields are indicated only by posterior points. In addition to the already mentioned scutal punctations, there is a cluster of several punctations on the scapulae and two to six others may be scattered on the scutum; interstitial punctations are faintly indicated.

Females: The scutum of specimens from Southwest Africa is subcircular and either as wide as long or slightly wider than long; lateral grooves are entirely absent but are replaced by a convex line of three to seven large punctations; in the median field four or five other large punctations are scattered and a few others are clustered on the scapulae; interstitial punctations are fine and cover most of the scutal surface. Lateral margins are slightly elevated, devoid of punctations posterior of the scapulae, and bear flat eyes. Cervical grooves are short, deep, and either convex or narrowly ovate and converging. Porose areas are small, circular, and not widely separated. Color is as in males; size is slightly greater than that of males but increases greatly when feeding; upon engorgement the body outline is subcircular.

As stated in REMARKS above, it is possible that when females of this species are found in the Sudan they will be similar to those described and illustrated herein except that the scutum will be considerably more elongate and narrowly pointed posteriorly.

Note: Zumpt (1950A) attributes the name *R. distinctus* to "Bedford, Fmg. S. Afr., no.11, 1935, p.6," an error repeated by Santos Dias (1953C). The name *R. distinctus* was proposed on page 523 of Bedford's (1932B) checklist.



265 267 266 268

Figures 265 and 266, ♂, dorsal and ventral views
Figures 267 and 268, ♀, dorsal and ventral views

RHIPICEPHALUS EVERTSI EVERTSI
Sudan Specimens

PLATE LXXV

RHIPICEPHALUS EVERTSI EVERTSI Neumann, 1897.

(Figures 265 to 268)

THE RED TICK

EQUATORIA PROVINCE RECORDS

L	N	♀	♂			
10	16			Kapoeta	*Elephantulus rufescens hoogstraali*	Apr (numerous)
	1		1	Lokila	*Ourebia ourebi aequatoria*	Feb
1		4		Torit	*Ourebia ourebi aequatoria*	Dec (3)
		2	2	Torit	*Hippotragus equinus bakeri*	Jan
		1		Terakeka	*Taurotragus oryx pattersonianus*	Jan (SGC)
		2	13	Torit	*Alcelaphus buselaphus roosevelti*	Dec (2)
		1	1	Kapoeta	domestic goats	Jul
		6	6	Kapoeta	domestic goats	Dec
		30	38	Labalwa	domestic goats	Dec
	1	9	30	Sunat	domestic goats	Dec
		21	15	Torit	domestic goats	Dec
	1	2	25	Torit	domestic goats	Nov
		53	60	Torit	domestic goats	Jan
	126	24	67	Loronyo	domestic goats	Jan
	3	17	8	Imurok	domestic goats	Jan
		27	38	Juba	domestic goats	Dec
		11	20	Kaguada	domestic goats	Dec
	151	48	89	Kajo Kaji	domestic goats	Dec
	2	2	2	Kapoeta	domestic sheep	Dec
			4	Kapoeta	domestic sheep	Jul
	9	2	3	Loronyo	domestic sheep	Jan
	14	1	4	Katire	domestic sheep	Jan
		3	14	Torit	domestic sheep	Nov
		4	7	Juba	domestic sheep	Dec
		16	21	Juba	domestic sheep	Jan
		4	9	Kaguada	domestic sheep	Dec
		3	2	Yei	domestic sheep	Jun
	3	1	3	Yambio	domestic sheep	Jun
		2	2	Kapoeta	domestic dogs	Dec
			2	Torit	domestic dogs	Jan
		1	1	Torit	domestic dogs	May (SVS)
			1	Torit	domestic pig	Dec
		1	3	Torit	domestic horse	May (SVS)

L	N	♀	♂			
		1		Kapoeta	domestic cattle	Dec
			2	Kapoeta	domestic cattle	Jul
		1	1	Iliu	domestic cattle	Oct (SVS)
		4	4	Loronyo	domestic cattle	Dec
		2	5	Katire	domestic cattle	Jan
		1		Katire	domestic cattle	Oct
		27	42	Gilo	domestic cattle	Dec
		26	29	Torit	domestic cattle	Nov (2)
	1	8	22	Torit	domestic cattle	Dec (2)
		5	1	Torit	domestic cattle	Jan
	2	1	2	Torit	domestic cattle	Feb
			2	Lobwara	domestic cattle	Sep
		9	22	Juba	domestic cattle	Dec (2)
		18	35	Juba	domestic cattle	Jan
		1	2	Terakeka	domestic cattle	Jan
		2	17	Terakeka	domestic cattle	Mar (SVS)
		1	6	Muni	domestic cattle	Mar (SVS)
	5	26	22	Kajo Kaji	domestic cattle	Dec (2)
		4	7	Meridi	domestic cattle	Jan (SVS)
		6	9	Li Rangu	domestic cattle	Apr
	1	2	2	Yambio	domestic cattle	Jan

DISTRIBUTION IN THE SUDAN

All Provinces, except Northern Province (King 1926). As noted below, however, Sudan Government collections contain specimens from Shendi, which is on the Nile in the southern part of Northern Province (16°42'N. latitude), but this tick is probably absent from most areas of Northern Province.

Collections containing specimens with the following data have been seen:

Bahr El Ghazal: Wau (sheep, goats, especially common on horses and donkeys; SVS, HH). Fanjak (sheep and goats; HH). Yirol and Galual-Nyang Forest (horses; SVS). Lake Nyubor (cattle; SVS). The absence of the red tick on the many wild animals examined in this Province is noteworthy.

Upper Nile: Akobo Post and Melut (mules; SGC). Bor (cattle; SGC). Maban (pigs and goats; SVS). Malakal (donkeys, sheep and cattle; HH; cattle and donkeys; Balfour 1911F).

Blue Nile: Singa (native goat with surago disease; SGC). Wad Medani (horses, donkeys, goats, sheep and cattle; HH, SGC). Roseires (cattle; SGC). Sennar (donkey; SGC).

Darfur: Fasher (goats; SVS). Zalingei (goats and sheep; SVS).

Kordofan: Talodi (mules and sheep; SGC).

Kassala: Abu Gamal (goats; SGC). Kassala (horses, goats, and cattle; SVS).

Khartoum: Khartoum (goats from Meshra, SGC; goats, sheep, horses, asses, and donkeys; HH). (Introduced into Khartoum on cattle and donkeys from Malakal: Balfour 1911F).

Northern: Shendi (sheep; SGC).

DISTRIBUTION

R. evertsi evertsi is widely distributed throughout the Ethiopian Faunal Region (including the mountains of Yemen, southwestern Arabia; Hoogstraal, ms.). It is not found in very dry regions of Southwest Africa (Theiler and Robinson 1954) where it is replaced by the banded-legged subspecies mimeticus. The two subspecies do occur together, however, in the savannah of northern Angola and range through the southwestern Congo to the Ubangi savannah near the Sudan border. The typical form is reduced in numbers or is absent in large areas of the Somalilands and in northern Nyasaland, but in these places it is not replaced by the banded-legged variety. It also appears to be absent in areas of West Africa.

WEST AFRICA: NIGERIA (Mettam 1940,1950. Unsworth 1949, 1952. Gambles 1951). TOGO (Ziemann 1905). GOLD COAST (Stewart 1933). FRENCH WEST AFRICA (Girard and Rousselot 1945. Rousselot 1951,1953B).

CENTRAL AFRICA: CAMEROONS (Zumpt 1942B. Rageau 1951,1953A,B. Rousselot 1953B). FRENCH EQUATORIAL AFRICA (Rousselot 1951,1953B. Unsworth 1952).

BELGIAN CONGO and RUANDA-URUNDI (Schwetz 1927A,B,C,1932. Schwetz and Collart 1929. Bequaert 1930B,1931. Bouvier 1945. Schoenaers 1951A,B. Rousselot 1951,1953B. Theiler and Robinson 1954. Santos Dias 1954D. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (Balfour 1906,1911F,H. King 1908,1911, 1926. Hoogstraal 1954B).

ETHIOPIA (Stella 1939A,1940. Roetti 1939. D'Ignazio and Mira 1949). ERITREA (Franchini 1929D. Tonelli-Rondelli 1932E, 1935. Niro 1935. Stella 1939A,1940). FRENCH SOMALILAND (Hoogstraal 1953D). ITALIAN SOMALILAND (Tonelli-Rondelli 1935. Stella 1938A,1939,1940).

KENYA (Neumann 1907C,1910B,1922. Neave 1912. Lewis 1931A, B,C,1932B,1934,1939A,B. Brassey-Edwards 1932. Walker 1932. Daubney 1933,1934,1936B. Daubney and Hudson 1934. Roberts 1935. Fotheringham and Lewis 1937. Mulligan 1938. Zumpt 1942B. Weber 1948. Binns 1951,1952. van Someren 1951. Wilson 1953. Wiley 1953). UGANDA (A. Theiler 1910A. Bruce et al 1911. Neave 1912. Neumann 1922. Loveridge 1923A. Poulton 1929. Mettam 1932,1933. Mettam and Carmichael 1936. Wilson 1948B,C,1949, 1950C,1953. Clifford 1954. Taylor 1954). TANGANYIKA (Neumann 1901,1907C,1910B,1911. Koch 1905. Neave 1912. Morstatt 1913. Loveridge 1923A. Moreau 1933. Evans 1935. Cornell 1936. Reichenow 1940,1941A,B. Zumpt 1942B. Beakbane and Wilde 1949. Wilson 1953).

SOUTHERN AFRICA: ANGOLA (Manetti 1920. Santos Dias 1950C. Note: Only the variety mimeticus is listed by Sousa Dias 1950). MOZAMBIQUE (Neumann 1897. Howard 1908,1911. Nuttall 1911B. De Oliviera 1915. Zumpt 1942B. Theiler 1943B. Tendeiro 1951B. Santos Dias 1947B,1948A,1952D,1953B,C,1954H. Bacelar 1950).

NORTHERN RHODESIA (Neave 1912. Chambers and Smith 1914. LeRoux 1937,1947. Matthysse 1954. Theiler and Robinson 1954). SOUTHERN RHODESIA (Koch 1903. Edmonds and Bevan 1914. Bevan 1920,1927. Jack 1921,1928,1942. Lawrence 1932. Theiler 1943A).

NYASALAND (Neave 1912. De Meza 1918A. Absent in northern area: Wilson 1945,1953).

SOUTHWEST AFRICA (Dönitz 1905. Howard 1908. Tromsdorff 1913,1914. Warburton 1922. Bedford 1926,1927,1932B).

UNION OF SOUTH AFRICA (Neumann 1897,1901,1911. Dixon and Spruell 1898. Lounsbury 1899C,1900A,1904A,B,1905B,1906B,C. A. Theiler 1905B,1906,1909A,B,C,1911B,1912B,1921. Howard 1908. A. Theiler and Christy 1910. Dönitz 1910B. Moore 1912. Van Saceghem 1914. Bedford 1920,1926,1927,1929,1932B,1934. Cowdry 1923,1925B,C,1926A,1927. Curson 1928. Bedford note in Cooley 1929. Cooley 1934. Clark 1938. McIntyre 1939. Bedford and Graf 1939. R. du Toit, Graf, and Bekker 1941. R. du Toit 1942B,C,1947. De Meillon 1942. Zumpt 1942B. Cluver 1944. Bekker and Graf 1946. Thorburn 1947,1952. Schreuder and Wright 1948. Graf and Bekker 1949. Whitnall and Bradford 1949. Bekker, Graf, Malan, and Van der Merwe 1949. Theiler 1950B. Meeser 1952. J. Gear 1954).

OUTLYING ISLANDS: ZANZIBAR (Neave 1912. Aders 1917). MAURITIUS (De Charmoy 1915. Moutia and Mamet 1947). CANARY ISLANDS (Nuttall lot 3226 in BMNH; H.H. det.). See also IMPORTED SPECIMENS below.

ARABIA: YEMEN: Franchini (1930) stated specimens had been found at the seacoast town of Hodeida. Our experience here indicates that if this locality record is correct, the ticks were from cattle imported from the Yemen highlands. Sanborn and Hoogstraal (1953), Hoogstraal (ms.).

IMPORTED SPECIMENS: MADAGASCAR: *R. e. evertsi* arrives at quarantine but is not established on the island (Bück 1940,1948A, Hoogstraal 1953E). EGYPT: Mason (1915,1916) reported specimens on cattle imported from the Sudan. Nowadays at the Cairo abattoir we find a few specimens on Sudan cattle and sometimes many specimens on Somali or Ethiopian cattle that occasionally reach here. Specimens from cattle and donkeys were reported by Mason (1916) without mention of source. The species is not established in Egypt. BRAZIL: Specimens "were found on angora goats in the animal hospital in Rio de Janeiro. If they had not been found they would certainly have been scattered throughout our country like *R. sanguineus*" (de Beaurepaire Aragao 1936).

HOSTS

Adult red ticks most commonly occur on domestic cattle, equines, goats, and sheep, and on wild antelopes, zebras and a few other large game animals. If a comparative host-predilection study of this species could be undertaken, it is likely that domestic horses, mules, and donkeys and wild zebras might rank highest as preferred hosts. [Although Lewis (1931B) considered it peculiar that horses in the Rift Valley of Kenya yielded no red ticks, I have subsequently collected many specimens from horses there]. Immature stages normally feed on the same type of large-size host as do the adults, though their feeding sites on the animal differ markedly. Under some conditions, larvae and nymphs attack hares, elephant shrews, tree rats, and baboons, but the factors causing these presumably atypical infestations are not known.

Domestic animals: Cattle are mentioned as hosts by all authors noted above and equines, sheep, and goats are also commonly listed by the same persons. A single record from camel is known (Wiley 1953). Dogs are seldom infested (Theiler 1953), as are pigs (Theiler, correspondence), although a few specimens from each of these animals have been taken in the Sudan. Dogs have been reported as hosts by Mettam (1932) in Uganda.

Wild antelopes: In one of the earliest host-lists of African ticks, Howard (1908) noted the eland and reedbuck. Bedford (1932B) listed the blue wildebeest, sable antelope, blesbok, roan antelope, Cape kudu, impala, steenbuck, Cape duiker, springbok, bushbuck, waterbuck, and (for nymphs) the bontebok, steenbok, and grysbok. In the Sudan, King (1926) noted specimens from the Isabella gazelle, while we have found others on the tel-tel (Roosevelt's hartebeest), eland, Baker's roan antelope, and oribi. Mettam (1932) reported duiker and kob from Uganda, and Weber (1948) took specimens from the eland, Grant's gazelle, duiker, hartebeest, and impala. The impala has also been reported by Meeser (1952; see ecology below), Santos Dias (1953B), and Tendeiro (1951A,B), while Jack (1942) added the tsessebe. In the Masai Reserve of Kenya, Lewis (1934) found the roan antelope, wildebeest, and hartebeest infested. The sable antelope, eland, wildebeest, and kudu were reported as hosts in Northern Rhodesia by Matthysse (1954). These records are representative of others relating to wild antelopes as hosts.

Other wild animals: Zebras, various kinds (Neumann 1907C, 1910B,1922, Loveridge 1923A, Lewis 1931B,1934, Bedford 1932B, Mettam 1932, Weber 1948, Matthysse 1954). Giraffe (Howard 1908, Neumann 1901,1907C,1910B, Moore 1912). Warthog (Neumann 1922, 1954; other specimens in MCZ). Cane rat (Bedford 1932B. These somewhat larger than ordinary rodents appear to harbor an unusual number of stray ticks that do not normally infest rodents).

Noninfestation of young antelopes: Mettam (1933) made the interesting observation that newly born kob, duiker, bushbuck, and reedbuck in an Entebbe paddock heavily infested with R. appendiculatus and R. evertsi were in no instance affected by these ticks. Wild adults of these antelopes are commonly attacked.

Immature stages: As already stated, larvae and nymphs commonly infest the same kinds of hosts as adults. Sometimes, however, they do attach to other animals, especially hares, for reasons not yet understood. Hares have been reported as immature stage hosts by Moore (1912), Bedford (1932B), Sanborn and Hoogstraal (1953), Matthysse 1954; and others; see also BIOLOGY below. Some specimens are found in ears of elephant shrews (Sudan records above) and Theiler (correspondence) has a single record from another genus, Nasilio, of these insectivores, as well as another from a tree rat, Thallomys. Bedford (1932B) reported nymphs from various antelopes, and Lewis (1932B) found both immature stages common in the ears of hartebeests. Dogs are satisfactory hosts for laboratory rearing of the immature stages (Lounsbury 1904A).

BIOLOGY

Life Cycle

R. evertsi is one of the few rhipicephalid ticks with a two-host type of life cycle. Both immature stages occupy the same hosts, but engorged nymphs drop and molt on the ground. As adults they seek a new host. All stages normally infest domestic or wild herbivores, but under some conditions immature stages may attack insectivores, rodents, and hares. Theiler (correspondence) has observed that this may be due to unusual or local factors: "For years my records did not show R. evertsi immatures on any hosts (other than herbivores), except as an incidental infestation perhaps; then last year (1950) we recorded heavy infestations among all species of hares in the East London district."

Details of the life cycle and periods of survival have been frequently reported by various South African workers beginning with Dixon and Spruell (1898). As noted by Theiler (1943B) these periods are:

PERIOD	DAYS
Oviposition to hatching	28 to 70
Larvae and nymphs on host	10 to 15
Nymphal premolting period	42 to 56
Female feeds	6 to 10
Preoviposition period	6 to 24
Total	92 to 175

The periods between larval hatching and feeding and between adult emergence and feeding and oviposition are not stated.

When larvae molt, they loosen their hold on the host. Nymphs reattach nearby on the same animal. Nymphs drop from the host when engorged and molt to adults on the ground. Adults mate on the host.

Unfed larvae survive for seven months and unfed adults survive twice as long.

Ecology

Adults attach almost invariably in the perianal region under the base of the tail, less commonly on the teats, at the base of the legs, or on the scrotum. Larvae and nymphs cluster deep in the depressions of the inner ear surface especially at the base of the auricula; rarely on the host's flanks. (For comparison, immature B. decoloratus and R. appendiculatus usually attach along the edge of the ear). All authors and our own observations are in agreement on these feeding-site predilections. It appears that the messy area in which adults usually feed influences to some extent the numbers of red ticks represented in collections made by Europeans though this is seldom a deterrent to "unspoiled" African assistants. An exception to the above statements, however, was made by Meeser (1952), who noted that red ticks on the impala antelope of southeastern Transvaal is infested on the genitalia and shanks and almost nowhere else on the body. R. e. evertsi, together with B. decoloratus, are the chief tick parasites of this common antelope there.

Theiler's (1950B) study of the distribution of the red tick in South Africa shows that it is present in all types of forest, in all parklands except dry ones, and in all types of grasslands. It maintains itself with difficulty in shortgrass country and is generally absent from desert-shrub areas, but may persist in thorn country and in mixed desert-shrub grassland. Altitude and low temperature do not limit the red tick, but rainfall below ten or fifteen inches per annum seems to be a limiting factor. There appears to be no seasonal variation in the activities of this species.

In parts of Africa warmer than South Africa, a somewhat higher critical level of annual rainfall is probably necessary for the red tick to maintain itself, but definite limits have not yet been ascertained.

As already noted, another subspecies (mimeticus) takes over from this subspecies in the arid areas of southwestern Africa but both are found together in the savannahs of western equatorial Africa. Such evolution of a rhipicephalid species in Africa is as unusual as the red tick's morphology and as its life cycle.

In Kenya, the red tick appears to be somewhat more adaptable than in South and West Africa. There it occurs in the deserts of Northern Province, in coastal areas and open plains, as well as in forests above 8000 feet altitude; "in fact ...... almost anywhere" (Wiley 1953).

Wilson (1953) noted that the red tick occurs in both the same areas as the R. pravus - A. gemma association (cf. page 681) and the R. appendiculatus - A. variegatum association (cf. page 274). While absent from wet zones of Nyasaland and Tanganyika, it is the dominant species in the Masai grasslands and occurs seasonally in small numbers in dry areas of the R. pravus - A. gemma association. The ecology of this tick requires further detailed investigation.

Around Mbui, Adamawa Province, Nigeria, the red tick forms sixty percent of the specimens in tick collections (Unsworth 1949). Reasons for this density should be interesting to investigate.

In the Sudan, the red tick is absent in true desert areas but does occur and is common in a wide variety of forested savannah and semidesert areas.

In Moreau's (1933) study of ticks in the stomachs of the tickbird, Buphagus erythrorhynchus (Stanley) in Tanganyika, specimens of R. e. evertsi were found in three of 58 birds examined. They numbered one, six, and eighteen ticks per stomach. In Kenya, van Someren (1951) found three adult red ticks in the stomachs of two of the same kind of bird, but none were found in ten other of the same kind that he examined and none were found in stomachs of seven B. a. africanus. A further discussion of this subject is presented under A. variegatum, page 275. The concealed places in which the red tick usually feeds probably protects it from this predator except in special circumstances.

Nymphal R. evertsi removed from hares, Lepus zuluensis, have been found infected with the chalcid parasite Hunterellus hookeri Howard, 1908 (Cooley 1934, see also note by Bedford in Cooley 1929).

REMARKS

Integumentary sense organs, which are fixed in number and location, and which are essentially similar in all stages of the tick, though more primitive in larvae, have been described and illustrated by Dinnik and Zumpt (1949). This subject has also been discussed by K. W. Neumann (1942).

Preliminary studies on spermatogenesis by Warren (1931), which do not appear to have been completed, indicate that in R. e. evertsi a single spermatid gives rise to several spermatozoa of extremely variable size. Warren's observations differ considerably from those of Nordenskiöld (1920) on Ixodes ricinus.

Misformed specimens of R. e. evertsi have been reported on by Santos Dias (1947B,1948A,1954H). An egg toxin has been found in this species (De Meillon 1942). Symbiotes have been reported and discussed by several workers: Cowdry (1923,1925C,1927), Buchner (1926), and Jaschke (1932). The arch of the eye has been briefly mentioned by Gossel (1935). Dönitz (1905) observed copulation - by insertion of the male hypostome into the female genital aperture while the legs are used as clasping organs adjacent to the corresponding legs of the female - but was unable to ascertain how seminal fluid was passed; Christophers (1906) stated that obviously it is accomplished by transfer of spermatophores during the mating act.

The life cycle and morphology of the red tick are so peculiar within this genus that a special subgeneric niche might seem indicated for R. evertsi. [Theiler informs me (correspondence) that Dr. Cooley also entertained this idea while he was in South Africa, but that the immature stages are so normally rhipicephalid as to dampen any urge to take this step].

DISEASE RELATIONS

MAN: Boutonneuse fever (Rickettsia conorii).

CATTLE: East Coast fever (Theileria parva). Pseudo-east coast fever (T. mutans). Redwater (Babesia bigemina). Spirochetosis (Borrelia theileri). Not a vector of heartwater (Rickettsia ruminantium). A secondary bacterial infection by Corynebacterium pyogenes causes an otitis leading to the sloughing of the host's external ear when infested by larvae and nymphs. The virus of "a specific transmissible petechial fever of cattle" may be transmitted to sheep by the red tick.

SHEEP: Lamb paralysis (?toxin). Apparently not a vector of Nairobi sheep disease (virus). See paragraph above.

HORSES, MULES, and DONKEYS: Equine piroplasmosis (biliary fevers) (Babesia equi and B. caballi). Spirochetosis (Borrelia theileri).

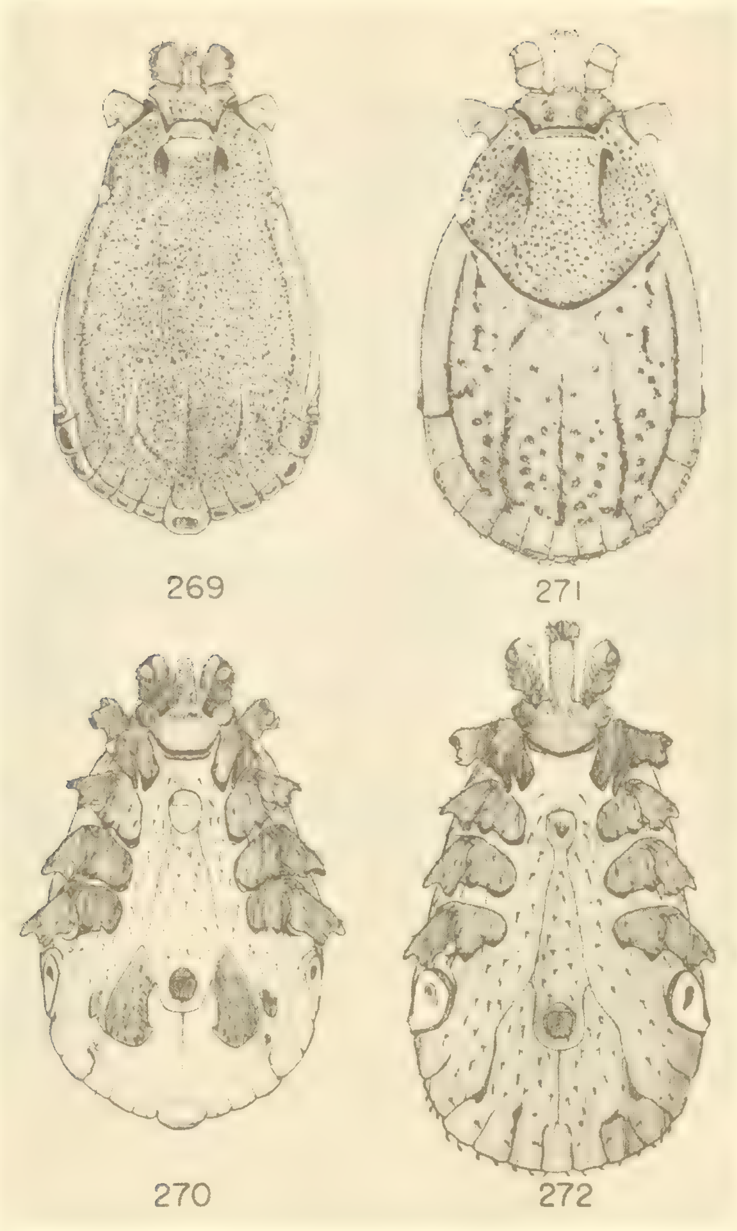
IDENTIFICATION

Males: The red tick is usually large (5 mm. long) though smaller specimens do occur. Its dark scutum contrasts greatly with the reddish body integument and saffron legs. The dark eyes are hemispherical, protruding, and orbited, similar to those of hyalommids but to no other rhipicephalids except *R. oculatus* (and, partially, to *R. pravus*). Scutal punctations are of medium and large size and so numerous as to cause the scutum to appear shagreened. Lateral grooves, a posteromedian groove, and paramedian grooves are pronounced. A large, pointed process from coxa I is visible dorsally. The huge adanal shields, very wide and posteriorly semicircular in outline, are also unique.

Female: This sex is colored as in the male and has similar scutal punctations and eyes so that it can never be mistaken. The scutum lacks lateral grooves.

The larva and nymph have been described and illustrated by Theiler (1943B).

Note: The subspecies *R. evertsi mimeticus* Dönitz, 1910(B), has yellow-ringed legs while those of the typical *evertsi* are unicolorous.



Figures 269 and 270, ♂, dorsal and ventral views
Figures 271 and 272, ♀, dorsal and ventral views

<u>RHIPICEPHALUS</u> <u>KOCHI</u>
Belgian Congo Specimens

PLATE LXXVI

RHIPICEPHALUS KOCHI Dönitz, 1905.

(= R. JEANNELI Neumann, 1913).

(Figures 269 to 272)

THE CENTRAL AFRICAN HIGHLAND BROWN TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
		1	1	Nagichot	domestic cow	Dec	
		2		Kipia	host not stated	Dec	(BMNH)
		2		Kipia	on grass	-	(Weber 1948)

The Nagichot specimens, from a cow at 6500 feet elevation in the Didinga Mountains, were collected by Mr. H. B. Luxmoore in 1951. The British Museum (Natural History) specimens, found unidentified in their collections, were taken by Mr. J. D. MacDonald in 1938 at Kipia, 8800 feet elevation, in the Imatong Mountains. The Weber specimens from the same locality, but reportedly at one hundred feet lower elevation, were identified (Weber 1948) as R. bursa. Weber's specimens, kindly loaned by Dr. J. Bequaert, were independently identified by Dr. Theiler and by me as R. kochi.

R. kochi is known in the Sudan only from the high mountains in the central part of the eastern half of Equatoria Province.

DISTRIBUTION

R. kochi, a tick of the more humid and temperate highlands of Central Africa, less commonly also inhabits the highlands of East Africa (see also Ecology of R. compositus, p. 625). Records previous to 1950 should be accepted with caution.

CENTRAL AFRICA: BELGIAN CONGO and RUANDA-URUNDI (Schoenaers 1951A,B. Rousselot 1953B. Theiler and Robinson 1954. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (As R. bursa: Weber 1948. Hoogstraal 1954B).

UGANDA (Wilson 1952,1953). KENYA (Neumann 1913. Anderson 1924A,B. Lewis 1931A,B,C,1934*. Daubney 1933. Binns 1952). TANGANYIKA (Dönitz 1905,1907, cf. HOSTS below. Neumann 1913. Morstatt 1913. Moreau 1933; cf. REMARKS below. Theiler 1947. Schoenaers 1951A).

HOSTS

R. kochi is known chiefly from domestic cattle. Duikers and other forest antelopes may be presumed to have been its original hosts. Animals on which immature stages feed are unknown.

Domestic animals: Cattle: Dönitz (1905,1907). Lewis (1934). Schoenaers (1951A,B). Rousselot (1953). Theiler's records are from cattle. Dönitz's material from Soadani and Lindi was probably taken from introduced cattle. Dogs (Lewis 1931B).

**Wild animals*: Lion and spurfowl (Lewis 1934). Buffalo (Theiler, unpublished).

BIOLOGY

Life Cycle

Eggs hatch in 24 days and larvae feed for five or six days according to Rousselot (1953B). No other details are known.

Ecology

Schoenaers (1951A,B) found *R. kochi* only above 2000 meters elevation in Ruanda-Urundi and specimens sent to Rousselot (1953B) were from altitudes between 2400 and 2500 meters elevations. Van Vaerenbergh (1954) also reported the same altitudinal range, and Theiler and Robinson's (1954) Congo localities are at similar elevations. As already noted, Sudan specimens have been taken

---

*Lewis (1934, p. 41, footnote), states that these specimens may be *R. capensis*.

only between 6500 and 8800 feet elevation. Wilson (1953) states that this tick is limited to upland forests in East and Central Africa, and work on its ecology and of that of another upland species, R. compositus (= R. ayeri) is in progress. See also Ecology of R. compositus (p. 625).

When present, this tick often appears in great numbers (Theiler and Robinson 1954). Its specialized high altitude preference may account for rarity in collections and for paucity of records.

DISEASE RELATIONS

Cattle: A vector of East Coast fever, Theileria parva, though, on epidemiological grounds some observers have indicated that this species is not a vector.

REMARKS

Our present knowledge of the biology, morphology, and taxonomy of those heavily-punctate rhipicephalids that have shallow lateral grooves or none at all is in an unsatisfactory state. This complex may be referred to as the "R. ziemanni group" in place of the "R. aurantiacus group" of Zumpt (1943B). Subsequently, Zumpt (1950A) has included several species of this group, previously considered as valid, in synonymy. Species now recognized are: R. ziemanni Neumann, 1904 (= R. aurantiacus Neumann, 1907, and R. cuneatus Neumann, 1908), R. kochi Dönitz, 1905 (= R. jeanneli Neumann, 1913), R. masseyi Nuttall and Warburton, 1908* /= R. attenuatus Neumann, 1908(B)* and ? = R. tendeiroi Santos Dias, 1950(E) 7 and R. mühlensi Zumpt, 1943(B). To this group should be added R. hurti Wilson, 1954 of Kenya and R. serranoi Santos Dias, 1950(G) of Mozambique. It is possible that these two species may eventually be shown to be heavily punctate specimens of R. kochi. /Theiler states (correspondence) that from evidence presently available, she agrees with the above synonymy 7.

---

*It appears that the R. attenuatus of Santos Dias (1954D) from Ruanda-Urundi is R. kochi, since Theiler, Schoenaers, and Vaerenbergh have found R. kochi "most plentiful" at the same collecting sites from which Santos Dias' material was sent. (Footnote continued on next page).

A more comprehensive morphological, taxonomic, and biological study of this group is indicated. Large series of specimens from many areas are required to solve these problems, which are outside the scope of the present work. In the known Sudan tick fauna, R. kochi is easily distinguished. The remarks below are only for local use and are not sufficiently detailed for differentiation of material from elsewhere in Africa. The Sudan material noted herein was identified by Dr. G. Theiler. Miss J. Walker is now reviewing this group.

Four specimens, identified as R. kochi by E. A. Lewis, were found by Moreau (1933) in the stomach of a tick bird in Tanganyika. I have examined these specimens, in the collections of British Museum (Natural History), but cannot identify them to species.

IDENTIFICATION

Males: Lateral grooves are replaced by a line of almost continuous punctations, the posteromedian groove is merely a fine, shagreened line, and the paramedian grooves are indicated by shagreening only. A blunt dorsal hump of coxa I is present. Scutal punctations are numerous, close or contiguous, mostly moderate

---

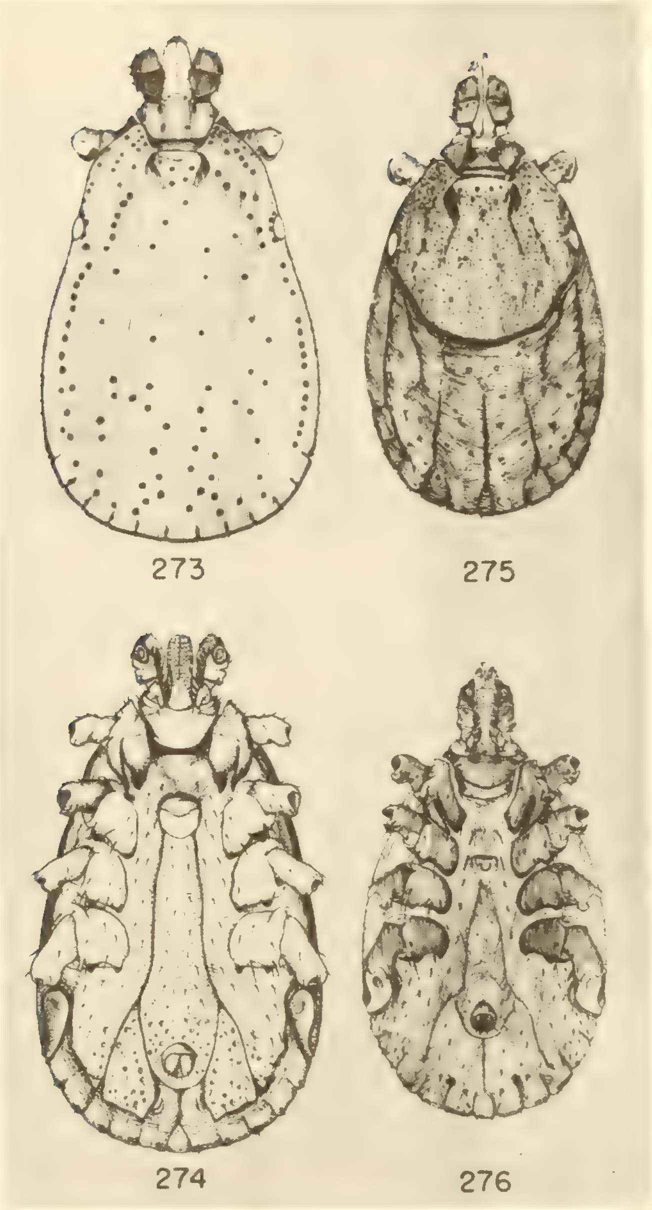
There has been some difference of opinion among specialists over which of the synonymous names, attenuatus or masseyi has priority. The background is as follows: Neumann's name attenuatus was published on 20 March, 1908. Although Nuttall and Warburton's name masseyi was read orally at a scientific meeting on 28 December 1907, it was actually published on 10 March 1908. Therefore, according to Opinion 15 (July 1910) of the International Code of Zoological Nomenclature (reconfirmed at the Paris conference, 1948), in which it is stated that, "The mention of the new name in a paper presented orally before a meeting of any kind" does not constitute publication, the question is decided definitely in favor of the name masseyi, which was published ten days earlier than attenuatus. Authority for the publication dates of these two papers is the Index-Catalogue of Medical and Veterinary Zoology, part II, pages 3539 and 3627 (1950). Some workers consider that the Nuttall and Warburton paper was published in May 1908, which, if true, would reverse the prior name of this tick.

size, with a scattering of widely separated large punctations among them. Certain populations have fewer punctations that are exceptionally shallow. Cervical pits are deep but cervical grooves are absent or very short. The central festoon, but not adjacent festoons, may be extended in engorged specimens. Basis capituli has prominent lateral angles. Body outline is pear-shaped. Adanal shields are distinctive, as illustrated (Figure 270).

Females: This sex also lacks a lateral groove and has scutal punctations similar to those of the male, but these punctations may tend to be somewhat larger. The cervical grooves are pronounced and gradually converge to the level of the eyes, thence diverge almost to the posterior margin of the scutum. The scutal shape is subcircular, slightly wider than long.

Note: Some variation is to be expected in specimens referable to *R. kochi* but the significance of such differences is difficult to evaluate at this time.

The larva and nymph have been briefly described and illustrated by Rousselot (1953B).



Figures 273 and 274, ♂, dorsal and ventral views
Figures 275 and 276, ♀, dorsal and ventral views

RHIPICEPHALUS LONGICOXATUS
♂, French Somaliland Specimen
♀, Kenya Specimen

PLATE LXXVII

RHIPICEPHALUS LONGICOXATUS Neumann, 1905.

(Figures 273 to 276)

THE SOMALI GLOSSY TICK

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal Province: Galual-Nyang Forest, 1♀ ex *Syncerus caffer aequinoctialis*, 18 February 1953, H. Hoogstraal *legit*.

DISTRIBUTION

R. longicoxatus is an extremely rare tick from scattered localities throughout East and Central Africa. The bulk of records referring to this species are from the arid Somalilands and coastal lowlands of East Africa, with a few savannah records from a circumscribed area in the interior of the continent.

CENTRAL AFRICA: FRENCH EQUATORIAL AFRICA (Rousselot 1953B).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

FRENCH SOMALILAND, BRITISH SOMALILAND, KENYA (Hoogstraal 1953D). TANGANYIKA (Neumann 1905. Hoogstraal 1953D). Note: Recently while identifying specimens for British Museum (Natural History), another male *R. longicoxatus* with the following data has been encountered: Camel, Las Anod, British Somaliland, 21 September 1936; B. F. Peck *legit* (with *R. pravus*, *Hyalomma dromedarii*, *H. rufipes*, and *H. truncatum*).

[?ITALIAN SOMALILAND: Figure 17 and 18 in Paoli (1916), reported as *R. ecinictus*, on the basis of two males, one from the ground and one from a camel, may refer to *R. longicoxatus* with the characteristic shape of the adanal shields, as illustrated, very slightly modified, or to *R. humeralis*.]

HOSTS

Domestic animals: Camel, goat, and sheep (Hoogstraal 1953D). Note the two other records for camels above.

Wild animals: African buffalo (Sudan record above) and bush-pig (Rousselot 1953B).

BIOLOGY

The East African records of R. *longicoxatus* give the impression that this is a Somali tick specialized for rather arid situations. The Sudan focus is in an area far removed but with a long, intense dry season. The fact that this tick also occurs in the more humid French Equatorial Africa is perplexing and indicates that we are still poorly acquainted with its biology. This appears to be a decidedly uncommon species.

DISEASE RELATIONS

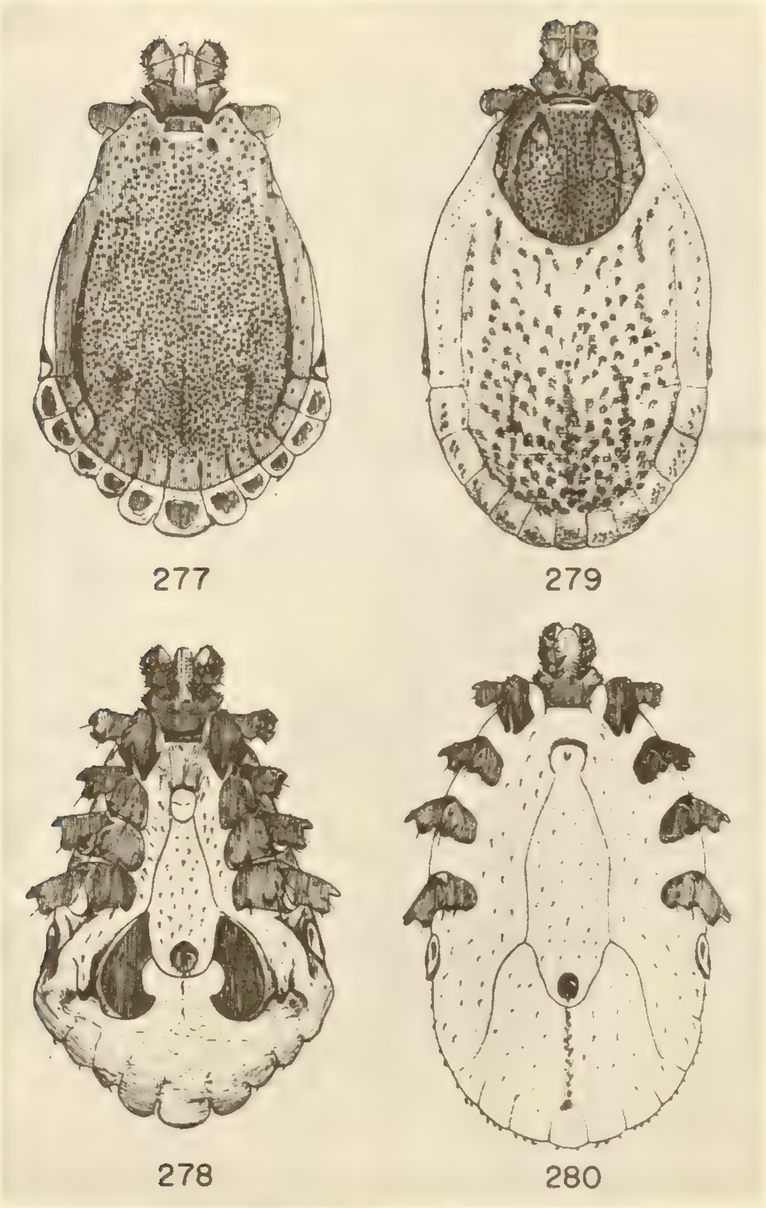
Unknown.

IDENTIFICATION

Male: The scutum varies from 2.0 to 4.5 mm. in length, and from 2.0 to 3.1 mm. in width; it is widest at about midlength or slightly posterior of this level, and slightly convex, shiny, reddish brown. Cervical grooves are short and deep; marginal grooves are lacking but indicated by a row of large, deep punctations. Festoons are short and superficial. Scutal punctations are rare, large, distant, in irregular lines like those of R. *s. simus*; interstitial punctations are very few to numerous, very fine or almost obsolete. The illustrated distribution of scutal punctations is typical. Posteromedian and paramedian grooves are absent though it is possible that posterior depressions may develop after death and contraction of the specimen simulate these grooves. Eyes are flat, yellowish, large, marginal or almost marginal (see note below). The adanal shields are strongly punctate and triangular; the juncture of the lateral and posterior margins is subrectangular; the juncture of the posterior and inner margin forms a very slight, rounded protrusion; and the inner margin is posteriorly slightly convex and sinuous, anteriorly narrowing, and slightly concave. The accessory shields are short, not heavily thickened, and do not extend beyond the outer margin of the adanal shields. The basis capituli dorsally is about twice as wide as long and with at least two punctations, lateral margins widest at anterior third, cornua broadly rounded. The hypostome has 3/3 dentition in files of nine to eleven denticles. Palpi are slightly longer than wide, flat dorsally. Coxa I has a distinct, dorsally-projecting process.

Note: In the very anterior position of the eyes, the specimen described and illustrated by Rousselot (1953B) conforms more closely to the original description of *R. longicoxatus* than do our specimens.

Female: The scutum is short and wide, with length not quite equalling width. Although Neumann originally described it as longer than wide, this is not true of the only available paratype specimen (cf. Hoogstraal 1953D). The posterior margin is broadly rounded. Lateral grooves are absent or slightly indicated posteriorly; cervical grooves are deep basally, distally superficial, and extend almost to the eyes or slightly beyond the eyes. Scutal punctations are variable in number but few, fine, and distant with very few, almost obsolete interstitials. The eyes are flat and on or very slightly removed from the lateral margin.



Figures 277 and 278, ♂, dorsal and ventral views
Figures 279 and 280, ♀, dorsal and ventral views

RHIPICEPHALUS LONGUS
Sudan specimens

PLATE LXXVIII

RHIPICEPHALUS LONGUS Neumann, 1907(A)*.

(Figures 277 to 280)

THE SCIMITAR-SHIELD CAPE BROWN TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
		2	3	Laboni	*Syncerus caffer aequinoctialis*	Feb
		3	3	Kheirallah	*Syncerus caffer aequinoctialis*	Mar (SGC)

R. longus is not known from other Provinces of the Sudan.

DISTRIBUTION

Although *R. longus* appears to be chiefly a Central and West African tick, scattered populations occur in East Africa and in the northern part of southern Africa, apparently in more humid areas. The possibility that some specimens in the reports listed below have been confused with *R. capensis* must be considered.

See footnote below.

WEST AFRICA: NIGERIA (Zumpt 1942B. Unsworth 1952). TOGO (Zumpt 1942B). LIBERIA (As *R. falcatus*: Neumann 1908C).

CENTRAL AFRICA: CAMEROONS (Zumpt 1942B. Rageau 1951,1953A, B. Unsworth 1952. Rousselot 1953B). FRENCH EQUATORIAL AFRICA (Rousselot 1951,1953B). BELGIAN CONGO (Neumann 1907A,1911. Nuttall and Warburton 1916. Schwetz 1932. Bequaert 1930A,1931. Fain 1949. Rousselot 1951,1953B. See also HOSTS below).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

UGANDA (As *R. falcatus*: Theiler 1947).

**R. falcatus* Neumann, 1908, is a synonym of *R. longus*, but few literature records of *R. falcatus* can be assumed to refer to *R. longus*. The name *R. falcatus* was long used indiscriminately as a "catch-all" for heavily punctate rhipicephalids with sickle-shape adanal shields and many species were lumped under it.

SOUTHERN AFRICA: ANGOLA (Zumpt 1942B. Theiler and Robinson 1954. See also HOSTS below). NYASALAND (All as R. falcatus: Neumann 1908C. Old 1909. Warburton 1912. Wilson 1950B. See also HOSTS below). MOZAMBIQUE (As R. falcatus: Theiler 1943B, 1947. Santos Dias 1952H,1953B).

HOSTS

Larger domestic animals and wild game animals serve as hosts of R. longus. Available data are not extensive enough to demonstrate further host predilection within this range.

Domestic animals: Cattle (Neumann 1907A, Schwetz 1932, Fain 1949, Rageau 1951,1953B, Rousselot 1951). Dogs (Nuttall lot 1950A from Angola in BMNH. Zumpt 1942A, Rageau 1951,1953B). Horses (Fain 1949, Wilson 1950B). Pigs (Fain 1949, Santos Dias 1952H,1953N).

Wild animals: Buffalo (Nuttall lot 434A from Semliki Plains in BMNH. Bequaert 1930A,1931, Zumpt 1942A, Theiler 1943B, Fain 1949, Wilson 1950B, Rousselot 1951, Santos Dias 1952H,1953B, and Sudan records above). Eland (Bequaert 1931). Sable antelope (Zumpt 1942A, Santos Dias 1953B). Roan antelope (Nuttall lot 227 from Nyasaland in BMNH. Wilson 1950B). Lichtenstein's hartebeest (Santos Dias 1952H,1953B). Wild pig (Schwetz 1932, Fain 1949). Warthog (Nuttall lot 1099A from Nyasaland in BMNH. Zumpt 1942A, Wilson 1950B, Santos Dias 1953B). Jackal (Fain 1949). Lion (Rageau 1953B).

BIOLOGY

R. longus appears to be a tick of somewhat more humid areas than the closely related R. capensis, or else it is a rainy season species, while R. capensis is a dry season form. The geographic range of the two, formerly considered to be West African and East African respectively, is now known to include some areas, Mozambique and Nyasaland, in which both occur, though the data are not sufficiently detailed to indicate whether they are found together or in different seasons or ecological zones within these political boundaries.

DISEASE RELATIONS

Unstudied.

REMARKS

Schulze (1944, p. 410) mentioned this species in a study of tick integument.

Zumpt (1942B,1950A) considered R. longus to be a West and Central African subspecies of R. capensis but has stated more recently (1950 correspondence) that, after having received additional material from Mozambique and Nyasaland, he has come to regard each as a separate species.

Santos Dias (1953D) confused R. longus and R. simus senegalensis and, in so doing described for the latter yet another species, obviously synonymous, R. pseudolongus. In an effort to determine his ideas concerning this species, we sent him (1954) Sudan specimens consisting of numerous R. simus senegalensis which were returned marked as R. longus, and all my available R. longus, which were returned as R. capensis pseudolongus.

R. longus is closely related to R. capensis, as already noted. Zumpt (1942B,1950A) stated that the range of "R. capensis capensis" includes the Sudan. This is most probably in error.

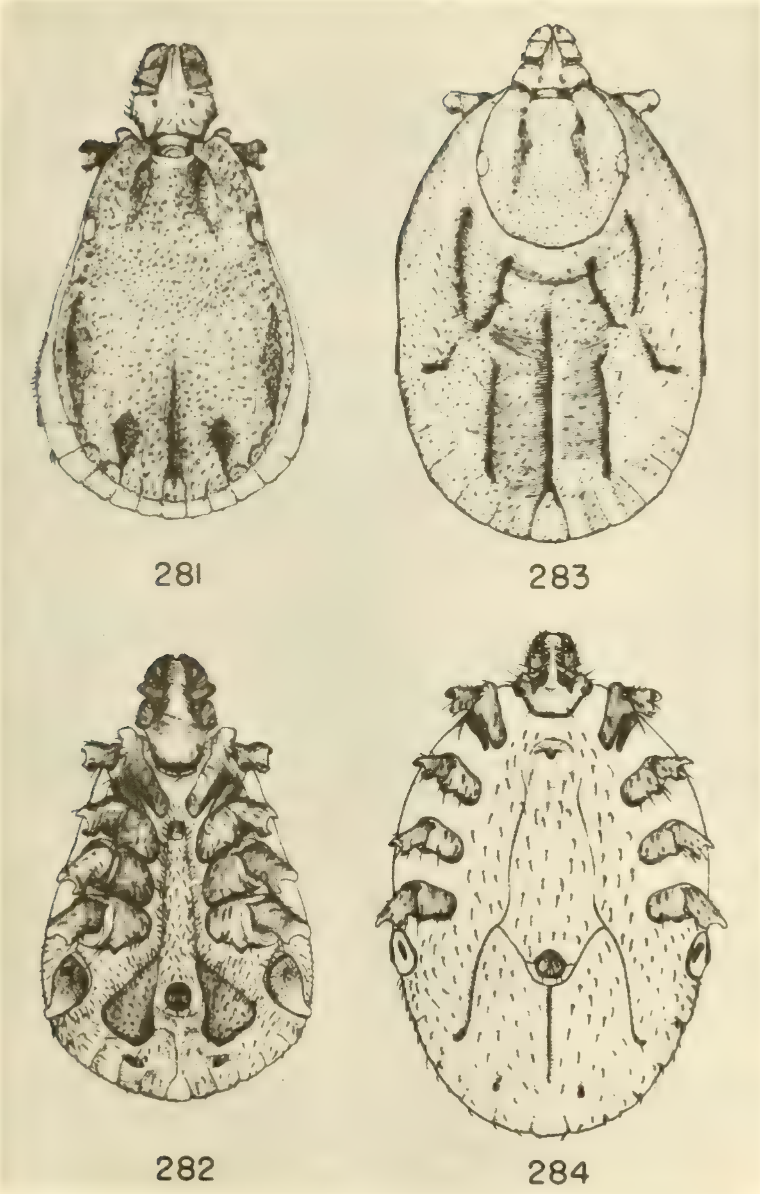
R. simus senegalensis males are mostly readily separated from those of R. longus, but individuals of the former species that have exceptionally heavy interstitial or secondary punctation may momentarily be confused with R. longus. Turning such a specimen obliquely to the source of the light will reveal the typical arrangement of larger posterior punctations as described for R. simus senegalensis (cf. page 759) among the smaller, more superficial, secondary punctations, a characteristic not associated with R. longus. Both species may occur on the same host.

IDENTIFICATION

Male: This is a fairly large, robust tick (up to 6.0 mm. long and 3.5 mm. wide), usually jet black in color (smaller specimens often reddish brown) with reddish brown legs. It has definite, long, deep lateral grooves but the narrow posteromedian groove is vague or obsolete and the paramedian grooves, if present at all, are even more vague. The scutal punctations are distinctive, being of a uniformly shallow, small or medium size, densely and closely distributed in irregular lines everywhere except in the scapular areas, on the festoons, outside the lateral margins, and in a narrow area just inside the lateral margins; most punctations are clean and discrete. Shallowness of punctations varies among individuals, but the pits are never deep and are sometimes quite superficial. The overall appearance is one of regularity of punctations within the impunctate periphery bordering the lateral grooves; no pattern of larger and deeper punctations is visible among the normal punctations. If the punctations are exceptionally shallow, those in the area of the posterior grooves tend to be slightly larger and deeper than elsewhere. Coxa I has a stump showing dorsally, but no dorsal process. In engorged specimens, the three median festoons protrude. The adanal shields of typically large specimens are sickleshaped, with a deeply curved inner margin, but in smaller specimens this feature may be considerably reduced (at the moment, I would not know how to distinguish runt specimens with narrowly elongate, uncurved adanal shields from small specimens of *R. capensis*).

Female: This sex (which, so far as known, cannot be distinguished from *R. capensis*) has a subcircular scutum densely beset with uniform, fairly large punctations very much like those of the male, but usually somewhat larger, deeper, and more dense; these punctations are evenly distributed in the depression within the lateral grooves but are sparse or almost entirely absent in a narrow area along the posterior margin and on the elevated ridge outside the lateral margins.

Note: A male and a female cotype of *R. falcatus* examined in British Museum (Natural History) collections conform to the description of typical specimens of *R. longus* as provided above.



Figures 281 and 282, ♂, dorsal and ventral views
Figures 283 and 284, ♀, dorsal and ventral views

RHIPICEPHALUS MÜHLENSI
Belgian Congo specimens
Gift of Dr. G. Theiler

PLATE LXXIX

RHIPICEPHALUS MÜHLENSI Zumpt, 1943(B).

(Figures 281 to 284)

MÜHLENS' BROWN TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD		
		1		Yei	domestic cattle	Jan

R. mühlensi is known in the Sudan by only a single specimen.

DISTRIBUTION

Theiler (correspondence) believes that R. mühlensi has been frequently misidentified and that its range is more extensive than present records indicate.

CENTRAL AFRICA: BELGIAN CONGO (Theiler and Robinson 1954. These authors also attribute certain other earlier published remarks by other authors to this species).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

KENYA (Specimens from Makueni; J. B. Walker, unpublished; see HOSTS). TANGANYIKA (Zumpt 1943B. Hoogstraal 1954C. J. B. Walker, unpublished; see HOSTS).

SOUTHERN AFRICA: MOZAMBIQUE (Santos Dias 1950B,1953B). UNION OF SOUTH AFRICA [As R. masseyi in Zululand: Theiler (1947) (Theiler, correspondence). See HOSTS.]

HOSTS

It is at present impossible to evaluate the relative importance of the few records from domestic animals in relation to the wide variety of large game animals that this tick is known to attack. As workers become better acquainted with the identity of this tick more accurate data concerning its hosts and biology are bound to result. Hosts of the immature stages are unknown, except for a single nymph (J. B. Walker, correspondence) from an African civet in Tanganyika.

Domestic animals: Cattle (Sudan and Walker's Kenya records, above). Dog (Santos Dias 1953B).

Wild animals: Bushbuck and giraffe (Zumpt 1943B). Roan antelope (Zumpt 1943B, Hoogstraal 1954C). Nyasaland warthog (Theiler 1947). Buffalo, nyala, and South African bushbuck (Santos Dias 1950B,1953B). Impala, sable antelope, suni antelope, reedbuck, greater kudu, Cape duiker, Zambesi eland, warthog, and buffalo (Santos Dias 1953B). Kudu (Walker's Kenya record above).

Theiler's (unpublished) host records (number of hosts, if more than one, indicated in parenthesis) are: from Mkuzi Game Reserve, Zululand, impala, nyala bushbuck (3), reedbuck (2), duiker (4), steenbuck, warthog, and bushpig; from Ubombo Flats, Natal, nyala bushbuck. In Miss Walker's collections (correspondence) from large numbers of game animals from Tanganyika, 19 males from two buffalos are represented.

BIOLOGY

This species is now being reared at Onderstepoort (Theiler, correspondence).

DISEASE RELATIONS

Unstudied.

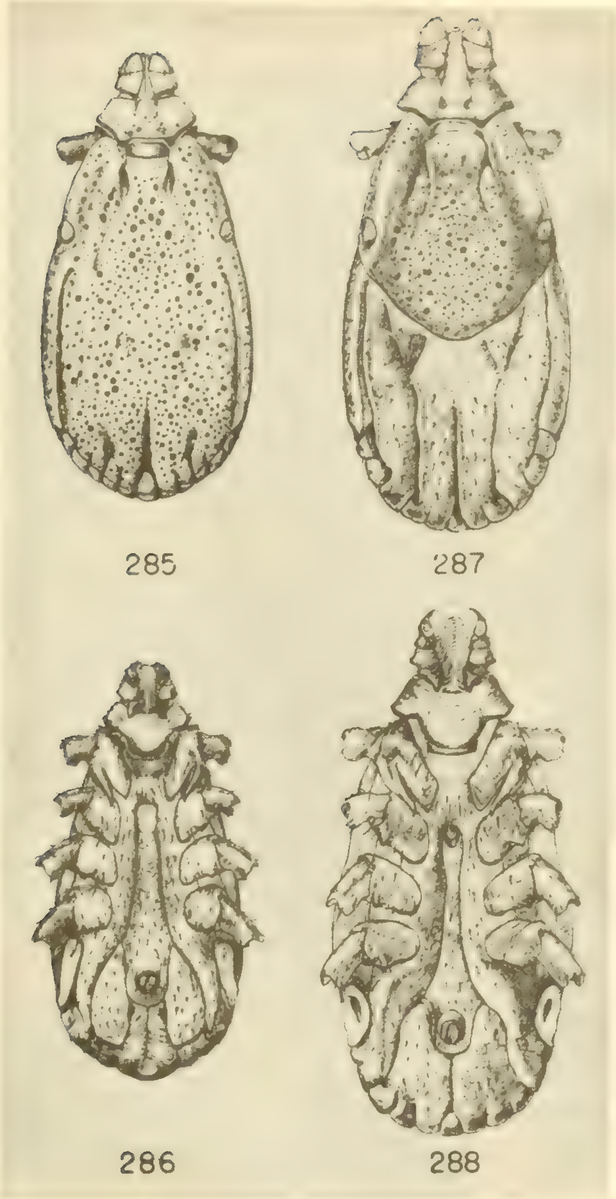
REMARKS

The Sudan material recorded above was compared by Dr. G. Theiler with type material in Dr. F. Zumpt's collection.

IDENTIFICATION

Male: A distinct, long dorsal process of coxa I associates this species with the *R. appendiculatus* group of Zumpt (1942C) but peculiar scutal characters place it with the *R. aurantiacus* group (1943B) to which it is referred, not, however, for reasons of indicating phylogenetic relationships but rather for the sake of convenience. Lateral grooves are indicated by a row of somewhat dense and regular punctations, though shallow lateral grooves as such may be present just anterior of the proximal festoons. Posteromedian grooves are shagreened, distinct, long, and narrow; paramedian grooves are shorter and wider, also shagreened. Punctations are of medium size, fairly superficial, and moderately dense; some fine interstitials may be apparent, especially laterally. The basis capituli is strongly angled laterally in small specimens (2.2 mm. long; 1.3 mm. wide) but more blunt and elongate in large specimens (4.7 mm. long; 2.6 mm. wide) (as in *R. appendiculatus*). It should be noted that in the specimen illustrated (Figure 281), the basis capituli is exceptionally short and wide. The adanal shields (Figure 282) are most characteristic though in some individuals the width of the posterior section is not so great as in the specimen illustrated. The body greatly bulges posteriorly upon engorgement and the median festoon protrudes. Long, pale hairs are especially conspicuous on numerous specimens in the present collection and should receive further study.

Female: The elongately ovoid scutum of this small species lacks lateral grooves and has punctations like those of the male; punctations are rare laterally anterior of the flat eyes and on the scapulae; cervical grooves are faintly indicated if at all. The basis capituli appears to be more consistently sharply angled than that of the male, but this might be a variable character.



Figures 285 and 286, ♂, dorsal and ventral views
Figures 287 and 288, ♀, dorsal and ventral views

RHIPICEPHALUS PRAVUS
Sudan Specimens

PLATE LXXX

RHIPICEPHALUS PRAVUS Dönitz, 1910(B)

(= R. NEAVI Warburton, 1912,

R. NEAVI PUNCTATUS Warburton, 1912; and others)

(Figures 285 to 288)

THE EAST AFRICAN CONVEX-EYED BROWN TICK

EQUATORIA PROVINCE RECORDS

L	N	♀	♂				
		1		Ikoto	MAN (feeding on)	Dec	
		1		Ikoto	MAN (feeding on)	Feb	
			1	Torit	MAN (feeding on)	Feb	
			1	Torit	MAN (crawling on)	Dec	
		2	3	Ikoto	*Atelerix pruneri oweni*	Aug	
191	210	84*	67*	Kapoeta	*Elephantulus rufescens hoogstraali*	Apr	(numerous)
18	90	21*	15*	Ikoto	*Elephantulus rufescens hoogstraali*	Nov	(numerous)
7	31	4*	2*	Ikoto	*Elephantulus rufescens hoogstraali*	Dec	(numerous)
82	16	12*	4*	Torit	*Elephantulus rufescens hoogstraali*	Dec	(numerous)
7	3	2*	2*	Torit	*Elephantulus rufescens hoogstraali*	Jan	(numerous)
	2			Obbo	*Elephantulus fuscipes*	Mar	
4	24	6	12	Kapoeta	*Lepus capensis* subsp.	Apr	(2)
		4	15	Ikoto	*Lepus capensis crawshayi*	Feb	(2)
		4	13	Torit	*Lepus victoriae microtis*	Feb	
		1	1	Magwe	*Poelagus marjorita oweni*	Sep	
		1		Torit	*Canis aureus soudanicus*	Apr	
	1		7	Torit	*Ourebia ourebi aequatoria*	Feb	
			1	Torit	*Alcelaphus buselaphus roosevelti*	Dec	
		2		Ikoto	*Rhynchotragus guentheri smithii*	Dec	
		3	4	Ikoto	*Rhynchotragus guentheri smithii*	Feb	(2)
			1	Torit	*Rhynchotragus guentheri smithii*	Nov	
		1	1	Torit	*Sus scofra senaarensis*	Mar	
		3	3	Kapoeta	domestic cattle	Jan	
		1		Torit	domestic cattle	Jan	
			1	Lowudo	domestic cattle	Jan	(SVS)
		37	60	Lodwara	domestic cattle	Jul	(2)
		58	58	Lodwara	domestic cattle	Sep	
		1	8	Goniryo	domestic cattle	Mar	

*Unfed adults taken leaving host after molting.

L	N	♀	♂			
		2	1	Kapoeta	domestic sheep	Jun (SGC)
		3	3	Kapoeta	domestic sheep	Dec
		2	3	Kapoeta	domestic sheep	Dec
		8	12	Kapoeta	domestic sheep	Dec
		9	10	Narongyet	domestic sheep	Jul
		4	3	Kapoeta	domestic goats	Dec
		8	8	Kapoeta	domestic goats	Jan
		1		Nagichot	domestic goats	Dec
			6	Katire	domestic goats	Jan
			64	Kapoeta	domestic dogs	Jul
			44	Kapoeta	domestic dogs	Dec
			1	Torit	domestic dogs	Dec

R. pravus is known only from Eastern and Torit Districts of Equatoria Province. Although absent or rare west of Torit District, apparent ecological preferences indicate that it may be expected to occur in Upper Nile Province, to the north of eastern Equatoria.

Some of the above-mentioned collections have already been quoted by Theiler and Robinson (1953B) and Walker (1956). Except for a few Kapoeta specimens, none from the Sudan have been found in Sudan Government collections or in British Museum (Natural History).

DISTRIBUTION

The drier areas of East Africa appear to be the center of distribution of *R. pravus*, which also extends into Central and Southern Africa and may range just inside the borders of West Africa. This species is often common in the localized areas where it occurs.

WEST AFRICA: NIGERIA (As *R. neavi punctatus*: Gambles 1951. Walker 1956).

CENTRAL AFRICA: CAMEROONS (Unsworth 1952). BELGIAN CONGO and RUANDA-URUNDI (Theiler and Robinson 1953B,1954, and Walker 1956 presume that *R. pravus* is the actual identity of the "*R.*

bursa" of Newstead, Dutton, and Todd 1907; Schwetz 1927C; and Bequaert 1930A,1931; however these authors have not examined the "R. bursa" specimens in question. Theiler and Robinson 1953B,1954 give the only available definitely correct locality records for this species here. As R. neavi: Santos Dias 1954D).

EAST AFRICA: SUDAN (Hoogstraal 1953B; ms. quoted by Theiler and Robinson 1953B and Walker 1956).

ETHIOPIA (Zumpt 1942C). ERITREA (Hoogstraal, personal collecting around Asmara; common). FRENCH SOMALILAND (Hoogstraal 1953D. Theiler and Robinson 1953B). BRITISH SOMALILAND (See record of R. pravus with R. longicoxatus, p. . Walker 1956). ITALIAN SOMALILAND (Numerous specimens in Hoogstraal collection. Walker 1956).

KENYA (As R. neavi and as R. pravus: Neave 1912 and Anderson 1924A,B. As R. neavi: Neave 1912; Warburton 1912; Daubney 1934; Lewis 1934,1939A; Mulligan 1938; Lewis, Piercy, and Wiley 1946; Binns 1952; Wilson 1953. As R. neavi punctatus: Lewis 1931C. As R. pravus: Zumpt 1942B; Hoogstraal 1954C; Walker 1956). UGANDA (As R. neavi: Neave 1912; Mettam 1932,1935; Wilson 1948, 1950C,1953. As R. pravus: Theiler and Robinson 1953B,1956. Common in Karamoja District: Haddow, correspondence). TANGANYIKA (Dönitz 1910B. Zumpt 1942B. Theiler and Robinson 1953B. Hoogstraal 1954C. Walker 1956).

SOUTHERN AFRICA: ANGOLA (As R. bursa and R. neavi punctatus: Santos Dias 1950C. As R. neavi punctatus: Sousa Dias 1950. As R. pravus: Theiler and Robinson 1953B). MOZAMBIQUE (As R. bursa: Howard 1908. As R. punctatus: Santos Dias 1951B,1953A,B. As R. neavi: Santos Dias 1950B,1952D,E,H,1953A,B,C. As R. mossambicus: Santos Dias 1950B,1952H. As R. piresi: Santos Dias 1950F,1952D,1953B. Synonymy of Santos Dias names by Walker 1956. As R. pravus: Santos Dias 1952D).

NORTHERN RHODESIA (As R. neavi: Warburton 1912. Neave 1912. Theiler and Robinson 1953B. Matthysse 1954. As R. pravus: Theiler and Robinson 1953B,1954. Matthysse 1954). SOUTHERN RHODESIA (Theiler and Robinson 1953B). NYASALAND (As R. neavi and R. neavi punctatus: Warburton 1912. Neave 1912. Davy and Newstead 1921. Wilson 1950B. As R. pravus: Theiler and Robinson 1953B).

BECHUANALAND and SOUTHWEST AFRICA (Theiler and Robinson 1953B). UNION OF SOUTH AFRICA (As R. bursa: Howard 1908. As R. pravus: many details in Theiler and Robinson 1953B).

Note: This species has undoubtedly been much misidentified, but more records for it will probably appear since Zumpt's, Theiler's, and Walker's recent works have established its identity. Many or most records of R. bursa from tropical and South Africa pertain actually to R. pravus according to Theiler and Robinson (1953B), but Lewis' various references to R. bursa in Kenya refer to R. kochi and to R. hurti Wilson, 1954 (Walker 1956) as well as to R. pravus.

HOSTS

R. pravus is rather more indiscriminate in choice of hosts than most other rhipicephalids, being common on domestic cattle, sheep, goats, and dogs, equally common on many antelopes and carnivores, and not at all uncommon on hares. Several incidental hosts, from a bird to an elephant, and including man, are listed below. Immature stages utilize rodents and insectivores as hosts.

Adult Hosts

Domestic animals: Cattle (Wilson 1950B, Unsworth 1952, Theiler and Robinson 1953B; Sudan records above; Hoogstraal Eritrean collections. Matthysse 1954 states that this tick is more common on wild game than it is on domestic cattle in Northern Rhodesia). Sheep (Sousa Dias 1950, Theiler and Robinson 1953, Hoogstraal 1953D, Matthysse 1954, Walker 1956; Sudan records above). Goats (Sousa Dias 1950, Theiler and Robinson 1953B, Walker 1956; Sudan records above). Dogs (Sousa Dias 1950, Theiler and Robinson 1953B; Sudan records above). Donkey (Theiler and Robinson 1953B, Matthysse 1954). Camel (Walker 1956. See also British Somaliland record of this species with R. longicoxatus, p. 661).

Man (Sudan records above. Haddow, correspondence).

Antelopes: Reedbuck (Warburton 1912). Kudu (Warburton 1912, Davey and Newstead 1921, Theiler and Robinson 1953B;

Haddow, correspondence). Impala (Warburton 1912, Davey and Newstead 1921, Santos Dias 1952D). Roosevelt's hartebeest (Sudan records above). Bushbuck (Schwetz 1927C, Bequaert 1931, Theiler and Robinson 1953B). Sable antelope (Santos Dias 1953D, Matthysse 1954). Eland (Davey and Newstead 1921, Matthysse 1954; Haddow, correspondence). Oryx (Dönitz 1910B, Zumpt 1942B, Theiler and Robinson 1953B). Grant's gazelle (Dönitz 1910B, Zumpt 1942B, Theiler and Robinson 1953B). Thomson's gazelle (Walker 1956). Bright's gazelle (Theiler and Robinson 1953B). Gerenuk or Waller's gazelle (Wiley 195). Nyala (Santos Dias 1952D, Theiler and Robinson 1953B). Steinbok (Santos Dias 1952D, Theiler and Robinson 1953B). Klipspringer (Theiler and Robinson 1953B). Various oribis and duikers (Wilson 1950B, Theiler and Robinson 1953B, Walker 1956; Haddow, correspondence; Sudan records above). Various dikdiks (Sudan records above; Haddow, correspondence).

Carnivores: Spotted hyena, leopard, lion and genet (Theiler and Robinson 1953B). Jackal (Sudan records above).

Lagomorphs: Hares (*Lepus* spp.) (Wilson 1950B, Tendeiro 1951A, Santos Dias 1952D, Theiler and Robinson 1953B; Haddow, correspondence). "Grass hare" (*Poëlagus* sp.) (Theiler and Robinson 1953B; Sudan record above).

Miscellaneous: Buffalo (Dönitz 1910B, Davey and Newstead 1921, Santos Dias 1952D, Theiler and Robinson 1953B, Matthysse 1954). Warthog (Schwetz 1927C, Theiler and Robinson 1953B; Haddow, correspondence). Wild pig (Sudan records above). Giraffe (Dönitz 1910B, Theiler and Robinson 1953B). Elephant (Hoogstraal collection from Italian Somaliland). Hedgehog (Sudan record above). Ground squirrel (As *R. piresi*: Santos Dias 1950F). Rodent listed as ?jerboa by collector, from Kenya (Hoogstraal 1954C). Elephant shrew (insectivore) (Matthysse 1954).

Bird (shrike) ("*Telephonus* sp.") from Kenya (Hoogstraal 1954C).

Immature-stage Hosts

Antelope (oribi) (Sudan records above).

Hares (Tendeiro 1951A, Santos Dias 1952D,1954C; Sudan records above).

Rodents (*Mastomys coucha*, *Aethomys namaquensis auricomis*, and *A. chrysophilis*) (Theiler and Robinson 1953B).

Insectivores [Elephant shrews, *Elephantulus rupestris* and *Nasilio brachyrhynchus* (Theiler and Robinson 1953B). *Elephantulus fuscipes* and *E. rufescens hoogstraali* (Sudan records above), and, species not indicated, from Tanganyika (Hoogstraal 1954C)]

BIOLOGY

Life Cycle

Wilson (1950B) was unable to rear *R. pravus* under ordinary atmospheric conditions in the laboratory. Theiler and Robinson (1953B) also found this tick difficult to rear, but consider that it is probably a three-host type. Lewis, Piercy, and Wiley (1946) had difficulty in inducing larvae to feed on cattle in the laboratory. They concluded that these animals were not suitable as larval hosts but were able to rear *R. pravus* on rabbits. The original specimens, stage not stated, were found on grass in tsetse-infested areas.

Recently, Walker (1956) has obtained life cycle data of the three-host type from engorged females maintained at 25°C. to 27°C. Larvae and nymphs were kept between 16°C. and 23°C. Under these conditions, the life cycle was as follows:

PERIOD	DAYS
Oviposition to hatching	28 to 33
Larva feeds	4 to 8
Premolting period	7 to 12
Nymph feeds	5 to 11
Premolting period	16 to 19
Female feeds	7 to 19
Preoviposition period	4 to 6
Total	71 to 108

Prefeeding periods are not included.

Ecology

"It would appear that R. pravus shows a preference for bush-veld or dry parklands (in South Africa, and) avoids open grasslands or more humid parklands. It occurs in areas with seasonal rainfall alternating with fairly long dry periods, and with a rainfall above ten inches and below 25 inches. It appears to be relatively frost-resistant, being established in areas with over 90 days of frost per annum." [Theiler and Robinson (1953B)].

These conditions are generally also true for the Sudan, except that R. pravus is not uncommon in the open grasslands and sparsely treed savannah of Torit District, where the annual rainfall varies between 40 and 50 inches. However, it is much more common in the more arid grasslands and savannahs of Eastern District. It is rare or absent in Juba and other districts to the west of Torit, which have higher rainfall, denser savannahs, and forests. Torit and Eastern Districts both have long dry seasons. The apparent absence of R. pravus north of Torit and of Eastern Districts may be due to paucity of collections or lack of population pressure on the northern periphery of its range.

Highland records from goats at Katire and Nagichot may represent introduced individuals, if not, they are difficult to explain from these humid, forested areas.

In Central Africa and Western Province of Nigeria, R. pravus may invade high rainfall areas (average over 60 inches per annum) as suggested by Walker (1956). Rosevear (1953) indicates that in areas with high average rainfall but long dry seasons, vegetation may be of a more xeric type than in areas with a lower rainfall but higher dry season humidity. Such factors may explain the rather implausible range of a xerophilic tick like R. pravus into certain outlying high-rainfall average areas. Cattle brought into these areas for slaughter may also influence the picture.

Lewis, Piercy, and Wiley (1946) found that in Kenya, R. appendiculatus and R. pravus occur together in some areas presumably marginal for both species (i.e.: Karati Forest, Taveta District, northwest section of Narok District in the Masai Reserve, southern part of Ukamba Reserve, Kapenguria area of Turkana Province, and between the Athi and Tiva Rivers; also several areas of Uganda and Tanganyika). However, only R. pravus occurs in drier areas, i.e.: Loita Plains in the Masai Reserve where the game of the open plains, savannah, and forest are favorite hosts and cattle and sheep are also infested. Native stock and wild game in the dry scrub country between the Tiva River and Somalia are heavily infested. R. pravus is also extensively distributed in certain desert areas of Northern Province and extends into Karamoja District of Uganda and into Tanganyika.

Since the above remarks were written, Wilson's (1953) interesting and important contribution, concerning the R. pravus (= R. neavi) - A. gemma association in the drier parts of East Africa and the R. appendiculatus - A. variegatum association in the more humid areas of East and Central Africa, became available. The latter association is discussed herein under A. variegatum (page 274). R. pravus and A. gemma are invariably associated where rainfall very rarely exceeds 20 to 25 inches per annum. [A. gemma is not known from the Sudan; the Sudan distribution of R. pravus is discussed above]. These two species range from the dry Karamoja District of northern Uganda and the arid Northern Frontier of Kenya in the dry belt of country between a line drawn east of Mt. Kenya and the Machakos highlands and west of the humid coastal belt of Kenya.

A. lepidum is also common in this area and R. e. evertsi, H. truncatum, and H. rufipes occur in smaller numbers in Karamoja. In Northern Frontier, Rhipicephalus pulchellus is also present in small numbers but it becomes very common in the dry eastern belt of Kenya, where smaller numbers of a great variety of ticks were found in association with the two species under discussion (R. simus simus, R. mühlensi, R. humeralis, etc.).

Karamoja soils (like those of much of the southern Sudan) are dark grey or dark brown calcareous clays (previously frequently called "black" or "cracking cotton soil") which become exceedingly sticky when wet and form large, deep cracks when dry. Vegetation is either open marshy grassland or grassland associated with Acacia and Combretum woodlands. In this area there is a long, intense dry period but in the shorter rainy season fifteen to twenty inches of rain falls per annum though once in every twenty years there is a rainfall of over 25 inches.

DISEASE RELATIONS

Man: Note the several records of *R. pravus* attacking man in the Sudan.

Domestic animals: There is a suspicion that the "*R. bursa*" which Daubney and Hudson (1934) considered as a possible vector of Nairobi sheep diseases is actually *R. pravus*. It may, however, have been *R. kochi* or *R. hurti*.

R. pravus is an efficient laboratory vector of East Coast fever (*Theileria parva*) but is not known to act in this capacity in nature, possibly because its immature stages do not feed on larger domestic animals.

REMARKS

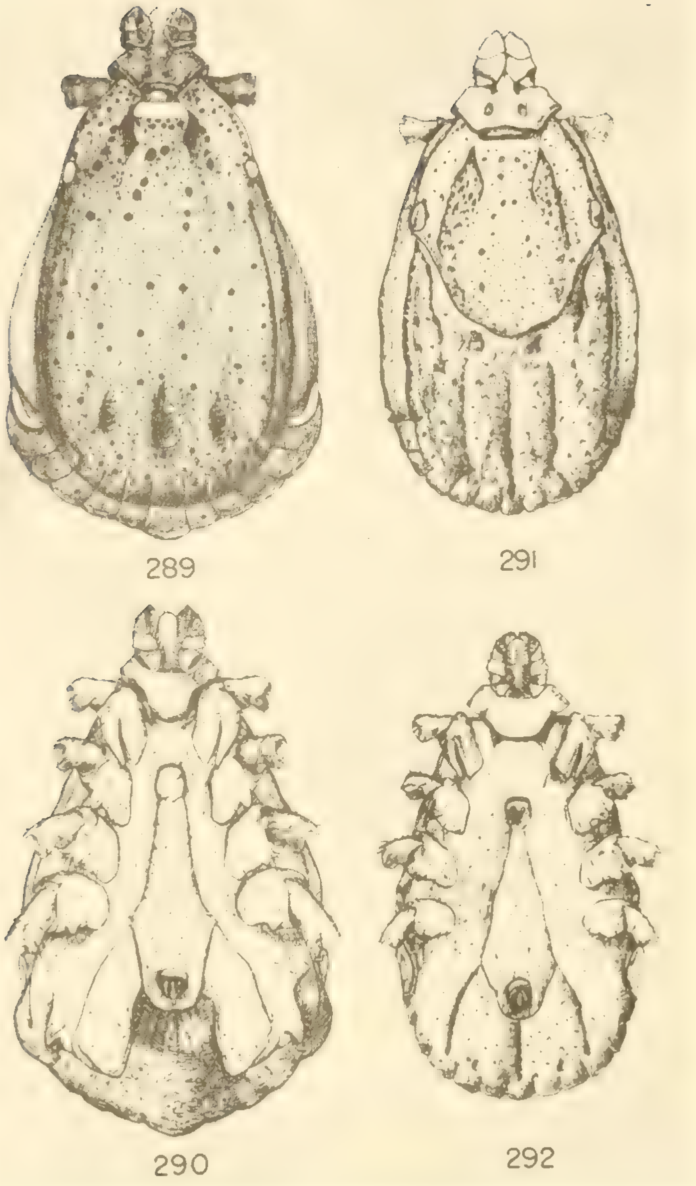
For synonymy of this species, see Theiler and Robinson (1953B, p. 134) and Walker (1956), who have also redescribed the adult stages and described the immature stages.

Santos Dias (1952E) has described a gynandromorph of *R. pravus* (as *R. neavi*).

IDENTIFICATION

Male: The combination of a large, triangular, dorsal projection of coxa I and of slightly convex eyes bordered by at least a furrow or usually by a completely encircling groove, readily distinguishes this from other species. In South Africa, the convexity of the eye seems to be more variable and the encircling furrow is confined to the anterior margin of the eye. No Sudanese specimens without convex, mostly fully encircled eyes have been seen. The moderately numerous, fine and medium-size punctations, and the shape of the adanal shields (Figure 286) further distinguish males, as does the narrow posteromedian groove and the short but wider posterolateral grooves. All Sudanese specimens are small (about 3.5 mm. long and 2.1 mm. wide) and shiny brown.

Females: This sex can be readily distinguished by the absence of lateral grooves which are replaced by a row of punctations, and by the conspicuous, convex (but not hemispherical) eyes, with a groove sometimes entirely but more usually only anteriorly bounding the eye. Scutal punctations are moderate in number, medium size with scattered larger punctations; the scutal outline is slightly longer than wide and has a strongly converging posterior margin. The body and legs are brown.

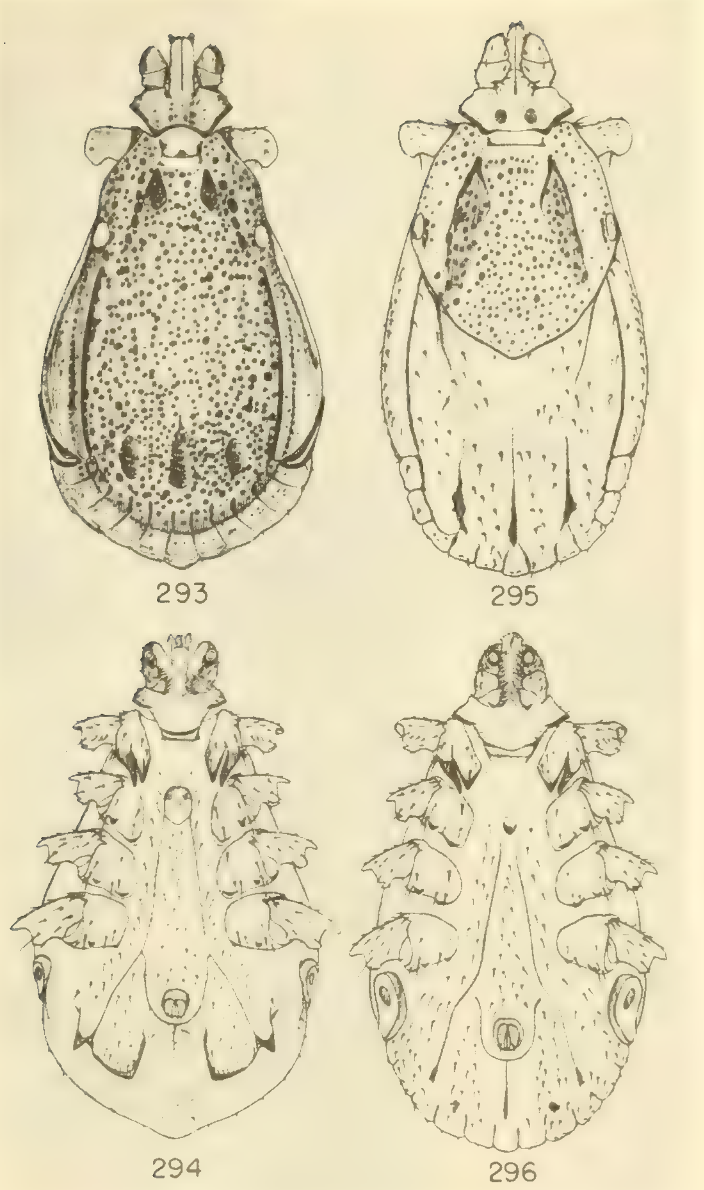


Figures 289 and 290, ♂, dorsal and ventral views
Figures 291 and 292, ♀, dorsal and ventral views

♂ greatly engorged, ♀ slightly engorged.
Typical large, lightly punctate specimens from northern Sudan.

RHIPICEPHALUS SANGUINEUS SANGUINEUS

PLATE LXXXI



Figures 293 and 294, ♂, dorsal and ventral views
Figures 295 and 296, ♀, dorsal and ventral views

Heavily punctate specimens, common in southern Sudan except on birds. These are sometimes confused with *R. sulcatus*.

RHIPICEPHALUS SANGUINEUS SANGUINEUS

PLATE LXXXII

RHIPICEPHALUS SANGUINEUS SANGUINEUS (Latreille, 1806)

(Figures 289 to 296)

THE KENNEL TICK*

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
			1	Torit	MAN (feeding on)	Jan	
		1		Torit	MAN (crawling on)	Aug	
			1	Khor Lado	MAN (no details)	Oct	(SVS)
		1		Torit	*Atelerix pruneri oweni*	Jan	
			3	Torit	*Atelerix pruneri oweni*	Feb	
		1		Sunat	*Atelerix pruneri oweni*	Jan	
	2			Torit	*Elephantulus rufescens hoogstraali*	Jan	
			1	Imurok	*Galago senegalensis senegalensis*	Feb	
		6	11	Torit	*Cercopithecus aethiops* subsp. (captive)	Feb	(2)
		2		Nagichot	*Lepus capensis crawshayi*	Sep	
			1	Farajok	*Lepus* sp.	Mar	
		10	9	Torit	*Lepus victoriae microtis*	Nov	
		2	2	Torit	*Lepus victoriae microtis*	Dec	
		1	4	Torit	*Lepus victoriae microtis*	Mar	
		6	22	Magwe	*Lepus victoriae microtis*	Sep	
		2	14	Juba	*Lepus victoriae microtis*	Nov	
		7	3	Azzar	*Lepus* sp.	Mar	(SGC)
		11	20	Magwe	*Poelagus marjorita oweni*	Sep	(2)
			1	Ikoto	*Heliosciurus gambianus hoogstraali*	Feb	
			1	Torit	*Heliosciurus gambianus hoogstraali*	Mar	
		1	2	Torit	*Canis mesomelas elgonae*	Dec	
		25	28	Torit	*Canis aureus soudanicus*	Apr	(3)
		1	1	Obbo	*Civettictis civetta congica*	Apr	
		2	2	Torit	*Genetta tigrina aequatorialis*	Aug	
		3	3	Torit	*Felis serval phillipsi*	Aug	(SVS)
			1	Opari	*Felis libyca ugandae*	Nov	(SVS)
			1	Imurok	*Heterohyrax brucei hoogstraali*	Feb	
		1	4	Nimule	*Ourebia ourebi aequatoria*	Mar	
			4	Ngangala	*Hippotragus equinus bakeri*	May	(SVS)

*Also known as the Brown Dog-tick or the Tropical Brown Dog-tick (Theiler 1952A,B).

L	N	♀	♂				
		1	3	Tarangore	*Taurotragus oryx pattersonianus*	May	(SVS)
			1	Boma Plains	*Syncerus caffer aequinoctialis*	Dec	
			1	Kapoeta	domestic cow	Jul	
			8	Kapoeta	domestic cattle	Dec	(several)
		1	5	Nagichot	domestic cattle	Jul	(several)
			6	Nagichot	domestic cattle	Jan	(several)
		4	4	Loronyo	domestic cattle	Jan	(several)
		1		Yei	domestic cattle	Mar	(SGC)
			2	Narongyet	domestic sheep	Dec	
		1	1	Kapoeta	domestic goat	Dec	
		2	2	Buya	domestic goat	Dec	
		1	1	Keyala	domestic goat	Dec	
		21	14	Labalwa	domestic goats	Dec	(8)
		17	8	Torit	domestic goats	Jan	(12)
		9	31	Loronyo	domestic goats	Jan	(20)
			1	Torit	domestic pig	Dec	
		1		Torit	domestic horse	Mar	
	19	11	4	Narongyet	domestic dog	Dec	
		4	3	Kapoeta	domestic dogs	Jun	(SGC)
			6	Buya	domestic dog	Dec	
		2	2	Nagichot	domestic dog	Dec	
	23	74	86	Loronyo	domestic dog	Jan	(6)
		37	37	Keyala	domestic dogs	Dec	(2)
		8	17	Gilo	domestic dogs	Dec	(3)
		2	2	Gilo	domestic dog	Jan	
		2	7	Katire	domestic dog	Jan	
	33	181	242	Torit	domestic dogs	Jan	(10)
		1		Torit	domestic dog	Feb	
		25	25	Torit	domestic dogs	Apr	(3)
		1		Torit	domestic dog	Jun	(SVS)
		1	5	Torit	domestic dogs	Nov	(2)
		2	4	Torit	domestic dog	Dec	
		7	8	Imurok	domestic dog	Jan	
		8	2	Juba	domestic dog	Dec	
		8	6	Juba	domestic dogs	Jan	(3)
		24	36	Kajo Kaji	domestic dogs	Dec	(3)
		9	10	Lingah (Yei River)	domestic dogs	Jan	(SGC)
34	9	44	49	Ngoli (Zande Dis.)	domestic dogs	Jun	(SVS)

L	N	♀	♂			
			1	Magwe	on grass	May (SVS)
			1	Mvolo	on grass	- (SVS)
		1	3	Tambura	on grass	Sep (SGC)
					BIRDS	
			8	Ikoto	*Neotis cafra denhami*	Feb
			4	Torit	*Neotis cafra denhami*	Jan (2)
			1	Torit	*Sphenorhynchus abdimii*	Jan

DISTRIBUTION IN THE SUDAN

According to King (1926), *R. sanguineus* "occurs throughout the country but is relatively scarce in the south ...... this is the common dog tick of the northern and central Provinces". This statement agrees with the present observations. Although the kennel tick may be very common locally on dogs in Equatoria Province, it is also frequently absent or rare in this Province. Its occurrence and numbers on wild animals is equally as erratic as on domestic dogs. Reasons for this variability of abundance are poorly understood and suggest an interesting topic for local investigation.

Localities, hosts, and sources of specimens that have been examined are the following:

Bahr El Ghazal: "Northern part of Province" (Dog; SVS). Fanjak (cattle and dogs; SVS, HH). Galual-Nyang Forest (dogs, hedgehogs, and hares; SVS, HH). Near Kordofan border (greater bustard; SVS). Kenisa (baboon; BM(NH)). Near Yirol (domestic dogs; SVS).

Upper Nile: Makier (cattle; SVS). Malakal (sheep, goats, and dogs; fairly common on cattle; SVS, HH). Melut (man; SGC). Akobo Post (lion; SGC). Bor (dogs and horse; SGC). Maban (sheep and lesser bustard; SVS). Ler (dogs; SVS).

Blue Nile: Wad Medani (cattle, sheep, dogs, goats, and horses; SGC, HH. *Herpestes ichneumon* and large vulture; SGC). Hodft and Hosh (hedgehogs; SGC). Singa (camels; SGC).

Kordofan: Heiban (hedgehogs; SGC). Jebel Tabuli (kudu; SGC). El Obeid (cattle; SVS). Koalib Hills (fox and bustard, *Lissotis melanogaster*; SGC). Tabanga (domestic pigs; SGC). Delami (hare and hedgehog; SGC). "Western Kordofan" (sheep; SVS).

Darfur: Radom (cattle; SVS). Sibdo (horse; SVS). Muhagariya (sheep; SVS). Zalingei (donkey; SVS). Kulme (*Vulpes pallida*; BMNH). Fasher (dog and goat; SVS). Nyala (dog; SVS). 60 miles north of Safaha (sheep; SVS).

Khartoum: Khartoum (dogs; Balfour 1911F. Kite, secretary bird in zoo, dog, and fox; SGC. Sheep, camels, horses, and goats; HH).

Kassala: Sinkat (hare; BMNH. Dogs; SVS). Port Sudan (dogs; SVS, BMNH. As *R. macropis*: Schulze 1936. Donkeys; SVS). Kassala (dogs, sheep, horses, goats, and camels; SVS). Tokar (dogs; SVS).

Northern: Wadi Halfa and Atbara (dogs; SGC, HH). Abu Hamed (fox, hare, dogs, and camels; HH). Jebel Barkal (fox; Sudan National Museum).

DISTRIBUTION

Although *R. sanguineus* was first described from France and authors have shown considerable hesitancy over considering this a typically African tick, there is no apparent reason for not doing so. The genus *Rhipicephalus* is well established as a tightly-bound group with Africa as its center of dispersal. The species *sanguineus* is so typical of the genus that it is assumed that this is an African tick whose predilection for domestic dogs and possibly for birds has facilitated its spread throughout the warmer parts of the world.

Cooley (1946) states that *R. sanguineus* is probably the most widely distributed tick species in the world. With the possible exception of the fowl argas, *Argas persicus*, this is undoubtedly true. The kennel tick now inhabits practically all countries between 50°N. and about 35°S. and is known frequently to spread rapidly once it becomes established in a new area.

Notwithstanding their wide distribution and domestic habitats, R. sanguineus populations vary considerably in density from one area to another. This tick gradually increases in number from southern Sudan, where it is frequently encountered but seldom exceedingly numerous, through central and northern Sudan to Lower Egypt in which areas it is usually a most ubiquitous pest. Although this picture appears to contradict the tick's preference for a warm, humid climate, it is undoubtedly influenced by human cultural patterns, man-made microhabits such as buildings and irrigated fields, and concentration of human and animal populations.

The known distribution of R. sanguineus up to January 1949, has been mapped by Leeson (1951). African areas left unmarked on this map are far too extensive. The American Geographical Society's (1954) map of the distribution of the kennel tick also contains many gaps in Africa as well as in other parts of the world where this tick exists. A literature survey and examination of British Museum (Natural History) collections, the Onderstepoort records, and our collection shows that this species is present almost everywhere in Africa except possibly in the most extreme situations of the great deserts of northern and southwestern Africa and perhaps in a few of the most isolated oases.

The following distributional records are for continental Africa, its outlying islands, and that part of Arabia within the Ethiopian Faunal Region, only.

NORTH AFRICA: EGYPT (As Ixodes linnaei: Savignyi 1826 and Audouin 1827. Neumann 1901,1911. Dönitz 1905,1910B. Samson 1908. Mason 1915,1916. Nuttall 1915. Bodenheimer and Theodor 1929. Carpano 1936. Said 1948. Hoogstraal, Wassif, and Kaiser 1955. Hurlbut 1956).

LIBYA (Franchini 1927,1928,1929A,B. Tonelli-Rondelli 1930A, 1932D. Giordano and Nastasi 1935. Giordano and Giordano 1935. Garibaldi 1935. Stella 1938C. Enigk 1943. Bartone 1950).

TUNISIA (Neumann 1911. Galli-Valerio 1911A. Chatton and Blanc 1916A,B,1917,1918. Brumpt 1919. Durand and Conseil 1930, 1931. Durand 1931,1932A,B. Anderson 1935. Anderson and Sicart 1937. Alexander, Mason, and Neitz 1939. Colas-Belcour and Rageau 1951).

ALGERIA (Neumann 1911. Senevet 1928B. A. Sergent 1933,1936, 1938A,B. A. Sergent and Levy 1935. Edm. Sergent, Et. Sergent, and Parrot 1935. Clastrier 1936. Donatien and Lestoquard 1935, 1936A. Edm. Sergent and Poncet 1937,1940,1952. Edm. Sergent, Donatien, and Parrot 1945. Edm. Sergent, Donatien, Parrot, and Lestoquard 1945. Edm. Sergent 1948,1953. d'Arces 1952).

MOROCCO (Velu 1921. Lavier 1923. Beros and Balozet 1929. Brumpt 1930A. Gaud and Nain 1935. Blanc and Bruneau 1948,1954. Blanc, Martin and Maurice 1946. Chabaud 1950A. Blanc, Bruneau, and Chabaud 1950B,1951. Blanc 1951).

TANGIER (Charrier 1925. Remlinger and Bailly 1939). SPANISH MOROCCO (Lopez-Neyra 1949).

<u>WEST AFRICA:</u> NIGERIA (Simpson 1912A,B. Connal and Coghill 1917. Pearse 1929. Philip 1931A,B. Mettam 1940. Findlay and Elmes 1947. Findlay and Archer 1948. Fiasson 1949. Gambles 1951. Unsworth 1952).

GOLD COAST (Warburton and Nuttall 1909. Simpson 1914,1918. Macfie 1916. Beal 1920. Stewart 1933. Findlay and Archer 1948). TOGO (Neumann 1911).

FRENCH WEST AFRICA (Neumann 1911. Nuttall 1925. Peltier, Carriere, Jonchere, and Arquie 1938. Blanc, Goiran, and Baltazard 1937,1938. Risbec 1944. Rousselot 1951,1953B. Villiers 1955). LIBERIA (Bequaert 1930A). SIERRA LEONE (Simpson 1913. Entomological Report 1916).

PORTUGESE GUINEA (Fontoura de Sequeira 1936. Tendeiro 1936A, B,1948,1951A,1952A,C,1953,1954). GAMBIA (Simpson 1911).

<u>CENTRAL AFRICA:</u> CAMEROONS (Neumann 1901,1911. Ziemann 1912A. Schulze 1943B. Rageau 1951,1953A,B. Rousselot 1951,1953B. Remarks by Dezest 1953 concerning "<u>Rhipicephalus</u>" probably refer to this species).

FRENCH EQUATORIAL AFRICA (Warburton 1927. Fiasson 1943B. Gaud 1949. Pellisier and Trinquier 1949. Pellisier, Troquereau, and Trinquier 1950. Giroud, Jadin, and Reizes 1951. Giroud 1951. Rousselot 1951,1953A,B).

BELGIAN CONGO and RUANDA-URUNDI (Newstead, Dutton, and Todd 1907. Massey 1908. Neumann 1911. Seydel 1925. Schouteden 1927. Schwetz 1927A,B,C. Tonelli-Rondelli 1930A. Bequaert 1930A,B,1931. Remarks concerning "*Rhipicephalus* sp. du chien" by Van Slype and Bouvier 1936, probably refer to *R. s. sanguineus*. Wanson, Richard, and Toubac 1947. Cooreman 1948. Fain 1949. Dubois 1949B. Schoenaers 1951A. Jadin and Giroud 1951. Rousselot 1951. Theiler and Robinson 1954. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (Balfour 1906,1908A,1911F. King 1908,1911, 1926. As *R. macropis*: Schulze 1936C. Hoogstraal 1954B).

ETHIOPIA (Neumann 1902B,1911,1922. Tonelli-Rondelli 1930A. Stella 1938A,1939A,1940. Roetti 1939. Cavazzi 1943. Charters 1946, quoting British Army Pathology Service). ERITREA (Franchini 1927,1929D,E. Tonelli-Rondelli 1930A,1932C. Stella 1938A,1939A,B, 1940. Cavazzi 1943. Sforza 1947. Ferro-Luzzi 1948). FRENCH SOMALILAND (Neumann 1901. Hoogstraal 1953D). BRITISH SOMALILAND (Neumann 1901,1911. Drake-Brockman 1913B. Stella 1938A,1939A). ITALIAN SOMALILAND (As *R. beccarii*: Pavesi 1883,1895. As *R. stigmaticus* and *R. limbatus*: Pavesi 1898. Pocock 1900. Paoli 1916. Neumann 1922. Franchini 1929C. Niro 1935. Stella 1938A, 1939,1940).

UGANDA (Neave 1912. Neumann 1922. Richardson 1930. Mettam 1932. Carmichael 1940,1942. Wilson 1948,1950C. Fiedler 1953. Steyn 1955).

KENYA (As *R. stigmaticus* and *R. punctatissimus*: Gerstäcker 1873. Neave 1912. Neumann 1912,1922. Anderson 1924A,B. Lewis 1931C,1932A,1934,1939A,B. Roberts and Tonking 1933. Paterson 1934. Kauntze 1934. Roberts 1935,1939. Daubney 1936B. Fotheringham and Lewis 1937. Mulligan 1938. Dick and Lewis 1947. Piercy 1948,1951. Heisch 1950B. Binns 1951,1952. Wiley 1953. Philip 1954).

TANGANYIKA (Dönitz 1905 stated that the *R. sanguineus* of Koch 1903 is a mistake in identity of *R. appendiculatus*. Neumann 1907C,1910B,1911. Morstatt 1913. Loveridge 1928. Allen and Loveridge 1933. Evans 1935).

SOUTHERN AFRICA: ANGOLA (Howard 1908. Gambles 1914. Sousa Dias 1950. Santos Dias 1950C. Fiedler 1953). MOZAMBIQUE (Howard 1908. Theiler 1943A. Santos Dias 1952D,H,1953B,1954C,H,1955A).

NORTHERN RHODESIA (Neave 1912. Theiler and Robinson 1954). SOUTHERN RHODESIA (Jack 1921,1928,1936,1942. Lawrence 1938B,1942). NYASALAND (Old 1909. Neave 1912. De Meza 1918A. Lamborn 1929. Wilson 1943,1950B. Hardman 1951).

BECHUANALAND (Few collections from Ngamiland, Ghanzi Well area; absent or rare in east: Theiler, correspondence). SOUTHWEST AFRICA (Sigwart 1915. Warburton 1922. Rare here; confined to northern areas: Theiler, correspondence). UNION OF SOUTH AFRICA (Neumann 1901,1911. Howard 1908. A. Theiler and Christy 1910. Dönitz 1910B. Moore 1912. Bedford 1920,1926,1927,1932B. A. Theiler 1921. Cowdry 1925C,1926A,1927. Curson 1928. Cooley 1934. Neitz and Thomas 1938. Neitz and du Toit 1938. Bedford and Graf 1939. Neitz, Alexander, and Mason 1941. Neitz 1943. Malherbe 1947. R. du Toit 1942B,1947A,B. Neitz and Steyn 1947).

OUTLYING ISLANDS: ZANZIBAR (Neumann 1911. Neave 1912. Aders 1917). REUNION (Gillard 1949). MAURITIUS (De Charmoy 1914,1915. Moutia and Mamet 1947). MADAGASCAR (Neumann 1911. Bück 1935, 1948A,C,1949. Bück and Lamberton 1946. Millot 1948. Hoogstraal 1953E). SEYCHELLES (Millot 1948).

ARABIA: ADEN and ADEN PROTECTORATE (As R. macropis: Schulze 1936C,1941. Hoogstraal, ms.). YEMEN (Franchini 1930. Mount 1953. Sanborn and Hoogstraal 1954. Hoogstraal, ms.). SAUDI ARABIA (Hoogstraal, ms.).

HOSTS

Introduction

The host lists available for *R. s. sanguineus* are vast and include numerous medium and large size mammals wherever the tick occurs. A listing of each host reported by various authors would be of no practical value. In addition to mammals, many larger ground-feeding birds and a few reptiles have been found infested.

Dissimilarity of frequent hosts from area to area is apparent. Obviously, the numbers and kinds of available animals vary over the great area infested by this tick and different climatic and ecological conditions affect the parasite's life cycle and its relation to different hosts. In certain areas, physiological races specially adapted to feeding on certain hosts may exist.

It appears well established (1) that domestic dogs are most frequently parasitized by R. s. sanguineus (though in tropical and southern Africa, Haemaphysalis l. leachii is often more common on dogs), (2) that parasitism of large groundfeeding birds, hares, hedgehogs, and domestic sheep and goats is common, (3) that all wild carnivores within the tick's range are frequently though seldom heavily parasitized, and (4) that wild ruminants and man are only erratically chosen as hosts. Wild animals in zoological gardens and others living under domestic conditions, especially when in manmade buildings or enclosures, are particularly susceptible to attack by this parasite.

Human Hosts

Available information on human parasitism by the kennel tick is difficult to evaluate. From accounts of this species in relation to boutonneuse fever in northwestern Africa and in southern Europe, it would appear that human beings are more frequently bitten in these areas than elsewhere in Africa. There is, however, no conclusive evidence, as yet, that this is true. The considerable kennel tick populations in North Africa and the density and intimacy of human beings and their domestic animals may be responsible for the greater incidence of human infestation in this area, as suggested by Philip (1952). At the same time consideration should be given to the possible existence of a biological race with a greater predilection for feeding from man.

In tropical and southern Africa, though isolated reports of parasitism of man exist, only Roberts (1933) and workers of his period in Kenya have published accounts of serious infestation. On one occasion boutonneuse fever, attributed to R. sanguineus but without biting specimens, was so prevalent that it caused disorganization of staffing arrangements of the Kenya and Uganda Railways. Roberts stated that when the land is covered by standing water these ticks seek shelter in houses and human inhabitants are likely to suffer. [This might be a seasonal coincidence since it would appear that in European areas of Kenya the kennel tick is more common as an indoor pest than as an outdoor one. At least, an interesting research problem on the overall subject is suggested.]

Only a single report of the kennel tick attacking people in the upland Kilimani area near Nairobi reached the Kenya Medical Research Laboratory during 1932. At the same time in coastal Mombasa, houses that were heavily infested by R. s. sanguineus yielded a number of cases of boutonneuse fever ("tropical typhus") following bites on the patients' body and legs, some resulting in primary lesions, and all definitely associated with this tick species (Kauntze 1934). In Cameroons, Rageau (1953B) reported feeding by a kennel tick in the ear of a young girl. Specimens sent to Theiler (correspondence) from Beitbridge, Southern Rhodesia (on the Limpopo River just beyond Messina) were said to have been biting people and causing great discomfort.

The few present records for parasitism of man by this tick in the Sudan are noted in the Equatoria and Upper Nile Province records above. Further, my associates and I have been bitten by R. s. sanguineus at Njoro, Kenya; several times in the wilds of southeastern Egypt, on the Mediterranean littoral, and in the oasis of Sinai; not infrequently in the mountains and lowlands of the Yemen; and once each in Aden Protectorate, French Somaliland, Eritrea, and Turkey. These incidents, while not common during many months in the field, bear consideration. We have never known of an Egyptian being bitten in Cairo or in the Nile Valley. After several years of canvassing the American community in Cairo, many of whose members have this tick in their home, only three children have been reported to be infested.

From field experience in Africa and the Near East, the impression has been gained that this tick attacks man more frequently in hot, dry areas than elsewhere, and especially that it does so in those situations where it is a common pest of cattle, sheep, and goats, but where domestic dogs and moderately large sized wild animals are not numerous.

Philip (1952) has remarked that during his fifteen months in West Africa he did not hear of a single dog owner being attacked by this tick.

One of the most striking accounts of R. s. sanguineus attacking persons comes from the Lake Region of Mexico. Elizondo Langagne (1947) wrote that this tick swarms in rural dwellings and indiscriminately attacks persons or dogs. In this area more than five hundred peasants, mostly young children, presented themselves at clinic for removal of adult ticks feeding in the canal of the external ear. These ticks were considered responsible for the cases of Rocky Mountain spotted fever that were especially frequent among children.

Much further north, in the State of New York, Tompkins (1953) found a specimen of this tick, that "had almost certainly left a rabid fox" embedded in his own left axilla. Other laboratory technicians exhibited - or refused to exhibit - tick bites on various parts of their body, but the attacker species was not identified. The human victims did not become rabid.

Previously, Philip (1952) had noted the few instances in which the kennel tick is known to have fed on people in the United States and he summarized the small amount of available data. A single case of a female tick biting a person, near the ankle, in Nebraska has been presented (Helm 1952). Fiasson (1943A) indicates that this tick does not bite man in Venezuela.

A notable Italian incident involved a female kennel tick lodged in the ear of a person who suffered severe pain and distress as a result (Condorelli Francaviglia 1913). The Cameroons and Mexican cases noted above were also reported from human ears.

In his study of Indian tick typhus, Philip (1952) indicated his belief that persons acquire this disease through bites of kennel ticks that have previously fed on infected dogs. There are, however, very few records of this tick attacking man in India. One such noted R. s. sanguineus on a patient and on his dogs. The patient showed no eschar but clinically resembled tick typhus; ticks from both kinds of hosts were infected but the dogs were not (Rao 1951). Four records of kennel ticks from man in India were presented by Strickland and Roy (1939). In Australia, this tick "seldom attacks man" (Roberts 1939).

In Europe, Cox (1942) states, R. s. sanguineus commonly bites man. From a review of the insignificant amount of supporting literature data, this would appear to be an overstatement. Throughout the Mediterranean basin of Europe to as far east as the Crimea and Kashmir, and in Northwest Africa, various forms of the frequently common disease, boutonneuse fever, are considered to be transmitted only by the bite of this tick. However, the widespread presence of the disease in these areas coupled with the few definite reports of the actual arthropod biting man, suggests that our present concepts of the epidemiology of this disease may eventually have to be revised.

Interestingly enough, since the above was written, French workers have theorized that transmission of boutonneuse fever from dogs to man is actually usually accomplished by rubbing one's eyes after deticking dogs or by some insect, especially a reduviid or some other Heteroptera (Sigalas and Lamontellerie 1954). A similar theory had already been advanced by Berri (1953) in Italy. While this novel approach remains to be demonstrated, it suggests the rôle of the kennel tick as merely a reservoir of infection or as a vector from dog to dog. This concept may explain the few definite records of this species as a parasite of man, even where the Mediterranean type of boutonneuse fever is common.

Lamontellerie (1954) presents some evidence to support his view that in southwestern France the kennel tick displays little if any aggresiveness in attacking man, even though boutonneuse fever is common. He cites some published references to indicate that the tick sometimes does attack man, but most of these refer to generalized or vague statements or to obvious repetitions of previously published reports.

In Manila, since it was claimed that larval kennel ticks attacked children, de Jesus (1939) attempted without success to induce larvae to feed on two men and on two children.

Cattle Hosts

Reports of the incidence of R. s. sanguineus on cattle show great disparity from locality to locality, as does the data in the present collection.

In the marshlands of Central Sudan cattle are frequently infested by R. s. sanguineus, sometimes in large numbers, but in southern Sudan cattle are only exceptionally and never severely infested. This fact may corroborate Roberts' suggestion (above) that at flood periods this parasite seeks exceptional shelter and hosts.

Reports of R. s. sanguineus on cattle in tropical and southern Africa are decidedly rare, though a few exceptions have been noted. The incidence of cattle infestation greatly increases as one travels through northern Sudan to the Mediterranean, but it is by no means constant. In certain localities of Yemen and Eritrea the incidence on cattle is fairly high (HH observation).

Fotheringham and Lewis (1937) state that R. s. sanguineus "is not often found on cattle in Kenya; in fact, only on a few occasions have very small numbers been collected from this host". Out of 200 nymphs placed on cattle by these investigators, only five fed. On the other hand, according to Roberts (1935), "it is of some importance to note that cattle in certain areas (of Kenya) carry quite a large population of R. sanguineus ...... Cattle in this colony are a privileged class with unrestricted license to wander over township areas, and even in gardens if herbage is available. (These animals) thus become a very potent factor in the distribution of ticks in residential areas. House dogs wandering in grass along roadsides and gardens gather up these ticks and carry them eventually into houses (where) enormous numbers of R. sanguineus (are) encountered". [Unless shown otherwise, it might be assumed that, as a rule in Kenya, the presence of dogs influences the incidence of attacks on cattle, rather than vice versa (HH).]

Cultural patterns of pastoral peoples probably influence the presence of kennel ticks on cattle, especially in those tribes where families and animals sleep in the same hut or corral, a not uncommon practice in Africa. This feature may also largely account for the occasional finding of another dog tick, H. leachii, on cattle. A survey of the present Africa, Arabian, and Near East collections indicates the considerable importance of this relation. In Bechuanaland, Theiler believes (correspondence), the kennel tick survives only where such conditions prevail, especially where cattle, goats, sheep, dogs, and people congregate around wells and pans.

Canine Hosts

What may be a considerably varying incidence of R. s. sanguineus on dogs throughout tropical and south Africa is difficult to relate to any climatic or ecological factor in the absence of detailed surveys. Many published remarks on this subject appear to have been too hasty, since observations were not made over any extended period of time.

Lewis (1934) stated: "Although some Masai huts (in Kenya) sheltered many dogs, no R. sanguineus were found after diligent search" ..... and (1939A) ...... "The tick has been observed to infest dogs heavily in townships and on farms; but the writer has never found (it) in native huts where dogs rest and sleep more or less with the family". This last statement is certainly contrary to our experience in Kenya and everywhere else.

On several recent trips to the southern Sudan we have checked native "pied dogs" and found them to be not only infested but frequently literally covered with R. s. sanguineus. Dogs kept by Europeans, when they were still in the Sudan, were usually so frequently deticked or doused with insecticide that a true picture of their infestation in relation to that of village dogs was impossible to obtain.

In the Kilimani area near Nairobi, dogs are infested with many specimens of H. leachii but few of R. s. sanguineus, while in lowland Mombasa R. s. sanguineus is by far the predominent species (Kauntze 1934). A number of generalized remarks concerning the incidence of ticks on dogs are provided under R. s. simus (page 738).

Feline Hosts

Domestic cats appear to be infrequent hosts of this tick. The large wild felines of Africa are sometimes attacked but then usually only by a few ticks.

Exceptional Hosts

Rare or unusual hosts that have been reported in Africa are: puff adder in Tanganyika (Loveridge 1928), bats (HH, collecting in Egypt), pangolin (Howard 1908), zebra in Somaliland (Stella 1939B), baboon (Sudan records above), bushbaby (Villiers 1955 in French West Africa and Sudan record above), okapi in the Congo (Bequaert 1930A).

Tortoise (Dönitz 1910B, Neumann 1911). If these remarks refer to the record of Michael (1899) from Lake Urmi, Iran, they are probably based on misidentification of *H. aegyptium*.

Laboratory Hosts

See *life cycle* below.

Commensal Rodent Hosts

In our field work in various parts of the tropics and subtropics of the world few commensal rodents have been found to be attacked by immature stages of the kennel tick. In two areas of Puerto Rico, Fox (1950) reported an infestation rate of only 0.5 and 3.2 percent on 1326 *Rattus* examined.

Wild Small-Mammal Hosts

Pearse (1929) collected specimens from the following animals in Nigeria: two species of hedgehogs, and four rodents (*Lemniscomys striatus*, *Taterillus gracilis angelus*, *Thryronomys swinderianus*, and *Praomys tullbergi*). The identifier and the stage of the ticks were not stated. These are most interesting data that few others have duplicated. In Tunisia, the gundi (Rodentia: *Ctenodactylus gundi*) is said to be frequently attacked by larvae and nymphs (Chatton and Blanc 1918).

The several unusual small mammal hosts found infested in Equatoria Province (listed above) were all taken in association with native villages. The elephant shrew, *Elephantulus rufescens hoogstraali*, was caught in an island of dense shrub and tree vegetation, among which shepherds and their animals sought refuge from the glaring sun, in the grasslands near a village. The bushbaby, *Galago s. senegalensis*, lived in a fig tree under which the village elders and their dogs congregated. The two infested tree squirrels, *Heliosciurus gambianus hoogstraali*, were feeding in a village tree and above a community watering hole, respectively. The rock hyrax, Heterohyrax brucei hoogstraali, occupied a ledge a few dozen yards above a group of hillside huts.

A significant observation of all stages of the kennel tick feeding on European rabbits, Oryctolagus cuniculus, in a forest near Casablanca has been reported by Blanc and Bruneau (1954). In the Yemen, tremendous infestations, representing varying proportions of all stages, were found on all hares examined (Sanborn and Hoogstraal 1953; Hoogstraal, ms.). In Egypt the same is true of hares, some two hundred of which have been examined. Equatoria Province records show numerous adults on hares and grass rabbits (or grass hares, Poëlagus), and in Bahr El Ghazal Province all stages were taken from the several specimens of hares. Indeed, it appears that in both the Ethiopian and Palearctic Faunal Regions of Africa and Arabia, lagomorphs may be exceedingly important as secondary hosts or possibly even as primary hosts of all stages of the kennel tick. Yet, there is no evidence available to indicate that domestic rabbits kept in hutches are seriously infested by this parasite, although as a rule merely housing any animal seems to be an important factor leading to its being attacked by this parasite. European rabbits, an integral part of every Bedouin tenthold in Egypt, are usually infested. These rabbits, which seldom venture far from their owners' tents, are carried from place to place in a bag on the side of a camel when Bedouins move in search of pasturage. Outside of Africa, hares have been found infested by notable numbers of this tick in Anatolia (Hoogstraal, ms.).

Without going into detail, a survey of field data indicates that hedgehogs may play a role in supporting this tick second only to that of lagomorphs. These spiny insectivores are commonly though seldom heavily infested.

In Egypt, most kinds of desert rodents are occasionally infested by larvae and nymphs, as are also grass rats, Arvicanthis n. niloticus, in cultivated areas. These data are too voluminous and complex to evaluate in the present study. It is, however, apparent that in field situations the life history differs from that of urban populations.

Avian Hosts

It should be of some interest to present the available African records of avian parasitism by *R. s. sanguineus* in the hope of instigating further investigation of this subject. The immediate concern over this problem is the fact that specimens from birds in Equatoria Province have much lighter interstitial punctations than those from mammals in the same Province. Material from birds resembles the majority of specimens from northern Sudan and Egypt and is in closer conformity to the general conception of the appearance of this species.

Recorded African avian hosts are the following:

Ostrich

Struthio camelus massaicus in Kenya (Neumann 1911,1912). *S. camelus* subsp. in Uganda (Theiler, unpublished). *S. camelus australis* in Mozambique (Santos Dias 1952D).

Bustards

Lissotis melanogaster in Mozambique [Specimens in BM(NH) and from Sudan (Kordofan Province record above). "Greater bustard" in Kenya (Lewis 1934). "Lesser" and "greater" bustards in Sudan (various Province records above). *Neotis cafra denhami* in Sudan (Equatoria Province records above). *Neotis cafra jacksoni* in Uganda (Theiler, unpublished).]

Secretary bird

Sagittarius serpentarius in Sudan (Khartoum zoo record above) and in Kenya (Lewis 1934).

Hornbill

Bycanistes albotibialis from Yaounde, French Cameroons (J. Mouchet *legit*, HH det.).

Storks

Sphenorhynchus abdimii in the Sudan (Equatoria Province record above). *Leptoptilos crumeniferus* in Uganda (Theiler, unpublished).

Ibis

Hagedashia hagedash subsp. (Neumann 1911) and as "*Theristicus leucocephalus*" in Tanganyika (Neumann 1907C,1910B).

Hawks, Kites, Buzzards, Eagles, and Owls

Kite in the Sudan (King 1926 and Khartoum record above). "Large vulture" in the Sudan (Blue Nile Province record above). *Butastur rufipennis* in Belgian Congo (Bequaert 1931). Eagle owl, *Bubo bubo ascalaphus* (= *Strix ascalaphus*) in Egypt (Neumann 1901, 1911).

Pigeon

"Ringed pigeon" in South Africa (Howard 1908).

There appear to be no African records of this tick from domestic fowls.

Specimens parasitizing birds are usually found on the crown of the head, near the eyes, around or in the ears, at the base of the skull, or in folds of skin beside the beak.

BIOLOGY

Laboratory studies on the general biology of the kennel tick are rather complete. However, field biology and ecology have been much neglected. The biology of this form when confined to houses harboring dogs, although accepted as being well known, has not been adequately studied.

Numerous biological and ecological questions concerning the kennel tick remain to be answered. Why is the density and distribution of African populations so uneven? What is the significance of morphological variations such as the lightly punctate forms from Equatoria Province birds in an area where most of those parasitizing mammals are heavily punctate? What "biological strains" or varieties exist in Africa and do some or all of these react with equal facility to domestication? What is the life cycle under field conditions and what are the host predilections of the immature and adult stages away from human and domestic canine habitations? Why does parasitism of persons - and boutonneuse fever - appear to be so much more common in northwestern Africa than elsewhere on this continent (and why is boutonneuse fever absent in Egypt)? Just what is there about a habitation shared by man and dogs, whether it be an African hut or a Florida mansion, that is so much more attractive to this tick than a fox den in a rocky hillside? Is the greater incidence of parasitism of all domestic non-canine animals in the Near East, as compared with tropical Africa, merely a matter of host availability? These are but a few of the innumerable inquiries that suggest themselves as a result of our lack of specific information concerning this common tick.

Life Cycle

The life cycle of R. s. sanguineus has been studied, under laboratory conditions, by Christophers (1907C), Hooker, Bishopp, and Wood (1912)*, Patton and Cragg (1913) with techniques illustrated, Nuttall (1915), and Regendanz and Reichenow (1931). In the discussion below, less specialized life cycle reports or studies for special purposes are noted following the summary of the above-mentioned papers.

All observers agree that this is a three-host tick. Variation in reports of length of feeding time of each stage may be due to the kind of host used in laboratory experiments (see below). During nonfeeding phases temperature and humidity exert considerable influence on the length of the life cycle. Nuttall concluded that feeding times are constant, irrespective of temperature variations, and that only the nonfeeding phases are affected by these variables (see also discussion of this aspect under H. dromedarii, p. 428).

*The extensive data in this important paper are not reviewed here.

In Nuttall's laboratory experiments, larvae fed on dogs and rabbits, nymphs on dogs, jackals, and hedgehogs, and adults on dogs and jackals. Larvae commenced feeding three to seven days after emergence, nymphs began about the same length of time after molting, and adults about a week after molting. Larvae fed for three to eight days (mostly four days) (temperature ranged from 6.5°C. to 20°C.). Nymphs fed for three to eleven days (mostly four days), on the dog or jackal; but when hedgehogs were used, the feeding time (ten to seventeen days) was about doubled* (temperature ranged from 8°C. to 18°C.). Females fed from one to three weeks (mostly eight days) but males remained attached indefinitely and transferred to another host if the first animal died.

As already stated, the length of intervals during which ticks are off the host appears to be influenced by temperature (though more exact and extensive research is certainly required). In Nuttall's tests, eggs hatched in from seventeen to nineteen days at 30°C. but required 75 days at 12°C. Larvae molted to nymphs from five to eight days after completing feeding (at 30°C.), and nymphs molted to adults in eleven or twelve days after feeding (at 30°C.). Oviposition commenced three to six days (average three or four days) after females left the host, when maintained at 30°C.; but at 12°C. they commenced oviposition after 25 days. Egglaying lasted for from nine to fifteen days.

The life cycle, under favorable conditions, may be completed in as little as 63 days. Under unfavorable conditions, it may be prolonged for many months.

[By way of contrast to Nuttall's findings and because the records of Christophers (1907C) "are not complete and do not indicate the temperature at which the specimens were reared", Sapre (1945) undertook similar experiments in India at 7500 feet altitude, with dogs said to be the hosts for all stages. Nonfeeding ticks were observed at 22°C. (eight degrees lower

---

*A similar situation has been reported for Ornithodoros arenicolous whose females feed on mice for 45 minutes but on hedgehogs for 70 minutes (average), and whose males feed on mice for 45 minutes and on hedgehogs for 57 minutes (average) (Hoogstraal 1953C).

than the temperature in Nuttall's experiments) and at 80% to 90% R.H. Unfortunately for purposes of comparison, Sapre neglected to report how soon after hatching larvae commenced feeding and other such details. In his summary, Sapre stated that feeding periods remain constant irrespective of temperature variation but nonfeeding periods appear to be inversely proportional to an increase or decrease in temperature. In the introduction it was stated that nonfeeding ticks were observed at 22°C. and the report of the experiment shows no comparative data for length of feeding time at different temperatures. The summary stated all stages were observed at 22°C.; the text stated hosts were maintained at anywhere from 1.4°C. to 11.6°C. for larval feeding, at 2.9°C. to 5.1°C. for nymphal feeding, and at 11.0°C. to 14.6°C. for adult feeding.]

Survival of unfed larvae may be as long as 253 days; nymphs appear to be less hardy, for only a few survived for as long as 97 days. Adults may live without food for as long as 568 days, with females appearing to survive longer than males when unfed. [Nuttall]

Nuttall noted that females may outnumber males by two to one and Sapre reported the sex ratio as three females to two males. Copulation occurs on the host; males may move about on the host and fertilize several females.

Nuttall counted 1400 eggs to 3900 eggs from individual females (Sapre said his females averaged 2140 eggs). Lombardini (1950) counted from 4000 to almost 5000 eggs. Regendanz and Reichenow observed that the number of eggs varies with the size of the female but averages from 3000 to 4000. However, not all eggs are deposited. When the female at last becomes exhausted and senile, some mature eggs remain in the oviducts and egg cells remain in the ovaries. A good egg batch, from an engorged female measuring from 8.0 mm. to 9.5 mm. long, weighs from 0.09 to 0.1 gram.

A classical study on oviposition and survival of eggs and larvae under certain conditions has been reported by Lombardini (1950). Five females laid from 4000 to almost 5000 eggs each, ovipositing for from 21 to 29 days each. The number of eggs laid in the latter half of the period dropped considerably, though erratically, from week to week. The mechanism of oviposition in the kennel tick is similar to that reported by Nuttall and Warburton (1915) for Haemaphysalis punctata. The cephalic gland, or gene's organ, secretes a liquid covering as each egg is emitted. This substance protects the eggs from dessication but absorbs oxygen, even under water. Immersed eggs hatched in 51 days as compared to 38 days in the air (20°C. to 25°C.), although some embryos were killed by a Fusarium fungus. Even larvae survived from 30 to 35 days in spring water, while others, unfed, succumbed in twelve days in moist petri dishes. Larval longivity when immersed in various fluids was also noted. Illustrated with handsome photographs of the egg covering, various glands and organs, the Fusarium which attacked eggs, and details of the larval external structure including integumentary sense organs, this paper should be studied by anyone seriously interested in tick biology.

Other laboratory hosts reported by various workers have been hamsters for the larval and nymphal stages (Malamos 1938). Larvae detached engorged in six days from hamsters. Nieschulz and Wawo-Roentoe (1930) used guineapigs for feeding all stages of the tick; mice were also used for larval feeding, although guineapigs were preferred. Feeding time was stated to be 24 hours for larvae and two or three days for nymphs. Dogs were preferred for adult feeding. These experiments, undertaken at 26°C. to 27°C. and at ordinary (high) humidity (of the Netherlands), are notable for the rapid feeding of the immature stages (ticks originated from Java). In contrast, Blanc and Caminopetros (1931), when using ground squirrels, or spermophiles, Citellus citellus, in Athens, noted larval feeding times of five to eight days. Korshunova and Petrova-Piontkovskaya (1949) fed all stages on guineapigs in their studies of boutonneuse fever in the Crimea. Blanc and Bruneau (1948) used guineapigs for feeding immature stages and a hedgehog as adult stage host. A brief abstract of rearing results using white rats and guineapigs for larval hosts and dogs for nymphal and adult hosts has been presented by Luttermoser (1947).

Ecology

In the preceding section on biology of the kennel tick the number of queries raised suggest how much information is lacking on the ecology of this parasite.

In Egypt it is certain that there is an urban race, attacking dogs almost without exception, and a field race that parasitizes rodents, hedgehogs, hares, and, when available, domestic animals. The field race occurs only on the Mediterranean littoral, rarely in scattered desert areas and oases, and in conjunction with a few rodents of cultivated areas. The domestic race is common in urban and settled areas; along with hyalommas it is almost the only ixodid ever found in those desert areas that support some grazing. However, the propensity of the domestic race for seeking out favorable niches of human habitations and domestic animals, which are always sheltered from thieves and from pedators in these areas, causes it to be more localized than are its ubiquitous field companions, such as *H. excavatum*. The actual relations of urban and field races we hope to determine as early as possible.

In tropical and southern Africa, it appears that *R. s. sanguineus* is generally distributed through the warm and humid zones of the continent. In the more arid parts of this area, its presence or absence seems to be dependent largely on human cultural patterns, especially of pastoral tribes (see Cattle Hosts, page 698). Whether urban and field races exist in Africa south of the northern deserts is at present difficult to determine from available data.

Most observations on host parasite relations presented below apply to domestic populations.

Larvae attach to the host mostly in hairy places but may occur anywhere on the body. Nymphs are found indiscriminately among the fur or elsewhere. Adults are especially common on and in the ears, though they may attach along the nape, between the toes, or anywhere else. Specimens on birds are usually found on the crown or about the ears, eyes, or bill.

Females often creep upward on walls after leaving the host and may hide tightly wedged in narrow cracks as high as fifteen feet above the ground (Christophers 1907C). Eggs are deposited, either near the ground or high above it, in crevices in woodwork, under plaster, whitewash, or paper, or, out-of-doors, under stones (Lewis 1934, Roberts 1935, du Toit 1947).

Tremendous infestations frequently occur. In Cairo, one may see houses "crawling with" kennel ticks and mongrel dogs with more ticks than hairs on them. Heavily infested houses are common elsewhere and are frequently noted in literature from the United States.

The rapid spread of this pest, once introduced to a new island or major geographical area, is also the subject of numerous reports. Sometimes, however, its paucity and relatively slow pace of spread in apparently favorable areas, as, for instance, Madagascar, is noted (Hoogstraal 1953E). In the United States, since first reported from Texas and New Mexico (Banks 1908 as R. texanus), R. s. sanguineus has spread widely (Bishopp and Trembly 1945, Kohls and Parker 1948) through much of the country. It now occurs in some areas where winters are severe but its spread northward appears to be much slower than in warmer states.

In those parts of the world where definite seasonal changes occur, a spring peak of abundance is commonly observed. During summer and fall, populations, even though great, are not so frequently noticed, probably because they are more scattered in minor peaks of abundance resulting from rapidity or delay with which ticks find hosts. As one example, dogs at Rabat, Morocco, which has seasonal and climatic conditions roughly similar to those of the southern United States, were observed to be very lightly parasitized during the months of December through February (Gaud and Nain 1935). In March, the number of ticks began to increase, and in April and May nymphs made their appearance. In May, the count was highest (33 ticks per dog, average), but the infestation rate remained high through August. A sharp decline in numbers was noted in September, followed, inexplicably, by an October rise. Among the 9000 ticks collected, the ratio of males to females was two to one. [In order to obtain a more accurate picture of seasonal incidence and abundance in relation to the tick's life cycle, presumably it would be advisable to disregard the long-feeding males and count only larvae, nymphs, and females (HH).]

In Algeria, adults appear suddenly in large numbers on domestic animals at the end of April and may be found till August, with the maximum numbers in May. Adults are rare or absent in autumn, winter, and early in spring. Nymphs are found on domestic animals in spring (Sergent and Poncet 1937,1940). This last observation would appear to indicate that the immature stages over-winter.

In southern and eastern Europe, adults appear on hosts in the middle of April, are most numerous from May to July, and by the middle of September again become scarce (Enigk 1947).

In equatorial climes with rainy and dry seasons, ticks are frequently reported as most noticeable at the commencement of the rains and this has been assumed to be an indication that they are then most numerous.

Though two or three generations a year seem likely almost wherever the kennel tick ranges, no definite reports concerning this based on observations in nature are available.

Overwintering of the tick in temperate climes is probably entirely indoors. For example, MacCreary (1945) states that there is no evidence of overwintering outdoors in Delaware. This tick does not survive long at temperatures under 5°C. (Enigk and Grittner 1953).

In NAMRU3 (Cairo) laboratories, as a piece of research correlative with field findings, Dr. Samira El Ziady is undertaking an ecological study of populations from domestic and from wild local stocks, under controlled conditions. Two years will be required to obtain significant data on this subject.

Parasites: The most commonly reported parasite of the kennel tick* is the chalcid, Hunterellus hookeri Howard, 1907 (= Ixodiphagus

---

*Habrolepis sp. (Chalcidoidea, Encyrtidae) has been reported to parasitize immature stages of R. s. sanguineus in French West Africa (Risbec 1944). An inquiry concerning this report, addressed to the United States National Museum, resulted in the following statement by Dr. B. D. Burks: "This undoubtedly refers to Habrolepis caniphila Risbec, 1951, Mem. Inst. franc. d'Afr. Noire, 13 (pt. 1), p. 170. This is Hunterellus hookeri How.; I saw the types in Paris last year. Ferriere had already (1953) published a note stating that Risbec's species probably was hookeri, just on the basis of the original description. In 1953, Risbec published a paper transferring his species to Hunterellus, but he still thinks his species can be separated from hookeri ......"

caucurtei du Buysson, 1912), a wasp known in many areas of the world. It is specialized for parasitism of ixodids and infests most genera. A related species, H. theilerae*, has been described by Fiedler (1953) from R. oculatus and H. truncatum in southern Africa. Our knowledge of these parasites will be completely reviewed in a forthcoming volume of this work, but a few preliminary remarks are indicated.

In Africa, parasitism of the kennel tick by H. hookeri has been occasionally reported. Nigeria (Philip 1931A,B). French West Africa (Blanc, Goiran, and Baltazard 1938. As Habrolepis sp.: Risbec 1944). Uganda (Fiedler 1953, Steyn 1955). Angola (Fiedler 1953). Kenya (Philip 1954). We have thus far been unable to find this wasp in Egypt, where the climate is probably too dry for its existence.

Other tick species known to be attacked in Africa are Hyalomma (sp. truncatum, according to Theiler, correspondence) and H. leachii in South Africa (Cooley 1929,1934); R. e. evertsi in South Africa (Bedford note in Cooley 1929); species not mentioned, from Mozambique (Howard 1908); and A. tholloni from the latter area (Santos Dias 1949D).

R. s. sanguineus also is attacked by H. hookeri in Brazil (da Costa Lima 1915), U.S.A. (Smith and Cole 1943, includes review of previous reports), and other areas of the world.

As summarized by Smith and Cole (1943), infestations of H. hookeri in nature are not known markedly to reduce tick populations. Experimental attempts in this direction have been ineffective for tick control even when millions of parasites were released (Cooley and Kohls 1933) to attack the Rocky Mountain spotted fever vector, Dermacentor andersoni (Stiles). Soviet experiences with this parasite have been reviewed by Pervomaisky (1947) and Blagoveschensky (1948).

---

*Dr. B. D. Burks states (correspondence) that this unquestionably is a distinct and valid species.

Larvae of H. hookeri feed on all contents of engorged nymphal ticks and pupate in the body of the host. Adult wasps emerge from the nymph by gnawing a hole through the host's expanded integument. Mating occurs soon after emergence. Oviposition, by insertion of the ovipositor through the tick's integument, may follow immediately after mating. Unfed nymphs are preferred for egg laying, though oviposition in engorged nymphs also occurs. Eggs are sometimes laid in tick larvae; in these, however, the parasite undergoes a latent period until after the larval-nymphal molt. Latency continues in unfed, hibernating ticks until they commence engorging. [Cooley and Kohls 1928,1934.]

Brumpt (1930B), who experimented with rearing this parasite in R. s. sanguineus, noted that a period of some 83 days passes before nymphs exhibit signs of parasitism, a factor of practical interest in transportation of the wasps to new areas or laboratories.

Adult wasps may sometimes be noticed running rapidly on the dog's hair in search of ticks (da Costa Lima 1915, Philip 1931A,B).

Morphological characters of tick-parasitizing wasps have been compared by Steyn (1955) who concludes that H. theilerae might be expected to be of greater value in biological control than the other species. (If, however, H. theilerae is actually as infrequent in nature as present scanty records suggest, its range of physiological adaptability may negate this possibility - HH).

Predators: In a Corsican house invaded by both kennel ticks and Theridiid spiders, Teutena triangulosa Wick., the spiders were observed feeding on the ticks (Sautet 1936). Under experimental conditions, they fed on both the immature and adult stages and young spiders attacked ticks shortly after hatching. Although the predators also fed on flies, they showed a preference for ticks. Under August, midsummer conditions, the spider life cycle from egg to adult required three weeks. Six to twelve eggs were laid in each webbed mass, and females produced from eight to ten of these balls.

In Russia, a staphylinid beetle, *Juracekia asphaltina*, devours *Rhipicephalus* ticks (?*R. sanguineus*) in nests of the ground squirrel, *Citellus pygmaeus* (Flegontova 1938).

DISEASE RELATIONS

Rôle in Nature

MAN: *R. s. sanguineus*, in some areas, is considered to be the principal vector of boutonneuse fever (tick-bite fever), *Rickettsia conorii*, (see, however, page 687). It is known to transmit the rickettsia causing the closely related "Indian tick typhus". It is a vector of Rocky Mountain spotted fever (*R. rickettsii*) in the warmer parts of the Americas. It is said to be the vector of a virus causing "Congolese red fever", a syndrome of moot identity and etiology.

Persons bitten by this tick sometimes complain of pruritus, due possibly to injection of a toxin while feeding.

A number of the pathogens listed under experimental relations below may be transmitted in nature but the details have not yet been elucidated.

DOGS: *R. s. sanguineus* transmits two diseases to dogs, the highly fatal canine rickettsiosis, caused by *Rickettsia canis*, and canine piroplasmosis, or malignant jaundice, caused by *Babesia canis*. In addition, it is an intermediate host of *Hepatozoon canis* which results in an anemia and infection when dogs swallow ticks. Tick typhus or boutonneuse fever, *Rickettsia conorii*, is apparently transmitted among dogs and from dogs to man by the kennel tick. It seems likely that this arthropod transmits *Salmonella enteritidis*, which causes a paratyphoid disease in dogs and in laboratory animals. When dogs are heavily infested, loss of blood and nervous energy from irritation may be severe. See also experimental relations below.

Other domestic animals: Spirochetosis of sheep, goats, horses, and cattle, caused by *Borrelia theileri*, is transmitted by the brown dog tick in some areas.

Although this tick has been incriminated as a vector of several pathogens of bovine diseases, it cannot be ascertained from the literature that they are yet known to play any real role in the transmission of these diseases in nature. The same is true for other diseases of horses, goats, sheep, and dogs, listed below.

Experimental (Human Diseases and Syndromes)

Tick paralysis (venom or toxin): This syndrome can be induced in experimental animals by injection of the ticks' eggs and ovaries.

Yellow fever: Although the virus remains viable in this tick for some time, it is not transmitted by biting.

Scrub typhus: *Rickettsia tsutsugamushi* is not transmitted by the kennel tick.

Q fever: *Coxiella burnetii* has been found naturally infecting *R. s. sanguineus* and experimental transmission has been demonstrated but apparently no cases of Q fever in man attributable to this tick have been reported.

North Queensland tick typhus: It has been suggested, on epidemiological grounds only, that *R. s. sanguineus* might possibly be a vector of this rickettsia.

/"Sao Paulo or Minas Gerais typhus": Rocky Mountain spotted fever; cf. above./

Louse-borne typhus: This tick does not transmit *Rickettsia prowazeki*.

Relapsing fevers: Spirochetes, *Borrelia hispanica*, can be transmitted to guinea pigs and man by the bite of this tick, which is not, however, known to be a vector in nature. Attempts at transmission of the "Greek variety" of *B. hispanica* have been unsuccessful and only exceptional transmission of *B. persica* has been obtained.

Plague: R. s. sanguineus does not appear to play a role in the natural transmission or preservation of Pasteurella pestis, although it is claimed that the subspecies schulzei has been found naturally infected.

Tularemia: Bacterium tularense survives from the larval to adult tick and may be transmitted by any stage.

Toxoplasmosis: Toxoplasma gondii acquired by immature stages feeding on an infected host may be retained during the later developmental stages of the tick. There is some possibility of transovarial infection but this has not been definitely proven. Results of experiments in these respects by various workers are contradictory. The probability of natural transmission remains unknown.

Kala azar: Leishmania donovani survives in the kennel tick but can be transmitted only experimentally.

Chagas disease: R. s. sanguineus may mechanically transmit Trypanosoma cruzi.

Experimental (Animal Diseases and Syndromes)

Tick paralysis: See above.

Toxoplasmosis: See above.

Guineapig pneumonia ("pneumopathie du cobaye"): The kennel tick is not a vector of the causative virus of this disease.

Equine piroplasmoses: R. s. sanguineus is a vector of both Babesia caballi and Nuttallia equi.

Rodent piroplasmoses: Circumstantial evidence indicates that this tick may transmit Piroplasma quadrigeminum of the gondi. This tick transmits a benign Nuttallia (?sp.) to jirds, Meriones tristrami.

Tropical theileriasis: It is said that this tick is a vector of Theileria annulata of cattle.

East Coast fever: R. s. sanguineus does not transmit Theileria parva of cattle.

Anaplasmosis: Gallsickness, *Anaplasma marginale*, of cattle is carried by the kennel tick.

Redwater: *R. s. sanguineus* may be a vector of *Babesia bigemina* of cattle.

Trypanosomiasis: The causative organism of surra, *Trypanosoma evansi* (= *T. annamense*), dies quickly in this tick, and that of an African trypanosomiasis, *T. congolense*, is not transmitted by it. Another flagellate, *Crithidia christophersi*, has been reported to occur in the kennel tick.

Rabies: Tompkins (1953) compares textbook statements that rabies is not transmissible by arthropods to saying that the aardvark is immortal because nobody has seen a dead one. He failed to become more rabid than this after serving as a host for a kennel tick that almost certainly had previously fed on a rabid fox. More than this nobody knows concerning rabies and ticks.

Rodent Cestodes: The mouse tapeworm, *Hymenolepis microstoma*, is said to be transmitted by this tick.

Canine Filariasis: The canine filaria, *Dipetalonema grassii*, is said to be transmitted by the kennel tick, which may also transmit *Dirofilaria immitis* and, questionably, *Dipetalonema reconditum*. So far as known, the role of *R. s. sanguineus* in the transmission of these parasites in nature has not been elucidated.

Salmonella: In dogs and laboratory animals; see Dogs above.

Experimental (Miscellaneous)

Mistaken Identity: *Cryptoplasma rhipicephali* Chatton and Blanc (1916A), grouped with the haemogregarines, was indicated by the same authors (1916B) to be really the tick's spermatozoa.

REMARKS

Taxonomy

In his generic revision of *Rhipicephalus*, Zumpt (1950A) considers *R. sanguineus* as a group of subspecies, which, besides the typical form, includes the subspecies sulcatus Neumann, 1908, of Africa, and both rossicus Yakimoff and Yakimoff, 1911, and schulzei Olenev, 1929, of Russia. R. sulcatus, now considered as a distinct species, is treated separately in the present study. The Soviets (Pomerantzev 1950) consider the Asiatic forms also as distinct species and add the following related species: R. turanicus Pomerantzev, 1940; R. pumilio Schulze, 1922; R. leporis Pomerantzev, 1946; and R. schulzei Olenev, 1929.

Owing to the obvious difficulty of an independent evaluation of Soviet species, Zumpt's (loc. cit.) terminology is utilized in the present report. However, a survey of our own material from the Near East and ecological observations leave us, at present, uncertain over which of these two schools of thought is the correct one.

More recently, Feldman-Muhsam (1952A) has designated as a very closely related species, R. secundus, distinguishable from R. s. sanguineus only by the form of the female genital aperture and of the capitulum of larvae and nymphs. Although Feldman-Muhsam's reared material shows these differences, Mr. Kaiser and I have been unable to distinguish R. secundus after weeks of study of a very considerable number of kennel ticks from tropical Africa, North Africa, Arabia, and the Near East. Feldman-Muhsam (1953) did not recognize R. secundus in American specimens she studied, but claims to have found it among materials from Palestine, Turkey, Yugoslavia, France, Algeria, and French West Africa (and - unpublished - Yemen and Egypt). Specimens identified as R. secundus by Feldman-Muhsam have been reported from Iraq along with R. s. sanguineus (Hubbard 1955).

It appears obvious that full understanding and agreement of the status of subspecies and species related to R. sanguineus awaits more refined laboratory and field techniques than have yet been accorded this problem; possibly a more advanced consideration of species criteria and of taxonomic tools than have yet been applied to ticks; and freer exchange of ideas and intercourse in presently antagonistic regions of the world.

It will be noted in the section on IDENTIFICATION, below, that an important diagnostic criterion for this tick is the presence of a scutal pattern of punctations arranged in four more or less regular longitudinal rows. This characteristic defines the R. simus group and it is suggested (page 751) that R. s. sanguineus might logically be considered as a member of the same group.

Structure and Physiology

Integumentary sense organs, which are fixed in number and location, and which are essentially similar in all stages of the tick, though more primitive in larvae, have been described and illustrated by Dinnik and Zumpt (1949). See also Lombardini (1950).

The integument and sections of the scutum have been illustrated by Schulze (1943B), who also mentioned the color of the gut contents.

Water balance studies of various ticks, as discussed for O. moubata (page 153), reported by Lees (1946A), include the observation that R. s. sanguineus falls in about the middle of the range among the species studied with respect to its power of limiting evaporation. Variations in this capacity may reflect specific differences in the nature of the epicuticular lipoid among these species. See also Lees (1947).

Teratological (malformed) specimens have been occasionally reported. Warburton and Nuttall (1909) illustrated a Gold Coast specimen with duplication of the posterior parts of the body. Nuttall (1914A) described asymmetrical specimens and others lacking one leg. Sharif (1930) also noted absence of legs. Others have been described by Sharif (1930) and Pavlovsky (1940). These reports have been incorporated in an overall review of the subject by Schulze (1950B). Posteriorly joined adanal shields were illustrated by Santos Dias (1955A). A remarkable larva in which one of the palps appears to be partially converted into a typical leg has been described and illustrated by Pavlovsky (1940) and reviewed by Campana (1947).

A gynandromorph has been described by Pereira and de Castro (1945). It is somewhat interesting, in view of the considerable attention devoted to this subject and to teratological specimens in some schools, that no other such observations concerning this common and widely ranging tick have been reported.

Tick feeding from tick: A male with its mouthparts inserted in the integument of an engorged female has been described by Sharif (1930). [In Egypt we observe that males of various tick species insert their mouthparts into the female body cavity when the latter is engorged and both are confined in tubes for several days after having been collected. This is especially common among specimens of B. annulatus (= B. calcaratus).]

Comparative measurements ("allometrie") of sexual variations among the Ixodidae have been investigated by Chabaud and Choquet (1953). For the kennel tick, the length of the adanal shields and the spiracular plates in relation to the tick's length is logarithmically illustrated. Because of sexual and nutritional dimorphism, these authors consider ticks as important biometric tools. They also believe that certain cases of intersexual ticks may result from nutritional allometry. If a male structure is similar to that of a female it has an isometric growth, but if different an allometric growth.

Variation in body size and morphology parallels that already discussed under R. appendiculatus (page 614) and the same comments apply. This subject has been studied by Cunliffe (1914A) and Pervomaisky (1954). See also remarks under IDENTIFICATION, below.

Growth and increase in size from stage to stage and with adult engorgement has been noted by Campana-Rouget (1954).

Internal anatomy was briefly described and diagrammatically illustrated by Regendanz and Reichenow (1941).

Haller's organ of this tick (= R. macropis) has been illustrated by Schulze (1941).

Oviposition and the larva have been described by Samson (1908). Included in this report is a sketch of the female laying eggs, a generalized discussion of the subject, and a short description of the morphology, including the internal organs (illustrated) of the larva. Spermatogenesis has been briefly described by Sharma (1943).

Cytology in the kennel tick was studied by Stella (1938B), who "examined the course of oögenesis and spermatogenesis ..... from the larva to the adult (stages) ...... The gonads assume their definitive aspect and begin to function only after the last nymphal casting. The maturation with expulsion of both polar bodies occurs inside the female in the ovary. The fertile spermatozoa are formed only in the adult male and are of a unique type with flagellum and undulating membrane. The chromosomes are probably 48 in number, grouped in twelve tetrads". This paper is nicely illustrated and the reproductive organs of both sexes are described and illustrated.

Cytoplasmic inclusions in the oögenesis of the kennel tick have been extensively reported by Das (1939), who correlated his own observations with a considerable amount of controversial conclusions by other workers.

Chromosome studies have been briefly reported by Dutt (1952).

Adult development within the nymph has been studied by Yalvac (1939).

Excretory habits and mechanisms were investigated by Enigk and Grittner (1952).

An "anatomical-physiological study of *R. s. sanguineus*" by Stella (1942) bears conclusions which I have translated freely as follows:

"(1) In the female, anatomical and histologic differentiation of most organs commences with digestion of blood; the gut develops completely and begins to function; the glands begin to activate secretion; the gonads enlarge and mature. The period of greatest functional activity corresponds nearly to the duration of the meal. Abandoning the host, the female begins oviposition, and during this period completely digests the engorged blood, thus its body, at first turgid and hard, becomes flaccid and soft. The malpighian tubules by this time are elaborating the substance of excretion, which fills the rectal ampule, and continue elimination during deposition of eggs. The glands concerned with oviposition become active the moment it commences; thus the accessory glands of the uterus secrete a substance to facilitate the passage of the eggs to the genital aperture; the gene's organ secretes a substance which cooperates in the formation of a gluey substance. The salivary and coxal glands, the function of which is associated strictly with the digestion of blood, work afterwards at the meal, reducing and degenerating it so that by the time the female has finished oviposition hardly any traces (of ingested blood) can be found."

"(2) The young, unfed male, whose genital organs are small, shows indifference, but, differently from females, these organs mature and form sperms although the individual has not yet taken a blood meal. The gut utilizes the gross substance accumulated during the immature stage, and this is sufficient for mating, after which the individual dies. The salivary glands develop only slightly and do not secrete anticoagulin or toxin; the coxal glands do not become differentiated, and the malpighian tubules are small and in a state of repose."

"In those males that feed on blood at a certain time in their life, always after having first mated, an immediate arousing of all the physiological activities commences in those organs that, except for the gonads, have been in a torpor. The salivary glands begin functioning, as well as the coxal glands, and produce substances of agglutination and anticoagulin for the duration of the blood meal. The gut, which has completely absorbed the reserve substance, proceeds to digest the blood and the malpighian tubules send the excretory products which they have elaborated to the rectal ampule. Successively, sperm formation increases the secretory activity of the seminal vescile and of the appendage of the white gland so that a flood of viscous secretion for the dilution and nutriment of the sperm appears."

"From the examination of the anatomical and physiological results it is evident that in the male and female of R. sanguineus there exist noticeable differences in the development and period of function of the various organs," etc.

Miscellaneous

Symbiotes of the kennel tick have been noted by Cowdry (1923) and Jaschke (1933). See also Mudrow (1932).

Artificial feeding of this and other ticks by a capillary tube arrangement in order to accomplish physiological and pathogen-transmission studies was described by Chabaud (1950A).

Whether host immunity is provoked by the feeding of this and other ticks has been investigated by Brumpt and Chabaud (1947) and Chabaud (1950B), who concluded that this phenomenon does not occur when the kennel tick feeds on dogs. Guineapigs, however, react with an almost complete immunity and rabbits with a partial immunity (1950B). Infestation of guineapigs by *R. s. sanguineus* does not protect the host against *Dermacentor pictus*. The kind of host and kind of tick, as well as experimental methods, influence experiments of this nature, and the earlier, classical results of Trager (1939A,B,1940) should not be generalized.

IDENTIFICATION

Males, though extremely variable in many morphological characters, retain a set of certain features that are constant and differentiate them easily. (1) Posteromedian and paramedian grooves are always present and distinct; and (2) no matter how variable the general scutal punctations may be, four more or less regular rows of widely spaced punctations, always larger and most commonly somewhat deeper than all others on the scutum, can be distinguished (when the specimen is turned obliquely to the source of the light) extending from the level of the paramedian grooves to the level of the eyes.

Males vary considerably in overall size, measuring from 1.7 mm. to 4.4 mm. long, or even more. Variation among most characters, except interstitial punctation, usually can be associated with size and robustness, though, uncommonly, a large or even enormous specimen is seen with weakly chitinized features normally associated with otherwise poorly developed, runty specimens.

A typical male, measuring some 3.0 mm. long, is pale yellow, brown, or reddish brown; has a pearshaped body; slightly convex scutum; deep lateral grooves and distinct festoons; a narrowly elongate or oval but medially expanded, deep posteromedian groove; shorter and broader but equally deep paramedian grooves; very slightly convex eyes; sharply angular basis capituli; elongate, angular, adanal shields that in the posterior half of their length are usually distinctly widened and anteriorly are elongately subtriangular; and fairly distinct accessory shields.

Scutal punctations always consist of four regular or irregular rows of fairly large more or less discrete punctations, among which a variable number of small to large interstitial punctations are indiscriminately scattered.

If the specimen is engorged, the pearshape of the body is frequently exaggerated by integumental bulging laterally and posteriorly, from eye to eye, and the legs are successively larger from the anterior to the posterior pair; the posterior pairs are often massive and armed with a formidable tarsal hook ventrally.

The single character that most frequently confuses identity of this species is the density and size of interstitial punctations. The general conception of this species is one of a tick with four more or less definite rows of larger punctations among which rather few and smaller insignificant punctations are promiscuously scattered. This form (Figure 289) is found throughout northern Sudan and Egypt, but in southern Sudan occurs, to the best of our knowledge, _only_ on larger groundfeeding birds, such as bustards and storks. In typical southern Sudan specimens, interstitial punctations are larger, deeper, and more numerous (Figure 293). If it were not for the four rows of largest punctations, one would be tempted to refer to much of this material as _R. sulcatus_ (as, indeed, some students of African and South American ticks are doing). In central Sudan, most specimens are fairly heavily punctate. (Although we have large files of notes on variation among specimens from throughout the world, a further discussion of this matter should await a thoroughly exhaustive study).

Spiracular plates in this species are surprisingly variable. These differences appear to be often correlated with nutrition

(Cunliffe 1914A) but other factors must also be involved since the plates of Egyptian average specimens are sometimes massive.

In smaller, weaker, poorly nourished individuals, the color is either pale or darker than usual, the scutal grooves are less distinct, the adanal shields are more linear and have more rounded junctures (similar to those of R. appendiculatus), the basis capituli is more linear, the legs are smaller, and other characters are less distinctly pronounced. However, a definite trace of the critical characters remains in all except exceedingly few, obviously misformed specimens.

Females are equally as variable as males. The above remarks concerning scutal punctations also apply to the female except that the larger punctations are less uniformly in rows but are scattered even more indefinitely over the central area of the scutum. In areas where males are lightly punctate, interstitial punctations of females are frequently more dense. The elongate scutum, normally five-sixths as wide as long, narrows acutely posterior of the eyes; halfway from the posterior margin of the eyes to the posterior angle the margin normally is obtusely angled, and at the posterior point there is a minute marginal expansion. Though difficult lucidly to describe, this slightly undulating scutal pattern forms a most distinctive picture after one has examined large series of specimens. This outline may be more generalized in poorly developed individuals, and its length-width ratio may be more equal, but it is often maintained even in runts and weak individuals. The usually pronounced lateral grooves of the scutum are additionally picked out by being inset with large punctations; they extend about three-fourths of the scutal length; though in lightly punctate specimens the lateral grooves are often less definite. In the cervical areas, shagreening or coarse punctations may occur and the scapulae usually have a group of large punctations. [Females of this species cannot be keyed in Zumpt's (1950A) revision, since the wrong section of couplet 21 applies.]

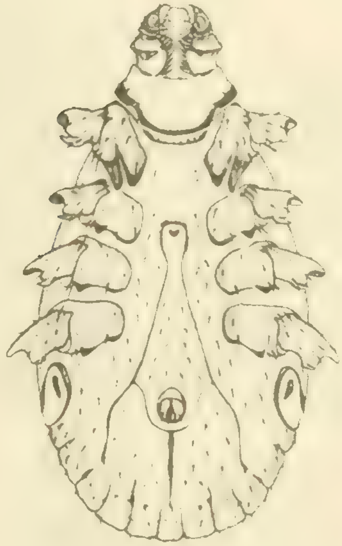
The immature stages have been described by Cunliffe (1914A), Theiler (1943B), Cooley (1946), Feldman-Muhsam (1952A), others noted in REMARKS, above, and in numerous other reports.

NOTE: For further references to variation, related species and subspecies, etc., see REMARKS, above.

297

299

298



300

Figures 297 and 298, ♂, dorsal and ventral views
Figures 299 and 300, ♀, dorsal and ventral views

RHIPICEPHALUS SIMPSONI
Sudan Specimens

PLATE LXXXIII

RHIPICEPHALUS SIMPSONI Nuttall, 1910.

(Figures 297 to 300)

THE CANE-RAT GLOSSY TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
			1	Torit	Thryonomys gregorianus subsp.	Feb
		2	5	Yei	"marsh rat"	Feb (SGC)

These records, from the east and west banks of Equatoria Province, are the only ones of this species from the Sudan. The Yei specimens in Sudan Government Collections were collected in 1911 by H. H. King, who had identified them as R. simus.

DISTRIBUTION

R. simpsoni has been reported from widely scattered localities throughout Africa within the Ethiopian Faunal Region and probably occurs wherever its favorite host, the cane rat, does. It is common in Kenya and Uganda although it has not previously been reported from Kenya.

WEST AFRICA: NIGERIA (Nuttall 1910. Simpson 1912B. Rageau 1953B).

CENTRAL AFRICA: CAMEROONS (Rageau 1953A,B). BELGIAN CONGO (Schwetz 1927C. Bequaert 1931).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

KENYA (Common on lesser cane rats, Choeromys g. gregorianus, at Subukia, Nakuru District, 6400 ft. alt.; Hoogstraal legit). UGANDA (Mettam 1935. Bedford 1936. Theiler 1947. Numerous specimens seen in collections of Uganda Veterinary Service. See HOSTS below). TANGANYIKA (Reichenow 1941B).

SOUTHERN AFRICA: NYASALAND (Wilson 1950B). MOZAMBIQUE (Santos Dias 1952G). UNION OF SOUTH AFRICA (Bedford 1936. Theiler 1947).

HOSTS

R. *simpsoni* has been reported only from cane (or "edible") rats, *Thryonomys* (= *Aulacodus*) spp. and *Choeromys* spp. (all authors). What appears to be an exceptional host is the giant forest rat, *Cricetomys gambianus*; specimens from this host from Uganda, A. D. Fraser *legit*, are in British Museum (Natural History) collections.

BIOLOGY

R. *simpsoni* appears to be almost entirely restricted to cane rats. The paucity of records is possibly due to rarity of host examination. Present evidence would indicate that this is one of the most host-specific of rhipicephalid ticks. Although R. *simpsoni* is closely related to R. *simus*, this latter species is seldom found on cane rats.

DISEASE RELATIONS

Unstudied.

REMARKS

Adults were figured and redescribed by Theiler (1947). The nymph was described by Santos Dias (1952G), who, incidentally, considered this species as a synonym of R. *simus longus* but who subsequently (1952G,H) recognized the obvious validity of R. *simpsoni*.

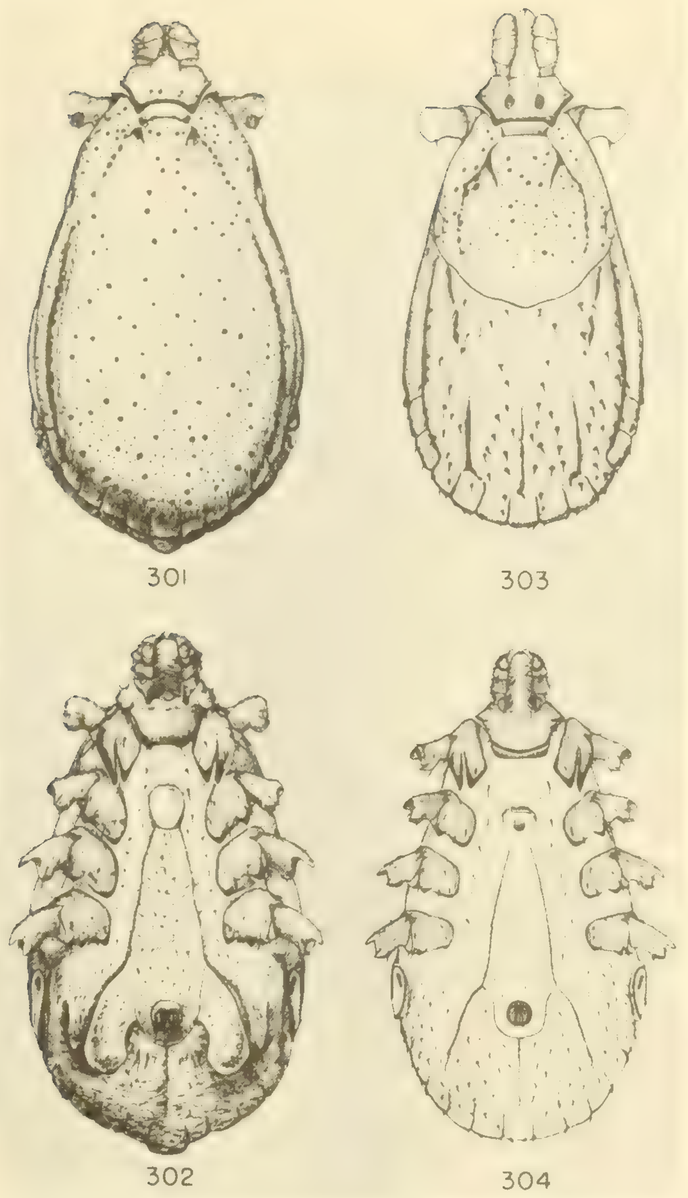
Generally one may be suspicious that records of R. *simus* from cane rats actually refer to R. *simpsoni*, although two males of R. *simus* from a cane rat near Yirol have been seen, (E. T. M. Reid *legit*). All other collections, labelled as R. *simus* from cane rats, that have been studied by the writer from various parts of Africa have proven to be R. *simpsoni*.

IDENTIFICATION

Male: Size is usually small, from 2.3 mm. to 3.6 mm. long and from 1.5 mm. to 2.2 mm. wide. Typical males are easily distinguished within the R. simus group by a combination of characters including broadly sickleshaped adanal shields; sparse, almost obsolete, shallow, scutal punctations; distinct lateral and posterior grooves; short, converging cervical pits; pearshaped body; and slight dorsal process of coxa I.

The several fairly large series of specimens in the present collection and other East African series that have been studied show considerable variation among individuals, though always one or more of the distinctive features of the species are retained. The posterior grooves may be very faint. In small, weak specimens the lateral grooves may be more shallow than usual or they may be indicated by only a row of punctations. In specimens with exceedingly small adanal shields, the characteristic sickleshape is frequently reduced. The pointed dorsal projection of coxa I is very small and in a number of specimens it is reduced to merely a blunt hump.

Female: This sex averages 3.4 mm. long and 2.0 mm. wide; it ranges from 2.5 mm. to 3.4 mm. long and from 1.5 mm. to 2.5 mm. wide. The scutum is about one-fourth longer than wide; its posterior margin is sinuous, with a slight medial protrusion; eyes are pale and flat; lateral grooves almost reach the posterior scutal margin; cervical grooves extend posteriorly for about half the scutal length. Scutal punctations are sparse and superficial; interstitial punctations are usually absent, but some fine ones may be present with a few larger punctations in lateral grooves. The great length of the scutum in relation to its width distinguishes females from those of R. s. simus, R. s. senegalensis, and R. bequaerti. This character is an especially important one in specimens in which interstitial punctation is more apparent than is common for R. simpsoni.



Figures 301 and 302, ♂, dorsal and ventral views
Figures 303 and 304, ♀, dorsal and ventral views

RHIPICEPHALUS SIMUS SIMUS
Sudan Specimens

PLATE LXXXIV

RHIPICEPHALUS SIMUS SIMUS Koch, 1844.

(Figures 301 to 304)

THE GLOSSY TICK*

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
			1	Torit	MAN (feeding on)	Jan
		1		Torit	MAN (feeding on)	Dec
		2	2	Torit	MAN (crawling on)	Dec (4)
		2	1	Torit	MAN (crawling on)	Jan (3)
		1	3	Torit	MAN (crawling on)	Feb
			1	Torit	MAN (feeding on)	Mar
			1	Juba	MAN (feeding on)	Dec
		2		Juba	MAN (crawling on)	Aug
	1			Gilo	Lemniscomys striatus massaicus	Feb
2	1			Torit	Lemniscomys striatus massaicus	Nov
1	2	2	3	Torit	Burrows of L. striatus massaicus	Dec (2)
	4			Torit	Lemniscomys macculus macculus	Dec
	2			Torit	Tatera benvenuta benvenuta	Dec
	13			Torit	Tatera benvenuta benvenuta	Nov
	11	4	5	Torit	Burrows of T. b. benvenuta	Nov (2)
2				Torit	Mastomys natalensis ismailiae	Dec
	1			Ikoto	Mastomys natalensis ismailiae	Nov
	1			Lotti Forest	Praomys tullbergi sudanensis	Apr
	5			Ikoto	Arvicanthis niloticus jebelae	Nov
	1			Torit	Arvicanthis niloticus jebelae	Dec
	18	6	7	Torit	Burrows of A. niloticus jebelae	Dec (6)
	30	19	18	Torit	Burrows of A. niloticus jebelae	Jan (8)
	1	31	28	Juba	Burrows of A. niloticus jebelae	Dec (4)
	1			Ikoto	Lepus capensis crawshayi	Feb
	1			Torit	Lepus victoriae microtis	Jan
			9	Torit	Panthera leo leo	Sep
		7	6	Torit	Canis aureus soudanicus	Nov
		1	1	Torit	Canis aureus soudanicus	Dec (2)
		6	7	Torit	Canis aureus soudanicus	Apr (2)
		2	3	Torit	Canis aureus soudanicus	Aug

*Also known as the black pitted tick, the glossy brown tick, and the tailtuft brown tick (cf. Theiler 1952A,B).

L	N	♀	♂				
		8	8	Torit	*Crocuta crocuta fortis*	Oct	
		8	6	Torit	*Mellivora capensis abyssinica*	Jan	
		2	2	Obbo	*Civettictis civetta congica*	Apr	
		1	2	Torit	*Civettictis civetta congica*	Feb	
		8	7	Lugurren	*Phacochoerus aethiopicus bufo*	Jan	
		4	5	Torit	*Sus scrofa sennarensis*	Apr	
		1	1	Nimule	*Hippopotamus amphibius amphibius*	May	
		1	1	Nimule	*Hippopotamus amphibius amphibius*	Oct	(SVS)
		1		Terakeka	*Damaliscus korrigum tiang*	-	(SGC)
			1	Kidepo	*Taurotragus oryx pattersonianus*	Jan	
		1		Torit	*Taurotragus oryx pattersonianus*	Feb	
		1	3*	Kapoeta	*Hippotragus equinus bakeri*	Dec	
		4		Torit	*Hippotragus equinus bakeri*	Jan	
		1		Ikoto	*Rhynochotragus guentheri smithii*	Dec	
		1	19	Boma Plains	*Syncerus caffer aequinoctialis*	Dec	
		21	32	Torit	*Syncerus caffer aequinoctialis*	Jan	
			2	Holo	*Syncerus caffer aequinoctialis*	Mar	
		1		Lolianga	*Syncerus caffer aequinoctialis*	Jan	
		5	2	Kapoeta	domestic dogs	Dec	
		8	14	Keyala	domestic dogs	Dec	
		22	25	Torit	domestic dogs	Dec	(3)
		6	6	Torit	domestic dog	Jan	
		1		Torit	domestic dog	Mar	
		1		Torit	domestic dog	Apr	
		4	2	Torit	domestic dog	Jun	
			1	Torit	domestic dog	Nov	
		3	1	Katire	domestic dog	Oct	
		3		Loronyo	domestic dog	Jan	
		8	8	Juba	domestic dog	Jan	
		7	8	Juba	domestic dog	Dec	(2)
			2	Juba	domestic dog	May	(SGC)
		1		Nimule	domestic dog	Mar	
		1	1	Lado	domestic dog	Sep	(SGC)
		67	69	Kajo Kaji	domestic dogs	Dec	(3)
		6	2	Torit	domestic pigs	Mar	

*With 1 ♂ *R. simus senegalensis*. This is the only collection seen from anywhere in Africa in which typical specimens of both subspecies have been found on a single host.

L	N	♀	♂			
		3	5	Torit	domestic pigs	Apr
			3	Torit	domestic pigs	Nov (2)
		20	44	Torit	domestic pigs	Dec (4)
		7	9	Torit	domestic pigs	Jan
			1	Torit	domestic cattle	Dec
		1	1	Katire	domestic cattle	Oct
		1	1	Lolepori	domestic cattle	Dec
		6		Loronyo	domestic cattle	Jan
		17	32	Juba	domestic cattle	Jan
		1		Juba	domestic cattle	Dec
		1	8	Juba	domestic horse	Jan
		6	17	Loronyo	domestic goat	Jan
			2	Juba	domestic sheep	Jan
		1	3	Juba	domestic sheep	Dec (SGC)
			3	Kajo Kaji	domestic sheep	Dec
		1		Torit	on grass	Aug
		?	?	Imatong Mts. (8700 ft. alt.)	? host	(Weber 1943)

DISTRIBUTION IN THE SUDAN

King (1926) stated that R. s. simus occurs throughout Equatoria, Bahr El Ghazal, Upper Nile, Blue Nile, Kordofan, and Kassala Provinces and that it had at that time only recently established itself in Northern Province where proper conditions of humidity for its development prevailed around newly installed pumps and basin irrigation. King apparently had no Darfur Province records for this species.

Sudan localities from which specimens of the glossy tick have been seen are:

Bahr El Ghazal: Galual-Nyang Forest (hyena, black-legged mongoose, leopard, lion, buffalo, and warthog; domestic dogs; old male baboons infested with as many as two hundred adult specimens; 2♂♂, 2♀♀ engorging on men; SVS, HH). Jur River (hippopotamus; SVS). Lau (cattle; SGC). Fanjak (domestic dogs and cattle; SVS, HH).

Wau (domestic pigs; SVS). Kenisa (numerous specimens from elephants; SGC). Several localities near Yirol (elephants; SVS). Yirol (hyena and cane rat; SVS).

Upper Nile: Duk Fadiat (wild pig and warthog; SVS). Akobo Post (lion; SGC). Maban (cattle and goats; SVS). Pariak (cattle; SVS). Kaka (roan antelope; SGC). Bor (domestic dogs; HH, leopard; SGC). Malakal (domestic dogs; HH).

Blue Nile: Roseires (cattle; SGC).

Darfur: Zalingei (camels and horses; SVS). Kulme, Wadi Oribo (fox; SMNH).

Kordofan: Tabanga (pigs; SGC). Talodi (cattle and pony; SGC). "Western Jebels" (cattle; SVS).

[Khartoum: No records.]

Northern: Letti Basin (fox; SGC). Shendi (bull; SVS, sheep; SGC). These populations are probably quite restricted.

DISTRIBUTION

R. s. simus ranges throughout the Ethiopian Faunal Region. In West Africa, it is more or less widely replaced by the subspecies senegalensis. The Arabian range of the glossy tick, as mapped by the American Geographical Society (1954), should be limited to the mountains of the Yemen.

[WEST AFRICA: Early records should be checked against R. simus senegalensis. The range of R. s. simus in West Africa is imperfectly known. NIGERIA (Simpson 1912A*,B. Unsworth 1949,1952. Mettam 1950). SIERRA LEONE (Neumann 1901,1911. Simpson 1913). TOGO (Neumann 1901,1911. Ziemann 1909). GOLD COAST (Simpson 1914. Beal 1920. Stewart 1934). IVORY COAST (Neumann 1901). PORTUGESE GUINEA (Tendeiro 1946A,B,1948,1951A,E,1952C,D,E,1954: wherever

---

*Specimens referred to as R. simus by Simpson (1912A, p. 325) are actually R. simus senegalensis. They were determined as R. simus falcatus by Nuttall and Warburton. These specimens are in British Museum (Natural History) collections.

MARINE BIOLOGICAL LABORATORY
WOODS HOLE
LIBRARY
MASS.

illustrated the specimens appear to resemble the subspecies senegalensis rather than simus). FRENCH WEST AFRICA (Neumann 1911. Rousselot 1953B. See also Sudan below. Theiler states (correspondence) that her extensive Senegal collections are all typical R. s. simus). NOTE: Tonelli-Rondelli's (1938) reports from Sierra Leone, Togo, and Gold Coast are probably repetitions from Neumann.]

CENTRAL AFRICA: CAMEROONS (Neumann 1902A. Zumpt 1943A. Rageau 1951,1953A,B). FRENCH EQUATORIAL AFRICA (Rousselot 1951, 1953B). BELGIAN CONGO and RUANDA-URUNDI (Newstead, Dutton, and Todd 1907. Massey 1908. Nuttall and Warburton 1916. Roubaud and Van Saceghem 1916. Schwetz 1927C,1932. Bequaert 1930A,B, 1931. Zumpt 1943A. Bouvier 1945. Wanson, Richard, and Toubac 1947. Schoenaers 1951A,B. Rousselot 1953B. Theiler and Robinson 1954. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN [The synonymous R. shipleyi from "Soudan" (Neumann 1902A) refers either to the Sudan or to French West Africa. King (1908,1911,1926). Zumpt (1943A). Weber (1948). Hoogstraal (1954B).]

ETHIOPIA (As R. simus, R. hilgerti, and R. erlangeri: Neumann 1902A,B,1911,1913,1922. Stella 1938A,1939A,B,1940. Roetti 1939. Zumpt 1943A. Charters 1946. D'Ignazio and Mira 1949). ERITREA (Stella 1939A,1940). FRENCH SOMALILAND (Hoogstraal 1953D). ITALIAN SOMALILAND (Paoli 1916. Franchini 1926,1927,1929C,E. Veneroni 1928. Niro 1935. Stella 1938A,1939A,1940). BRITISH SOMALILAND (Drake-Brockman 1913B. Stella 1938A,1939A,1940).

KENYA (As R. perpulcher and R. praetextatus: Gerstäcker 1873. As "R. perpulcher from Mombas, Zanzibar": Neumann 1904. As R. ecinctus: Neumann 1908,1922. Neumann 1911,1912,1913,1922. Neave 1912. Loveridge 1923D. Anderson 1924A,B. Lewis 1931A,B,C, 1932A,B,1934,1943,1950. Brassey-Edwards 1932. Walker 1932. Daubney 1933,1934,1936B. Daubney and Hudson 1934. Kauntze 1934. Roberts 1935. Fotheringham and Lewis 1937. Mulligan 1938. "Kenya Vet. Serv." 1939A,B,1940,1947,1949,1951,1952. Lewis and Fotheringham 1941. Zumpt 1943A. Lewis, Piercy, and Wiley 1946. Dick and Lewis 1947. Weber 1948. Beaumont 1949. Heisch 1950B. Binns 1951,1952. van Someren 1951. Wilson 1953. Wiley 1953. Lumsden 1955).

UGANDA (A. Theiler 1910A. Bruce *et al* 1911. Neave 1912. Neumann 1922. Richardson 1930. Mettam 1932. Carmichael 1934. Wilson 1948B,C,1950C. Lucas 1954).

TANGANYIKA (Neumann 1901,1907C,1910B,1911. Morstatt 1913. Loveridge 1923A. Bequaert 1930A. Allen and Loveridge 1933. Moreau 1933. Evans 1935. Cornell 1936. Zumpt 1943A. J. B. Walker, unpublished, see various parts of HOSTS section below).

SOUTHERN AFRICA: ANGOLA (Manetti 1920. Sousa Dias 1950. Santos Dias 1950C). MOZAMBIQUE (Howard 1908,1911, larval identification in 1908 paper open to question. As *R. ecinctus*: Howard 1909B. Sant'Anna 1911. Theiler 1943B. Zumpt 1943A. Santos Dias 1947B,1952D,H,1953C,1954A,H,1955A).

NORTHERN RHODESIA (Neave 1912. Le Roux 1934,1937,1947. Matthysse 1954. Theiler and Robinson 1954). SOUTHERN RHODESIA (Robertson 1904B. Edmonds and Bevan 1914. Bevan 1920. Jack 1921,1928,1937,1942. Lawrence 1942). NYASALAND (Old 1909. Neave 1912. De Meza 1918A. Davey and Newstead 1921. Zumpt 1943A. Wilson 1943,1945,1946,1950B).

BECHUANALAND (Theiler, unpublished). SOUTHWEST AFRICA (Trommsdorff 1913,1914. See immature HOSTS below). UNION OF SOUTH AFRICA (Koch 1844. Neumann 1901,1911. Lounsbury 1903A, 1904A,B,1905B,1906C. Robertson 1904. A. Theiler and Stockman 1904. A. Theiler 1905B,1909B,1911B,1912A,1921. Howard 1908. Galli-Valerio 1909B. Speiser 1909. A. Theiler and Christy 1910. Dönitz 1910B. Moore 1912. Van Saceghem 1914. Breijer 1915. Bedford 1920,1926,1929,1932,1934,1936. Cowdry 1925B,C, 1926A,1927. R. du Toit, Graf, and Bekker 1941. Curson 1928. Cooley 1934. Bedford and Graf 1935,1939. R. du Toit 1942B,C, 1947. Zumpt 1943A. Zumpt and Glajchen 1950. Meeser 1952).

OUTLYING ISLANDS: ZANZIBAR (Neave 1912. Aders 1917). SEYCHELLES (Desai 1952).

/MADAGASCAR: "Neumann (1901,1911). Poisson (1927). Tonelli-Rondelli (1938). Buck (1948A) indicated that this species ("*Haemaphysalis simus*") is not established on Madagascar. Hoogstraal (1953E)./

ARABIA: YEMEN (Sanborn and Hoogstraal 1953. Hoogstraal, ms.).

NOTE: The known distribution of this species in Arabia on the map of the American Geographical Society (1954) should be limited to the mountains of the Yemen.

MISCELLANEOUS: Tonelli-Rondelli (1938) noted that Stella (1938D) had reported *R. simus* from ITALY and indicated that this report is certainly an error in identification; also that this species is absent from LIBYA [reported as present by Stella (1938C)], ALGERIA, TUNISIA, and MOROCCO. Records for Mytilene, GREECE (Senevet 1920), repeated without further substantiation by Pandazis (1947), and records for TURKEY (Stefko 1917) are probably also erroneous or refer to introduced, non-established specimens.

Neumann (1911) listed *R. simus* from EGYPT and Brumpt (1920) stated that East Coast fever exists in Egypt and might be carried by this tick. Mason (1922B) quoted this as an erroneous statement that *R. simus* occured in Egypt, to which Brumpt (1923, p. 43, footnote) replied that he had merely hypothesized this possibility on the basis of Neumann's record. Carpano (1936) reported micro-organisms in specimens of this tick (?imported or misidentified - HH) collected from carnivores in the Cairo zoological gardens. Actually, the glossy tick is not established in Egypt, as confirmed earlier by Mason (1922B).

Records from TURKESTAN (Yakimov and Kohl-Yakimov 1911, Yakimov 1917,1922,1923) are based on material now considered as subspecies of *R. sanguineus* (cf. page 717). The "*R. simus* or *R. sanguineus*" from tortoises in IRAN (Michael 1899) probably refers to *H. aegyptium*.

Data from BORNEO (Neumann 1901) probably refers to *R. sanguineus* subsp. or to *R. haemaphysaloides* subsp.

Christophers (1907C) reported *R. simus* from southern INDIA but, as Sharif (1928) says, this too is probably a misidentification. Patton's (1910) remarks concerning the transmission of *Piroplasma gibsoni* of India by a new species of tick related to *R. simus* have been elaborated in subsequent reviews to indicate that *R. simus* transmits this organism.

HOSTS

Adult hosts of predilection are carnivores, pigs, buffalo, and other large or medium size game animals. Antelopes are usually second-choice hosts. Among domestic animals, dogs and pigs frequently are preferred. The incidence on cattle varies locally and may be either very high or very low even where the glossy tick is common. People are frequently attacked, especially in the vicinity of their dwellings. Although Matthysse (1954) considers adults to be parasites of medium size mammals, overall data indicate that host size is only one factor, the type of host being an equally important consideration. Larvae and nymphs feed chiefly on burrowing rodents, less commonly on other small animals.

Adults

Cattle: Factors influencing parasitism of domestic cattle by *R. s. simus* are still unknown. Although this tick is common throughout Equatoria Province, its incidence on cattle is nil or low everywhere except in Juba District where the rate may run fairly high. In Central Sudan, the numbers on cattle are variable but never high.

R. s. simus is one of the five species of this genus that occurs with any degree of frequency on Uganda cattle but in most districts the rate of infestation is low (Wilson 1950C).

In South Africa, the glossy tick "does not appear to thrive well on cattle" (Lounsbury 1904B). Theiler (correspondence), however, reports that in cattle raising areas of South Africa these animals are the favorite host of the glossy tick.

Wilson (1950B) considered this to be an uncommon Nyasaland tick because he took it on only 24 occasions during an extensive three year tick survey. Ten of these collections were from cattle. Earlier, Wilson (1946) doubted that females ever become fully engorged on cattle. Theiler (correspondence) has found that the glossy tick is more common in Nyasaland than Wilson believed. Rarity of cattle infestation here probably accounts for this discrepancy inasmuch as relatively few wild animals were examined. Matthysse (1954) considers this to be a rather important Northern Rhodesian cattle parasite, but does not provide a clear cut analysis of the situation there.

Low incidence of R. s. simus on cattle is not universal. It is not only common but numerous on cattle on the coastal plains of Kenya (Dick and Lewis 1947).

Dogs: Throughout the range of R. s. simus, domestic dogs are frequently among its most common hosts and are mentioned by many authors. In Equatoria Province, dogs are infested by this parasite as frequently as they are by R. s. sanguineus, but the numbers of simus are considerably lower in all collections except those from Kajo Kaji. The yellow dog-tick, H. l. leachii, is much less common on dogs in the Sudan but in certain other areas of Africa this is one of their most important arthropod parasites. Kauntze (1934) and Roberts (1935) did not consider R. s. simus to be an important pest of dogs when studying boutonneuse fever in Kenya, but Dick and Lewis (1947) found this common tick to be only slightly less numerous on dogs than R. s. sanguineus in the coastal area of Kenya. At Nelspruit, South Africa, Lounsbury (1904A) collected more glossy ticks than kennel ticks on canines in the same place. According to Theiler (correspondence), R. s. simus and H. l. leachii generally are more common on South African dogs than is R. s. sanguineus, and H. l. leachii is usually the most common of the three. Matthysse (1954) listed R. s. simus only once from Northern Rhodesian dogs, and noted R. appendiculatus, R. s. sanguineus, and R. tricuspis more frequently.

Pigs: Wherever I have encountered domestic pigs in the range of the glossy tick, a close association between the two and a high rate of infestation has been noted. No mention of similar situations is found in the literature. Wild warthogs and bushpigs (see below) are commonly infested. In South Africa, on the other hand, domestic pigs are amazingly free of ticks and more are recorded from bushpigs than from warthogs (Theiler, correspondence).

Tendeiro's reports from Portugese Guinea (listed above) contain numerous references to R. s. simus and R. s. senegalensis on domestic pigs. The identity of West African specimens should be checked.

Other domestic animals are more or less frequently reported as hosts, but the incidence is seldom if ever mentioned. In addition to the Sudan records given above, some of these are:

Cat (Jack 1921,1942).

Horses (Neumann 1901,1902B,1911, Howard 1908, Massy 1908, Lewis 1931A, Bedford 1932B).

Goats (Howard 1908, Lewis 1931A, Bedford 1932B, Wilson 1950B).

Sheep (Howard 1908, Lewis 1931A,C,1932A,1934, Daubney and Hudson 1934, Wilson 1950B).

Camels (Neumann 1902B,1911).

Chickens (Lucas 1954).

Man

More specimens of R. s. simus were taken on members of our parties in southern Sudan than any other tick species. Several of these were engorging and others might have done so if they had not been removed. Galli-Valerio (1909B), Jack (1942), and Lumsden (1955) noted incidental attacks on man. Veneroni (1928) and Zumpt and Glajchen (1950) reported human paralysis after bites of the glossy tick. Others have said specifically that no specimens were found on people during surveys, for example, Kauntze's (1934) report on the Kilmani area near Nairobi. J. B. Walker (correspondence), however, reported five males and three females from man in tall grass country south of Arusha, Tanganyika.

Wild Animals

Primates: In Bahr El Ghazal, hundreds of specimens were collected from old male baboons, some of which harbored as many as 200 glossy ticks, chiefly in the axilla. In the same areas, baboons travelling in community groups were consistently free of ticks. In Kenya, we found specimens on Colobus monkeys (see also I. schillingsi, page 558), but, except for a note by Lumsden (1955), there is no reference in the literature to similar collections. Theiler (correspondence) has a single record from Galago crassicaudatus agisymbanus from Zanzibar.

Carnivores: These animals, along with some of the larger and thicker skinned herbivores of Africa, appear to be hosts of choice: Lions [All extensive African collections studied by the writer contain specimens from lions. Reported by Neumann

(1901,1907C,1910B,1911,1922), Howard (1908), King (1926), Bedford (1932B), Lewis (1932A,1934), Wilson (1946B,1950B), Weber (1948), Santos Dias (1952H,1953C), and others 7. Leopards (Loveridge 1923A, King 1926, Bequaert 1930A, Lewis 1932A,1934, Zumpt 1943A, Wilson 1950B. Numerous specimens in BMNH collections).

Cheetah (Lewis 1932A,1934). Serval (Lewis 1931B,1932A). Various foxes (King 1926, Weber 1948, J. B. Walker, unpublished). Various hyenas (Neumann 1922, Loveridge 1923A, Lewis 1934, Zumpt 1943A, J. B. Walker, unpublished). Various jackals (Neumann 1902B, Lewis 1931A,1932A,1934, Zumpt 1943A). Various civets (Loveridge 1923A, Bequaert 1930A, Allen and Loveridge 1933, Zumpt 1943A, Matthysse 1954). Genet (Bequaert 1930A). Hunting dogs, Lycaon pictus (Howard 1908, Van Saceghem 1914, Lewis 1931A, Bedford 1932B; J. B. Walker, unpublished). Ratel (Sudan records above). Marsh mongoose (Loveridge 1923A). The Onderstepoort collection, BM(NH), and the present collections contain numerous other specimens from these and similar carnivores.

Antelopes: In Equatoria, the only records of this tick from antelopes are from two common elands, a tiang, a large-snouted dik-dik, and two roan antelopes. None others were found on the several hundred antelopes examined in Equatoria and Bahr El Ghazal Provinces. Elsewhere in the Sudan, there is only a single record from a roan antelope at Kaka in Upper Nile Province; this was reported by King (1926). King also noted the gazelle as a host, but specimens are not now available.

Simpson's (1914) records for a West African oribi and a reedbuck quite possibly pertain to the subspecies senegalensis.

Other published records from antelopes are: Duiker (Bedford 1932B). Grant's gazelle (Lewis 1934). Kudu (Bedford 1932, Lewis 1932A). Bushbuck (Lewis 1931A,1932A). Eland (Lewis 1931A,1932A). Wildbeest (Lewis 1932A,1934). Sable antelope (Santos Dias 1950). Impala (Meeser 1952). Steinbuck (Lewis 1931B).

On 49 Tanganyika Thomson's gazelles that yielded many ticks, R. s. simus was represented by only two females although this subspecies was common on many other kinds of hosts from the same area. (J. B. Walker, unpublished). A single male was found on an eland.

In Wilson's (1950B) list of nine kinds of hosts of this tick in Nyasaland, no antelopes are represented, and none were included among Howard's (1908) eleven kinds of hosts from southern Africa. The Onderstepoort collection contains only seven collections of glossy ticks from various antelopes throughout Africa (Theiler, correspondence). In addition to the kinds mentioned above, these are a topi from Uganda, a gemsbok from Southwest Africa, and an oribi from Southern Rhodesia.

Other hosts: Elephants [In Equatoria Province these animals are either normally attacked by A. tholloni or are free of ticks; but in Bahr El Ghazal Province all elephants examined were heavily infected by R. s. simus and none harbored A. tholloni. Numerous specimens of R. s. simus have been examined in various collections from elephants in other parts of Africa. Others have been reported by Mettam (1932)]. Buffalo [These animals are usually infested in the Sudan and frequently harbor numerous specimens of R. s. simus. Elsewhere they are also important hosts of this tick. Records have been published by Neumann (1907C,1910B,1911,1922), Davey and Newstead (1921), Bequaert (1930A,1931), Lewis (1931B,C, 1932A,1943), Mettam (1932), and Santos Dias (1952D)]. Rhinoceroses [The black, or narrow-lipped rhinoceros is hardly an important host because it is seldom numerous in nature, but where it occurs most individuals appear to be infested by the glossy tick. See Neumann (1922), Lewis (1932A), Zumpt (1943A), J. B. Walker (unpublished). The excessively rare white, or square-lipped rhinoceros has been reported as a host by Breijer (1915) and Zumpt (1943A); these reports apply, however, only to the southern race]. Hippopotamus [Specimens were found on the ears of three specimens examined in the Sudan; three other specimens were free of ticks. No other records are available]. Pigs [The warthog and bushpig are frequently infested in the Sudan and elsewhere. See Neumann (1901,1907C,1910B,1911), Howard (1908), Bequaert (1930A,1931), Lewis (1931B,C,1932A), Bedford (1932), Mettam (1932), Weber (1948), Wilson (1950B), and J. B. Walker (unpublished)]. Zebras [Reported by Neumann (1907C,1910B,1911), Lewis (1931B,1932A), Mettam (1932), and Santos Dias (1952D)]. Antbear or aardvark, Orycteropus afer [Neumann (1922), Bedford (1932), Lewis (1932A), Wilson (1946B, 1950B), Matthysse (1954)]. African porcupines [Neumann (1907C, 1910B,1911), Lewis (1932A), Matthysse (1954), J. B. Walker (unpublished)]. Pangolin [Mettam (1932)].

[Giraffe: Inasmuch as adults commonly parasitize so many large game animals, infestation of giraffes is to be anticipated. However, no published records have been found indicating that this is so. In Bahr El Ghazal Province, where this is a common tick and where numerous giraffes were examined, *R. s. simus* was not found on these animals.]

Exceptional hosts: Hedgehogs (Howard 1908, Van Saceghem 1914, Bedford 1932B). Hares (Loveridge 1923A, Bedford 1932B, Lewis 1932A). In the laboratory, Lewis (1932A) found that adults feed readily on hares (see also immature stages below). Rabbit (Howard 1908). Cane rats (See also next paragraph. Sudan records include a single collection from Bahr El Ghazal and the Onderstepoort collection contains three lots from Southern Rhodesia). Rodents (South African *Otomys*, *Aethomys*, and *Rhabdomys*; four records: Theiler, correspondence).

?Mistaken identity: Specimens from a cane rat (Bedford 1932B) were later found to be *R. simpsoni* and not *R. simus* (Bedford 1934). Neumann's (1922), Mettam's (1932) and Loveridge's (1923A) specimens from cane rats should be checked against *R. simpsoni*. See HOSTS of *R. simpsoni*, page

"Large gray cattle tick (?*Rhipicephalus sinus* Koch) (sic) attached to and completely blocking up the ear opening" of a lizard, *Mabuia striata* (Loveridge 1923D). This sounds like an *Aponomma* tick.

Note

Adults, found frequently in rodent nests in which the immature stages feed, are always newly molted, unmated, unfed individuals biding their time before venturing forth to find a host more attractive to them than rodents.

Larval and Nymphal Hosts

Rodent hosts: All of the numerous records of adults in the Onderstepoort collection are from larger size animals and most records of immature stages are from small, nest-inhabiting mammals (Theiler, correspondence). Our field experience in East Africa and Arabia follows the same pattern. The details have been best worked out by Roberts (1935) (also noted by Kauntze 1934) who found the immature stages in the Nairobi area in nests of the following rodents: grass rats or kusu, Arvicanthis sp.; groove-toothed rat, Otomys sp.; striped grass mouse, Lemniscomys sp.; four-striped grass mouse, Rhabdomys pumilio; and multimammate rat, Mastomys (= Mus) coucha.

In the Sudan, some larvae and many nymphs were taken on the same types of animals mentioned by Roberts and also on gerbils, Tatera b. benvenuta. Engorging specimens were taken on these animals trapped away from their nest. We also took a single nymph from two different kinds of hares in two localities but it seems that hares should be considered as exceptional hosts for immature stages. In Northern Rhodesia, Matthysse (1954) also reports larvae from hares.

British Museum (Natural History) collections contain a nymph from another probably exceptional host, a ground squirrel Fermosciurus sp., collected by Karl Jordan in Southwest Africa. A breakdown of collections of immature stages from South Africa in the Onderstepoort collection (Theiler, correspondence) shows that nine are from hares, two are from springhaas, five from hyraxes, one from ground squirrel; 125 from the following genera of murid rodents: Aethomys (56), Rhabdomys (24), Lemniscomys, Mastomys, Thallomys, Arvicanthis, Rattus, and Mus; and forty from the following cricetid rodents: Otomys (33), Myotomys, Parotomys, Tatera and Gerbillus.

Other reports of immature stage hosts are short-haired rats, Praomys sp. for larvae (Bedford 1932B) and Praomys jacksoni for nymphs during the dry season around Leopoldville (Wanson, Richard, and Toubac 1947), and an elephant shrew for a nymph "probably of this species" in Kenya (Lumsden 1955).

Exceptional hosts of immature stages in the Onderstepoort collection (Theiler, unpublished) are three elephant shrews and one Crocidura shrew (insectivores), one hartebeest, one mongoose, and one mierkat. Also included are three birds from the region of the Sabi-Lundi Function, Southern Rhodesia, the puff-back shrike, Dryoscopus cubla, the blue-breasted waxbill, Uraeginthus angolensis, and the dusky-faced warbler, Tricholais scotops. It is difficult to determine whether so many kinds of exceptional hosts are the result of wider and more extensive field search or of ecological differences (see BIOLOGY below).

Laboratory hosts: Lewis (1932A) observed that although nymphs and adults fed readily on hares, larvae were more reluctant to do so. From this Lewis concluded that hares are less preferred hosts of larvae than they are of other stages, an inference that probably should be modified by other biological considerations. At Onderstepoort, both larvae and nymphs feed readily on guinea-pigs (Theiler, correspondence).

Questionable remarks and conclusions: Lewis (1932A), after examining Roberts' specimens from rodent burrows, concluded that larvae feed less readily on rodents than do nymphs. Supporting data were not provided but, unless we are still unaware of some unique phase in the life cycle of this tick, it appears that in East Africa, at least, larvae and nymphs attack the same host. Data from collections made throughout the entire year will be necessary before other conclusions can be drawn.

Lewis (1932A) noted a number of larger mammals, from the size of porcupines to rhinoceros, as nymphal hosts, and Stella (1939B) indicated guineafowl. Reidentification of pertinent material is indicated. The Onderstepoort collection (Theiler, correspondence) contains a single collection of nymphs from a red hartebeest in Natal.

Lounsbury (1904A) "wholly failed in attempts to rear larvae on dogs, not one of many thousands applied having fed to repletion", but later (1906C) succeeded in doing so. The ox was considered an unsuitable host for larvae but "nymphs and adults do not appear to dislike cattle".

Around Lourenco Marques, Sant'Anna (1911) noted, larvae of R. s. simus are encountered and so is a human disease, possibly that now called boutonneuse fever, following tick bites. Subsequent reviewers have elaborated this remark to indicate that larval simus bite man, and the more enthusiastic have quoted this report as stating that the larvae transmit boutonneuse fever.

BIOLOGY

Life Cycle

Laboratory studies indicate that *R. s. simus* undergoes a three-host type of life cycle.

Under experimental conditions, Theiler (unpublished), Lewis (1932A), and Lounsbury (1905) have found the life cycle periods to be as follows:

PERIOD	DAYS			°C. TEMPERATURE
	Theiler	Lewis	Lounsbury	Lewis
Oviposition to hatching	20-24	31		21-27
Larval prefeeding period	3	7		
Larva feeds	2- 5	3	2	
Premolting period	8-12	11	6	23-26
Nymphal prefeeding period	14	7		
Nymph feeds	3-11	5	3	
Premolting period	13-21*	27	14	21-25
Adult prefeeding period	7	7		
Female feeds	7-24	7	9	
Preoviposition period	3- 6	6		23-26
	80-125	111		

Note: Theiler rearings at 24°C. to 26°C. and approximately 80% R.H.

Hares were used as hosts for all stages in Lewis' experiments, though not with great success. The ease with which these observations could be repeated using normal hosts and normal conditions of temperature and humidity found in rodent burrows suggests an interesting study for collecting comparative data.

Field observations indicate that both immature stages feed on nest-inhabiting rodents. The nymphal-adult molt occurs in the same nest, and adults remain in the nest for some time before seeking larger hosts. As discussed below, a considerable amount

*2 months in winter.

of additional field study is required to answer many questions concerning the life cycle of R. s. simus. This tick and H. leachii are the only ubiquitous African species that in their immature and adult stages, respectively, feed first on nest-inhabiting rodents and then on larger animals. More rigid field observations, besides being a most pleasurable occupation, should be easily accomplished.

In the following paragraph the question of where the female oviposits is raised. In this connection, Howard's (1909B) observation of an unengorged male and female of R. simus (= R. ecinctus) mating on the leaf of an Acacia thorn tree on the Zambesi River is of special interest (although the possibility of misidentification of these specimens must be considered). Almost invariably, rhipicephalid ticks mate on the host, as do most other ixodids. Howard's note indicates the necessity of further research to determine whether R. s. simus possesses a unique type of mating and egg laying, and, if so, whether this is a constant or an exceptional phenomenon, and whether it is associated with an ability of larvae to seek out their preferred habitat and hosts rather than waiting for a passing rodent.

Mating observed by J. B. Walker (correspondence) in Kenya has been of the ordinary rhipicephalid type, on the host. Walker also says that engorged females that have already dropped from the host will mate with males that have been feeding on the same host and then removed and placed with these females. This might be merely a mating act and not initial or essential fertilization (HH), for generally, it appears, female engorgement is not complete or normal unless copulation has been effected.

Ecology

From Roberts' (1935) studies in the Nairobi area it appears that the immature stages of R. s. simus prefer slightly subsurface rodent nests rather than deeper nests of the same and of other kinds of rodents. The grass rat, Arvicanthis, is possibly the most important immature stage host. It is not known whether larvae actually seek out the nest and attack the animal there, or whether they attach to a rodent wandering in search of food and are then carried to any nest that their host might be inhabiting. It would be contrary to all previous observations on ixodids to assume that the female selects the situation in which she oviposits, although this possibility must be investigated.

By way of comparison, immature stages of H. leachii in the Nairobi area prefer deeper nests of Mastomys coucha. In the Njoro area of Kenya and in the Sudan, however, we have taken larvae and nymphs of these two ticks species in both shallow and deeper nests.

Arvicanthis nests are usually within a foot of the surface of the ground, but sometimes they are two or three times as deep. The nest is reached by a network of a few or many tunnels, each with a small exit among vegetation. The round nests, composed of lesser or greater amounts of moist grass and leaves, appear to be occupied for several generations. Slight rises, such as borrow heaps, mounds beneath bushes, or pathsides are favorite burrowing sites. These rodents frequently nest and search for food in close association with human activities.

Habitats of some of the chief South African hosts of immature stages (see HOSTS above) differ widely. Aethomys namaquensis frequents rock crevices and piles of stones while A. chrysophilus is more terrestrial and lives in sheltered bush on the plains, among rocks, or in burrows under bushes or rocks. Otomys lives in holes in the ground or in selfmade shelters in matted vegetation; those in the Karroo construct these shelters from large piles of weeds while others utilize small grass or weed nests in marshes or among rocks. Rhabdomys hides in holes in the ground and its pathways run through dense vegetation. It is evident, therefore, that the usual ecological niches of hosts of immature stages in East Africa differ from those in southern Africa.

In southern Africa, Theiler (unpublished) finds that the glossy tick occurs from the eastern tall grass veld (Port Elizabeth) northwards through subtropical overgreen and deciduous tree and thorn forest into northern Transvaal, Southern Rhodesia, and Mozambique. In these subtropical stretches, the heavy rainfall areas of Natal are comparable with the coastal plains of Kenya, and the dry, warm conditions in Kruger National Park and northern Transvaal are comparable with central Kenya (see next paragraph). Records indicate this tick to be less common west of the Drakensberg escarpment, but to occur up to 10,000 feet elevation in Basutoland. It is common in Highveld with good annual rains, heavy frost, and snow in winter but seldom recorded from dry Highveld. In the mixed grass veld of the middleveld, with ten to 25 inches of rainfall annually and cold, sharp winter frosts, it is almost entirely absent, though it does occur in southern Transvaal middleveld. It is numerous in the Bankenveld and Limpopo highlands and also in Bushveld regions of Transvaal. In Karroo areas it dies out in areas with less than ten inches of rainfall annually. Records from Southwest Africa are only from the northern, more moist areas. In Southern Rhodesia, it is especially common in eastern and northern areas.

In the hot, more or less humid, coastal lowlands of Kenya, R. s. simus is especially common (Wiley 1953). Dick and Lewis (1947) consider this to be the most abundant and widely distributed tick in the Kenya coastal lowlands and Wilson (1953) also notes its frequency there in areas where R. pravus and A. gemma are found (cf. pages 681 and 274). In the arid Northern Province of Kenya, the glossy tick is less common than elsewhere in the Colony, but it does occur anywhere under a variety of conditions, whether these be hot and arid, cold, damp high altitudes, or hot, moist coastal lowlands (Wiley 1953). Theiler (1943B), supported by subsequent remarks by Santos Dias, noted that R. s. simus is not only particularly abundant but actually the most ubiquitous tick in some parts of Mozambique.

Study of data for the Somalilands, in the coastal areas just north of Kenya, suggests that R. s. simus is common only under local conditions in these less humid areas. From details published by all investigators concerning the Belgian Congo it would appear that in most parts of the colony this tick is decidedly less common than it is in southern Sudan.

In the Sudan, R. s. simus is common everywhere in the south and at least frequent in southcentral areas. It becomes more localized and uncommon with the approach of semidesert conditions. Many areas in which it occurs have a long, severe dry season but rainfall of twenty to almost fifty inches annually during the wet season. King (1926) noted that although this tick is absent in the desert areas of Northern Province, populations had established themselves there when local conditions of humidity were modified after pump and basin irrigation was introduced.

Altitudinal distribution in Kenya is from sea level to 11,000 feet (Lewis 1932A). Lewis (1931C) considered this species as one relatively little affected by conditions influenced by altitude. In Ruanda-Urundi, the glossy tick ranges to about 5600 feet altitude (Schoenaers 1951B). Neumann's (1907C,1910B) Tanganyika records include specimens from altitudes up to about 6000 feet. In Arabia this tick is known only from the temperate, watered 3500 foot to 7000 foot range of the Yemen mountains but not from drier and hotter lowlands (Hoogstraal, ms.).

The seasonal cycle of R. s. simus is not well known. During the colder months of the year, Wilson (1946) found no adults in Northern Province, Nyasaland but his collections were mostly from cattle, which are not common hosts there. Engorged females were found during the wet season (Wilson 1950B). In the Sudan newly molted adults were collected in rodent nests during the dry season and engorged adults on larger hosts chiefly during the dry season. In Northern Rhodesia, Matthysse (1954) found adults on cattle chiefly during the rainy season, but some also in dry periods. The emergence of adults and the length of time they normally remain in their host's nest at different seasons of the year should be investigated.

On cattle, adults of R. s. simus are usually found on the tail switch, feet, and anus (Theiler 1943, Wilson 1948B, Matthysse 1954). On dogs they feed almost anywhere, as noted by Theiler (1943B) and Wiley (1953). Our Sudan specimens from hippopotamus were all found on the hosts' ears. Neumann's thirty specimens from a Kenyan rhinoceros were taken from the host's inguinal area.

Adults awaiting a host show "a marked predilection for tall grass overhanging paths, but are common everywhere", including in human habitations, where they were associated with boutonneuse fever by Dick and Lewis (1947). They are also found in houses in Somaliland (Drake-Brockman 1913B, Veneroni 1928), where they bite children and cause paralysis. The close association between the glossy tick and man is easily understandable. Adults are common on domestic dogs and less frequently, under local conditions, on cattle. The immature stages feed on rodents that frequently nest under vegetation bordering garden plots and cultivated fields, beside roads and paths, near buildings, or in the vicinity of streams where people congregate. Many of these rodent hosts are also attracted to man's agricultural activities and the adult ticks frequent tall grass in search of hosts. All these factors bring man and tick closer together.

When dragging for ticks in Nyanza Province of Kenya, Lewis (1931C) obtained adult glossy ticks only in shady woodlands while the other species, R. appendiculatus, A. variegatum, and H. leachii were obtained from open country with grass and bushes.

In Moreau's (1933) study of the food of the tickbird, Buphagus erythrorhynchus (Stanley), in Tanganyika, fifteen specimens of R. s. simus were found in the stomachs of four of 58 birds examined. In Kenya, van Someren (1951) examining the stomachs of twelve of the same kind of bird found four females in two of them. He found seven adults in three out of seven stomachs of B. a. africanus.

DISEASE RELATIONS

MAN: Boutonneuse fever (Rickettsia conorii). Paralysis (?toxin).

CATTLE: East Coast fever (Theileria parva). Gallsickness (Anaplasma marginale). Redwater (Babesia bigemina).

PIGS : Piroplasmosis (Babesia trautmanni).

SHEEP: Not a vector of Nairobi sheep disease (virus).

[CARNIVORES: Statements that R. simus may transmit Babesia gibsoni among jackals and dogs and B. felis among pumas are based on errors in tick identification and on errors in quoting original reports.]

REMARKS

Misshapen specimens have been reported by Santos Dias (1947B, 1955A). In the latter paper, a gynandromorph is also described and illustrated.

Symbiotes have been reported by Cowdry (1925C,1926A,1927) and reviewed by Jaschke (1933).

Dinnik and Zumpt (1949) reported on larval integumentary sense organs in relation to those of nymphs and adults as well as of other species.

The "R. simus group" of Zumpt (1942A) consists of the species R. simus with two subspecies simus and senegalensis, and of several related species, R. longicoxatus, R. lunulatus, R. tricuspis, R. distinctus, R. p. planus, and R. p. complanatus, R. simpsoni, and R. reichenowi (probably = R. zumpti Santos Dias 1950B). These are all Ethiopian Faunal Region species. Zumpt also included the Indo-Malayan species R. h. haemaphysaloides and R. h. pilans, but I hesitate so to consider them.

The outstanding diagnostic criterion of the R. simus group is a scutal pattern of few large, fairly deep punctations arranged in about four more or less regular, individually characteristic, longitudinal rows. Among these, interstitial punctations are usually inconspicuous. Adanal shields of males of each species are distinctive. Female scutal patterns may be more variable and those of certain closely related species or subspecies may be difficult to differentiate.

Actually, R. s. sanguineus conforms to this group criterion and might well be considered as a member of the R. simus group. It would then also be much easier to associate the Indo-Malayan species, mentioned above, with this group. Theiler (correspondence) writes that she agrees with this view. Santos Dias (1952C) has considered this group differently.

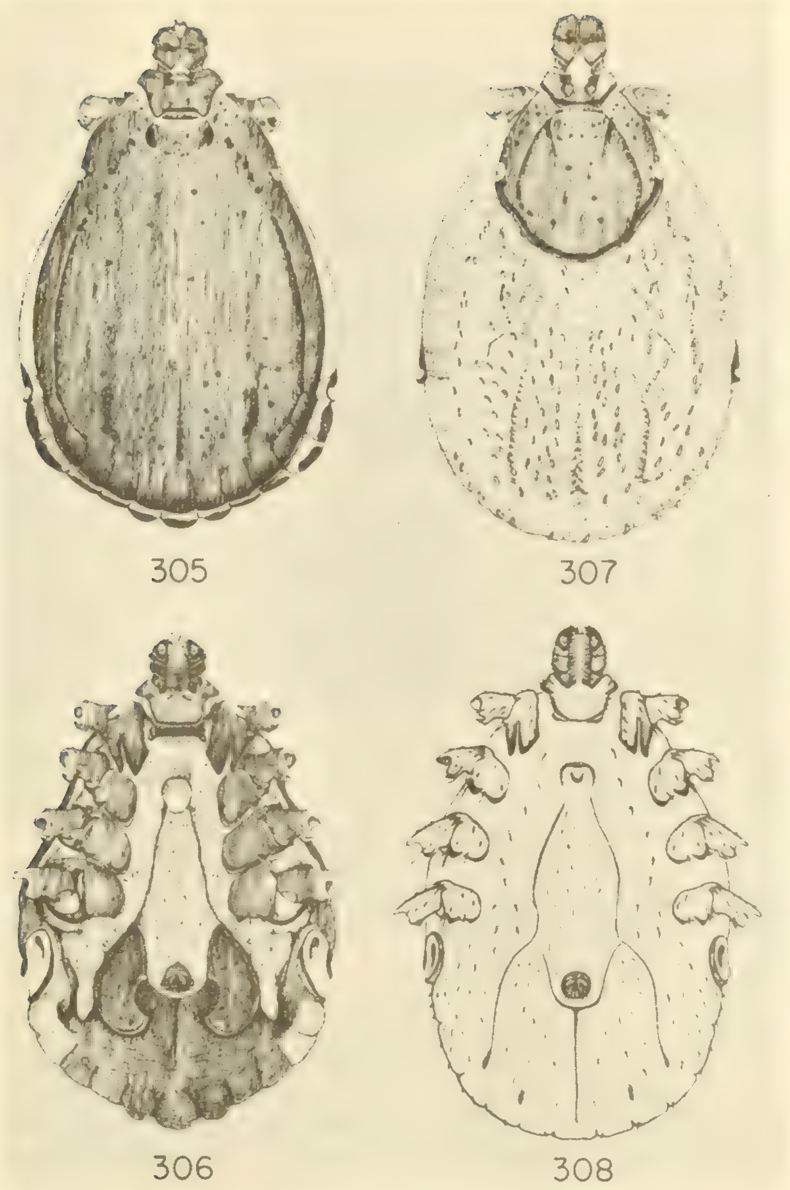
IDENTIFICATION

Males: This sex is easily recognized and extremely few specimens ever cause doubt as to their identity. The group criterion of four more or less regular rows of rare scutal punctations is always definite, but their distribution and depth are somewhat variable. Although interstitial punctations are usually faint or obsolete, a few specimens show them more distinctly, though never enough to confuse the picture. Posteromedian and paramedian grooves are absent; rarely they are just barely discernible, but never pronounced. This latter fact is an important distinction between R. s. simus and those specimens of R. s. sanguineus that otherwise closely approximate R. s. simus in appearance. The scutum is arched and usually shiny black, less commonly reddish brown or reddish yellow, with definite, deep lateral grooves and clear festoons. The central festoon may protrude with engorgement. A hump of coxa I projecting dorsally frequently is large enough to resemble a pointed projection, but closer inspection indicates its bluntness. Ventrally, the shape of the adanal shields, with their rounded external and internal margins, is usually characteristic; but in some specimens, in which they are abnormally narrow and with a deeply concave inner margin, they approach the sickleshape of the subspecies senegalensis. Size is extremely variable, running from minute (1.9 mm. long - rarely) to well over 5.0 mm. long.

Female: The outline of the black (rarely reddish) scutum is subcircular with a broadly rounded, slightly sinuous posterior margin; the length-width ratio is approximately equal or slightly wider than long. Punctations are normally rare but may be somewhat heavier and more distinct than in the male. Interstitial punctations are rare and inconspicuous, or absent; rarely they are somewhat pronounced and slightly confuse the typical picture of this species. Lateral grooves are of variable distinctness and length; frequently they are extended posteriorly by a few punctations; in some individuals they are much reduced. The converging and thence diverging cervical grooves usually clearly extend to or almost to the posterior margin, but may be obsolete on the posterior third of the scutum. Lateral fields usually contain two or three punctations; eyes are flat. Size is variable with tremendously engorged individuals reaching 15.0 mm. in length.

Most females are easily keyed but those with reduced lateral grooves are apt to be confusing. Females of the subspecies simus and senegalensis are quite similar.

The nymph and larva have been described and illustrated by Theiler (1943).



Figures 305 and 306, ♂, dorsal and ventral views
Figures 307 and 308, ♀, dorsal and ventral views

RHIPICEPHALUS SIMUS SENEGALENSIS
Sudan Specimens

PLATE LXXXV

RHIPICEPHALUS SIMUS SENEGALENSIS Koch, 1844.

(Figures 305 to 308)

THE SCIMITAR-SHIELDED GLOSSY TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
		5	5	Nimule	*Lycaon pictus somalicus*	Jul	(SVS)
			1	Kapoeta*	*Hippotragus equinus bakeri*	Dec	
		1	17	Boma Plains**	*Syncerus caffer aequinoctialis*	Dec	
			2	Holo	*Syncerus caffer aequinoctialis*	Mar	
			3	Mongalla	*Syncerus caffer aequinoctialis*	-	(SGC)
			4	Kheirallah	*Syncerus caffer aequinoctialis*	Mar	(SGC)
			1	Lugurren	*Phacochoerus aethiopicus bufo*	Jan	
		10	15	Sunat	*Phacochoerus aethiopicus bufo*	Apr	
		3	4	Kheirallah	*Phacochoerus aethiopicus bufo*	-	(SGC)
			2	Bundle (Lado)	domestic dog	Mar	(SGC)
		4	4	Magwe	on grass	May	(SVS)
		4	4	Mvolo	on grass	-	(SGC)
		1	3	Mvolo	on grass	Jul	(SVS)

Specimens in the Sudan Government collection noted above were collected by H. H. King in 1910 and 1911. They had been identified as *R. simus* and as *R. falcatus*.

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: 1♂, 1♀ from buffalo, Guar, Galual-Nyang Forest, *8 June 1953*, P. J. Henshaw *legit*. 1♂, and 5♂♂ and 18 ♀♀

---

*Collected with 3♂♂ and 1♀ *R. simus simus*. This is the only collection seen from anywhere *in Africa in* which typical specimens of both subspecies have been found on a single host. The host was obviously a migrant.

**For comment, see BIOLOGY below.

from two warthogs, same locality as above, 7 June 1953, and 8 January 1954, collected by E. T. M. Reid and P. Blasdale. Numerous other specimens collected in the same area in July by the same persons, but without host data. 1♂, 2♀♀, recently molted clinging to grass (with Dermacentor rhinocerinus), 25 miles west of Yirol, 23 November 1954, E. T. M. Reid legit. 10♂♂ and 22♀♀ (some of which intergrade with R. simus simus) (cf. IDENTIFICATION below), from elephant near Kenisa, May 1953, E. T. M. Reid legit. Sudan Government collections contain other Kenisa area specimens from elephants, collected in 1911, which show similar intergradation with R. s. simus (cf. REMARKS below). Mr. Reid has sent me numerous specimens from three elephants shot near Yirol; these are typical R. s. simus.

DISTRIBUTION

R. simus senegalensis is a West and Central African tick with scattered loci in more humid areas of East Africa as far south as northern Nyasaland.

WEST AFRICA: NIGERIA (Unsworth 1952. As R. simus: Simpson 1912A, p. 325; det. by Nuttall and Warburton as R. simus falcatus; see p. . As R. simus longoides: Unsworth 1949, Mettam 1950, Gambles 1951). FRENCH WEST AFRICA (Koch 1844. Rousselot 1951, 1953B. As R. simus longoides: Villiers 1955). SIERRA LEONE, IVORY COAST, GOLD COAST, TOGO (Zumpt 1943A*). PORTUGESE GUINEA (Tendeiro 1952B,C,1953,1954).

CENTRAL AFRICA: CAMEROONS (Zumpt 1943A*. Rageau 1951,1953A, B). FRENCH EQUATORIAL AFRICA (Zumpt 1943A*. Rousselot 1951). BELGIAN CONGO and RUANDA-URUNDI (?As R. simus shipleyi: Bequaert 1930B,1931. Zumpt 1943A*. Rousselot 1953B. Theiler and Robinson 1954. Van Vaerenbergh 1954. See HOSTS below).

EAST AFRICA: SUDAN (In part as R. simus and as R. falcatus: King 1926. Hoogstraal 1954B,C). UGANDA and TANGANYIKA (Hoogstraal 1954C. J. B. Walker, unpublished; see HOSTS below).

---

*All Zumpt (1943A) records are under R. simus longoides subsp. nov. which Zumpt (1950A) later synonymized under R. simus senegalensis.

SOUTHERN AFRICA: NYASALAND (As R. falcatus: several specimens, Nuttall lot 1099A in BMNH, with numerous R. longus, from Chitipa Valley, Dowa District, 1910, J. B. Davey legit).

NOTE: Koch's (1844) record from Egypt, subsequently quoted by numerous authors, is either based on a mistaken locality label or on a specimen of R. s. sanguineus. Koch based his original description on females, only, from Senegal (French West Africa) and Egypt. See REMARKS below.

HOSTS

Like the subspecies simus, R. simus senegalensis attacks a variety of larger game and domestic animals. The immature stages probably feed on rodents, but no data concerning their host preferences are available.

Domestic animals: Cattle (Zumpt 1943A*, Rousselot 1951, 1953B, Unsworth 1952, Rageau 1953B, Hoogstraal 1954C**). Horses (Nuttall lot 182 in BMNH, see NIGERIA above. Zumpt 1943A*). Pigs (Rousselot 1951,1953B, Rageau 1953B). Sheep (Rousselot 1951,1953B). Dogs (Rousselot 1951,1953B, and Uganda and Sudan records above).

Wild animals: Bushpig (Zumpt 1943A*). Warthogs (Nuttall lot 1099A, see NYASALAND above. Rousselot 1951,1953B. Sudan records above. Uganda specimens in BMNH). [?Giant eland (Bequaert 1930B,1931, see BELGIAN CONGO above)]. Wildebeest (Walker, unpublished). Bongo (Rageau 1951). Roan antelope (Sudan record above). Buffalos (Hoogstraal 1954C**, Van Vaerenbergh 1954, Villiers 1955, Theiler, unpublished. Walker, unpublished. Sudan records above). Forest dwarf buffalo (Tendeiro 1952B,C,1953,1954). Elephants (Common hosts in Bahr El Ghazal; recorded above). Hunting dog, Lycaon pictus (Sudan record above). Lion (Congo specimens in MCZ and HH collections).

---

*All Zumpt (1943A) records are under R. simus longoides subsp. nov. which Zumpt (1950A) later synonymized under R. simus senegalensis.

**My 1954C report of domestic cattle should be wild buffalo ("Bos caffer" on label).

NOTE: Rousselot (1951,1953B) records specimens from the cane rat, *Thryonomys swinderianus*. These specimens should be checked against *R. simpsoni*. In the same reports he states that the short-haired rat, *Praomys jacksoni*, is a host in the Belgian Congo. Unless this note refers to parasitism by an immature stage, this animal would be a most unusual host. Santos Dias (1952C,1953, 1954) states that one nymph along with many males has been taken from a forest dwarf buffalo.

BIOLOGY

Life Cycle

It cannot be determined whether the life cycle data presented by Rousselot (1953B, p. 92) under *R. simus senegalensis* concern this subspecies or the subspecies *simus*; other remarks under the same heading refer obviously to the subspecies *simus*. Unfortunately, no clues to the life cycle of *R. simus senegalensis* in nature are available. Rousselot (1953B, p. 91) claims that this is a three-host subspecies.

Ecology

This is a tick of West African higher rainfall areas. Populations that range into East Africa appear to be confined to animals found in forests, in more heavily vegetated savannah, and in the vicinity of lakes. The Boma Plains buffalo on which some Sudan specimens were taken was probably a migrant, for the Boma Plains are too arid for many months of the year to allow this tick to survive.

According to Unsworth (1952), in Nigeria the subspecies *senegalensis* "appears to have approximately the same distribution as ... *simus*, but it is not so common".

DISEASE RELATIONS

It is claimed that specimens of *R. simus senegalensis* naturally infected with Q fever (*Coxiella burnetii*) have been found in Portugese Guinea.

REMARKS

Koch (1844) based his original description on females only. His material was reported as from Senegal and Egypt. It is most likely that the Egyptian record is due to a mistaken locality label. Just how the Senegal specimen has been associated with what is today called *R. simus senegalensis* has not been determined. A female specimen of the *R. simus* group from Koch's time would be difficult to identify with any degree of certainty, especially to subspecies. Neumann (1911) synonymized *senegalensis* under *R. simus*. Zumpt (1943A,1950A) described what is now considered as *R. simus senegalensis*.

A number of the Sudan and Tanganyika collections listed herein were sent to Santos Dias for identification, along with some specimens of *R. longus*. The *R. simus senegalensis* material was determined by him as *R. longus* and the *R. longus* material was labelled *R. capensis pseudolongus*.

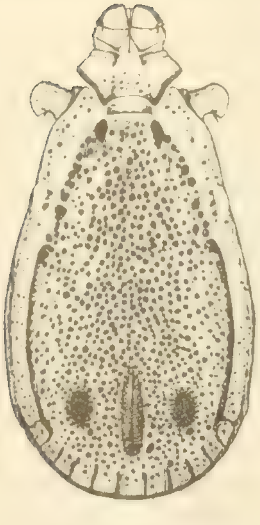
Zumpt (1943A,1950A) warns his readers that heavily punctate *R. simus senegalensis* may superficially resemble *R. longus*. The *R. longus* of Santos Dias (1953D) appears to be what Zumpt considers a heavily punctate *R. simus senegalensis*.

A further note is necessary concerning collections listed above as *simus-senegalensis* intergrades from elephants near Kenisa, Bahr El Ghazal Province. These are comparatively small, brownish specimens, with *simus* scutal punctation, posteromedian and paramedian grooves absent or very faintly indicated, and adanal shields showing every degree of variation from the most typical *simus* type to the most typical *senegalensis* type. These series nicely corroborate Zumpt's treatment of *senegalensis* as a subspecies of *simus*.

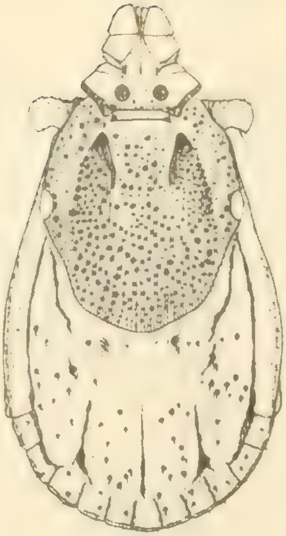
IDENTIFICATION

Male: Within the *R. simus* group, as described in the key and under *R. simus*, males of the subspecies *senegalensis* are referred to a group with sickleshaped adanal shields. The scutal outline is definitely wider in relation to length than in most specimens of *R. s. simus* and the scutal surface is flat, not arched as in the subspecies *simus*. The posteromedian groove is long and narrow, the paramedian grooves are shorter and wider; these three grooves vary in depth and distinctness from specimen to specimen but are never deep or strikingly apparent. The distribution of large scutal punctations is an important criterion in distinguishing this tick. On the anterior three-fifths of the scutum, large or moderate size punctations are arranged in four irregular rows of three to six puncations each. On the posterior two-fifths, there are from six to twenty large punctations in one and a half to three irregular, closely grouped rows on either side of the posteromedian groove. Scattered about the paramedian grooves are four to eight scattered large punctations. The interstitial punctations are always very shallow but they may vary in distinctness from almost absent to large enough (though still superficial) initially to confuse the basic pattern of large punctations as described above. On close examination, however, this pattern is easily discernible. The lateral grooves are usually deep and long. One or three median festoons may protrude when engorged. The average size is that of the largest *R. s. simus* and the color, while usually jet black, may also be brownish, especially in smaller specimens.

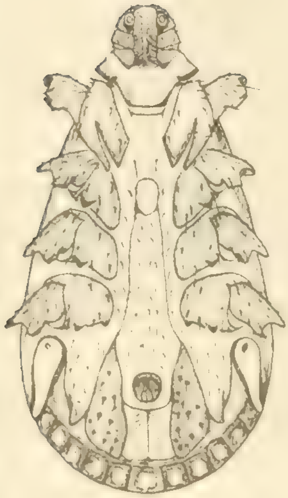
Female: This sex is difficult to distinguish from that of the subspecies *simus*, but in general its larger size, similarity of scutal punctation in comparison with that of the male, and its association with the male refers most specimens to the subspecies *senegalensis*.



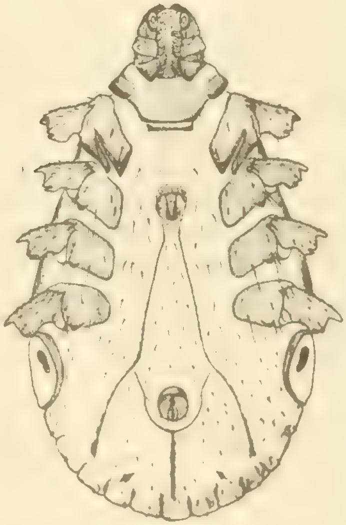
309



311



310



312

Figures 309 and 310, ♂, dorsal and ventral views
Figures 311 and 312, ♀, dorsal and ventral views

<u>RHIPICEPHALUS SULCATUS</u>
Sudan Specimens

PLATE LXXXVI

RHIPICEPHALUS SULCATUS Neumann, 1908.

(Figures 309 to 312)

THE GROOVED BROWN TICK

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: 2♂♂ from an oribi, *Ourebia ourebi* subsp., near *Tonj*, *18 March* 1953, N. A. Hancock *legit*. 1♂♂, 3♀♀ from chest of leopard, *Panthera pardus* subsp. and 1♀ crawling on leg of man, Alel, 36 miles south of Yirol, 18 March 1953, E. T. M. Reid *legit*. These specimens are in the HH collection.

These are the only definite records of *R. sulcatus* from the Sudan. Those reported by King (1926) have proven, upon examination of his specimens by Dr. Theiler, to be *R. s. sanguineus*. A single male was *R. supertritus*.

DISTRIBUTION

(Known Correct References)

As now known, the range of *R. sulcatus* extends from the Congo and southwestern Sudan to Nyasaland. Whether this distributional picture is more restricted than this tick's range in nature remains to be seen.

CENTRAL AFRICA: "CONGO" [Type locality as stated by Neumann (1908). According to Bequaert (1931) this probably refers to French Equatorial Africa (French Congo) but Theiler and Robinson (1953B) refer it to the Belgian Congo.]

EAST AFRICA: SUDAN [Hoogstraal (1954B). Material identified by Dr. G. Theiler.]

TANGANYIKA [A few actual ♀♀ *R. sulcatus* among *R. s. sanguineus* collection reported as *R. sulcatus* by Zumpt (1942B); see Theiler and Robinson (1953B).]

SOUTHERN AFRICA: NORTHERN RHODESIA (Theiler and Robinson 1953B,1954). NYASALAND (♀ from Chitala, Theiler and Robinson 1953B).

Known Incorrect References

FRENCH WEST AFRICA: Rousselot (1951) reported specimens of "*R. sanguineus sulcatus*", which, as illustrated (1953, figure 37), represent a typical ♂ and ♀ of *R. s. sanguineus*.

BELGIAN CONGO: Bequaert's (1931) "*R. sulcatus*" is *R. longus* according to Zumpt (1942B) and confirmed by Theiler and Robinson (1953B).

SUDAN: The material reported by King (1926) as *R. sulcatus* has been identified by Dr. Theiler as *R. s. sanguineus* (Sudan Government collections). The specimen from a dog at Bor is *R. supertritus*.

TANGANYIKA: Zumpt (1942B) in part. See *Known Correct References* above.

Questionable References

FRENCH WEST AFRICA: Adults provisionally identified, from goats at Dakar (Theiler and Robinson 1953B). CAMEROONS: Rageau (1953A,B). UGANDA: Two doubtful ♀♀ mentioned by Theiler and Robinson (1953B). Mettam (1932) recorded a puff adder as host. BELGIAN CONGO: Schwetz (1927C); specimens need checking. NORTHERN RHODESIA: Adults from hares, civet, and genet (Matthysse 1954). SOUTHERN RHODESIA: Jack (1921,1928,1942); specimens need checking. MOZAMBIQUE: As R. *sanguineus punctatissimus*: (Santos Dias 1952H). SOUTHWEST AFRICA: Questionable ♀ mentioned by Theiler and Robinson (1953B). UNION OF SOUTH AFRICA: Cooley (1934); specimens need checking.

HOSTS

(From Known Correct References Only)

Hare (*Lepus saxatilis*) and two leopards (Theiler and Robinson 1953B). Leopard (Zumpt 1942B). An oribi and a leopard, also one crawling on leg of *man* (Sudan records above).

BIOLOGY

Life Cycle

The developmental periods under summer laboratory conditions have been reported by Theiler and Robinson (1953B) to be:

PERIOD	DAYS
Preoviposition to larval hatching	44
Larva feeds	3 to 5
Postfeeding period	8 to 18
Nymph feeds	5 to 16

Adults did not attach. The laboratory hosts were guinea pigs (Theiler, correspondence).

Ecology

Unstudied.

DISEASE RELATIONS

Unstudied.

REMARKS

Zumpt (1942B) included *R. sulcatus* in the *R. capensis* group, which is represented in the Sudan also by *R. longus* (see page 665) and *R. supertritus*.

The original specimens of *R. sulcatus* are in collection number 1439 of the Veterinary School of Toulouse.

Santos Dias (1952H) considers *R. sulcatus* Neumann, 1908, to be a synonym of *R. sanguineus punctatissimus* Gerstäcker, 1873, which Zumpt (1950A) considers to be a synonym of *R. s. sanguineus*. Inasmuch as the original description of *R. sanguineus punctatissimus* is not sufficiently detailed satisfactorily to settle this question, and the type specimens have not been examined by Santos

Dias, the more conservative approach of Zumpt for this difficult problem is utilized here.

Theiler and Robinson (1953B) stress the difference between this species and R. capensis Koch, 1844, and R. serranoi Santos Dias, 1950, two ticks not known to occur in the Sudan. In our territory, R. sulcatus is easily differentiated from all species but R. s. sanguineus in its coarser forms. In northern Sudan and usually in Central Sudan, R. s. sanguineus is usually not coarse enough to be confused with R. sulcatus, but in southern areas both species may superficially resemble each other. Although Neumann's original description of R. sulcatus, together with its illustration, was excellent, the perplexing variation in R. s. sanguineus and the previously unrecognized fact that the latter species has a pattern of large punctations, no matter how densely punctate it may be, has long confused the real identity of R. sulcatus. We have spent dozens of hours trying to differentiate among hundreds of collections of R. s. sanguineus before the arrival of R. sulcatus specimens from Dr. Theiler's reared series. Afterwards, no question concerning their specific differences remained.

If one turns a questionable male obliquely to the light, punctations of coarse R. s. sanguineus will be observed to be relatively shallow, mostly nondiscrete and sloping. Most important, a few more or less clearly defined rows of widely-spaced, large, deeper, punctations will be noted among the shallower interstitial punctations. In R. sulcatus no row formation of large punctations is present, large punctations are numerous and deep, and medium size punctations are also deep. Specimens, if well preserved, should be briskly rubbed with damp tissue paper until their surface shines in order best to distinguish these characters.

In females, the relative isolation of large punctations among small or medium size ones usually differentiates R. s. sanguineus from R. sulcatus in which large and medium size punctations are indiscriminately scattered. The actual relatively greater length of the sulcatus scutum, which gives a first impression of being even longer than it is, easily distinguishes most specimens. Some variable R. s. sanguineus females may so closely approximate this elongate scutal appearance that care must be used when applying this character.

Material referred to as R. sulcatus by Enigk and Grittner (1953), in their remarks on the breeding and biology of ticks, should be re-examined for identity.

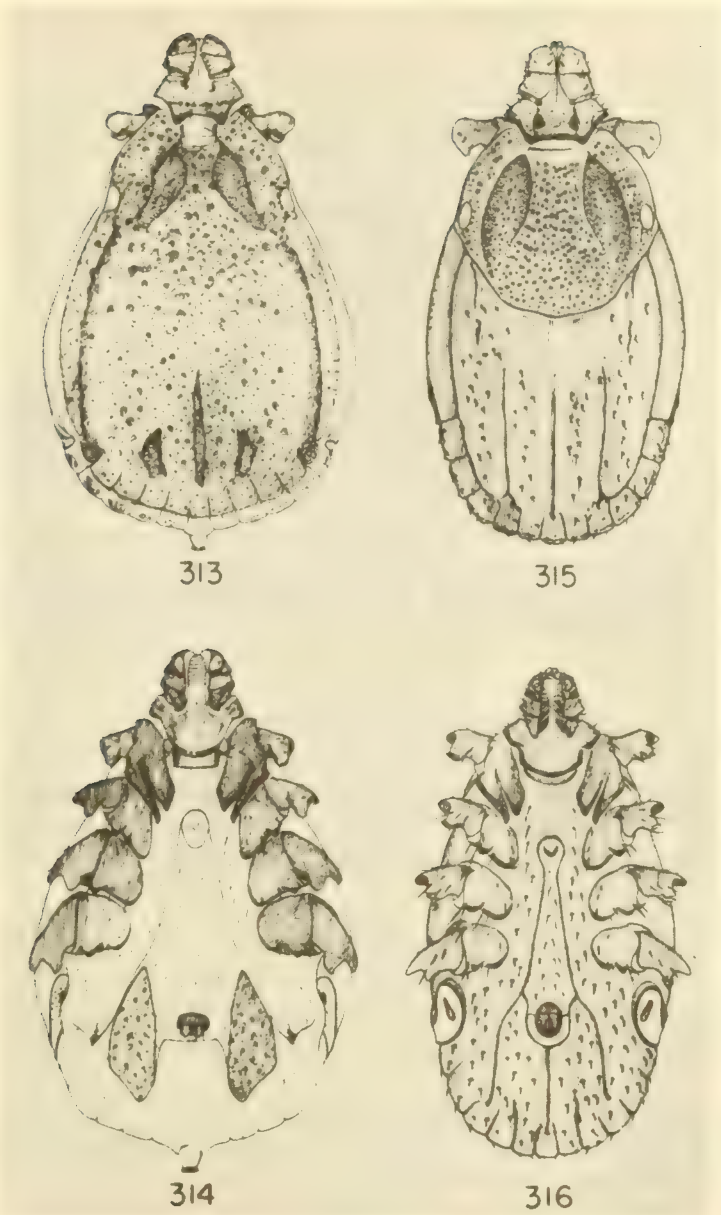
IDENTIFICATION

The diagnosis presented below is modified from Theiler and Robinson (1953B).

Male: Size small, averaging 2.5 mm. long and about 1.5 mm. wide (Neumann's specimens from 2.9 mm. to 3.4 mm. long and from 1.5 mm. to 1.8 mm. wide). Scutum narrow anteriorly, widening posterior of level of eyes, surface slightly convex, shiny. Lateral grooves discrete and pronounced, may contain large punctations; in some specimens extended to include penultimate festoon. Posteromedian and paramedian grooves widely elongate, wrinkled. Punctations deep, medium to large size, dense, some confluent; fewer laterally but some on festoons, scapulae, and lateral folds. Eyes flat, may be bounded by a few large punctations. Coxa I may have a dorsal, unpointed hump. Basis capituli one and a half to two times as wide as long, with pronounced lateral angles at anterior third of length (Neumann's original, frequently reproduced illustration of this species shows the basis capituli extremely wide and pointed, most probably the artist's impression, drawn foreshortened, gained from a downward-pointing capitulum). Adanal shields typically like those of large R. s. sanguineus but in some specimens they may be more elongately rounded and the inner margin emarginate (as is common in smaller R. s. sanguineus); an approach to the sickleshape is seen in a small Sudan male.

Female: Medium size, unengorged about 3.00 mm. long and 1.75 mm. wide (Neumann: 3.0 mm. x 1.5 mm.). Scutum flat, shiny, rich brown, emargination wide; as broad as long or slightly longer than broad, but appearing long due to the pronounced lateral grooves and the somewhat tapering, sinuous posterior margin (Neumann: 1.5 mm. x 1.25 mm.). Cervical pits short, deep; cervical grooves short and inconspicuous. Lateral grooves pronounced, with external ridge, and picked out with irregular punctations which may be confluent. Eyes large, flat, flush with surface, may be bounded dorsally by a few large confluent punctations. Punctations medium to large, deep, somewhat unevenly densely scattered, sometimes confluent, extending onto lateral folds. Basis capituli about three times as broad as long; cornua short, blunt points; lateral angles fairly sharp at midlength; surface not so heavily punctate as in male; porose areas circular, a little more than their own diameter apart. Palpi slightly longer than basis capituli and twice as long as broad, segments 2 and 3 as long as broad, segment 1 visible dorsally.

The larva and nymph have been described and illustrated by Theiler and Robinson (1953B).



Figures 313 and 314, ♂, dorsal and ventral views
Figures 315 and 316, ♀, dorsal and ventral views

RHIPICEPHALUS SUPERTRITUS
Sudan Specimens

PLATE LXXXVII

RHIPICEPHALUS SUPERTRITUS Neumann, 1907(B).

(Figures 313 to 316)

THE EAST-AFRICAN SHAGREENED TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORDS			
		1	2	Kajo Kaji	*Syncerus caffer aequinoctialis*	Jan	
		1	1	Juba	*Syncerus caffer aequinoctialis*	Nov	(SVS)
			1	"Alangu-Acholi"	*Syncerus caffer aequinoctialis*	-	(SGC)

The male in the Sudan Government Collection, collected by H. H. King, had been identified by him as *R. falcatus*. The collecting locality of this specimen may now be just inside the Sudan or just over the Uganda border.

DISTRIBUTION IN THE SUDAN

Upper Nile: Sudan Government collections contain a male specimen, collected from a dog at Bor by H. H. King, which had been identified and reported by him (1926) as *R. sulcatus*.

DISTRIBUTION

R. supertritus is an uncommon East African tick that ranges into Central Africa and into the northern part of southern Africa.

CENTRAL AFRICA: CAMEROONS (Schulze 1941). BELGIAN CONGO (Neumann 1907B,1911. Massey 1908. Nuttall and Warburton 1916. Bequaert 1930B,1931. Zumpt 1942B).

EAST AFRICA: SUDAN (In part as *R. sulcatus*: King 1926. Hoogstraal 1954B).

ERITREA (HH collection from Nacta). UGANDA (Nuttall lot 2396 in BMNH collections, from Gomba). KENYA (Lewis 1931A,C, 1933,1934). TANGANYIKA (Zumpt 1942B).

SOUTHERN AFRICA: ANGOLA (As R. coriaceus: Nuttall and Warburton 1908 and Warburton 1912. Sousa Dias 1950. Santos Dias 1950C). NORTHERN RHODESIA (Theiler and Robinson 1954). SOUTHERN RHODESIA (Jack 1921,1928,1942). NYASALAND (As R. coriaceus: Nuttall and Warburton 1908, Old 1909. Warburton 1912. Neumann 1908C,1911. Neave 1912. Zumpt 1942B. Theiler 1947. Wilson 1950B. Hoogstraal 1954C). MOZAMBIQUE (Santos Dias 1950B,1952D,1952H,1953B).

HOSTS

R. supertritus is an uncommon parasite of larger wild animals and appears to feed only occasionally on domestic animals. Hosts of immature stages are unknown.

Domestic animals: Horse (Neumann 1907B,1911, Massey 1908). Dog (Sudan record above). Cattle (Nuttall and Warburton 1916, Matthysse 1954, Theiler and Robinson 1954).

Antelopes: Eland (Bequaert 1930B,1931). Zambesi eland (Santos Dias 1953B). Kudu (Jack 1942, Santos Dias 1953B, Hoogstraal collection from Eritrea. Hartebeest (Zumpt 1942B, Wilson 1950B). Lichtenstein's hartebeest (Santos Dias 1952H,1953B). Sable antelope (Theiler 1947, Wilson 1950B).

Other mammals: Buffalo (Theiler 1947, Wilson 1950B, Santos Dias 1950B,1952D,1953B, Sudan records above). Rhinoceros (Lewis 1933). Warthog (Hoogstraal 1954C). Lion (Lewis 1934). Zebra (Zumpt 1942B).

BIOLOGY

This interesting tick seems to be rare wherever it occurs. Its life cycle is unknown. It sometimes occurs in large numbers on single animals or herds. For instance, in Matthysse's (1954) study of ticks in Northern Rhodesia, this tick was found only once on cattle, but the collection consisted of eighteen males and fifteen females.

DISEASE RELATIONS

Unstudied.

REMARKS

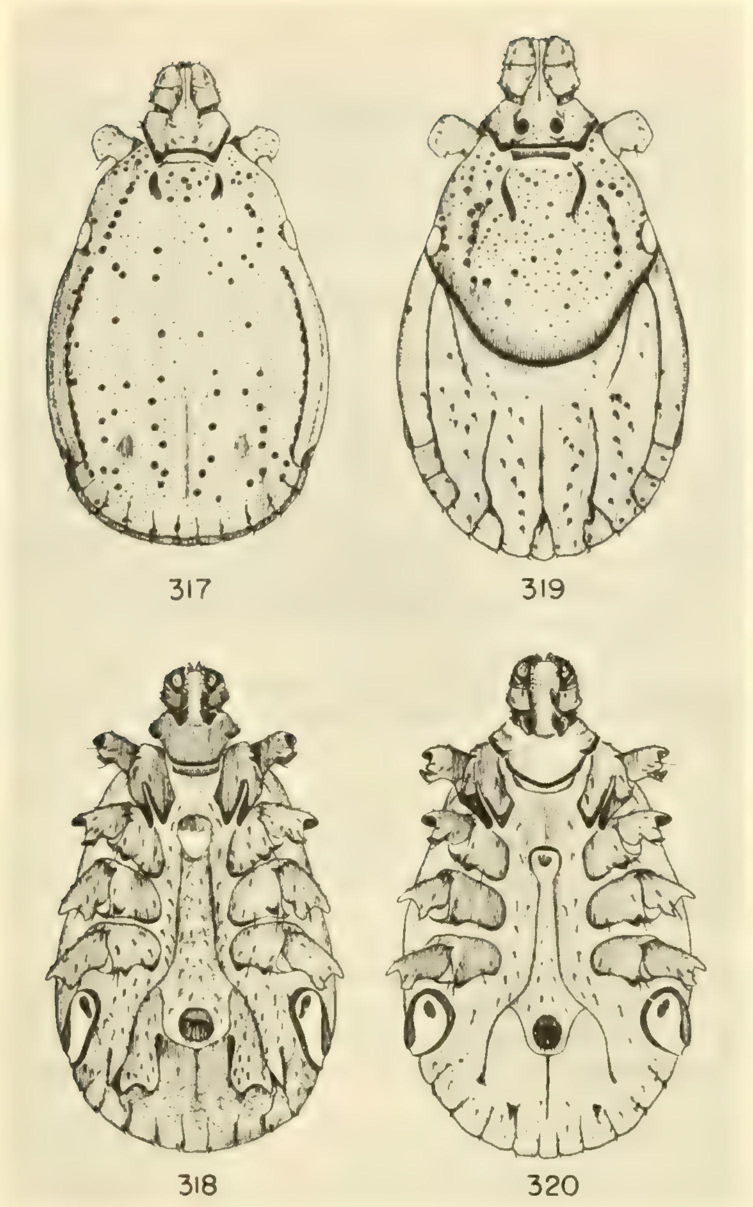
The haller's organ of R. supertritus has been illustrated by Schulze (1941). Zumpt (1942B) includes R. supertritus in the R. capensis group (see R. longus, page 667).

IDENTIFICATION

This rugose species has been described best by Theiler (1947). Variations are within the general remarks below.

Male: This species is usually large, from 3.3 mm. to 5.3 mm. long and from 1.3 mm. to 3.3 mm. wide, and usually black. It is easily recognized by a combination of characters including a pointed dorsal projection of coxa I; scutal punctations that are large, dense, and closely spaced or contiguous; and conspicuous reticulation or shagreening of the cervical areas and of the posterior grooves. The posteromedian groove is longer and narrower than the paramedian grooves; the lateral grooves are wide and deep. One or three median festoons protrude upon engorgement. The narrowly elongate adanal shields have a moderately convex outer margin and an almost straight or slightly concave inner margin; these margins meet at a pointed or a rounded anterior and posterior juncture and the shields are more ovoid than triangular in shape.

Female: Conspicuous shagreening or reticulation of the cervical areas and of the lateral grooves also distinguishes females of this species. The punctations are coarse and rugose, adjacent or contiguous centrally. The dark brown scutum, which is about as wide as long, has flat eyes at about midlength and a sinuous or gradually rounded posterior margin. Its pronounced lateral grooves are impunctate and extend to the posterior margin; the cervical grooves are deep and converging anteriorly, superficial and diverging posteriorly.



Figures 317 and 318, ♂, dorsal and ventral views
Figures 319 and 320, ♀, dorsal and ventral views

RHIPICEPHALUS TRICUSPIS
Sudan specimens

PLATE LXXXVIII

RHIPICEPHALUS TRICUSPIS Dönitz, 1906*

(= *R. LUNULATUS* Neumann, 1907B).

(Figures 317 to 320)

THE TRICUSPID GLOSSY TICK

DISTRIBUTION IN THE SUDAN

Bahr El Ghazal: All from Galual-Nyang Forest, 1953; E. T. M. Reid or N. A. Hancock, collectors: 2♂♂, 2♀♀ from tiang, *Damaliscus korrigum tiang*, April. 1♂ from warthog, *Phacochoerus aethiopicus* subspp., 4 September. 1♂ from oribi, *Ourebia ourebi* subspp., 7 June. 1♂ from giraffe, *Giraffa camelopardalis* subspp., 17 August. 2♂♂, 1♀ from domestic horse from Busseri, 20 June.

R. tricuspis is not known from elsewhere in the Sudan but probably also occurs on the west bank of Equatoria Province.

DISTRIBUTION

R. tricuspis is scattered throughout Africa, within the Ethiopian Faunal Region.

WEST AFRICA: NIGERIA (Unsworth 1949,1952. Gambles 1951). TOGO (As *R. glyphis*: Dönitz 1910A). SIERRA LEONE (Zumpt 1943A). FRENCH WEST AFRICA (Rousselot 1951,1953B). PORTUGESE GUINEA (Tendeiro 1951E,1952B,C,E,1953,1954). GOLD COAST (Stewart 1935).

---

*Dr. G. Theiler has kindly made an extensive study of the morphological variation, distribution, ecology, and taxonomy of this species especially for this work. See also her review of *R. tricuspis* (1947, pp. 292-298).

CENTRAL AFRICA: *CAMEROONS (Unsworth 1952. Rageau 1953A,B). *FRENCH EQUATORIAL AFRICA (Rousselot 1953B). *BELGIAN CONGO (Neumann 1907B. Massey 1908. Schoenaers 1951A. Nuttall and Warburton 1916. Schwetz 1927B. Bequaert 1930B,1931. Fain 1949. Theiler and Robinson 1954. Santos Dias 1954D. Van Vaerenbergh 1954).

EAST AFRICA: SUDAN (Hoogstraal 1954B).

ITALIAN SOMALILAND (Paoli 1916. Stella 1940).

UGANDA (Neave 1912. Mettam 1932. Wilson 1950C). KENYA (Lewis 1931C. Binns 1951). TANGANYIKA (Dönitz 1910B. As R. glyphis: Dönitz 1910A. Zumpt 1943A).

SOUTHERN AFRICA: *ANGOLA (Gamble 1914. Sousa Dias 1950. Specimens collected by Wellman seen in BMNH; see also HOSTS below). MOZAMBIQUE (Santos Dias 1950D,1952C,D,H,1953B).

NORTHERN RHODESIA (Theiler 1947. Matthysse 1954. Theiler and Robinson 1954). *NYASALAND (Neave 1912. Warburton 1912. Theiler 1947. Wilson 1950B).

*BECHUANALAND (Dönitz 1906,1910B. Theiler 1947). SOUTHWEST AFRICA (Dönitz 1910B). *UNION OF SOUTH AFRICA (Howard 1908. Bedford 1920,1926,1932B. Theiler 1947).

HOSTS

Domestic animals and many larger game animals serve as hosts for R. tricuspis. Immature stage hosts in nature are unknown.

Domestic animals: Horses (Neumann 1907B, Massey 1908, Zumpt 1943A, Sudan records above). Cattle (Dönitz 1910A,B, Nuttall and Warburton 1916, Schwetz 1927B, Zumpt 1943A, Theiler 1947, Wilson 1950B, Binns 1951, Rousselot 1951,1953B, Schoenaers 1951A, Santos Dias 1953B, Matthysse 1954, Van Vaerenbergh 1954). Sheep and

---

*Theiler (correspondence) has seen additional material from these territories.

goats (Nuttall and Warburton 1916, Theiler 1947, Wilson 1950B). Pigs (Gamble 1914, Tendeiro 1951E,1952E). Dogs (Gamble 1914, Nuttall and Warburton 1916, Wilson 1950B, Santos Dias 1952D, Matthysse 1954).

Wild animals: Lion and serval (Wilson 1950B). Leopard (Zumpt 1943A). "Wild dog" (Lewis 1931C). Buffalo (Wilson 1950B, Santos Dias 1953B). Forest dwarf buffalo (Tendeiro 1951E,1952B, C,E,1953,1954). Zebra, Lichtenstein's hartebeest, and sable antelope (Santos Dias 1953B). Oribi (gwape) and steinbuck (Wilson 1950B). Duikers, various (Wilson 1950B, Santos Dias 1953B). Waterbuck and bushbuck (Mettam 1932). Reedbuck (Wilson 1950B, Santos Dias 1950D,1953B). Oribi, tiang, and giraffe (Sudan records above). Bushpig (Dönitz 1910A, Zumpt 1943A, Santos Dias 1950D,1953B). Warthog (Wilson 1950B, Santos Dias 1953B, Sudan record above). Hedgehog (Neumann 1911). Hares (Theiler 1947, Wilson 1950B). Fruit bat (Specimens collected by Karl Jordan, now in BMNH; probably a decidedly exceptional host).

BIOLOGY

Life Cycle

R. tricuspis has been reared by Theiler (correspondence) for the morphological studies reported by her (1947). The life cycle details will be published subsequently.

Ecology

In order to determine whether there might be ecological or other distributional factors between *R. tricuspis* and what has been reported as *R. lunulatus*, Theiler (correspondence) has checked all locality records against data for vegetation type, rainfall, extent of dry season, and relative humidity. She finds that both range indiscriminately from (1) dry forests of the Rhodesian highlands through (2) highgrass-low tree savannah or Guinea-southern Congo savannah, and (3) acacia desert grass savannah of the Sudan and northern Kalahari to (4) tallgrass subtropical evergreen and deciduous tree and thorn forest.

In South Africa (Theiler 1947), R. tricuspis occurs in the warmer areas with thorn trees, from the semiarid bushveld of the Kalahari to the moister bushveld of the lowveld of northern and eastern Transvaal and of Natal. It is absent in the Karroo scrubveld, the open grassveld of Orange Free State, and the middleveld and highveld of Transvaal.

Dr. Theiler's present study indicates that R. tricuspis appears to be resistant to a wide range of humidity and aridity. It may be found in heavy rainfall areas with 42 inches annually and in areas where there is as much as seven months of drought. Santos Dias' (1950D,1952C) records of R. tricuspis and "R. lunulatus" are from areas with the same kinds of vegetation and drought periods and the same average rainfall. Dönitz's (1910B) specimen from Little Namaqualand probably fell from its host when the Trekboers were migrating with their sheep from Bushmanland and the southern Kalahari into Namaqualand in search of rains and pasturage.

In Northern Rhodesia, Matthysse (1954) found adults of the tricuspid brown tick mainly in the tail brush of cattle but also on the feet, anus, and ears. Most specimens that I have seen have been from the tail brush. They appear to be present chiefly during the rains but also in the dry season.

DISEASE RELATIONS

MAN: Specimens from Portugese Guinea have been reported to be free of Q fever (Coxiella burnetii).

PIGS: This tick is "possibly a vector of porcine piroplasmosis (Babesia trautmanni)".

REMARKS

R. tricuspis was described by Dönitz (1906) from the Kalahari of Bechuanaland. The following year, Neumann (1907B) described R. lunulatus from the Congo, and in 1910(A) Dönitz described R. glyphis from Togo and Tanganyika. Dönitz's papers were long overlooked by earlier workers, and obvious specimens of R. tricuspis were identified as R. lunulatus.

Zumpt (1943A,1950A) accepted the differing descriptions of R. tricuspis and R. lunulatus as referring to separate species. He synonymized R. glyphis under R. lunulatus but did not see specimens of R. tricuspis. Theiler (1947) reared R. tricuspis and observed that the range of variation in the F_1 generation from a single female included characters ascribed to R. tricuspis as well as to R. lunulatus. For the purposes of the present work, Theiler has restudied her material and confirmed her earlier observations. Santos Dias (1950D,1952C) described differences, which Theiler has found to be intraspecific, for R. tricuspis and R. lunulatus.

It might be indicated that in Theiler and Robinson (1954) the term R. lunulatus is used only for literature references of that name, but does not infer that these authors consider R. lunulatus to be a valid species.

In the following description, the range of variation in Theiler's material is noted. Only typical specimens were described in her 1947 paper, in which R. tricuspis was compared with R. simus simus.

IDENTIFICATION

Male: The somewhat linear arrangement of the few large, deep scutal punctations identifies R. tricuspis in the R. simus group within which it stands out easily by the curiously sinuous posterior margin of the adanal shields that are projected more or less as a spur at the inner or outer juncture, or at both junctures. In typical specimens, these two pointed spurs and the pointed, heavily sclerotized accessory anal shields give this area of the tick a tricuspid appearance. The spurlike outer juncture is pronounced but the inner point is frequently more rounded and shorter. Lateral grooves, usually well indicated, rarely may be much reduced or indicated by only a line of adjacent punctations. The posterior grooves are typically distinct but in some specimens tend to disappear. [Note that in specimens of R. simpsoni from a single host the same variation in scutal grooves occurs. Small rhipicephalid species that crowd into a small area of the host frequently show these modifications.7 Small or fine interstitial punctations are present, though they may be faint. Coxa I bears a pointed dorsal projection that typically is prominent but in some specimens is smaller, though still pointed. This reddish to black tick usually has a pearshaped body and measures up to 3.5 mm. or even 4.3 mm. long.

Female: Usually small size (up to 4.5 mm. long and 2.3 mm. wide) and association with the male distinguishes this sex from that of *R. s. simus*. Clearcut characters to distinguish these two females are difficult to define in view of the frequent reduction of the lateral grooves in *R. s. simus*. In most specimens of *R. tricuspis* the shieldshaped scutum contrasts with the subcircular scutum of *R. s. simus*. The lateral grooves are characteristically short (shorter than in *R. s. simus*) and contain four to six closely adjacent punctations.

Larvae and nymphs have been described by Theiler (1947) and compared with those of *R. s. simus*.

RHIPICEPHALUS ?SP.

(not illustrated)

L	N	♀	♂	EQUATORIA PROVINCE RECORDS		
2	17			Imatong	*Heterohyrax brucei hoogstraali*	Feb
1	1			Imurok	*Heterohyrax brucei hoogstraali*	Feb

REMARKS

These nymphs were originally identified as those of *R. mühlensi* (Hoogstraal 1954B). Subsequent study of the difficult problem of immature rhipicephalid identification indicates that they are of a different species and most closely resemble *R. maculatus* Neumann, 1901, (Theiler, correspondence) an ornamented species from southeastern Africa that is not known from the Sudan.

Note (page 637) that it is quite possible that these specimens are the immature stages of the species referred to herein as *R. ?distinctus*.

ANIMALS AND OTHER SOURCES FROM WHICH TICKS HAVE BEEN COLLECTED

The following lists are a résumé of Sudanese tick host records in the present collection. The fauna of Torit District in Equatoria Province has been most thoroughly studied, that of Eastern and Juba Districts, to the east and west of Torit District respectively, has also received considerable attention though not to the extent of that in Torit District. These three Districts comprise that part of Equatoria Province lying east of the Nile. The west bank of Equatoria Province remains poorly known and will undoubtedly provide a rich source of new data to future workers.

In Bahr El Ghazal Province, the area from Yirol to Wau and northwards has been fairly well studied; the remainder of this Province has been surveyed but should receive more attention. Upper Nile Province is the least studied of this group of three Provinces with tropical African savannah landscape and big game animals. Some East African tick species presently unknown in the Sudan may occur on animals in this area. Hosts from which ticks have been collected in the remaining Provinces, comprising desert scrub, semidesert, and desert zones of the Sudan, are mostly domestic animals. Kassala and Northern Provinces are less well represented in these collections than Darfur and Kordofan Provinces.

Equatoria Province data are more representative of the overall picture of host parasite relationships than those of other Provinces and are, therefore, reviewed in greater detail than data for other Provinces. Certain significant negative data are also included.

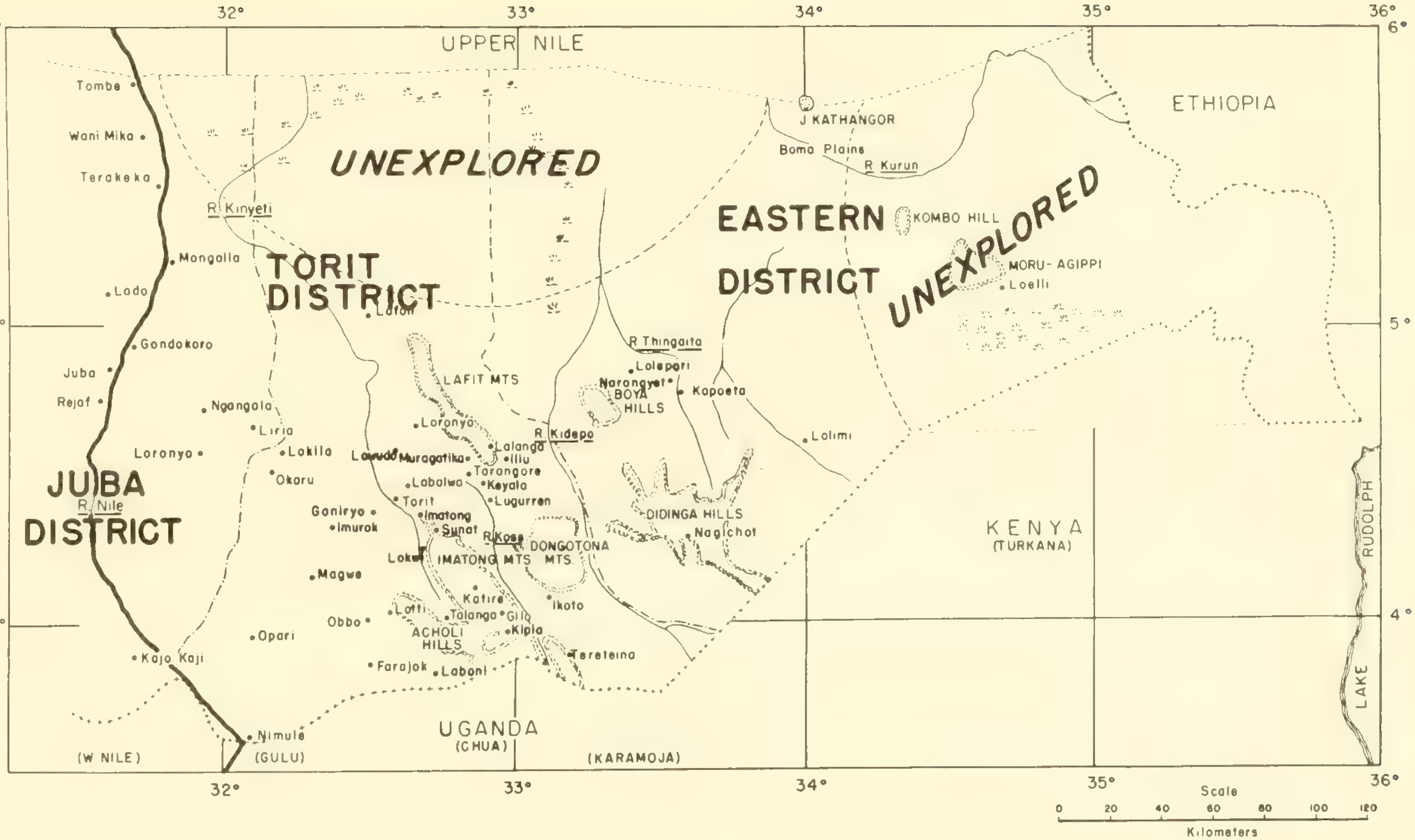


Figure 321

EQUATORIA PROVINCE COLLECTING LOCALITIES
EAST BANK

PLATE LXXXIX

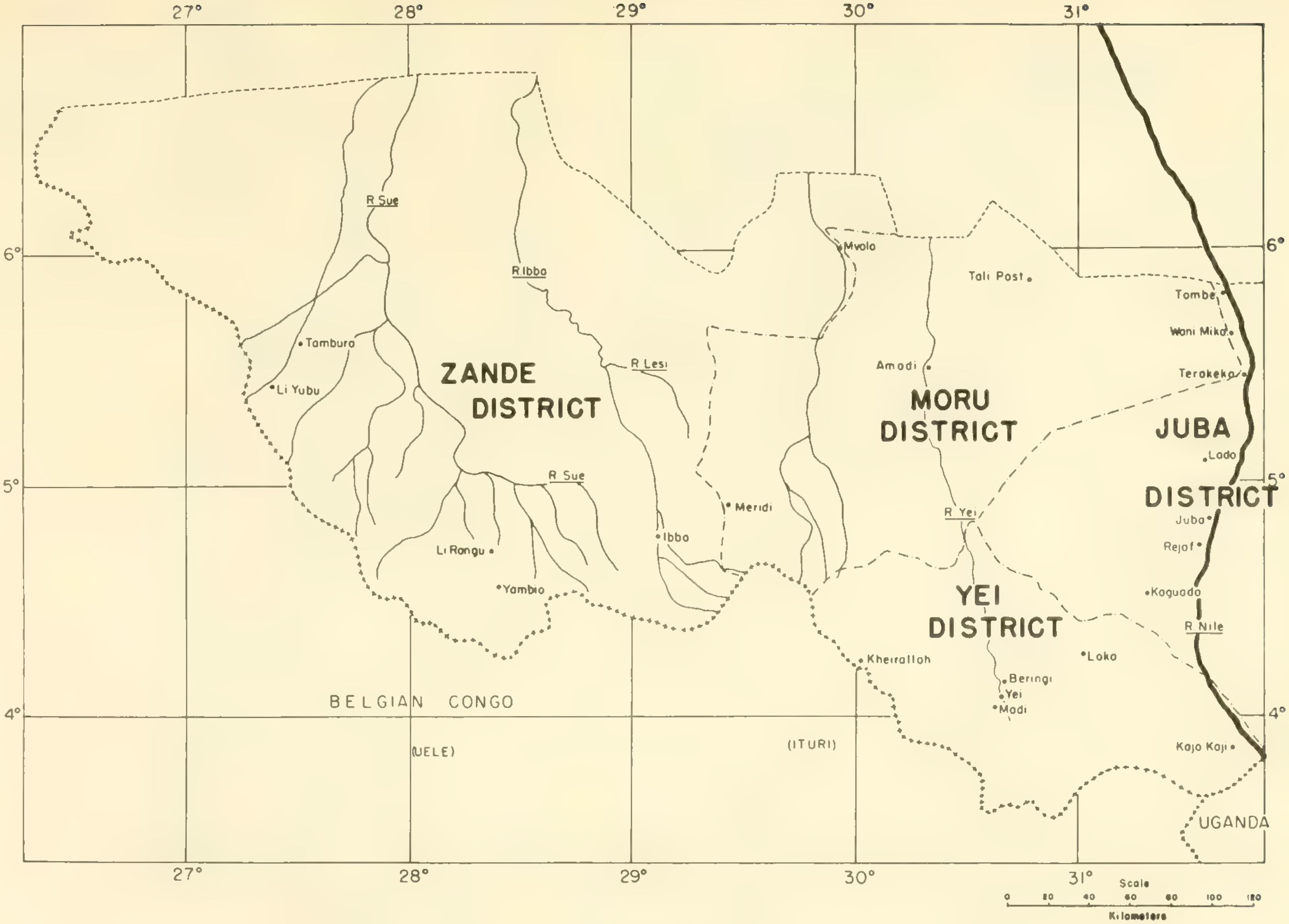


Figure 322

EQUATORIA PROVINCE COLLECTING LOCALITIES
WEST BANK

PLATE XC

EQUATORIA PROVINCE

REPTILIA*

OPHIDIA (SNAKES)

NAJA MELANOLEUCA Hallowell. Black Cobra.
NAJA HAJE Linne. Egyptian Cobra.
PYTHON REGIUS Shaw. Regal Python.
DENDROASPIS P. POLYLEPIS (Günther). Black Mamba.
BOAEDON L. LINEATUS Dumeril and Bibron. Common House Snake.

Small numbers of adults of the snake tick, Aponomma latum, were found on individual hosts of the above species; nymphs were also found on the black cobra. All specimens were taken during the dry season at Torit except that from Boaedon, which was collected during the rainy season at Katire in the forested Imatong Mountains. These hosts are all large, poisonous snakes. Numerous specimens of the same and smaller snakes examined in Torit and other Districts of Equatoria were free of ticks. Ticks are usually found between the host's dorsal scales, especially just behind the neck, sometimes on the head, rarely on the venter. In exceptional instances, the host may be literally covered with ticks of this species.

LACERTILIA (LIZARDS)

VARANUS N. NILOTICUS Laurenti. Nilotic Monitor or Waran.

---

*Reptiles were identified by Dr. K. P. Schmidt, Emeritus Chief Curator of Zoology, Chicago Natural History Museum. Information on the same and other reptiles mentioned in the text was kindly given by Mr. A. Loveridge, Museum of Comparative Zoology, Harvard University, who has published a paper on snakes of Torit District (Sudan Notes and Records, 1955).

This large lizard is common in Equatoria Province, especially near streams and in association with trees. A few among many specimens examined yielded small to moderate numbers of nymphs and adults of the monitor lizard tick, Aponomma exornatum. A single lizard yielded a nymphal Amblyomma nuttalli and four nymphs and a male of A. marmoreum (group). The incidence of infestation is not high. Infested monitors were found in Torit, Juba, and Yei Districts.

VARANUS E. EXANTHEMATICUS Bosc. Northern Savannah Monitor.

This monitor is less common than niloticus and fewer were examined. Two Torit hosts yielded a nymphal A. nuttalli during the dry season and a number of adults and nymphs of Aponomma exornatum during the rainy season.

CHAMELEO G. GRACILIS Hallowell. Graceful Chamelon.

A nymph of the elephant amblyomma, A. tholloni was found on a chameleon at Lokila. Many other chameleons and hundreds of smaller lizards examined in eastern Equatoria Profince were free of ticks.

CHELONIA (TORTOISES)

KINIXYS B. BELLIANA Gray. Bell's Eastern Hinged-Tortoise.

Land tortoises are fairly common on the east bank of Equatoria Province and are not infrequently tick infested. Tortoises must be anesthesized or killed in order to find ticks attached deep in the axillae, otherwise specimens are easily overlooked. A pair of adult H. truncatum was found on a Juba tortoise, another yielded numerous adults and nymphs of A. marmoreum (group). The latter species was found in small numbers on a Torit tortoise, and at Farajok and near Meridi two tortoises bearing a few adults of A. nuttalli were taken.

AVES*

FRANCOLINUS CLAPPERTONI GEDGII Grant. Uganda Clapperton Francolin

These common savannah birds were one of our chief articles of diet and hundreds were rapidly examined for ticks. The three specimens found, all from Torit during the dry season, were a nymph of A. nuttalli, another of A. cohaerens (identification questionable), and a female H. hoodi hoodi.

NUMIDA MELEAGRIS MAJOR Hartlaub. Uganda Tufted Guinea Fowl

As many of these common savannah birds as of those mentioned above were briefly examined with equally unspectacular results. Only nymphs were found, all during the month of December. These were one A. cohaerens (identification questionable) at Ikoto, five A. variegatum at Kapoeta, and one Hyalomma sp. at Torit.

GUTTERA EDOUARDI SETHSMITHI Neumann. Blue-spotted Forest Guinea Fowl

These handsome birds are confined to forest patches and open gallery forests and therefore very localized in the Sudan. The two specimens examined in Lotti Forest in April yielded eleven larvae and sixteen nymphs of H. parmata.

SPHENORHYNCHUS ABDIMII (Lichtenstein). Abdim's Stork

Of several specimens examined at Torit during the dry season, one yielded two nymphs of H. hoodi hoodi and another two nymphs of A. variegatum and a male R. s. sanguineus. Large flocks of Abdim's storks feed in durra fields in Torit District, but they appear to be migrants or to have a wide range of feeding areas.

---

*Domestic birds are listed with DOMESTIC ANIMALS. Bird identifications were provided by Dr. A. L. Rand, Chief Curator of Zoology, Chicago Natural History Museum, who also kindly checked references to birds mentioned elsewhere in the text.

NEOTIS CAFRA DENHAMI (Children). Denham's Greater Bustard

In Torit District ten greater bustards from open savannah were examined during the dry season. A male *A. lepidum* and four male *R. s. sanguineus* were found on the head of one at Torit and eight males of the latter species were taken from the head of another at Ikoto.

LISSOTIS M. MELANOGASTER (Rüppell). Black-bellied Bustard

Search over a dozen black-bellied bustards in Eastern and Torit Districts resulted in only three larvae and a nymph of *A. variegatum* at Kapoeta during the dry season. These birds are common in open grasslands and fields in Torit District and especially numerous in Eastern District.

TURDUS LIBONYANUS CENTRALIS Reichenow. Great Lakes Kurrichane Thrush

A specimen examined at Obbo late in the dry season yielded a single nymph provisionally identified as *A. cohaerens*.

TCHAGRA SENEGALA ERLANGERI (Neumann). Sudan Black-headed Tchagra Shrike

Several specimens were examined. One at Torit during the dry season was infested with a nymph of *A. variegatum*. This is one of the most common birds of the area.

MAMMALIA*

INSECTIVORA (INSECTIVORES)

FAMILY ERINACEIDAE

ATELERIX PRUNERI OWENI Setzer, 1953. Owen's Four-toed Hedgehog

---

*Mammal host identifications are based on Setzer's (1956) study of mammals (excluding bats) of the Sudan, a project resulting from collections made for the present study of ticks and related studies of other ectoparasites. Bat hosts were identified by Mr. C. C. Sanborn, formerly Curator of Mammals, Chicago Natural History Museum.

Owen's four-toed hedgehog is common in eastern Equatoria but comparatively few were examined for ticks. At Torit, a nymph of A. variegatum, a female H. leachii muhsami, and three male and a female R. sanguineus were found on hedgehogs during the dry season. A single female of the latter species occurred on a Sunat host and two male H. leachii muhsami were attached to a Tarangore specimen. A number of hedgehogs at Juba were free of ticks.

FAMILY MACROSCELIDIDAE

ELEPHANTULUS FUSCIPES (Thomas, 1894). Dark-footed Elephant Shrew

The only specimen of dark-footed elephant shrew, which is rare in Torit District, was found to have two nymphs of R. pravus on its ears (dry season).

ELEPHANTULUS RUFESCENS HOOGSTRAALI Setzer, 1956. Hoogstraal's Rufous Elephant Shrew

These little animals, previously identified as E. rufescens dundasi (Hoogstraal 1950, Hoogstraal, Huff, and Lawless 1950), are common in islands of vegetation in Torit and Eastern Districts. Practically every specimen is infested, often heavily, by immature stages of R. pravus. Occasionally immature R. e. evertsi attack these animals and two nymphs of R. s. sanguineus were among the ticks removed from the hundreds of elephant shrews handled in this area.

FAMILY SORICIDAE

CROCIDURA SP. Shrew

A single nymph of Ixodes alluaudi from the tail of an unidentified shrew from Kipia at 8000 feet elevation in the Imatong Mountains is present in collections of the British Museum (Natural History).

CROCIDURA NYANSAE TORITENSIS Setzer, 1956. Torit Nyanza Shrew

Twenty-five Torit Nyanza shrews were examined. Two of them at Torit yielded four nymphs of H. leachii leachii (subspecies uncertain).

CHIROPTERA (BATS)

A considerable number and variety of bats were examined on the east bank of Equatoria Province but few ticks were found on them. The report on these bats, not included in Setzer's (1956) work on Sudan mammals, will be presented separately. Caves in which bats rest in this area are rare and rock crevices usually too concealed and narrow for examination for ticks.

FAMILY PTEROPIDAE

ROUSETTUS AEGYPTIACUS (E. Geoffroy, 1818). Egyptian Fruit Bat.

A larval *A. vespertilionis* was found on a fruit bat at Lokwi.

FAMILY EMBALLONURIDAE

TAPHOZOUS PERFORATUS HAEDINUS Thomas, 1915. Tomb Bat.

At Sunat several larvae of *A. boueti*, *A. confusus*, and *A. vespertilionis* were removed from tomb bats; also a nymphal *A. boueti*.

FAMILY RHINOLOPHIDAE

RHINOLOPHUS LOBATUS Peters, 1852. Horseshoe Bat.
RHINOLOPHUS CLIVOSUS ZAMBESIENSIS Andersen, 1904. Horseshoe Bat.

Seven larval *A. boueti* were found at Torit on *R. lobatus* and a nymphal *I. simplex simplex* on a Katire specimen of the latter bat.

FAMILY VESPERTILIONIDAE

*EPTESICUS PUSILLUS (Leconte, 1857). Serotine Bat.

At Torit, a larval *A. confusus* was taken from a serotine bat.

---

*Host name on collector's label; host identity not checked by specialist in bats.

*MIMETELLUS ?MOLONEYI (Thomas, 1891).

Four larval A. vespertilionis were found at Katire.

*PACHYOTUS SP. Brown Bat.

Single larvae of Argas sp. and of A. confusus infested a brown bat at Latome.

FAMILY MOLOSSIDAE

CHAEREPHON MAJOR (Trouessart, 1897). Free-tailed Bat.

A Torit specimen was infested by two larval A. confusus.

HOST UNIDENTIFIED

A nymph of Ixodes vespertilionis was taken at Torit.

PRIMATES (PRIMATES)

FAMILY LORISIDAE

GALAGO S. SENEGALENSIS E. Geoffroy, 1796. Senegal Galago or Bushbaby.

One of the eleven galagos taken in Torit and Juba Districts was infested by a male R. s. sanguineus.

FAMILY CERCOPITHECIDAE

PAPIO DOGUERA HEUGLINI Matschie, 1898. Heuglin's Baboon.

It is noteworthy that the numerous specimens examined in Torit District were free of ticks.

---

*Host name on collector's label; host identity not checked by specialist in bats.

CERCOPITHECUS MITIS STUHLMANNI Matschie, 1898. Stuhlman's Guenon Monkey.

Twelve specimens examined in Lotti Forest and the Imatong Mountains were free of ticks.

CERCOPITHECUS AETHIOPS SUBSP. (Captive).

Numerous wild specimens of this common monkey were free of ticks but seventeen adult R. s. sanguineus were removed from two caged specimens at Torit. Captive monkeys were frequently infested but the vials containing ticks removed from them during the present study have been lost.

ERYTHROCEBUS PATAS PYRRHONOTUS (Hemprich and Ehrenberg, 1832). East African Red Monkey.

None of many specimens examined yielded ticks.

FAMILY COLOBIDAE

COLOBUS POLYKOMOS DODINGAE Matschie, 1913. Didinga Mountain Colobus Monkey.

A single female Ixodes schillingsi was found in Lotti Forest on the eyelid of one of twelve colobus monkeys taken in Torit District. These monkeys inhabit forests, fairly dense stands of trees along streams and rivers, and restricted savannah areas with numerous trees.

PHOLIDOTA (PANGOLINS)

FAMILY MANIDAE

MANIS TEMMINCKII Smuts, 1832. Temminck's Pangolin.

No ticks were found on the single pangolin taken in Torit District, where this animal is exceedingly rare.

LAGOMORPHA (HARES and RABBITS)

FAMILY LEPORIDAE

POËLAGUS MARJORITA OWENI Setzer, 1956. Owen's Grass Rabbit (or Hare).

A number of specimens of this strange and highly localized grass rabbit from the Katire area were free of ticks but two individuals taken during the rainy season at Magwe yielded a male and female R. pravus and 31 exceptionally heavily punctate adult R. s. sanguineus.

LEPUS CAPENSIS CRAWSHAYI DeWinton, 1899. Crawshay's Hare.

Ticks from these hares at Ikoto included a nymph of R. s. simus, ten female R. arnoldi, nineteen adult R. pravus and a male H. leachii muhsami. A hare from Nagichot, at 6500 feet elevation in the Didinga Mountains, bore two female R. s. sanguineus. These hares are common in elevations somewhat above the average of the plains of Torit District.

LEPUS VICTORIAE MICROTIS Heuglin, 1865. Victoria Hare.

Victoria hares, frequently tick infested, are common in the savannah from Torit to Juba. The only immature tick found was a nymph of R. s. simus at Torit during the dry season. Many were attacked by moderate numbers of adults of R. s. sanguineus, fewer by R. pravus, and one by Ixodes rasus ?subspecies.

LEPUS CAPENSIS SUBSP.

Several Kapoeta specimens of this yet unidentified hare were infested by all stages of R. pravus and by two nymphs of A. variegatum and one female H. leachii muhsami.

LEPUS SP.

Hosts from various sources were infested by adult R. s. sanguineus.

RODENTIA (RODENTS)

The paucity of tick specimens from Equatoria Province rodents is of particular interest since several thousand savannah-inhabiting rodents were examined under conditions most likely to retain ecto-parasites and reveal them after sacrificing the animals. Many rodents found to be infested in Equatoria Province are from the limited collections from mountains and high altitude forests, riparian brush and forests, and stands of trees and shrubs in and about villages. In other parts of East Africa, findings have been similar relative to rate and type of infestation of rodents. Although African rodents are generally reputed to harbor numerous ticks, it appears evident that a large number of savannah species do not conform with this generalization. The ubiquitous field rodents such as *Arvicanthis* and *Lemniscomys* are frequently parasitized by the nest-inhabiting immature stages of *H. l. leachii* and *R. s. simus* but seldom by other ticks.

Theiler's (1949C) observations in South Africa are similar. She reports: "It has always been taken for granted that the numerous species of our field mice serve to feed the immature stages of all those ticks of which the adults only are to be found on our domestic stock. Thus far the tick survey, in itself still very incomplete, does not bear out this assumption. Our field mice are extraordinarily free of parasites - as I know from personal trapping experience and as Dr. Roberts and Mr. Davis will bear me out. The numbers present on individual mice, and on the mouse population in general, in no way correspond with the number of adults found on the large herbivores and carnivores".

It is significant that in desert and semidesert areas from northern Africa to the Far East where *Hyalomma* and *Ornithodoros* ticks are common, rodents are the most important hosts of immature stages of both genera and also of adult *Ornithodoros*.

FAMILY SCIURIDAE

HELIOSCIURUS GAMBIANUS HOOGSTRAALI Setzer, 1954. Hoogstraal's Gambian Tree Squirrel.

Ticks are rare on tree squirrels and the two male *R. s. sanguineus* on hosts at Ikoto and Torit were taken in close proximity of villages.

EUXERUS ERYTHROPUS LEUCOUMBRINUS (Rüppell, 1835). Light-sided Ground Squirrel.

All stages of the specific parasite of ground squirrels, H. houyi, infest a good proportion of these common animals on the east bank of Equatoria Province. Specimens were taken during the dry season at Kapoeta, Torit, and Latome. Six nymphs of A. variegatum were also found on a ground squirrel at Torit.

EUXERUS ERYTHROPUS ?LACUSTRIS (Thomas, 1905).

A specimen examined at Yei was infested by a nymph and a male H. houyi.

FAMILY CRICETIDAE

TATERA BENVENUTA BENVENUTA (Hinton and Kershaw, 1920). Benvenuta Tatera.

Tatera gerbils, although numerous in the Torit vicinity, yielded only fifteen nymphs of R. s. simus and two of H. l. ?leachii. Two burrows of these animals yielded eleven nymphs, four females, and five males of the former species. The adult ticks were unengorged.

TATERILLUS EMINI EMINI (Thomas, 1892). Emin's Lesser Tatera.

These are about as common as the Benvenuta Tatera but no ticks were found on them. Approximately a hundred of each of these tateras were examined.

FAMILY MURIDAE

GRAMMOMYS MACMILLANI ERYTHROPYGUS Setzer, 1956. Red-rumped Arboreal Rat.

Upwards of seventy arboreal rats examined in and around Torit were not infested, however, a nymph tentatively identified as A. cohaerens was taken on a host at Obbo.

ARVICANTHIS NILOTICUS JEBELAE Heller, 1911. Southeastern Sudan Kusu or Grass Rat.

Large numbers of this rodent, possibly the most common one in Torit and Juba Districts, yielded only a few nymphs of H. l. ?leachii and R. s. simus. However, burrows examined during the dry season at Juba and Torit were inhabited by fairly large numbers of nymphs and recently molted, unfed adults of the same tick species.

LEMNISCOMYS MACCULUS MACCULUS (Thomas and Wroughton, 1910). Striped Grass Mouse.

Four nymphal R. s. simus were taken from this uncommon mouse at Torit.

LEMNISCOMYS STRIATUS MASSAICUS (Pagenstecker, 1855). Masai Striped Grass Mouse.

The Masai striped grass mouse is exceedingly common in eastern Equatoria Province and many were examined. A small number of immatures of R. s. simus were found on a few grass mice and in the nests of others. A nymphal H. aciculifer was also taken on a grass mouse at Torit.

MASTOMYS NATALENSIS ISMAILIAE (Heller, 1914). Ismailia Multimammate Rat.

Two multimammate rats infested by a few nymphs of Ixodes nairobiensis were found at Torit and in Lotti Forest. This tick was not found on other mammals in the Sudan. At Torit and Ikoto two hosts yielded a few immature R. s. simus. Over a hundred other multimammate rats examined in Torit, Juba, and Eastern Districts were free of ticks.

PRAOMYS TULLBERGI SUDANENSIS Setzer, 1956. Lotti Forest Soft-furred Rat.

This rat inhabits higher altitudes of Torit District. Four specimens in Lotti Forest were infested by a few immature ticks representing H. aciculifer, H. l. ?leachii, R. s. simus, and R. ?arnoldi. No ticks were found on twenty-two other specimens in Lotti Forest.

ACOMYS HYSTRELLA Heller, 1911. Nimule Spiny Mouse.

Many spiny mice representing various species and subspecies were unsuccessfully examined in eastern Equatoria but at Nimule eight specimens of A. hystrella yielded a few immatures of A. brumpti and H. l. ?leachii.

FAMILY GLIRIDAE

GRAPHIURUS MURINUS SUDANENSIS Setzer, 1953. Sudan Dormouse.

It is interesting to note that no dormice, which are common in village trees, huts, and houses in Torit District, were infested by ticks.

FAMILY THRYONOMYIDAE

"MARSH RAT".

Several adults of R. simpsoni, the specific parasite of cane rats, also known as marsh rats or edible rats, from Yei are present in Sudan Government collections.

THRYONOMYS GREGORIANUS SUBSP. Cane Rat.

A single male R. simpsoni was found on a cane rat at Torit. The few other cane rats examined there were brought in dead by tribespeople, which may have accounted for the absence of ticks on them.

CARNIVORA (CARNIVORES)

Infestation density ranging from light to fairly heavy but representing only a very limited number of tick species and subspecies is a feature of carnivores in Equatoria Province and in most of East Africa and southern Africa. In West Africa the variety of carnivore infesting ticks is frequently somewhat greater.

FAMILY CANIDAE

Available data tend to indicate that H. leachii leachii favors members of this family over all other carnivores. It is certainly more numerous on canines than H. leachii muhsami, not only in Equatoria Province but elsewhere in Africa.

CANIS AUREUS SOUDANICUS Thomas, 1903. Sudanese Jackal.

The Sudanese jackal is numerous around Torit village but only twelve were examined for ticks. H. leachii leachii was represented by 183 adults and one nymph, H. leachii muhsami by four adults, R. sanguineus sanguineus by 53 adults, R. simus simus by 33 adults, R. pravus by a single female, and A. variegatum by five nymphs and two larvae.

CANIS MESOMELAS ELGONAE (Thomas, 1914). Elgon Black-backed Jackal.

A single black-backed jackal from Yubo was infested by 36 adult H. l. leachii. On two Torit specimens, a male of the same subspecies and three adults of R. s. sanguineus were found.

LYCAON PICTUS SOMALICUS Thomas, 1904. Somali Hunting Dog.

Five pairs of adult R. simus senegalensis were collected from a Somali hunting dog at Nimule.

FAMILY MUSTELIDAE

MELLIVORA CAPENSIS ABYSSINICA Hollister, 1910. Ethiopian Ratel or Honey Badger.

The only specimen known from this Province yielded three adults of H. leachii muhsami and fourteen of R. s. simus.

FAMILY VIVERRIDAE

GENETTA TIGRINA AEQUATORIALIS Heuglin, 1866. Equatorial Genet.

Five Torit hosts were infested by two pairs of adult R. s. sanguineus, three adult H. leachii muhsami, and a larval A. variegatum. Several other genets in Torit District were free of ticks.

CIVETTICTIS CIVETTA CONGICA Cabrera, 1929. Congo Civet.

Five hosts at Torit and Obbo during the dry and rainy seasons yielded a pair of adult *Ixodes cavipalpus*, seven adult *R. s. simus*, a pair of adult *R. s. sanguineus*, fifteen adult and two nymphal *H. l. leachii*, and thirty adult *H. leachii muhsami*.

HERPESTES SANGUINEUS SANGUINEUS (Rüppel, 1835). Black-tipped Mongoose.

Several animals were examined between Juba and Kapoeta but ticks were found only on one at the latter locality. They were six immatures of *A. variegatum* and seventeen adult *H. leachii muhsami*.

ICHNEUMIA ALBICAUDA ALBICAUDA G. Cuviet, 1829. White-tailed Mongoose.

A few adults and two nymphs of *H. l. leachii* were found on specimens at Yei and Torit. Infestations of *H. leachii muhsami* were much heavier, approximately two hundred adults and three nymphs having been taken from seven hosts in these localities. Several other white-tailed mongooses examined were not parasitized.

FAMILY HYAENIDAE

CROCUTA CROCUTA FORTIS Allen, 1924. Spotted Hyena.

The only spotted hyena taken at Torit was host to eight pairs of adult *R. s. simus*.

CROCUTA CROCUTA SUBSP.

At Jebel Kathangor a nymphal *A. variegatum* was the only tick found on a spotted hyena.

FAMILY FELIDAE

FELIS LYBICA UGANDAE Schwann, 1904. Uganda Wild Cat.

An Opari specimen yielded a male *A. lepidum* and a male *R. s. sanguineus*; another at Torit a female *H. leachii muhsami*.

FELIS SERVAL PHILLIPSI Allen, 1914. Phillips' Serval.

Three pairs of adult R. s. sanguineus were found on a serval at Torit.

PANTHERA PARDUS CHUI Heller, 1913. East African Leopard.

Several leopards examined at various localities throughout Equatoria Province were free of ticks.

PANTHERA LEO LEO Linnaeus, 1758. African Lion.

Only two of many lions examined yielded ticks; these, from Torit, were ten adult H. l. leachii and nine adult R. s. simus.

TUBULIDENTATA (AARD-VARKS)

Aard-varks (ORYCTEROPODIDAE, Orycteropus afer) were not encountered in this Province.

PROBOSCIDEA (ELEPHANTS)

FAMILY ELEPHANTIDAE

LOXODONTA AFRICANA OXYOTIS Matschie, 1900. Sudan Plains Elephant.

No elephants were examined in this Province west of the Nile but specimens of D. c. circumguttatus found on grass near Kajo Kaji probably had been associated with these animals. East of the Nile four of many elephants seen immediately after death were infested. The numbers of ticks on each, all adult A. tholloni, were six, twelve, 23, and 197. It is of interest that in Bahr El Ghazal Province numerous elephants were infested only by large numbers of R. simus simus and R. simus senegalensis, none by the specific elephant parasite, A. tholloni.

HYRACOIDEA (HYRAXES)

FAMILY PROCAVIIDAE

HETEROHYRAX BRUCEI HOOGSTRAALI Setzer, 1956. Hoogstraal's Large-toothed Rock Hyrax.

This is the common hyrax of rocky outcrops in the plains east of the Nile and some twenty were examined. Thirteen larvae and a female A. brumpti infested three specimens at Imurok and Imatong. Eleven adults and a nymph of the East African hyrax tick, H. bequaerti, were also attached to the two Imurok specimens as well as a single male R. s. sanguineus. Twenty-one immature R. ?sp. were also found on these hyraxes; these latter may prove to be R. ?distinctus. Elsewhere in Torit and Juba Districts no ticks occurred on these hyraxes.

PROCAVIA HABESSINICA SLATINI Sassi, 1906. Slatin's Rock Hyrax.

In western Juba District and west of the Nile, Slatin's rock hyrax is common. A single male R. ?distinctus was taken at Rejaf and seven male H. bequaerti at Lui. Both ticks are specific on hyraxes.

PERISSODACTYLA (ODD-TOED UNGULATES)

FAMILY RHINOCEROTIDAE

CERATOTHERIUM SIMUM COTTONI (Lydekker, 1908). Northern Square-lipped or White Rhinoceros.

DICEROS BICORNIS SOMALIENSIS (Potocki, 1900). Somali Black Rhinoceros.

No ticks from either of these animals are available from the Sudan and none were examined for ectoparasites during the present investigation. The white rhinoceros occurs only west of the Nile and the black rhinoceros only east of the Nile though stragglers of the latter are reputed rarely to be seen west of the Nile. It is probable that the Sudan specimens of A. rhinocerotis and D. rhinocerinus from both Equatoria and Bahr El Ghazal Provinces, all found on grass, were associated with these animals.

ARTIODACTYLA (EVEN-TOED UNGULATES)

FAMILY SUIDAE

PHACOCHOERUS AETHIOPICUS BUFO Heller, 1914. Sudan Warthog.

A warthog at Lugurren was infested by a female H. truncatum, fifteen adult R. s. simus, and a male R. simus senegalensis. At Sunat, 25 adults of R. simus senegalensis were taken from one host and at Kheirallah seven adults of the same tick were found on a warthog. Several warthogs in Torit District were uninfested.

SUS SCROFA SENNAARENSIS Gray, 1868. Sudan Wild Boar.

Two wild boars near Torit were infested by a few adults of H. truncatum, R. pravus, and R. s. simus.

FAMILY HIPPOPOTAMIDAE

HIPPOPOTAMUS AMPHIBIUS AMPHIBIUS Linnaeus, 1758. Hippopotamus.

Two hippos shot at Nimule in May and October (rainy season) each had a pair of adult R. s. simus attached to the ears.

FAMILY GIRAFFIDAE

GIRAFFA CAMELOPARDALIS SUBSP. Nubian Giraffe.

Scattered giraffe populations occur from the Nile eastward at least to Kapoeta but no specimens were obtained for the present study. A comparatively large amount of significant data on infestation of giraffes is presented under Bahr El Ghazal Province.

FAMILY BOVIDAE

SYNCERUS CAFFER AEQUINOCTIALIS (Blyth, 1866). Northeastern Buffalo

Buffalos are common from Yei District eastwards and are almost invariably infested by ticks all of which (in the present collection) are adults. The buffalo amblyomma, A. cohaerens, however, is represented by only a single collection of 34 males from the Boma Plains; fifteen male A. lepidum were taken from the same animal, along with twenty R. s. simus, eighteen R. simus senegalensis, a single R. s. sanguineus, and 55 A. variegatum. Variable numbers of this last tick infest almost every buffalo on the east bank of Equatoria Province. Small numbers of H. rufipes and H. truncatum on a few buffalos in this Province are in striking contrast to the high rate and density of infestation by these ticks in northeastern Bahr El Ghazal Province. In eastern Equatoria, infestations of R. s. simus are most common next to those of A. variegatum. In Juba and Yei Districts smaller numbers of R. compositus, R. longus, and R. supertritus have been collected from buffalos.

Possibly the most interesting data resulting from listing the antelopes below are the generally low or moderate numbers of ticks infesting them on the east bank of Equatoria Province. Had more collections been obtained during the rainy season, the rate and density of infestation might have been somewhat higher.

TRAGELAPHUS SCRIPTUS BOR Heuglin, 1877. Nile Bushbuck.

Several bushbucks obtained near Nimule were uninfested.

TAUROTRAGUS DERBIANUS GIGAS (Heuglin, 1863). Derby's Giant Eland.

Near Meridi, five adult B. annulatus and thirteen adult B. decoloratus were taken from a giant eland.

TAUROTRAGUS ORYX PATTERSONIANUS Lydekker, 1906. East African Eland.

An eland at Loronyo bore a female A. lepidum and a pair of adults and seven nymphs of A. variegatum. Single adults of R. s. simus were the only ticks found on two elands near Torit and Kidepo. At Tarangore another yielded four adult R. s. sanguineus and one at Terakeka a single adult R. e. evertsi.

CEPHALOPHUS CAERULUS MUSCULOIDES Heller, 1913. Eastern Blue Duiker.

Blue duikers are not uncommon in the mountain forests east of the Nile but they are difficult to obtain. A female H. parmata has been taken from an animal in the Noli Hills.

SYLVICAPRA GRIMMIA ROOSEVELTI Heller, 1912. Roosevelt's Duikerbok.

Five adults and two nymphs of A. variegatum were infesting a duikerbok near Torit. Several others in this area were uninfested.

KOBUS DEFASSA HARNIERI (Murie, 1867). Harnier's Waterbuck.

"Several" H. aciculifer from Muragatika have been reported in literature. Waterbucks that we examined near the Nile were uninfested.

ADENOTA KOB LEUCOTIS (Lichtenstein and Peters, 1854). White-eared Kob.

No ticks were recovered from a few kobs shot in Eastern District.

REDUNCA BOHOR COTTONI (W. Rothschild, 1902). Cotton's Reedbuck.

A few reedbucks examined near Nimule and Juba yielded no ticks.

HIPPOTRAGUS EQUINUS BAKERI Heuglin, 1863. Baker's Roan Antelope.

About half the roans obtained in Juba, Torit, and Eastern Districts were parasitized by small numbers of adult ticks representing A. lepidum, A. variegatum, R. appendiculatus (rare east of the Nile), R. e. evertsi, R. s. sanguineus, and R. s. simus.

DAMALISCUS KORRIGUM TIANG (Heuglin, 1846). Tiang.

Sudan Government collections contain single adults of A. lepidum and R. s. simus from Terakeka.

ALCELAPHUS BUSELAPHUS ROOSEVELTI (Heller, 1912). Roosevelt's Hartebeest.

In Torit District from one to fifteen ticks were found on infested hartebeests, locally called "tel-tel", but a number of others examined were tickless. Adults and nymphs of A. lepidum and A. variegatum were represented as well as fifteen adult R. e. evertsi, single adults of R. pravus and H. aciculifer, and a pair of B. decoloratus.

ALCELAPHUS BUSELAPHUS SUBSP.

Two male H. aciculifer from an unidentified hartebeest from Atiambo (Alungwe) are present in Sudan Government collections.

OUREBIA OUREBI AEQUATORIA Heller, 1912. Southern Sudan Oribi.

Approximately one in eight oribis examined in Torit District was tick infested. The number of parasites per animal was eight or less. Single nymphs of A. nuttalli, A. variegatum, H. aciculifer, and R. pravus, as well as adults of H. aciculifer, R. pravus, and R. s. sanguineus were found.

RHYNCHOTRAGUS GUENTHERI SMITHII Thomas, 1901. Smith's Long-snouted Dik-dik.

The rate and density of tick infestation of the long-snouted dik-dik are similar to that of the oribi. Near Torit and Ikoto, two specimens bore three and fifteen nymphal A. variegatum, others single adults of H. leachii muhsami and R. pravus, and two yielded seven adults of the latter species.

GAZELLA GRANTI BRIGHTI Thomas, 1901. Bright's Gazelle.

Bright's gazelle, to the best of our knowledge, occurs only in Eastern District. A specimen at Jebel Kathangor in December was infested by sixteen nymphs, evenly divided between A. lepidum and A. variegatum, and four adults of the former species.

MAN

Europeans and Americans who venture into the field in eastern Equatoria commonly pick a few ticks off themselves afterwards. The ticks are usually quickly noticed due to the open clothing and numerous baths that are indulged in this area. Available specific records derive only from our own party; other persons informed us of being bitten by ticks but failed to preserve the specimens. No infestation of indigenous people was observed.

Ticks actually feeding on man at Torit and Ikoto were nymphal A. variegatum and R. appendiculatus, female R. pravus and R. s. simus, and male R. pravus, R. s. sanguineus, and R. s. simus; the last named tick was also recorded at Juba. The nymph of R. appendiculatus taken from the leg of one of our party at Torit the day after returning from Kajo Kaji is of especial interest since the parasite undoubtedly attached at Kajo Kaji, some three hundred miles from Torit.

Ticks removed from human beings but not attached were adults of the three rhipicephalid species noted above. A male R. s. sanguineus "from man" at Khor Lado was presented by Mr. Reid.

STRUCTURES

HUMAN DWELLINGS

Three specimens of the African relapsing fever vector, O. moubata, were collected in a hut at Liria (cf. page 121). Others have been taken in a hamlet in the Kajo Kaji area and reported from "four Equatoria Province rest houses north of Nimule".

Ixodids were frequently observed in houses but the only one retained with data was an adult A. lepidum.

POULTRY HOUSES

Wherever chickens are confined in any numbers in Juba, Torit, and Eastern Districts A. persicus can be found. Few specific data were retained but numerous casual observations were made.

PIGEON COTE

A cote at Juba twice yielded a few A. reflexus but additional material could not be found on subsequent visits. Other cotes at Juba were uninfested. Pigeon cotes elsewhere in the Sudan were not investigated.

DOMESTIC FOWLS

CHICKENS

The same remarks as for poultry houses (above) apply to the hosts themselves. At Torit, twelve nymphs of *A. variegatum* were also found on chickens.

TURKEYS

Seven nymphs of *A. variegatum* infested a turkey at Katire.

DOMESTIC MAMMALS

Large numbers of ticks collected from domestic mammals allow generalized conclusions concerning distribution and host predilection. Systematic collections throughout the year and throughout the Province were not undertaken. Eastern District, the mountains of the east bank, and the area west of Yei deserve more attention. Significant data should be obtained from more intensive collecting during the rainy season.

HORSES

There were probably no more than fifty horses in Equatoria Province during the period of the present study and it is unlikely that many of these remain. Ticks found on horses at Torit and Juba were nymphal *A. variegatum*, nymphs and adults of *B. decoloratus*, and adult *R. e. evertsi*, *R. s. sanguineus*, and *R. s. simus*.

DONKEYS

Small numbers of donkeys are maintained by the Taposa of Eastern District and by small tribes in this area but these animals were not examined for ticks. Nymphs of *B. decoloratus* have been taken from a donkey at More (Yei River).

PIGS

Fewer than fifty pigs were seen, all at Torit and Katire. A few pigs kept at Amadi did not thrive. At Katire, nine nymphal

A. variegatum were the only ticks on four pigs. At Torit, several adults of R. s. simus could be found on each pig whenever a search was made and 99 were collected along with single males of R. e. evertsi and R. s. sanguineus.

DOGS

Dogs maintained by the few Europeans previously living in Equatoria Province were deticked every day or two and yielded the same species found on pie-dogs. Infestations of pie-dogs, often tremendous, were characterized by preponderence of R. s. sanguineus in practically every collection throughout the Province, smaller numbers of R. s. simus almost everywhere, and a paucity of H. l. leachii. The last-named tick, which in Equatoria Province appears to be more common on dogs at high altitudes, is represented by about 45 specimens, but the subspecies H. l. muhsami by only a single specimen. In Eastern and Torit Districts, A. lepidum and R. pravus parasitize dogs; near the Nile a few adults of R. simus senegalensis have been taken. A single female B. decoloratus was found at Gilo. The localization of A. variegatum infestations is of some interest. This ubiquitous tick was found on dogs only at Katire and Kajo Kaji. Both localities are at higher elevations than the plains and received less attention than Torit and the surrounding country.

CATTLE

Cattle are so frequently of considerable importance in supporting and transporting large numbers of ticks of known or potential medical and veterinary importance that special consideration should be given to cattle history, breeds, numbers, husbandry, and movements wherever a tick survey is attempted.

Before the devastating slave raids of the nineteenth century cattle were more numerous in areas bordering the Nile than now. Since the low ebb of that period, herds of livestock have varied greatly due to epidemics, encroachment of tsetse flies, and intertribal relations. The largest cattle populations occur in Eastern District, eastern Torit District, and the Kajo Kaji area. Elsewhere small herds are maintained in isolated situations but west of Yei cattle are rare indeed.

Luxmoore (1950) lists three breeds of cattle in this Province. The huge, big humped, short legged, short horned Taposa breed of Eastern District is guessed to number from 60,000 to 70,000 head. It will be generations before a thorough study of cattle-tick relations can be undertaken in this fascinating, wild area. The second, or Mongalla breed, is a dwarf East African zebu, less than four feet high, with thin skin, fine coat, nervous disposition, and considerable agility. This isolated mountain breed is much less common than the Taposa. The Didinga mountain cattle may represent a separate breed. Long-horned Nilotic type cattle, for which the Sudan is famed, are kept in small numbers near the Nile by the Mandari, Bari, and Nyangwara tribes. Nilotic cattle were frequently brought into various parts of the Province, mostly for slaughter, during the period of the present study. In Torit District small herds of mixed Mongalla-Taposa breeds exist in tsetse-free areas. Juba District, once an important cattle area, now possesses only small herds as does Yei District except for the Kajo Kaji area. A strong cattle tradition from the nineteenth century persists in this area. A hundred square miles of tsetse-free area around Kajo Kaji support some 15,000 Kuku tribesmen and some 6000 head of Mongalla cattle. Westward, very few cattle are maintained except for a few government herds and isolated groups such as the Lanya herd that remains to this day after having been saved from Arab slave traders by being hidden in Lanya Hill caves.

A. variegatum is represented in practically every collection from cattle throughout the Province but the few collections from the west bank contain many more specimens than those from the east bank. B. decoloratus, also common from Torit westward, is rare or absent east of Torit except in the mountains. Varying numbers of R. e. evertsi frequently parasitize cattle in many parts of the Province. Several species are common only in certain Districts. A. lepidum and R. pravus, most numerous in Eastern District, are less common in Torit District and extremely rare or absent to the west. B. annulatus is scattered throughout the west bank but rare or absent on the east bank except possibly in the mountains. Other species entirely or largely restricted to east bank mountains are H. aciculifer, H. parmata, and R. kochi. Species that are almost entirely restricted to Yei District are R. appendiculatus, R. muhlensi, and A. pomposum; the latter two are rare. Small collections from scattered localities include

H. rufipes, H. truncatum, R. s. sanguineus, and R. s. simus. An exceptionally large collection of the last named species from Juba is inexplicable.

SHEEP

Smaller numbers of sheep run with the goat herds of east bank tribes. Except for the Taposa fat-tailed breed of Eastern District and a few in mountainous areas, Equatoria sheep are "miserable little beasts that always look prepared to give up the unequal struggle with the least encouragement" (Luxmoore 1950).

Ticks are seldom if ever numerous on sheep in this Province. Small numbers of R. e. evertsi are found everywhere. In Eastern District, R. pravus is common and A. lepidum occurs on some hosts. In Yei District, R. appendiculatus parasitizes sheep in some numbers. Small numbers of A. variegatum, B. decoloratus, H. truncatum, R. s. sanguineus, and R. s. simus also attack sheep in various localities.

GOATS

Goats are kept by all tribes from Yei District eastward and large numbers exist in Torit District where they largely substitute for cattle as food and dowry. Although far from impressive in appearance, goats thrive on the east bank and in parts of Yei District. Their importance as tick hosts is difficult to assess. Hundreds were found to be free of ticks but several collections suggest that goats must not be overlooked in epidemiological considerations.

Those goats that are tick infested harbor the same species as sheep. R. s. sanguineus, however, is somewhat more numerous and frequent on goats but R. s. simus is scarce. In Katire and Kajo Kaji collections, nymphal A. variegatum were present in good numbers. At Loronyo and Kajo Kaji large numbers of nymphal R. e. evertsi were also found.

MISCELLANEOUS SITUATIONS

ON GRASS

Small numbers of adults of R. kochi, R. s. sanguineus, R. s. simus, and R. simus senegalensis and A. variegatum were collected from grass at various localities. The only specimens of A. rhinocerotis, D. c. circumguttatus, and D. rhinocerinus known from the Sudan were taken on grass.

MAMMAL BURROWS AND DENS

Mammal burrows and dens should be carefully studied in Equatoria Province. A special trip planned to investigate this important aspect of tick biology was cancelled due to unsettled conditions in southern Sudan. See pages 792 and 793.

BAHR EL GHAZAL PROVINCE*

All statements below pertain to the Galual-Nyang Forest unless other localities are specified. For a description of this forest, see Reid (1955). The Galual-Nyang Forest, Yirol, and Wau areas have been moderately well explored for ticks, although much remains to be accomplished in this region. Scattered records for other localities noted on Figure 3 have been obtained. The western half of the Province should yield many interesting new data.

---

*Data from this Province result chiefly from the energy and interest of Mr. E. T. M. Reid, veterinary entomologist, and to his associates on the Tsetse Survey and Reclamation Team, Messrs. N. A. Hancock, A. W. Wild, P. J. Henshaw, W. I. A. Dees, P. Blasdale, and H. C. Brayne, under the direction of Mr. T. W. Chorley. Our own visit to Wau and the Galual-Nyang Forest, at the invitation of Mr. J. T. R. Evans, formerly Director, Sudan Veterinary Service, and as a guest of Mr. Chorley, produced many worthwhile specimens and observations due largely to the courtesy and assistance of the persons mentioned above. In this and the following Provinces, a small amount of host data omitted from the main body of this work are included.

The western half of Bahr El Ghazal is poor, hilly country with uneven rainfall, more or less dense forests with tsetse flies, and few permanent herds of cattle. The eastern half is characterized by rich dry season meadows, or toich, along the numerous rivers, several lakes, and the northern "Nile sponge" area that becomes a vast lake during the rains. Large numbers of livestock are maintained in eastern Bahr El Ghazal and restricted populations of the big game animals of Africa reach their northern limit here.

REPTILIA

No records for monitor lizards or tortoises are available from this Province. A number of specimens of *A. latum* have been taken from cobras and pythons in the eastern sector.

AVES

Infestations of *Francolinus clappertoni* by nymphs of *A. variegatum* in the Forest area are heavier and much more common than those observed in Equatoria. A female *H. h. hoodi* was found on a tchagra shrike. Near the Kordofan border and near Yirol several adults of *R. s. sanguineus* and a single male *A. lepidum*, respectively, were taken from two greater bustards.

MAMMALIA

Thirty HEDGEHOGS, *Atelerix pruneri oweni*, were examined; six were infested by two to four adult *R. s. sanguineus* and a total of five male *H. leachii muhsami*. A male and female of the latter tick were also collected from a hedgehog by Mr. Reid.

Although Mr. Reid examined some BATS, no ticks were obtained.

Among primates, some fifty GALAGOS, or bushbabies, examined by Dr. T. Work and the writer were uninfested. A number of BABOONS from several large families throughout the Forest were also free of ticks, but all old male hobos wandering alone were infested by several to two hundred adult *R. s. simus*. British Museum (Natural History) collections contain a few adult *R. s. sanguineus* from a baboon at Kenisa (on the Bahr El Ghazal - Upper Nile border).

HARES were seldom collected. Seven adult R. s. sanguineus specimens from one host are represented.

GROUND SQUIRRELS, Euxerus erythropus subsp., are common in the Forest. Five squirrels obtained in February yielded twelve males, six females, and four nymphs of H. houyi.

Small MURID RODENTS have not been collected and searched in this Province. Twelve male and six female H. leachii muhsami were found on a small rodent burrowing in a termite mound.

CANE RATS (THRYONOMYIDAE) are not known to be infested by R. simpsoni in this Province but an unusual record of two male R. s. simus from a cane rat at Yirol was obtained by Mr. Reid, who also found a nymph of A. variegatum on a cane rat 37 miles west of Yirol.

CARNIVORES have received considerably less attention than antelopes, buffalos, giraffes, and warthogs in this Province. A black-legged mongoose in the Forest (May) was infested by sixteen adult H. leachii muhsami, another at Yirol (January) by only a single male of this species. A leopard 36 miles south of Yirol bore two males of the same tick as well as a male and three females of R. sulcatus. Another mongoose in the Forest was infested by adults of R. s. simus, a tick also represented by a single male from a hyena, seven adults from a leopard, and a male from a lion. A hyena at Yirol yielded a male H. l. leachii and seven adult R. s. simus. It is of some interest that no specimens of R. s. sanguineus were recovered from carnivores.

ELEPHANTS in this Province appear to be outside the geographic range of their usual parasites, A. tholloni and D. c. circumguttatus. Small to moderately large numbers of R. s. simus and R. simus senegalensis infested every elephant examined in the southeastern spur of this Province (including Kenisa on the Upper Nile Province border). In the case of R. s. simus, both sexes were taken on elephants during each season of the year. Mr. Chorley, who shot several elephants in the western part of the Province, stated that no ticks infested these animals.

No specimens of RHINOCEROS were examined but seven male and six female D. rhinocerinus on grass from two localities near Yirol suggest this tick's infestation of those animals that do occur.

WARTHOGS were common in the Forest. Ticks from six hosts were:

Host	Month	♂	♀	
1	Jan	5	18	R. simus senegalensis
2	Feb	6		R. cuspidatus
3	Feb	1		R. s. simus
		9	31	R. cuspidatus
4	Apr	4	1	R. s. simus
5	Jun	1		R. simus senegalensis
		2	6	R. cuspidatus
6	Sep	1		A. variegatum
		1		R. tricuspis
		3		R. s. simus
		5		R. simus senegalensis
			9	R. simus subspecies

Discovery of the eyeless tampan, O. moubata in three warthog burrows in the Forest area is of extreme interest (pages 121,129, 144,149).

A HIPPOPOTAMUS shot in the Jur River, in the northeastern corner of the Province, in April had nine male and one female R. s. simus on its ears.

GIRAFFES in northeastern Bahr El Ghazal comprise one of the most northern populations of these animals in eastern Africa. The first four hosts on the table (page 813) were taken at Liednhom on the south bank of the Jur River, near the Galual-Nyang Forest where the remainder of the hosts were secured. Data for the number of giraffes examined but free of ticks were not obtained. The chief tick species infesting thirty hosts are listed in the table on page 813.

There were no significant differences between infestations of male and female hosts. The only ticks in addition to those listed in the table were a male R. s. simus (Host 3), two male A. lepidum (Hosts 8 and 17), and a male R. tricuspis (Host 30).

Inasmuch as cattle passing the boundaries of this area are heavily infested by A. variegatum, the absence of this tick on seventeen of these giraffes and the light to moderate infestations on the remainder of these animals is noteworthy. These data contribute to other from this area indicating that the bulk of the *A. variegatum* population does not commence reproduction until well into the rainy season (June, July).

The presence of two male *A. lepidum* on these giraffes is of some interest inasmuch as ecological conditions in Bahr El Ghazal seldom meet this tick's requirements. *A. lepidum* populations in this Province are either small, rare, and restricted, or else introduced but not thriving. From the fact that only a single male *R. s. simus* and no *R. e. evertsi* were taken it would appear that giraffes are not favored hosts of these ticks, which are common on other animals in the area.

The frequency with which both sexes of *H. rufipes* and of *H. truncatum* were found on the same hosts from March through June indicates breeding of these species late in the dry season and through the first half of the rains. Data for other seasons are not available. The small amount of data for both sexes of *H. truncatum* feeding in August may indicate that adults continue to appear and mate throughout the rainy season or else that a second generation has reached adulthood later in the rains.

M. reidi sp. nov. is known only from these collections. Whether it is a typical parasite of giraffes remains to be determined. The small amount of available data suggest that the reproductive season commences early in the rains.

TICKS FROM GIRAFFES

HOST	MONTH	A. VARIEGATUM		H. RUFIPES		H. TRUNCATUM		HYAL. SP.	M. REIDI		
		♂	♀	♂	♀	♂	♀	Nymphs	♂	♀	N
1	Mar								14	10	
2	Mar										1
3	Mar					42	20				
4	Mar					6	2				
5	Mar					24	4				
6	Apr					18					24
7	May										
8	May			8	8						
9	May	1		18	13						
10	May	2		14	3	4	3				
11	May	9	1	11	4						
12	May			14	7	2					
13	May	1		3	2	11	5				
14	May	2			3						
15	May	1		5							
16	May			2							
17	May			3	5	1	8				
*18	May							2			
19	May			3	2						
20	Jun					33	9				
21	Jun	1		3							
22	Jun			3	5						
23	Jul	1	1								
24	Jul	2									
25	Jul	2	1								
26	Jul	1	1								
27	Aug	18	6								
28	Aug					4	6				
29	Aug					3	8				
30	Aug	9	2			2					
TOTAL		50	12	87	52	150	65	2	14	10	25

*Immature host.

Nineteen BUFFALOS in the Forest were infested by 186 ticks, as shown in the table below. Seasonal data for males and females are in general similar to those obtained from ticks infesting giraffes in this area. The low incidence of infestation of these buffalos by *H. truncatum* is noteworthy.

TICKS FROM BUFFALOS

HOST	MONTH	*A. VARIEGATUM*		*H. RUFIPES*		OTHERS		
		♂	♀	♂	♀		♂	♀
1-3	Feb			6	4	(*R. longicoxatus*		1
						(*H. truncatum*	7	6
4	Feb	1				*R. s. simus*	16	4
5	Mar			6	9	*A. lepidum*	1	
6	Mar	2						
7	Mar			2	1			
8	Apr	1				*H. truncatum*		1
9	Apr					*R. s. simus*		1
10	Apr					*H. truncatum*	18	
11	Apr					*R. s. simus*	4	1
12	May	2			3			
13	May	1		5				
14	May	2						
15	Jun	18	6					
16	Jun		1					
17	Jun	6	2	2	1			
18	Jun	10	7			*R. s. senegalensis*	1	1
19	Jun	17	9					
TOTAL		60	25	21	18		47	15

Of the ANTELOPES, the TIANG was most common in the Forest area and all specimens observed were tick infested. When we arrived in February, approximately a hundred dried skins of tiang obtained earlier in the dry season were examined. Each bore from one to 23 dead nymphs of *A. variegatum*, the average number being in the vicinity of ten or twelve. A few dead male *H. truncatum* and *A. variegatum* also remained on the skins. Several hosts secured early in the rainy season were infested by adult A. variegatum. The high incidence of A. variegatum infestation and the absence of other common ticks (i.e. R. s. simus, R. e. evertsi, H. rufipes) on the tiang is of interest. Animals examined immediately after death yielded, besides A. variegatum, only a few H. truncatum and B. decoloratus. In April, two pairs of R. tricuspis and a female of H. leachii muhsami were found on one host and in July four males and seven females of H. aciculifer were removed from another. The latter species also infested a tiang near Tonj (March).

Also noteworthy is the fact that no ticks were found on a number of WATERBUCKS and WHITE-EARED KOBS in the Forest. Three ROAN ANTELOPES were infested by (1) two male and a female H. truncatum and the same number of A. variegatum (September), (2) seven male and a female A. variegatum (August), and (3) a male H. truncatum and a nymphal A. variegatum (March). On a HARTEBEEST shot in July, single adults of A. variegatum and B. decoloratus were found. An ORIBI obtained in June yielded a male R. tricuspis; another, near Tonj in March, two male R. sulcatus.

MAN

Two pairs of adult R. s. simus and nine nymphal A. variegatum were taken engorging on members of our party in the Forest in February. South of Yirol, a female R. sulcatus was taken while crawling on the collector's leg.

DOMESTIC FOWLS

A. persicus is common at Wau, the only locality in which a search for this tick has been made.

DOMESTIC MAMMALS

HORSES are attacked chiefly by B. decoloratus and R. e. evertsi; several collections from single hosts contain as many as sixty ticks of each species. One horse at Wau was infested by twenty adult A. variegatum, another at Busseri by eleven adults of this tick as well as by three adult R. tricuspis, and others by single males of H. rufipes.

DONKEYS are heavily infested by R. e. evertsi. Found on them in lesser numbers are nymphal A. variegatum, and adults of B. annulatus, B. decoloratus, H. rufipes, and H. truncatum.

A PIG at Wau (August) was infested by five male and two female A. variegatum and a pair of adult R. s. simus.

DOGS throughout the Province are almost invariably infested by several specimens of R. s. sanguineus and some serve as host for dozens of nymphs and adults. Rare adults of R. s. simus and H. l. leachii and nymphs of A. variegatum were also found at various localities. A number of female B. decoloratus from Dinka dogs at Fanjak indicate that where dogs and cattle sleep in the same hut the former are attacked by the latter's parasite.

CATS at the Forest and at Wau provided a few specimens of H. leachii muhsami.

CATTLE were observed in all areas shown on the map (Figure 3).

Dinka long-horn cattle are regarded with religious fanaticism by their owners. During the dry season the young tribesmen and their great herds migrate to the toich, low lying pastures along the rivers that are inundated during the floods. At the onset of rain they return to their homeland for grazing. People, dogs, and cattle sleep together around the campfire or in huge, smoke filled huts. It was estimated that a quarter of a million cattle passed the Jur Narrows area, in which the Galual-Nyang Forest is situated, on their annual trek to the toich, but no estimate of the total livestock population of this Province is available. For twelve months, 1950-1951, the Veterinary Department reported 64,031 hides from Bahr El Ghazal; in contrast, only 775 from Equatoria.

Cattle are almost always parasitized by variable numbers of A. variegatum. The infestations are commonly moderate but not infrequently heavy, as many as fifty to a hundred ticks being found on a single animal. During the dry season the proportion of females to males is in the range of one to five hundred, but late in April it becomes one to fifty, and in July and August one to twenty. The July-August figures probably represent the peak reproductive season of A. variegatum. A single dry season collection from Wau (February), not included in the breakdown above, was exceptional in that eight females and 35 males were found on a single cow. Nymphs were carefully searched for on many large cattle herds in the Forest area in February but fewer than a dozen were found. This is in notable contrast to the invariable infestation of tiang by nymphs in January and February.

Other species common on cattle in this Province are B. decoloratus and B. annulatus. In the dry season, B. decoloratus was approximately ten times as common as B. annulatus but during the rains the ratio became more equalized and in some collections B. annulatus exceeded B. decoloratus in numbers. B. decoloratus is represented in all collections from this Province. Very light infestations of H. rufipes are frequent but H. truncatum is represented by only seven adults in three collections. Exceptional parasites of cattle are A. lepidum (three adults in two collections), R. s. simus (six adults in two collections), and a single female R. e. evertsi. This last named tick is so common on sheep, goats, and equines in Bahr El Ghazal that its almost complete absence on cattle is striking; it is also common in Equatoria Province collections from cattle.

GOATS and SHEEP are infested chiefly by R. e. evertsi, most collections containing only this species. Other ticks on these animals are A. variegatum and B. decoloratus.

UPPER NILE PROVINCE*

Available data for this poorly explored Province refer chiefly to localities in the vicinity of Nile steamer wood stations and,

*Data for this Province are from several lots of specimens in Sudan Government and British Museum (Natural History) collections and small amounts of material obtained by personnel of the Sudan Veterinary Service and by the writer. In this report, some references to Kenisa, on the Upper Nile-Bahr El Ghazal border, are included under the latter Province.

to a lesser extent, along the Sobat River and the Malakal-Juba land track. Host-tick relationships in this Province are probably similar to those of the east bank of Equatoria Province. Some East African species not yet recorded from the Sudan may occur near the Ethiopian border.

As one travels northwards in this Province the big game animals of Africa gradually decrease in numbers and disappear. Er Renk is the northern boundary of the fine, lean, naked Nilotic tribes of Negro Africa; further on the country is inhabited by white-gowned Arabs of unique personal dignity and character.

REPTILIA

Cobras at Kenisa, Nasir, and Er Renk have been found infested with A. latum while A. exornatum has been collected from monitor lizards at Er Renk.

AVES

R. s. sanguineus and R. s. simus were taken from lesser bustards at Maban.

MAMMALIA

BABOONS are infested by R. s. simus.

GROUND SQUIRRELS at Bor were the source of H. houyi.

A LION at Akobo Post was parasitized by single pairs of R. simus, R. s. sanguineus, and H. l. leachii and a LEOPARD at Bor by a pair of R. s. simus.

Probable infestation of RHINOCEROS is indicated by King's specimens of A. rhinocerotis from grass near Bor.

WARTHOGS and WILD PIGS shot near Duk Fadiat were hosts of numerous A. variegatum and R. s. simus.

Two BUFFALOS at Rom were infested by six male and four female A. lepidum (July).

A ROAN ANTELOPE at Kaka supplied four male A. lepidum and one female R. s. simus. A TORA HARTEBEEST on the Daga-Kigille track yielded a few female B. decoloratus.

MAN

Two male R. s. sanguineus feeding on man at Melut were sent for identification.

DOMESTIC FOWLS

Argas persicus has been recovered at Malakal.

DOMESTIC MAMMALS

HORSES, DONKEYS, and MULES are attacked chiefly by R. evertsi but several collections including A. lepidum and B. decoloratus have also been made and others contain R. s. sanguineus and B. annulatus.

A PIG at Maban was infested by two B. decoloratus and three R. e. evertsi.

DOGS at Er Renk and Bor were the source of two unusual tick records, one female Ixodes nairobiensis and one male R. supertritus having been secured by King. The first tick is the only one of this species known from the Sudan and the second, not known from other specimens in this Province, is rare wherever it occurs. Infestation by H. l. leachii is known only from Sobat; special efforts made to secure this tick at Malakal were unsuccessful. R. s. sanguineus is represented in all collections.

CATTLE density, breeds, and handling habits here are in general similar to those of Bahr El Ghazal and long east-west migrations are undertaken in search of grazing. Herds observed in Upper Nile were invariably parasitized by A. variegatum and B. decoloratus. Frequently included were smaller numbers of A. lepidum, B. annulatus, H. rufipes, R. e. evertsi, R. s. sanguineus, and R. s. simus. Inclusion of the last two rhipicephalids, not ordinarily found on cattle in the Sudan, is difficult to explain, yet several collections from different localities contain a number of specimens. Infestations of R. e. evertsi are similar to those of Equatoria but heavier and more widely spread than those of Bahr El Ghazal. H. truncatum is represented by only a single collection from Makier.

SHEEP and GOATS have furnished specimens of A. lepidum, R. e. evertsi, R. s. sanguineus, and R. s. simus.

DARFUR PROVINCE*

Northward from the Bahr El Arab (River) that separates Darfur from Bahr El Ghazal Province, the landscape gradually changes from tall to short grasslands with fewer and fewer trees and thence to desert scrub and extreme desert conditions. Few big game animals exist across the Bahr El Arab and those that do are confined to the southern periphery of Darfur. Camels make their first appearance here and horses and donkeys are considerably more common than heretofore. Cattle and sheep abound. Volcanic, fertile, terraced Jebel Marra, with an altitude of almost 10,000 feet, is unexplored for ticks. Differences in the tick faunae of plains, hills, and mountains, and various kinds of grasslands remain to be investigated.

MAMMALIA

A FOX was infested by R. s. simus and another (Vulpes pallida) by R. s. sanguineus.

DOMESTIC FOWLS

A. persicus has been found at Fasher.

---

*Most data for Darfur are from material collected by Sudan Veterinary Service personnel from domestic animals in six areas in the central part of the Province during the dry season. Scattered records in Sudan Government collections have also been obtained.

DOMESTIC MAMMALS

CAMELS, common in the north, graze down to the southern grass lands in the dry season but not to the Bahr El Arab toich. These animals transport goods throughout northern and central Sudan. They are infested chiefly by H. rufipes, possibly the most common tick of Darfur, and frequently by smaller numbers of H. dromedarii, H. impeltatum, H. impressum, and H. truncatum. O. savignyi also occurs and R. s. simus is present in a single collection. Few specimens of H. dromedarii from camels are included but most collections from Darfur cattle include several specimens of this tick.

DOMESTIC RABBITS are parasitized by R. s. sanguineus.

DOGS carry R. s. sanguineus and a single lot of H. l. leachii has been obtained.

HORSES, DONKEYS, and MULES are common and of good breeds. They are usually infested by a number of B. decoloratus and H. rufipes. Most collections also contain H. dromedarii, H. impressum, and H. truncatum and several include H. impeltatum, R. s. sanguineus, and R. s. simus. O. savignyi has also been collected from a horse.

CATTLE and goats and sheep are numerous in Darfur. It is said that sheep are more common and important than goats here. Cattle migrate over a wide area, feeding on the Bahr El Arab toich during the dry season and grazing up to 13°N. during the rains.

Herds in each of the areas represented are most heavily parasitized by H. rufipes, the total number of specimens of which equal those of all other species. Also common but fewer in numbers are H. dromedarii, H. truncatum, H. impressum, and H. impeltatum. A few specimens of A. lepidum, A. variegatum, B. decoloratus and R. s. sanguineus are also present.

GOATS and SHEEP include R. e. evertsi in all collections but this tick has not been found on other Darfur hosts. Less numerous but frequent are R. s. sanguineus, H. rufipes, and H. truncatum. Single collections contain H. dromedarii from goats and B. decoloratus from sheep.

KORDOFAN PROVINCE*

The very few available data from Kordofan are divided between collections from El Obeid, in the short grass-scattered acacia region, and from various localities in the southwestern Nuba Mountain area. The Nuba Mountains, which reach an altitude of some 5000 feet, with permanent water supplies in the mountains and nearby plains, influence the area sufficiently to allow the survival of such tropical ticks as *A. variegatum* and *R. s. simus*. The gradual gradation of the plains from acacia tall grass forest to desert scrub in the north is similar to that of Darfur.

REPTILIA

A. brumpti infests the LIZARD *Agama colonorum* in the Nuba Mountains; *A. exornatum* has been taken from *Varanus e. exanthematicus* at Khuwei, and *A. nuttalli* is known from a LAND TORTOISE at Talodi.

AVES

GUINEA FOWL examined for *A. brumpti* were free of this tick (page 84). A BUSTARD in the Koalib Hills provided *R. s. sanguineus*.

MAMMALIA

The presence of *A. brumpti* in the Nuba Mountains infers parasitism of small mammals.

R. s. sanguineus has been found on HEDGEHOGS at Heiban, and Delami (numerous in both localities), on a HARE at Delami, on a FOX in the Koalib Hills, and on a KUDU on Jebel Tabuli.

DOMESTIC FOWLS

A. persicus occurs at Delami.

---

*Kordofan data were obtained largely by Mr. C. Karrar of the Sudan Veterinary Service. The few wild animal records are from Sudan Government and the HH collections.

DOMESTIC MAMMALS

CAMELS bear H. dromedarii, H. excavatum, and H. impressum, and O. savignyi also feeds on them.

PIGS at Tabanga are infested by R. s. sanguineus and R. s. simus.

HORSES provide H. excavatum at El Obeid and R. s. simus at Talodi.

MULES at Talodi yield R. e. evertsi.

CATTLE populations and movements are comparable to those of Darfur. Herds at El Obeid and northwards are infested by B. decoloratus, H. dromedarii, H. excavatum, H. marginatum, H. rufipes, and R. s. sanguineus. B. decoloratus is probably chiefly transported this far north. In the south herds are parasitized by A. variegatum, B. annulatus, B. decoloratus, H. impressum, H. rufipes, H. truncatum, and R. s. simus. A few B. annulatus and H. detritum have been taken from Kordofan cattle at Quarantine Stations.

SHEEP and GOATS have provided specimens of H. excavatum from El Obeid and of H. dromedarii, R. e. evertsi, R. s. sanguineus, and R. s. simus from the west and south.

BLUE NILE PROVINCE*

The chief tick species and a few of the more uncommon ones are known from this Province but collections have been sparse, scattered, and uneven. Careful surveying should show differences between tick faunae in the sparse grass semidesert north of Wad Medani, the acacia short grass scrub southwards that becomes

*Most Blue Nile data were supplied by Sudan Government veterinarians and by the writer's collections from Wad Medani. Specimens from wild animals are from Sudan Government collections, Mr. D. J. Lewis, and Museum of Comparative Zoology.

acacia tall grass forest south of Singa, and the heavily cultivated, irrigated fields of the Gezira Scheme.

REPTILIA

Infestation of LIZARDS by A. brumpti, specimens of which have been secured at Gebelein and in "Blue Nile districts", appears likely. A. exornatum has been taken from monitor lizards at Singa and Hassa Heissa.

AVES

A male and two female R. s. sanguineus parasitized a "large VULTURE" at Wad Medani.

MAMMALIA

A. brumpti is assumed to infest a variety of small mammals in this Province but definite records are lacking.

HEDGEHOGS at Hodft and Hosh provided several pairs of R. s. sanguineus.

A CHEETAH in the Sennar area has been reported to be infested by A. lepidum and specimens of H. l. leachii were taken from a CARACAL. At Wad Medani, eight H. leachii muhsami and several R. s. sanguineus occurred on a MONGOOSE.

GROUND SQUIRRELS at Roseires parasitized by H. houyi have been reported.

MAN

A male A. lepidum was taken at Wad Medani feeding between the toes of a man.

DOMESTIC FOWLS

A. persicus is present in several localities.

DOMESTIC MAMMALS

CAMELS are heavily infested by O. savignyi at Wad Medani and Kosti. Material from Wad Raiya has also been seen. This tampan probably occurs in most areas where camels are employed. A. lepidum is also common but specimens of H. dromedarii are restricted to the northern half of the Province as are those of H. excavatum. H. rufipes and R. s. sanguineus are represented by single collections and H. truncatum by scattered collections. R. e. evertsi, although common on equines, goats, and sheep, is not present in collections from camels.

HORSES, DONKEYS, and MULES throughout Blue Nile are frequently parasitized by R. e. evertsi and to a lesser extent by R. s. sanguineus. A. lepidum is not uncommon on these hosts. Numerous H. excavatum occur on some horses at Wad Medani.

DOGS bear numerous R. s. sanguineus.

CATTLE are localized in Blue Nile Province. Large areas, although apparently suitable for grazing and close to markets and transportation, support little livestock. In cultivated areas some work animals are employed. In Kosti District, the Baggara tribes do, however, maintain large herds of cattle, goats, and sheep, and migrate with them to northern Kordofan or down to Er Renk in search of grazing. Other pastoral tribes inhabit the area between the Blue Nile and Kassala.

Herds are commonly parasitized by A. lepidum and, at Wad Medani, by H. rufipes. B. decoloratus, A. variegatum, and R. s. simus are represented by single collections from the southern half of the Province, while H. excavatum and H. dromedarii infest cattle in the northern half. H. truncatum is present in scattered localities.

GOATS and SHEEP are hosts of R. e. evertsi and R. s. sanguineus. Comparatively heavy infestations of either or both of these species are common in most areas of Blue Nile Province.

KASSALA PROVINCE*

Grading from a small area of acacia tall-grass forest in the extreme south to large wastes of barren desert in the north, Kassala, by reason of its hilly character and humid sea breezes, undoubtedly supports a number of tick species not yet recorded from this Province. A few miles north of Kassala Province, in Egypt, we have found Ornithodoros foleyi, and H. truncatum follows the coastal plain to its northern limit just inside Egypt. Excellent riding camels are a notable product of Kassala and camels and goats are common throughout the Province except in the inland deserts. Cattle herds range from the south to somewhat north of Port Sudan and sheep are common in the same area except in the far south.

WILD ANIMALS

The presence of A. brumpti at Erkowit indicates parasitism of reptiles and small mammals. A. exornatum has been taken from a Varanus LIZARD in the Butana area. A HARE at Sinkat was infested by R. s. sanguineus.

MAN

O. savignyi has been taken feeding on human beings, near a well, and in several other situations (page 191).

DOMESTIC FOWLS

A. persicus has been found at Suakin.

DOMESTIC MAMMALS

CAMELS at Kassala are infested by numerous H. dromedarii and fewer numbers of H. excavatum, H. marginatum, H. rufipes, and R. s. sanguineus. O. savignyi is also present (page 191).

*Dry and early rainy season data for livestock parasites from several localities were provided by Mr. M. J. Henigan of the Sudan Veterinary Service. Sudan Government, British Museum (Natural History), and the HH collections have added a few additional records.

DOGS at all localities surveyed are heavily infested by *R. s. sanguineus*. In May at Port Sudan, 44 nymphs of this tick and a few adult *H. l. leachii* were also taken.

HORSES and DONKEYS are parasitized chiefly by *H. excavatum* and by fewer *H. detritum*, *H. dromedarii*, *H. impeltatum*, *R. e. evertsi*, and *R. s. sanguineus*.

CATTLE bear chiefly *H. dromedarii*, *H. excavatum*, *H. impeltatum*, *H. rufipes*, and *H. truncatum*, along with fewer *A. lepidum*, *H. detritum*, and *R. e. evertsi*.

GOATS and SHEEP yield chiefly *H. excavatum* and *R. s. sanguineus*, and fewer *H. truncatum* and *R. e. evertsi*.

KHARTOUM PROVINCE*

Khartoum Province, a small area around the capital, Khartoum, industrial town, Khartoum North, and residential and marketing center, Omdurman, is a region of poor grass acacia scrub with no special biological features except for small, irrigated gardens along the Nile. Large numbers of horses, donkeys, camels, sheep, and goats live here or come into the Province, and some cattle are maintained.

The presence of a zoological garden and of a cattle quarantine station brings many wild and domestic animals with a large variety of ticks into the Khartoum area and several exotic records for this locality appear to have been based on material of species not established in this Province.

AVES

King reared *H. rufipes* from nymphs from a KITE, *Milvus migrans*. Adults of *R. s. sanguineus* were found on another kite.

---

*Khartoum data derive from the writer's collections, a few lots in Sudan Government collections, and four lots sent by Sudan Veterinary Service personnel.

MAMMALIA

BATS are parasitized by _A. confusus_ and _A. vespertilionis_.

RODENTS in the desert often bear larvae and nymphs of _Hyalomma_ ticks; immature tick specimens of this genus have not yet been identified. A FOX shot near Khartoum bore a number of _H. l. leachii_ and another four male _H. l. muhsami_ and several _R. s. sanguineus_.

DOMESTIC FOWLS

A. persicus is common in Khartoum and Omdurman.

DOMESTIC MAMMALS

CAMELS yield large numbers of _H. excavatum_, _H. dromedarii_ and _R. s. sanguineus_, and smaller numbers of _H. impeltatum_ and _H. rufipes_. _O. savignyi_ is common here.

DOGS bear _R. s. sanguineus_ and less commonly _H. l. leachii_, _H. dromedarii_, _H. excavatum_, and _H. rufipes_.

HORSES and DONKEYS are parasitized chiefly by _H. excavatum_ but also bear good numbers of _H. impeltatum_, _H. dromedarii_, _H. excavatum_, _H. rufipes_, _R. e. evertsi_, and _R. s. sanguineus_ and a few _B. decoloratus_. Small populations of the last named species appear to be established in irrigated gardens along the Nile.

CATTLE provide _H. dromedarii_, _H. excavatum_, and _R. s. sanguineus_, and fewer _H. impeltatum_ and _H. rufipes_.

SHEEP and GOATS are parasitized by the same species as cattle, except that _R. e. evertsi_ is also common on them.

NORTHERN PROVINCE*

Small herds of domestic animals are maintained in the narrow strip of cultivation along the Nile. Away from the Nile, Northern Province is a vast barren desert that supports little life. The few available tick collections are from the Nile area. Xerophilic tick species undoubtedly remain to be discovered in the desert.

MAMMALIA

BATS at Dongola are infested by A. confusus and A. vespertilionis. FOXES in the desert near the Nile rarely bear R. s. simus, more commonly H. l. leachii and R. s. sanguineus. The latter tick has also been found on HARES.

DOMESTIC FOWLS

A. persicus occurs in a number of localities along the Nile.

DOMESTIC MAMMALS

CAMEL yards frequently contain O. savignyi. H. dromedarii is the chief tick parasite of camels but H. excavatum, H. rufipes, and R. s. sanguineus also occur on them.

DOGS are infested by R. s. sanguineus and H. excavatum.

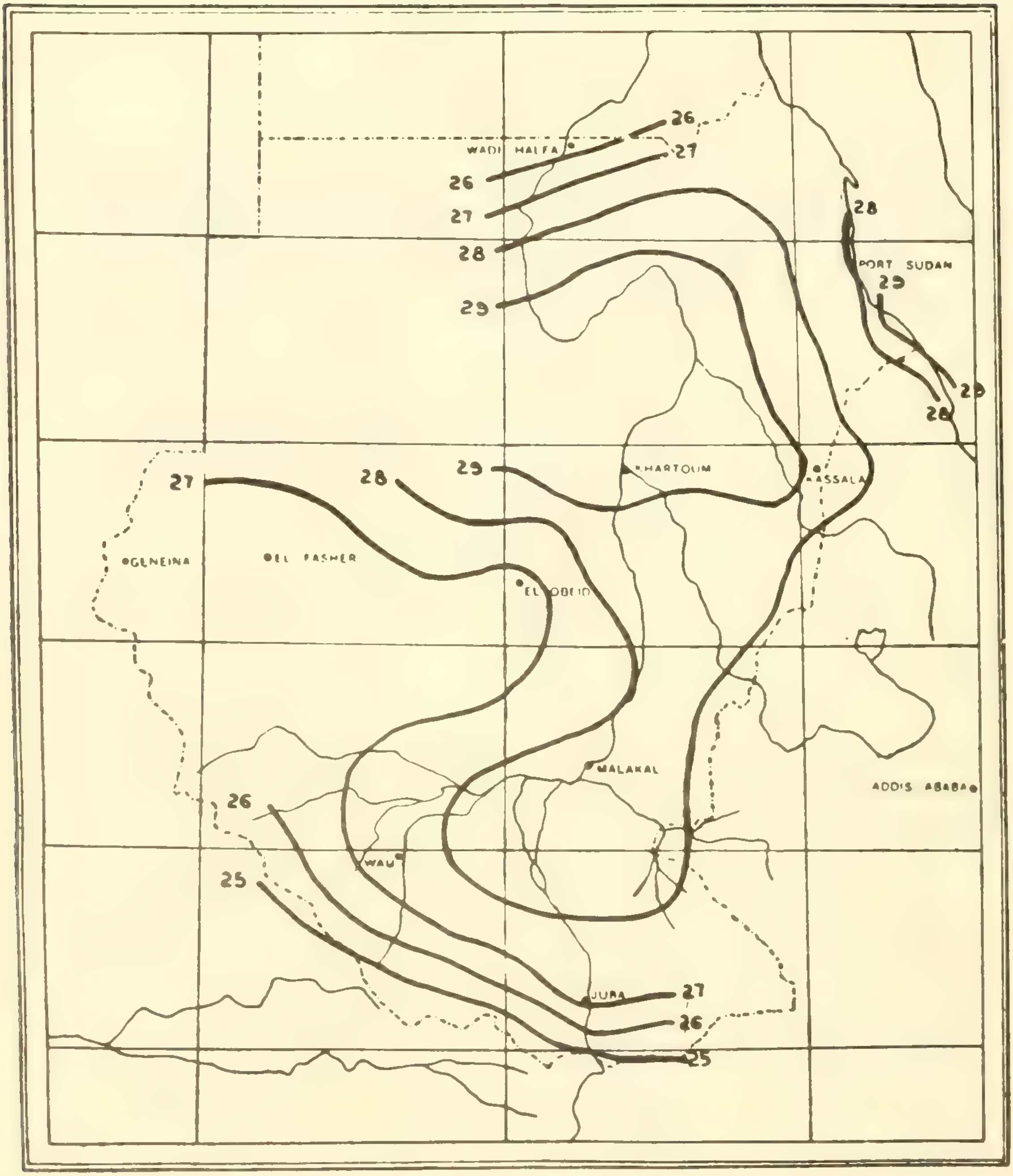
HORSES and DONKEYS bear H. excavatum and fewer H. dromedarii, H. rufipes, and R. s. sanguineus.

CATTLE yield H. dromedarii and H. excavatum; less commonly H. rufipes and R. s. sanguineus; rarely R. s. simus at Shendi.

SHEEP and GOATS harbor H. excavatum and R. s. sanguineus. At Shendi a few R. e. evertsi occur.

---

*Northern Province data were obtained by Sudan Veterinary Service personnel and the writer. A few lots from this Province are in Sudan Government collections.



MEAN ANNUAL TEMPERATURE (°C)
(TO 1940)

Figure 323
MEAN ANNUAL TEMPERATURE OF THE SUDAN
/From Ireland (1948). In: Agriculture in the Sudan.
With permission of Oxford Press and Sudan Government./

PLATE XIC

VI

CLIMATIC AND BIOTIC FEATURES OF THE SUDAN

CLIMATE*

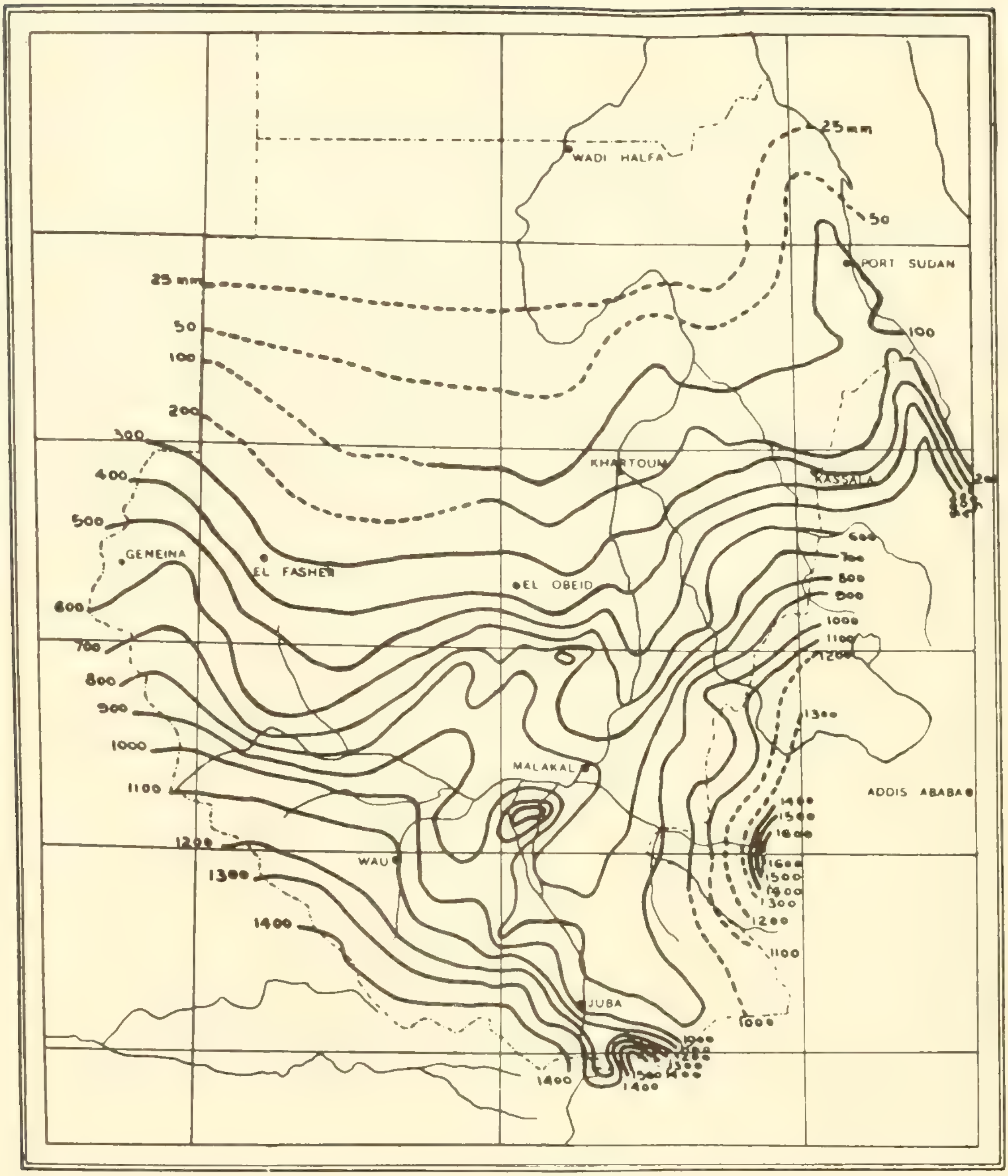
The Sudan, entirely within the tropics from latitudes 22°N. to 3°N. and with a simple topography from the meterological aspect, is almost entirely landlocked and possesses a continental climate. Maritime characteristics are confined to the narrow eastern coastal plain and eastern slopes of the Red Sea Hills. Elsewhere the vast plain is broken only by the Marra Mountains of Darfur, the Nuba Mountains of southern Kordofan, (and the few small ranges of Equatoria). The swampy Sudd of the Upper Nile is the only inland body of water large enough to influence climate. The Sudanese plain extends far west and north, but eastward and southward it is limited by the Ethiopian, East Africa, and Congo highlands.

Mean annual isotherms, or lines of equal temperature, in the Sudan (Figure 323) range from 25°C. to 29°C. Temperatures in this figure are not reduced to a standard level and caution is necessary in dealing with these due to relatively small amount of available data.

In the north and the Red Sea area, the highest mean maxima occur in June or July; these are in the range of 41.1°C. to 43.8°C. Elsewhere they precede the rains and vary from May at Khartoum to January in Equatoria; these range from 36.9°C. to 40.9°C. in the plains and less in highland localities. The lowest mean maxima occur in January in the north and during the rains, July or August, south of about 14°N. Seasonal variation decreases from north to south. The highest daily maxima (37.5°C. to 52.5°C. at Wadi Halfa) occur in the north, the lowest in the south (36.7°C. to 43.7°C. at Juba).

---

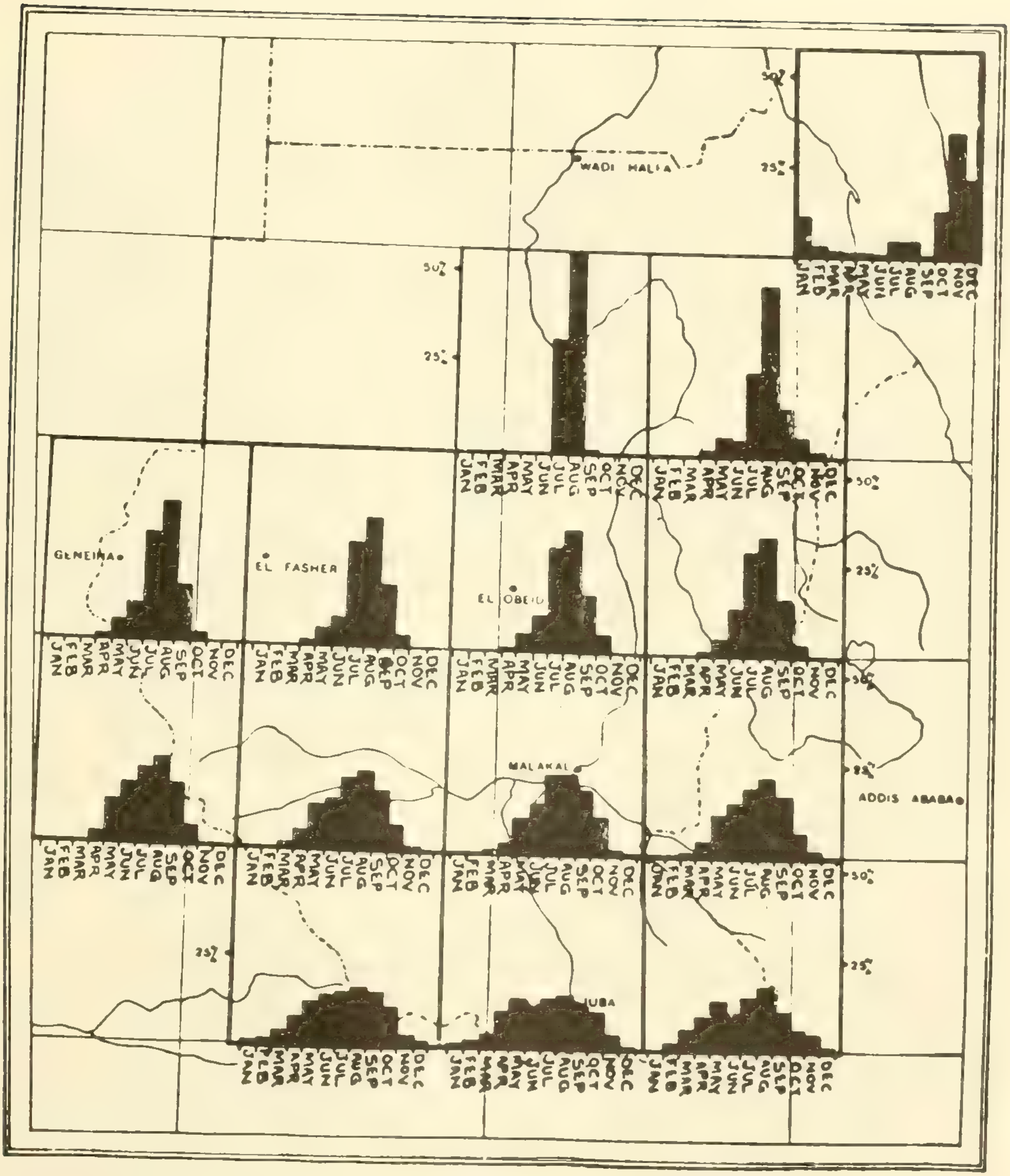
*This section is abstracted from Ireland (1948) in Agriculture in the Sudan.



MEAN ANNUAL RAINFALL (MM)
(TO 1940)

Figure 324
MEAN ANNUAL RAINFALL OF THE SUDAN
[From Ireland (1948). In: Agriculture in the Sudan.
With permission of Oxford Press and Sudan Government.]

PLATE XIIC



MEAN ANNUAL RAINFALL DISTRIBUTION
(TO 1940)

Figure 325
MEAN ANNUAL RAINFALL DISTRIBUTION IN THE SUDAN
[From Ireland (1948). In: Agriculture in the Sudan.
With permission of Oxford Press and Sudan Government.]

PLATE XIIIC

The lowest mean minima throughout the Sudan occur in the winter. Mean daily minima are lowest in the extreme north (7.8°C. to 23.8°C. at Wadi Halfa) and in the west and highest in the Red Sea area (19.2°C. to 28.8°C. at Port Sudan). At Juba they range from 19.8°C. to 22.0°C.; at Wau from 17.6°C. to 22.4°C.; and at Wad Medani from 14.3°C. to 24.3°C. The seasonal variation decreases from north to south and is very small south of Malakal. Numerous other temperature data may be found in Ireland's (1948) original summary.

Rainfall in the Sudan (Figures 324 and 325) is characterized by a remarkably regular decrease in mean annual total from 1400 mm. in the south (1500 mm. in eastern Equatoria mountains) to 25 mm. or less in the northern deserts. Figure 325 shows the annual rainfall distribution expressed as monthly percentages of the total. Except coastally, diagrams represent means over four degree squares. Inland increase in rainy season length from north to south and the anomalous Red Sea area régime are clearly shown, as is the notable latitudinal uniformity and the equatorial double maximum in the extreme south. See Ireland (1948) for further details.

Climatically the Sudan may be divided into three regions:

1. North of about latitude 19°N.
2. South of about latitude 19°N.
3. Red Sea coast and eastern slopes of Red Sea Hills.

North of about latitude 19°N. the desert receives little, infrequent rain or none at all. Strong winter winds with sandstorms and occasional frontal rain occur with an influx of cold air behind a vigorous Mediterranean depression. The desert climate characteristically experiences wide diurnal and annual temperature variations.

South of about latitude 19°N. the typical tropical continental climate is dominated by the annual movement of the boundary between dry northerlies and moist southerlies, a boundary reaching its northern limit in midsummer and its southern limit in midwinter. The southerlies bring rain that extends five hundred miles or so south from the actual boundary. The rainy season is shortest in the north and longest in the south. Most of the rain is convectional with a marked afternoon and evening maximum. Dry winter weather is very stable but intense thunderstorms occur in summer. In the semiarid north, early rainy season winds associated with thunderstorms bring dust storms or hoboobs.

The Red Sea coast and the eastern slopes of the Red Sea Hills, influenced by the Red Sea, have northerlies throughout the year. These bring rain and clouds, rain falling chiefly in winter. The higher relative humidity of this narrow coastal strip markedly influences the flora and fauna of the area.

FLORAL DISTRICTS

The vegetation of the Sudan (Andrews 1948) is divided into seven principal Districts from north to south (Figure 326):

1. Desert
2. Acacia Desert Scrub
3. Acacia Short Grass Scrub
4. Acacia Tall Grass Forest
5. Broad-leaved Woodland and Forests
6. Forests
   - A. Gallery Forests
   - B. Bowl or Depression Forests
   - C. Cloud Forests
7. Swamps and Grasslands
   - A. Permanent Swamps
   - B. Seasonally Inundated Land
   - C. Grassland
   - D. Mountain Meadow

Isolated areas unrelated to their immediate surroundings are the Red Sea Hills (Erkowit) and Gebel Elba (southeastern Egypt adjacent to the Sudan frontier and administered by the Sudan Government).

The following brief abstract provides a generalized picture of the chief floral aspects of the Sudan. For further details, see Andrews (1948) and various chapters in Tothill (1948).

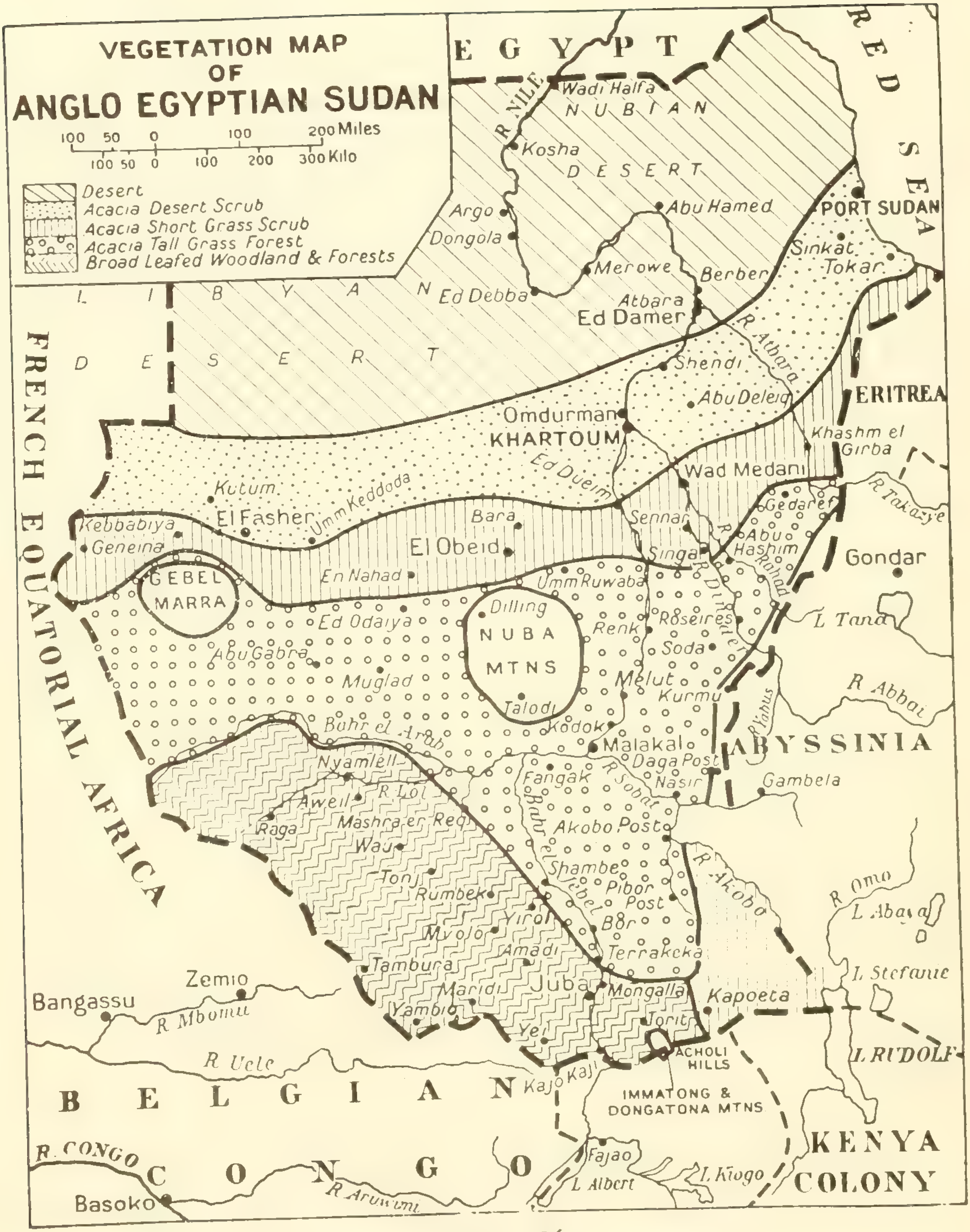


Figure 326

FLORAL DISTRICTS OF THE SUDAN

[From Anderson (1948), In: Agriculture in the Sudan. With permission of Oxford Press and Sudan Government.]

PLATE XIVC

1. Desert District

The Libyan and Nubian Deserts receive from zero to two inches of unequally distributed rainfall annually. The southern margin of this District west of the Nile is about 16°N. Towards the Nile and eastwards, this margin swings gradually northward from a point immediately south of Damer to just north of Port Sudan. Except for the Nile area, vegetation in these areas is confined to a few depressions and rare watercourses harboring some runoff moisture. Almost no woody plants occur. Towards the southern boundaries, on broadly undulating plains of loose red sand, a very few clumps of plants exist and towards the Nile scant stands of samr acacias appear. In the stark, rocky mountain masses of Kassala Province slight vegetation persists in valleys.

In the Nile Valley there are a greater variety of plants, especially date and dompalms, and some shrubs, herbs, and grasses, besides four species of acacia trees. Cultivation of the seluka type, confined to Nile basin areas, utilizes silt deposited by Nile floods. Some waterwheels, saqiyas, are used. Even this will disappear with the advent of the lake behind the proposed High Dam just south of Aswan in Egypt.

2. Acacia Desert Scrub District

This and the following semidesert areas are nowhere so rich as semidesert in the American sense of the word. The Acacia Desert Scrub District extends as a sandy, rocky two hundred mile wide belt, sometimes rolling and with dunes, bordering the northern desert area. Two to twelve inches of annual rainfall is distributed through the four winter months. Many areas are entirely treeless; where vegetation does occur Acacia trees and some shrubs, or a few shrubs, short grasses, and no trees are found. A slightly greater variety of trees exist near the Nile. The Red Sea Hills at the eastern periphery of this District support a separate flora characterized by the dragon's blood tree and various drought-resistant herbs. Here, too, valleys and plains contain dompalms and samr acacia trees. The seacoast supports a separate flora, among which mangrove is noteworthy.

3. Acacia Short Grass Scrub District

A rather narrow, short grass belt fringes the Desert Scrub District to the south. Rainfall increases from twelve to twenty inches annually and falls six to eight months a year, thus maintaining an open woodland type of country with short grasses and herbs. The soil is more water-retaining than that of deserts and supports a greater variety of trees, of which Acacia species dominate. The Butana area (Figure 3) is partially treeless desert and elsewhere open grass plain with thorn scrub. Taller grasses, and denser shrubs and trees grow near the Atbara River and dompalm forests exist at the River's upper reaches.

The southern limit of the distribution of camels in the Sudan coincides with the southern margin of this District.

The intensively cultivated and irrigated Gezira area between the Blue and White Niles is a special feature of this region. Resources from this area produce most of the revenue for the Sudan Government and it is one of the most densely settled areas of the Sudan.

For purposes of the present study, special attention should be called to the outlier of the Acacia Short Grass Scrub District in eastern Equatoria Province, from near Kapoeta eastwards, and in southeastern Upper Nile Province.

4. Acacia Tall Grass Forest District

Extending from the previous District to the Bahr El Arab and thence southwards to the borders of Equatoria Province, the Acacia Tall Grass Forest District is the largest single vegetational unit of the Sudan. Much of it is frequently called the Central Rainlands, on which vast herds of cattle graze and some effort devoted to cotton, peanuts, melons, various legumes, dura, and teff grass is undertaken. Three highland areas, the Gebel Marra group, the Nuba Mountains, and the Ingassana Hills, break the monotonous plains. The vast sudd or papyrus swamps of the Nile and the seasonally inundated "toich" areas are special features of this area. Rainfall ranges from twenty to forty inches annually and soil types vary from dark heavy clays to light sandy loams. While acacia trees are still outstanding, Combretaceous and other broad leaf trees are scattered among them, in some places quite thickly and with ground cover not seen to the north. The species of Acacia also differ in part from those northwards. A large number of floral associations are described by Anderson (loc. cit.) from this District. This is the area of vast migrations of domestic animals from May to September during the rainy season.

5. Broad-leaved Woodland and Forest District

This red ironstone area, with forty to sixty inches of rainfall annually, supports grassy woodlands of varying characteristics, swamps, toich, and luxuriant tropical forests. From Yei westward we find the most extensively forested area of the Sudan. In this area of high elephant grass woodlands, depression and gallery forests are interspersed with forested grasslands and low mountains and hills. Northwards from the Congo watershed the trees become shorter but much varied in species and density. Extensive swamps and important dense, highland forest areas occupy part of the east bank. Gradually, from Yei to near Kapoeta, the grassy plains lose their forest aspect and become more open. Thorny acacias are scattered on the plains and broad leaf trees are confined to patches surrounding termite mounds and fringes bordering streams.

From Kapoeta eastwards less rain falls and an outlier of the Acacia Short Grass Scrub District takes over.

6. Forest Districts

A. Gallery Forests fringe larger streams in the previous District and are most highly developed in the Yambio and Yei areas. In eastern Equatoria these forests are restricted to streams at the base of mountains and to mountain ravines. On smaller streams the forest is only a single ranked fringe; downstream it consists of heavier gallery forest trees in wider ranks that form a close canopy and provide rain forest conditions.

B. Bowl or Depression Forests occur where there is sufficient runoff of water from surrounding slopes. These are the Azza Forest in Meridi District, and the Lotti and Laboni Forests of the Acholi Hills. These approach the true climatic rain forests of the Congo.

C. Cloud Forests of the Sudan are limited to the higher reaches of the Dongotona and Imatong Mountains.

7. Swamps and Grassland Districts

A. Permanent Swamps are chiefly the vast Sudd area of the White Nile and others on smaller rivers. These are of lesser importance for the present study.

B. Seasonally Inundated Land, or toich, along the White Nile and its tributaries, supports the vast cattle herds of the Dinka and Nuers. Tree growth is inhibited and vast grass meadows stretch to the horizon. A foot or so of water covers these meadows during the rains. Other seasonally inundated land along the Blue Nile supports sunt forest.

C. Grasslands as such are negligible in the Sudan except for the toich and deforested areas or recently abandoned cultivation. Short turf occurs on rocky hills, plateau, and ironstone pans.

D. Mountain meadows on shallow soil high in the Imatong and Dongotona Mountains contain grasses and herbs growing to a height of three feet.

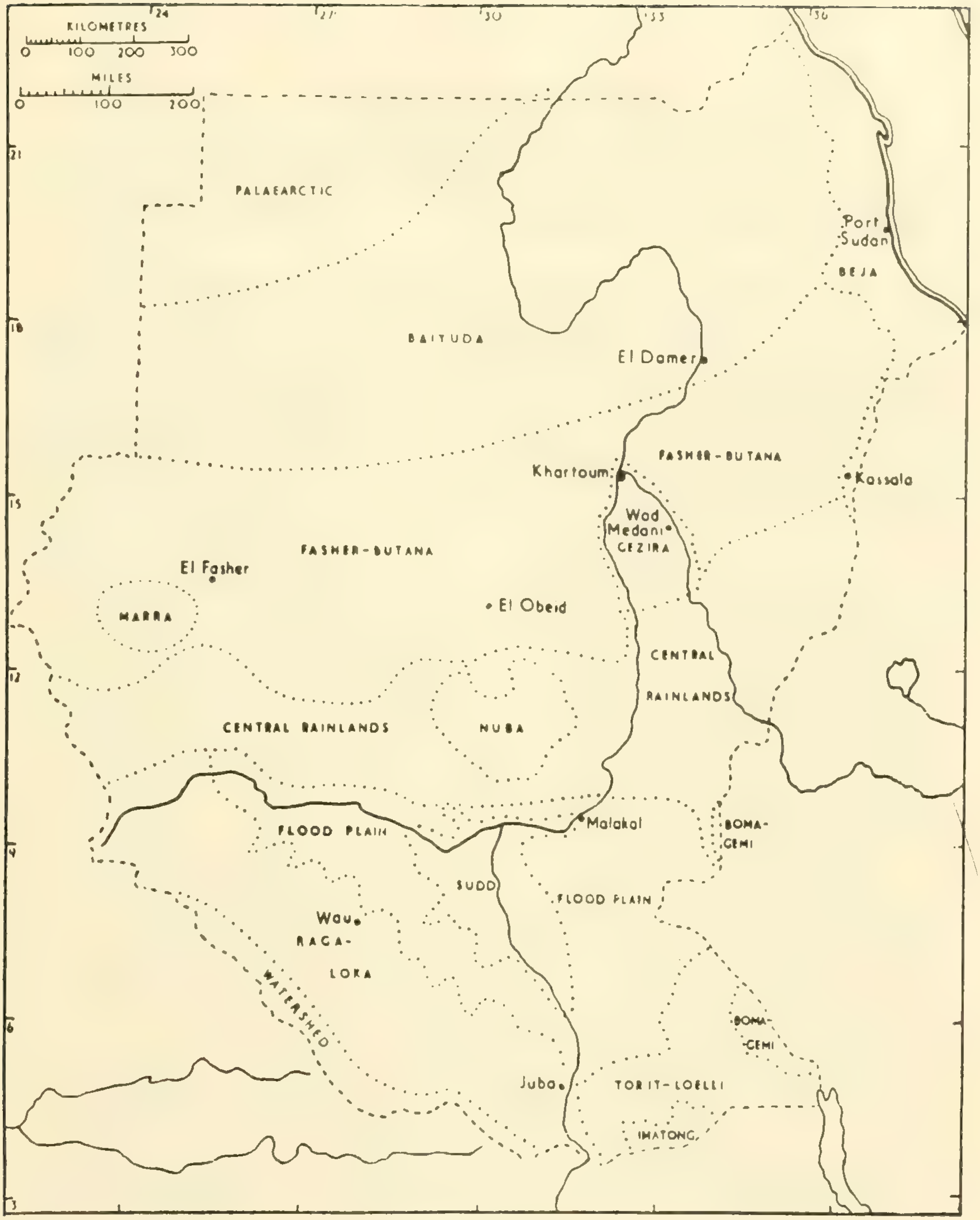


Figure 327
FAUNAL AREAS OF THE SUDAN
Based on Tabanidae. [From Lewis (1953).]

PLATE XVC

FAUNAL DISTRICTS AND AREAS

All of the Sudan, from an overall zoögeographical standpoint, lies within the Ethiopian Faunal Region (Figure 1) except the desert wastes in the extreme northwestern corner that are included in the Palaearctic Faunal Region.

Faunal Districts, although based on a combination of factors, are mightily influenced in the Sudan by quantity and seasonal distribution of rainfall. The effect of rainfall is dramatically illustrated as one travels from north to south by the gradual gradation from extreme desert to African savannah with few trees and short grass in the north and more numerous trees and tall elephant grass in the south. Restricted patches of "jungle-type" forest are encountered in western Equatoria, along the Congo watershed, and in the mountains of eastern Equatoria.

Except for a small component of the fauna that requires a cool climate combined with relatively high rainfall and is therefore confined to the highlands of eastern Equatoria, distribution of animal life in the Sudan is in general less modified by extremes of temperature than by rainfall. Those animals that do range into the Sudanese plains are *per se* adapted to high temperatures and within the Sudan their distribution is limited primarily by floral and rainfall factors. Before differences in temperature extremes can exert definitive influence the animal has succumbed to extremes of other factors.

The Faunal Districts of the Sudan and of the remainder of the Ethiopian Faunal Region (Figure 3), as delineated by Chapin (1932) for birds, nicely illustrate zoögeographical relationships and differences on a continental basis. Disregarding the bulge of the Palaearctic Faunal Region into northeastern Sudan, a barren and almost entirely lifeless desert, the northernmost fringe of the country is part of the narrow Sudanese Arid District belt that extends across Africa from the Atlantic to the Red Sea. As readily realized from data concerning temperature (page 831), rainfall (page 834), and vegetation (page 837), the extremely sparse animal life that exists here is limited to the world's most highly adapted xerophilic species. Bordering this District to the south, the Sudanese Savannah District, extending from the Atlantic to the Ethiopian highlands, embraces most of the vast plains of the Sudan. Here short to tall grasslands are dotted with scattered trees that are often thorny acacias and in southern latitudes include various broadleaf species. Although including much of West Africa beyond approximately 5°N.*, both of these Districts are faunistically an extension of the East and South African Subregion.

West African faunal elements in the Sudan are confined largely to Bahr El Ghazal Province, Equatoria Province west of the Nile, and isolated populations in and about the bases of mountain masses in eastern Equatoria Province. This fauna, in the Ubangi-Uelle Savannah District, reaches southwestern Sudan from central Nigeria. Isolated from that of the more open savannahs of East African Districts, this fauna is composed of numerous genera, species, and subspecies not found in East Africa. It is a peripheral, grassier extension of the West African (Guinean) Forest Districts that in the Sudan are represented by only a few limited forests in Equatoria Province.

In southern Sudan, Equatoria Province east of the Nile and southern Upper Nile Province support populations of animals typical of the East African Highland District. Open, grassy plains, with scattered thorn trees and with broad leaf trees around termite mounds and beside rivers, carry to its northern limit the magnificient plains fauna for which East Africa is famed. In general, these animals differ at least subspecifically from their relatives west of the Nile, although there is some interdigitation of East African elements into the western and northern Districts bordering the East African Highland.

Eastward, the effect of the Abyssinian Highland District is expressed in poorly explored outlying hills just within the Sudan frontier.

The Red Sea coast and the eastern slopes of the Red Sea Hills, by reason of higher relative humidity and more rainfall than surrounding areas, carry the fauna of the Somali Arid District northward at least to Port Sudan.

---

*See modification of this latitudinal zonation for the Sudan, page 844.

As already stated, Chapin's outline of Faunal Districts is a most functional one for generalized faunistic concepts. Before turning to the relation of ticks to these Faunal Districts it is useful to consider briefly the only study devoted to Faunal Areas* of the Sudan, that of Lewis (1953) based on the distribution of Tabanids (Figure 327). In Lewis' map, the combination of the Raga-Loka Areas with the eastern Flood Plain Area and the Sudd Area collectively form a unit equivalent to though slightly wider than Chapin's Ubangi-Uelle District. Lewis' Beja Area, on the Red Sea coast and extending as a narrow inland strip to Kassala, is a slightly extended version of that part of Chapin's Somali Arid District that reaches into the Sudan. The division of Chapin's Sudanese Savannah District into a Central Rainlands Area in the south and a Fasher-Butana Area in the north reflects the effects on animal distribution of increasing aridity from south to north. Chapin's Sudanese Arid District is modified by Lewis' eastward restriction of the Baiyuda Area to exclude the plains south of El Damer. These discriminations, resulting from Lewis' vast experience with insects of medical importance in the Sudan, considerably assist the evaluation of data for distribution of ticks in this country.

TICK DISTRIBUTION

Introduction

Prior to analysis of the Sudanese tick fauna distributionally, it might serve a useful purpose to analyze briefly a few of the specialized criteria that must be applied to ectoparasites and especially to ticks.

A complex variety of factors limits the geographic range of any animal and determines the optimal and marginal environments in which populations may thrive or simply survive. For ectoparasites in general a number of apparent and obscure intrinsic host-ectoparasite relationships must be considered in

---

*Faunal Areas, as here used, are regional subdivisions of Faunal Districts that, in turn, are regional subdivisions of the two Subregions of the Ethiopian Faunal Region, i.e. the West African Subregion and the East and South African Subregion.

addition to such extrinsic environmental factors as physical barriers, temperature, and humidity. For ectoparasites that commonly attack both wild and domestic animals a double set of values needs be employed.

The distribution of parasites that utilize widely differing hosts in each developmental stage is effected not only by the physiological range tolerable to the ectoparasite but also by that tolerated by the several types of hosts required to complete the life cycle. In families of insects consisting of many species certain basic distributional patterns are more easily discerned than in the family Ixodidae composed of relatively few species variously adapted to a wide range of environments and hosts.

In Africa and in the Sudan in particular, where both domestic animals and many wild animals make long migrations in search of water and grazing, particular caution should be exercised in geographic evaluation of collections consisting only of male ticks, which remain attached to the host for many months. Males may be unaccompanied by females, which generally feed for four to ten days, either because the reproductive season is not yet at hand or because they have been transported far beyond their normal range by hosts wandering in search of food and water. When outside their normal geographic range, these unassociated males are not only false zoögeographic indicators but of reduced epidemiological significance since they do not normally leave the host and attach to another. Inasmuch as domestic animal parasitizing ticks are frequently those also directly or indirectly associated with human diseases these considerations assume additional importance.

The wide disparity in size and beauty between different species of ticks as well as in degree of exposure or concealment of feeding sites on the host may give a false distributional picture when collections are gathered haphazardly and by nonspecialists.

It goes without saying that in great areas of the world and especially in the Sudan, remoteness of considerable areas and lack of general and specialized interest by collectors may often result in skewed data or samplings that are far from homogenous.

Tick species having marked host predilections may occupy the same geographic area as the favorite host or only a certain segment of the host range; for example, H. houyi appears to be present in most areas where its favorite host, the ground squirrel Euxerus erythropus, occurs. On the other hand, the elephant parasite A. tholloni is not known from the northern and southern periphery of its host's range, the Varanus lizard parasite A. exornatum does not follow its host into arid areas, and such hyrax parasites as H. bequaerti and its related species occur in only a restricted area of the host's range.

Distributional data for most argasid species of the world are extremely sparse due to the specialized and laborious techniques necessary for collecting them. Even such a commonplace species as that presently considered to be O. moubata, long believed to be well understood geographically, is now confused by a mounting body of biological evidence that tends to discredit or at least to modify critically earlier impressions but is yet too limited to be definitive.

The number and variety of hosts an individual species utilizes throughout its life cycle profoundly effects its distribution and density. A single host tick such as B. decoloratus that feeds on easily available herds or groups of antelopes and cattle is spared many of the dangers resulting from being forsaken as a newly hatched larva or a newly molted nymph or adult in an inhospitable environment where it must seek an entirely different type of host for survival. It may thus become locally numerous and also be carried afar by both wild and domestic hosts under conditions frequently favorable for survival and reproduction. Similarly, a species that utilizes the same type of host for all developmental stages, even though it releases and reattaches two or three times, has advantages over one that cannot survive unless a certain variety of hosts for nourishing the different stages are present.

The frequency with which immature stages of several African amblyommas attack birds probably accounts in part for their relatively wide distribution and population density. In semiarid climes of North Africa and the Near East, where small mammals are rare or localized, the great predilection of immature hyalommas for birds is most important for the survival and distribution of these species. Bird migrations may be of extreme importance in spreading certain ticks; in Egypt a considerable body of yet unstudied data is being amassed on this subject.

The apparent adaptability of some hyalommas and rhipicephalids in altering the number and kinds of hosts they require when and if the situation demands is a most important factor where the supply of a variety of hosts is a critical factor of survival, which in turn determines distribution.

The only serious studies on African tick distribution are those of Theiler (1948,1949A,B,1950A,B,C,1956), Theiler and Robinson (1953A), and Theiler and Salisbury (1956), for South Africa. In these, a combination of valuable criteria, i.e., vegetation plus range, mean, and seasonal distribution of temperature and rainfall, are carefully correlated with localities from which ticks have been collected. Vegetation types are shown to have a close kinship to outlines of tick distribution and the same appears to be largely true in the Sudan. These reports should be studied by anyone interested in the geographical distribution of ticks. Theiler frequently mentions uneven distribution, an aspect of the overall picture often most difficult to evaluate because of the complex factors mentioned in the present brief discussion.

For epidemiological and economic purposes tick species to be considered zoogeographically are more numerous than those that may be readily considered academically strictly as indicators of zoogeographic Districts. Domestic animal parasitizing ticks, so important from the standpoint of human and animal diseases and numerically so common in observations and collections, are often more widely distributed than they might be in the absence of domestic hosts. Similarly, host specific ticks of wild animals, which are frequently those rapidly disappearing with the advance of civilization and hunters, are becoming more restricted in their contemporary range. In the following discussion an attempt has been made to strike a functional medium from both the practical and the academic standpoints.

The known Sudanese tick fauna comprises 62 identifiable species plus two additional subspecies. It is conservatively estimated that twelve to fifteen additional species remain to be discovered here and that when a future count is made the presently unknown components of the fauna will include approximately equal numbers of northern, eastern, and western species. Of the 64 known forms, ten are either Palaearctic in origin or are tentatively referred to this Region, one is an introduced American (Neotropical) species, and 53 are Ethiopian.

Palaearctic Species

H. dromedarii	A. persicus
H. excavatum	A. reflexus
H. impeltatum	?O. savignyi
H. detritum	?I. s. simplex
H. marginatum	I. vespertilionis

The hyalommas are Palaearctic in origin and distribution although they invade a narrow vegetated northern fringe of the Ethiopian Region. H. impeltatum has also gained fairly extensive foothold in the savannahs of West Africa. The first three species listed above conceivably could have reached the far flung areas where they do exist even without the assistance of domestic animals although there is little doubt that these vehicles have greatly facilitated their spread. Details of the distribution of H. detritum and H. marginatum in the Sudan and elsewhere outside of the Palaearctic Region in Africa are vague.

I. vespertilionis and A. persicus probably should be treated as Palaearctic species that have been able to establish themselves as far south as the Cape through bat and human agencies.

Consideration of O. savignyi, A. reflexus, and I. s. simplex as Palaearctic species is entirely tentative. The xerophilic tampan ranges from India to Southwest Africa and its distribution has probably been influenced by common association with camels, except in southern Africa where other factors must be considered. O. savignyi in the Sudan is confined strictly to arid areas. The bat parasite I. s. simplex is known only from a few, scattered Oriental, Palaearctic, and Ethiopian records that defy zoogeographical evaluation. The pigeon parasite A. reflexus, probably Palaearctic in origin though possibly Oriental, is seldom established in tropical Africa; the single population of this species known from the Sudan may already have died out (page 75).

In summary, H. dromedarii, H. excavatum, H. impeltatum, and O. savignyi might be considered as normal inhabitants of the semi-deserts or short grass savannahs of the Sudan, although extensively distributed by domestic animals. The presence of H. detritum and H. marginatum in the Sudan is inexplicable on the basis of our present information. The two bat parasites, I. s. simplex and I. vespertilionis are not unexpected due to their hosts' flight range. A. persicus and A. reflexus are here as a result of human activities.

Ethiopian Species

Fifty-three of the Sudan's 64 tick species appear to have originated in the Ethiopian Faunal Region and few exist elsewhere except for the now cosmopolitan R. s. sanguineus, A. brumpti that reaches a comparatively few miles into Egypt, and A. variegatum that has become established adventitiously in the West Indies.

The Ethiopian tick fauna of the Sudan is largely East and South African in origin. It appears best to dispose briefly of the uncertain elements and of the small and relatively unimportant West African and montane components of the fauna before considering the bulk of the species.

Uncertain Components

Several species in the present collection are represented by so few specimens and data that inferences as to manner of occurrence in the Sudan or in certain local areas should be postponed pending further facts. A. reflexus, H. detritum, and H. marginatum have been discussed under Palaearctic species (page 848).

The single specimen of A. pomposum appears to be far from its favored montane habitat and movements of cattle between montane areas known to be infested and Yei are not believed recently to have occurred. This specimen may, however, point to a limited, undiscovered focus in poorly-explored mountains near Yei.

R. longicoxatus appears to be so patently a rare Somali lowland tick that the single specimen from Bahr El Ghazal and others reported from French West Africa are difficult to reconcile with previous information, and their significance cannot be evaluated properly until further specimens and data become available.

Montane Components

The Imatong Area mountain masses (page 859) harbor outliers of the flora and fauna of both the West and of the East and South African Subregions that occur almost nowhere else in the Sudan. H. parmata, R. bequaerti, and R. kochi are typical West African Subregion forms found in the Imatong and Didinga Mountains. The few specimens of H. parmata from the plains level around Torit are assumed to have been acquired by their hosts in the vicinity of the single stream reaching this area from the mountains.

The bat parasite I. s. simplex has already been discussed under Palaearctic species (page 848). Two other species, I. schillingsi and I. alluaudi, occur on monkeys and on shrews, respectively, in the Imatong forests and reach here from eastern and southern Africa.

R. compositus, a species of eastern Africa that also extends into limited areas of western and southern Africa, is generally associated with highland or montane areas but attacks a wide variety of game animals not necessarily confined to these zones. The several specimens from the Sudan have been found near mountains but not actually in them. This species is tentatively categorized as montane on the basis of its known distribution elsewhere.

West African Components

West African savannah species in the Sudan fauna are B. annulatus*, D. c. circumguttatus, R. cuspidatus, R. longus and

---

*B. annulatus is an introduced American species that in the Ethiopian Faunal Region is known chiefly from the West African Subregion.

R. simus senegalensis; the last two forms have limited extensions into East Africa. West African forest species, in the Sudan known only from montane forests and lower streambanks of the Imatong and nearby mountain masses of the east bank of Equatoria Province, are H. parmata, R. bequaerti, and R. kochi. The Imatong Area also harbors several specialized East African forms not found elsewhere in the Sudan.

The occurrence of populations of any of the first five species listed above outside of the Raga-Loka Area (Figure 328) is exceptional.

It should be noted that the term West African, as here used zoogeographically, applies to elements originating in the first six of the Faunal Districts listed in Figure 1. Several species logically considered as West African from a generalized point of view and in common name terminology are not considered West African in the more strictly defined zoögeographical sense of the term. For instance, H. impressum, although confined to West Africa in the generalized geographical sense, is a savannah species of the East African (zoögeographical) Subregion. H. houyi appears to be common in the savannahs of both Subregions; although it is difficult to determine in which Subregion it should be considered typical the evidence strongly suggests East Africa.

M. reidi sp. nov. is tentatively included here as a species of the West African Subregion since it has been found in only a restricted sector of the Raga-Loka Area (Figure 328). Further investigation may modify this concept but it is unlikely that a large amount of data will ever be amassed on this curious species. The unique biological characteristics and distributional picture of the two species in this genus, combined with their localization in remote areas, confuse an interpretation of their pattern of distribution.

East African Components

Species limited mostly to the area politically considered as East Africa are of considerable value as zoögeographical indicators for the present study. The fact that several of these species, such as Amblyomma gemma and Rhipicephalus pulchellus, are not known to reach the Sudan, is of additional interest.

Two East African species, A. lepidum and R. pravus are especially interesting in that they are typical of the Kapoeta Area (Figure 328) and extend to Torit but little if any further west into Equatoria Province. The reduced rainfall and consequent modification of vegetation in the Kapoeta Area has already been noted (pages 836,838,839). R. pravus is unknown elsewhere in the Sudan; A. lepidum does spill over via the Eastern Floodplain to the Central Rainlands where it is often common. A. lepidum is a species strictly confined to East African areas with reduced rainfall while R. pravus, though most common in the same areas, has a number of restricted outlying populations in southern and western Africa. It is therefore noteworthy that A. lepidum appears to be more aggressive in its Sudanese distribution than R. pravus. Reasons for these differences should be sought among the various factors noted for uneven tick distribution (pages 845 to 848).

A. cohaerens, a strictly East African species that reaches its western limits in eastern Belgian Congo, is also known in the Sudan chiefly from the Kapoeta Area and questionably from adjacent parts of the Torit Area. H. bequaerti of Torit and Raga-Loka Areas is confined to East Africa except for a single known population in western Sudan; this tick belongs to a group of hyrax parasitizing species not known otherwise to occur in West Africa. R. appendiculatus, on the other hand, is chiefly an East African species, but in the Sudan occurs only in the Imatong forests and a small corner of the Raga-Loka Area, where it is common. R. appendiculatus requires a more humid environment than many East African species and is therefore absent in most East African areas of the Sudan. Populations of this tick also occur in the highlands of Central and southeastern Africa, probably in part due to movements of cattle.

East African components typical of arid areas not infrequently extend their range into the Southwest Arid District (southwestern Union of South Africa, Ovamboland, Angola). An example of this pattern is A. brumpti. The ability of this species to reach and survive in dry niches such as hyrax dens in otherwise humid areas may account for its wide distribution and presence in areas that appear unsuitable for its survival. Although A. brumpti thrives and is best known from dry areas, its range of humidity toleration may be more extensive than presently realized. The general outline of the distribution of O. savignyi in Africa is somewhat similar to that of A. brumpti.

East African components of montane forests, I. schillingsi and R. compositus, have already been mentioned (page

Species not already discussed are in part too poorly known to be designated as typically East African or as typically South African. Examples are A. marmoreum (group), R. ?distinctus, and I. rasus ?subspecies, the exact relationships of which are still unknown. Others, such as R. arnoldi, R. muhlensi, and R. supertritus, are widely spread but data are so few and incomplete that they shed little light on ecology or distribution patterns.

A certain group of species that commonly attack domestic animals and that tolerate a moderately low to medium range of humidity factors are widely distributed throughout the Ethiopian Faunal Region. They are common in much of the Union of South Africa, in western Africa, and in the Sudan. In the Sudan, their range includes the Central Rainlands and sometimes even fairly arid areas such as the Red Sea Hills and coastal plains. The outstanding examples of this group of pan-Ethiopian species are R. s. simus, R. e. evertsi, R. s. sanguineus, B. decoloratus, H. l. leachii, H. rufipes, and H. truncatum.

Another important group of species is almost as widely spread as those listed above but their apparent demand for high temperature and a medium humidity range restricts them from much of the Union of South Africa and from the northern savannahs (Fasher-Butana Area) of the Sudan. These species are often common in western and eastern Africa as far south as Mozambique. The outstanding example is A. variegatum. H. h. hoodi, H. aciculifer, and A. tholloni are other species in this group. R. supertritus and R. muhlensi might also be considered in this category.

DISTRIBUTION OF TICKS IN

SUDANESE SAVANNAH AND ARID AREAS

CHIEF PARASITES OF DOMESTIC ANIMALS

FAUNAL REGION	ETHIOPIAN					MIXED ETHIOPIAN-PALAEARCTIC	
SUBREGION	WEST AFRICAN	EAST AND SOUTH AFRICAN					
	SAVANNAH					ARID	
DISTRICT	UBANGI-UELLE	E. AFR. HIGHLAND	SUDANESE			SUDANESE	SOMALI
AREA	RAGA-LOKA	TORIT-KAPOETA	EASTERN FLOOD PLAIN	CENTRAL RAIN-LANDS	FASHER-BUTANA	BAIYUDA	BEJA
A. persicus	N	N	N	N	N		N
R. s. sanguin.	C	C-1	C	C	C		C
H. l. leachii	C	C-1	U	L	L		L
R. pravus		C*					
A. lepidum	R	C*	C	C	U		L
A. variegatum	C	C-1	C	L			
B. decoloratus	C	C-1	C	C	L		R
B. annulatus	C	1		L			
R. e. evertsi	C	C-1	C	C	C		C
R. s. simus	C	C-1	C	C	L		S
H. truncatum	L	C	L	C	L		L
H. rufipes	N	L	C	C	C		C
H. excavatum				L	C	S	C
H. impeltatum				C	C	S	C
H. dromedarii				L	C	S	C
H. impressum				C	L		
R. appendicul.	N	1					
O. savignyi					C	S	C

Species apparently largely confined in Sudan to Imatong Area montane forests: H. parmata, R. bequaerti, R. compositus, R. kochi, I. alluaudi, I. s. simplex, I. schillingsi.

Species of questionable relationships in Sudan: A. reflexus, A. pomposum, R. longicoxatus, H. detritum, H. marginatum.

MISCELLANEOUS PARASITES

AREA	RAGA-LOKA	TORIT-KAPOETA	EASTERN FLOOD-PLAIN	CENTRAL RAIN-LANDS	FASHER-BUTANA	BAIYUDA	BEJA
O. moubata	L	L					
A. brumpti	L	L		L	L	S	L
A. boueti	S	L	S	S	S		S
A. confusus		L	S	S	L		S
A. vespertilionis	S	L-I	S	S	L		S
A. cohaerens		R*	S				
A. marmoreum (gr.)	U	C	S				
A. nuttalli	U	C	S	U			
A. rhinocerotis	L	L					
A. tholloni		C					
A. exornatum	U	C	L	L	L		
A. latum	C	C-I	U				
D. c. circumgut.	L						
D. rhinocerinus	L	R*					
H. aciculifer	L	L-I					
H. bequaerti	L	L					
H. h. hoodi	L	L					
H. houyi	C	C	S	U	S		
H. l. muhsami	C	C	S	U	U		
I. cavipalpus		R					
I. nairobiensis		R-I	S	R			
I. rasus ?subsp.		R					
I. vespertilionis		R					
M. reidi sp. nov.	L						
R. arnoldi		R-I					
R. cuspidatus	N						
R. ?distinctus	R						
R. longus	U	U					
R. muhlensi	U						
R. simpsoni	U	U					
R. s. senegalensis	C	R					
R. sulcatus	U						
R. supertritus	R						
R. tricuspis	R						

SYMBOLS

N Numerous in certain areas
C Common generally
L Localized, apparently not numerous
U Incidence uncertain
R Rare
* Rare or absent west of Torit; i.e., chiefly in Kapoeta Area.
S Suspected to occur
I Imatong range extension

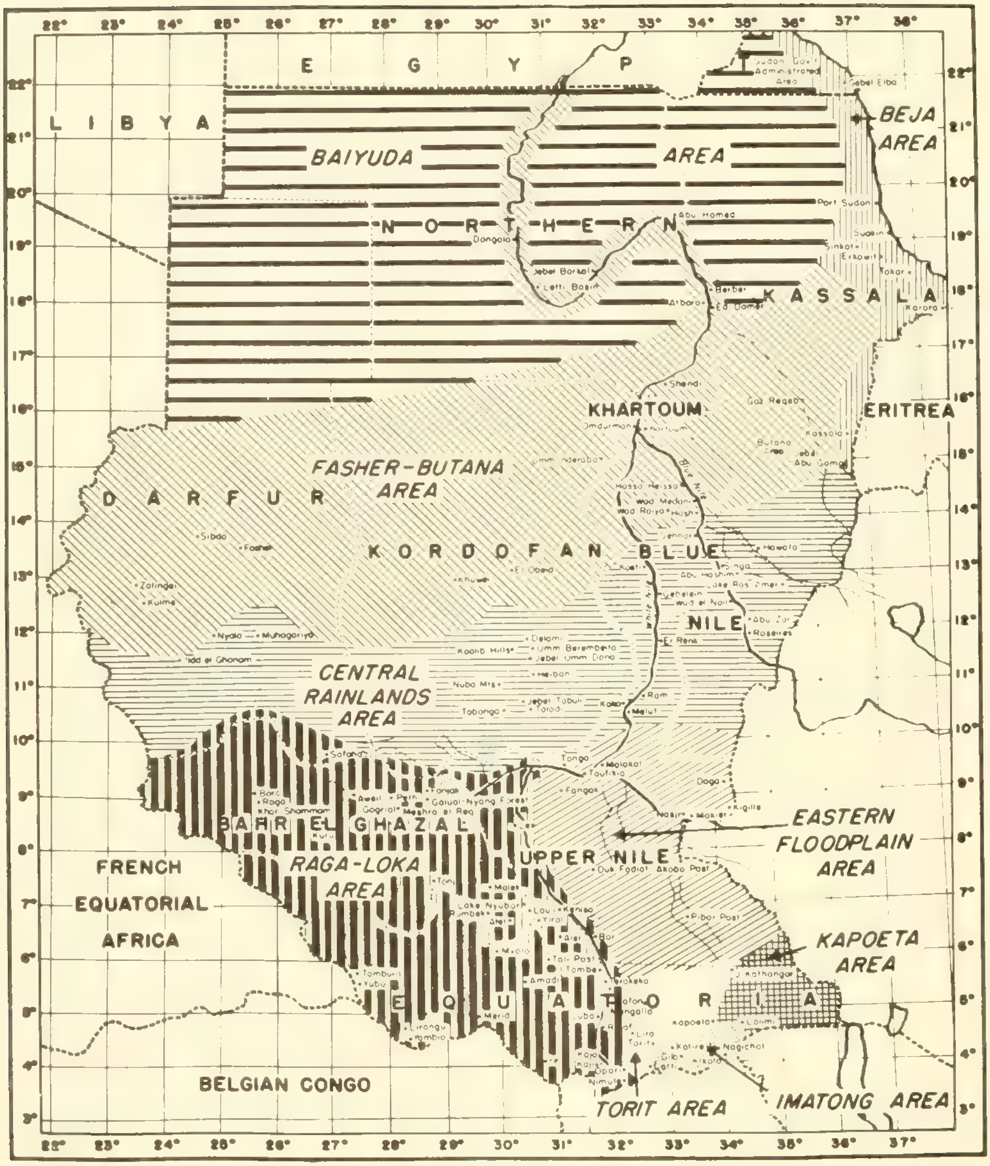


Figure 328

SUDANESE FAUNAL AREAS BASED ON TICK DISTRIBUTION

PLATE XVIC

Sudanese Faunal Areas Based On

Tick Distribution

A somewhat arbitrary, preliminary mapping of Faunistic Areas of tick distribution in the Sudan has been suggested (Figure 328, and pages 854 and 855). This scheme conforms as closely as permissable with that of Lewis (1953), which reflects the importance of critical and specialized factors of aquatic and semiaquatic breeding places of Tabanids as well as availability of hosts. Further study may reveal that additional divisions should be designated for ticks but the limits are not presently well understood. Lewis' Watershed, Marra, Nuba, Boma-Gemi, (western) Floodplain, Sudd, and Gezira Areas are not charted for ticks since data are not yet sufficient to indicate the specialized character of tick fauna in these regions. The more intensive tick collections from southeastern Sudan, however, allow the specification that Lewis' Torit-Loelli Area may be separated into two distinct areas, the Torit Area and the Kapoeta Area. Inasmuch as Lewis' western sector of the Floodplain Area is abandoned for the present purposes, the eastern sector is referred to here as the Eastern Floodplain Area.

WEST AFRICAN SUBREGION

UBANGI-UELLE SAVANNAH DISTRICT

RAGA-LOKA AREA

The Raga-Loka Area, as here considered (Figure 328), is wider than that originally proposed by Chapin as the zone typical of West African fauna in the Sudan (Figure 1). It is a combination of Lewis' several southwestern Areas (Figure 327), the (Congo) Watershed, the Raga-Loka, the (western) Flood plain, and the Sudd. Consisting of various types of forests and savannahs with more numerous trees than found elsewhere in the Sudan, this Area largely lacks the broad grassy plains character of so much of the Sudan. Indicator tick species are those characteristic of the West African Subregion (page 852) though they represent only a small part of the total tick fauna endemic in West Africa. As already stated, indicator species typical of the West African Subregion are exceptional in the Sudan outside of the Raga-Loka Area.

Forests and wooded savannahs of this Area also shelter several species of the East and South African Subregion that are unknown elsewhere in the Sudan. These are R. sulcatus, R. supertritus, R. tricuspis, and R. mühlensi. Restriction of these four ticks to this Area may indicate that they are characteristic of more humid and shaded East African areas than those found elsewhere in the Sudan and therefore they have survived only here. Each is a species of little known biology.

EAST AFRICAN SUBREGION
EAST AFRICAN HIGHLAND DISTRICT
TORIT AREA

Data for this Area are more extensive than for any other in the Sudan. Commencing a few miles west of the Nile, which does not in itself appear to be an effective barrier, Torit Area is a vast, tree-dotted and clustered grassy plain that gradually becomes short grassy scrub east of Kapoeta. From its southern margin rise the various montane masses of limited extent that comprise the Imatong Area. To the north, the area becomes less densely wooded and numerous tick species vanish in the tall grass savannah. Few permanent streams break the plain but several extensive, poorly explored swamps fill depressions in the northern part of the Area.

Almost half of the tick species known from the Sudan have been collected in this Area. West African components are rare indeed owing primarily to the open forest or scattered tree aspect of the plains and absence of extensive forests fringing streams. As already noted, such moderately xerophilic species as A. lepidum and R. pravus occur in the eastern sector of this Area but are considerably less common than in Kapoeta Area. Ticks requiring moderately cool temperatures and high humidity, such as R. appendiculatus, are absent here. Others that require moderate humidity, such as A. variegatum, are common here but their numbers are not so great as when the same species occur in restricted situations in the Raga-Loka Area to the west.

IMATONG (MONTANE) AREA

The specialized tick fauna representative of both Subregions that is supported in these low, cool, partially forested mountains is listed on page 850.

The montane masses consist of the horseshoe shaped Acholi-Imatong Mountains, the highest peak of which is Mount Kinyeti (10,456 feet elevation). To the east, the Dongotona Mountains that rise to 8605 feet elevation have an isolated northwesterly extension in the Lafit Hills. The more eastern Didinga Hills with Mount Lotuke the highest point at 9169 feet elevation, are carried to the northwest by the Boya Hills. The base of these mountains in the plains is at an approximate altitude of 2000 feet. The vertebrate and tick fauna of none of these montane masses is well known.

SUDANESE SAVANNAH DISTRICT
KAPOETA AREA

Kapoeta Area, an extension of Karamoja District of Uganda, is characterized by three important species that are common here but become less numerous westwards toward Torit, their western boundary in southern Sudan. These are *R. pravus*, *A. cohaerens*, and *A. lepidum*. Only the last named species is known to extend northward into the Eastern Floodplain Area from where it fans out and becomes quite common in the Central Rainlands. A number of species present in adjacent Torit Area are not known from the Kapoeta Area. The more intensive work in the Torit Area may partially account for this disparity but the short grass scrub aspect of the eastern plains and the long and intense dry season are factors that may exclude many of these species. This is the area of vast migrations of tens of thousands of game animals from Upper Nile Province (Zaphiro 1949), a spectacular phenomenon that should be investigated for its significance in relation to tick distribution.

EASTERN FLOODPLAIN AREA

The picture of tick distribution in this Area is characterized by the presence of most of the widely ranging, common tropical species of the Sudan plains and by the apparent absence of numerous more specialized tropical species and northern species. More extensive exploration is required before the true composition of the tick fauna of this Area can be evaluated.

CENTRAL RAINLANDS AREA

In the Central Rainlands, ticks of big game animals are exceedingly restricted or entirely absent. Few species typical of tropical East Africa that do range into this zone extend further north. Some populations of North African hyalommas penetrate this area though whether they are merely transported or actually reproduce here is uncertain. The presence of two Palaearctic species is intriguing. *H. marginatum* may be established here from nymphs introduced by migrating birds but this explanation cannot be applied to the single host tick *H. detritum*. The northern limit of this Area is probably the most critical and definite of any boundary in the Sudanese plains save those of the few montane masses that rise from these plains. *H. impressum* is found only in this and parts of the adjacent Area to the north.

The Nuba Mountains should be considered as a separate sector of this Area but data on tick distribution are not yet sufficiently definitive to allow designation of these mountains as a distinct faunal Area.

FASHER-BUTANA AREA

Here the desert aspect emerges. Further research will probably show that this Area may be divided into a southern sector in which rare, small populations of several tropical African tick species survive and a northern sector inhabited only by xerophilic species. The narrow Nile Valley carries a small number of species northwards to its great bend, beyond which only *H. l. leachii* is established. Various hyalommas, *R. s. sanguineus*, and *O. savignyi* are the indicator species of this Area in which few others are known to be established. Palaearctic components are here a strong feature, especially in the north. Like the Nuba Mountains in the Central Rainlands, the Marra Mountains may prove to be a distinct faunal Area after sufficient data have been obtained from this region.

ARID DISTRICTS

BAIYUDA AREA

No tick records are available from these harsh deserts although rare populations of argasids and hyalommas are suspected to occur in restricted localities.

BEJA AREA

Specialized collecting will probably reveal a small but interesting specialized tick fauna mixed with the Fasher-Butana fauna that exists on the coastal plains and in valleys of the eastern slopes of the Red Sea Hills. This Area might be subdivided into a southern sector containing tropical ticks such as *R. e. evertsi* and *B. decoloratus*, species that make their last stand among the hyalommas, *R. s. sanguineus*, and *O. savignyi*. In the north, even these are lost but *Hyalomma* and *R. s. sanguineus* populations are denser than in the desert and undiscovered Palaearctic species are expected to occur. The preponderence of *Hyalomma* species provides this Area with a strongly Palaearctic aspect. Specialized Somali tick fauna of the more southerly coastal plains is not known to reach the Sudan. The composition of tick species that intrude into this Area has some similarity with that further south along the coast but population densities appear to be much lower.

VII

APPENDIX

Additional data and references pertinent to a given species obtained or noticed too late for inclusion in the main body of the text are included herein. For the sake of completeness it is intended that this section be continued in subsequent volumes in an attempt to provide up-to-date information on all species treated.

ARGAS PERSICUS

TASCHENBERG (1873). Egypt. Mention of specimens.

JACK (1910). Southern Rhodesia. Control and general remarks.

WILLCOCKS (1922). Egypt. Remarks on habitats, hosts, importance.

NICOLLE, ANDERSON, & COLAS-BELCOUR (1928D). Tunisia. Local material used for adapting Spanish strain of fowl spirochetes.

OLENEV (1929A,B,1931A,1934). USSR. Life cycle graphically portrayed in 1931A report; others deal with distribution.

GRIMALDI (1934). Libya, Eritrea, Somalia, Ethiopia; collecting localities.

PAVLOVSKY (1940). Abnormality. "A heart-like shape of the body of Argas persicus is described in different degrees of development. Analogous forms are shown in the literature in other ticks also (Amblyomma, Ixodes); it is doubtful that this character, observed in the only tick specimen in hand, should have any taxonomical significance". I should hope not! (HH).

SHARMA (1944). Spermatogenesis briefly described.

CHUMAKOV (1954). USSR. Isolation of Q fever (R. burnetii).

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

SCHULZE (1955). Discussion of metabolic products.

TAYLOR _et al_ (1955). Egypt. Larvae become infected with Sindbis virus when feeding; nymphs and adults are not susceptible to paraenteral infection.

WALKER, J. B. (Correspondence). Tanganyika. Although no published records of the fowl tick appear to be available from this territory, Mr. Evans, formerly Senior Veterinary Research Officer there, states that it is certainly present and in fact widespread in Tanganyika.

ARGAS REFLEXUS

OPPERMANN (1935). As _A. columbarum_: studies on sperm formation.

MACNAY (1954). Canada. Specimens reported, with other ticks, from a bird's nest in British Columbia. Kohls (correspondence) finds that these specimens are similar to those referred to as _A. reflexus_ elsewhere in North America.

PETRISHEVA (1955). USSR. Presence in certain areas, with respect to control of disease foci.

SCHULZE (1955). As _A. columbarum_: discussion of metabolic products.

BOETTGER & REICHENBACH-KLINKE (1955). Germany. As _A. columbarum_: well documented and illustrated account of syndrome in person following tickbite.

ZHMAEVA, PCHELKINA, MISHCHENKO, & KARULIN (1955). USSR, Uzbekistan. Parasite of field sparrows and host and vector of _C. burnetii_ (Q fever).

ARGAS BRUMPTI

MOUCHET, J. (1956 correspondence). Cameroons. A male specimen from a warthog burrow, Waza, North Cameroons, sent for identification, represents the first population known from West Africa and a new host record.

*ORNITHODOROS ANNULATUS

GRIMALDI (1934). Libya (page 508). Nomen nudum, probably misprint for Boophilus annulatus.

*ORNITHODOROS CAPENSIS

SPEISER (1909). Ascension Island, South Atlantic Ocean. Record of two specimens.

*ORNITHODOROS FOLEYI

GRIMALDI (1934). Libya. As O. franchinii, collecting localities.

*ORNITHODOROS LAHORENSIS

FRANCHINI (1927X). Libya. Erroneous report, refers to O. foleyi.

GRIMALDI (1934). Libya. Repetition of Franchini.

ORNITHODOROS MOUBATA

MASSEY (1908). Angola. Tick common in Benguela District.

JACK (1910). Control and general remarks, apparently not based on personal observation.

SCHOUTEDEN (1929). Belgian Congo. Abundant in Kivu.

GRIMALDI (1934). Libya. Erroneous report. Eritrea, Ethiopia, and Somalia, collecting localities.

CHERRY (1955). Uganda. Summary: "A campaign using a water miscible preparation of BHC and simple equipment against O. moubata in heavily infested areas is described and its effects on the incidence of relapsing fever assessed. The cost is low and its success favors the acceptance of other public health measures by primitive communities". Other observations on therapeutics of the disease in human beings.

---

*This species is not known from the Sudan (cf. pages 114 and 115).

WALTON (1955). Kenya and neighboring areas of Tanganyika. A valuable account of conditions under which O. moubata exists in Digo (Kwale) District and epidemiology of relapsing fever, this report of an unique area should point the way for further comparative research under a variety of conditions. Although settled tribes engage in fishing and a small amount of animal husbandry, farming, and home industries, there is quite a little movement of peoples. On the sandy coastal plain, vegetation varies from short grasslands with forest patches to grasslands with open bush and termite-mound dominated islands of vegetation giving way to scant thorn bush in the interior. Rain falls each month (50 to 60 inches annual at coast, 30 to 40 inches in hinterland). Mean air temperature is 80°F., RH at 0830 about 79%, falling to 70% at 1430.

Domestic fowls are an important source of blood meals for O. moubata in huts (cf. pages 128,129,147,148,150,181), 113 of 124 samples being positive for fowl blood by the precipitin test. In another sample of 25 ticks from Tiwi, all had fed on fowls alone (the question of chickens preying on ticks is not considered). Ticks were not found on the fowls or in their nests, but usually in dusty cracks, holes, or depressions in the floor near chickens' roosting places. Scarcity of chickens and absence of ticks in damp houses is (inconclusively) correlated.

Other blood meals among the 124 samples mentioned above were eight for man only, two for man and fowl, and one for sheep or goat (from this it would appear either that fowls are more accessible and therefore more frequently utilized as hosts or else that the author was possibly dealing with a fowl-blood adapted strain - HH). It could not be demonstrated that the presence of sheep and goats in dry or in humid areas acted as a deterrent to ticks (cf. pages 127,128,147), also, it does not appear from this study that sheep and goats are frequently parasitized.

Bedsteads are a definite deterrent to tick infestation (cf. pages 147 and 180) because ticks have difficulty in climbing smooth legs, bedlegs do not break the floor, and sweeping and repairing floors is easier. More primitive beds are easily reached and provide shelter for ticks. Broken floors are favorable to the tick (cf. pages 146 and 180).

Human urination in huts, as a single factor, cannot be correlated with tick infestation. Coastal strip recent sediments and corals, combined with correct climatic conditions, are admirably suited to tick infestation (cf. page 145), but Duruma sandstones, grits of the karroo, and limestone and shale areas are less suitable. Many huts seem to have been infested by visitors traveling from infested areas with blankets (cf. pages 145 and 180) for social purposes, funerals, shopping, and during troop movements.

One of the most interesting aspects of this study is the correlation of infestation with definite climatic conditions. The coastal area, with over fifty inches of rainfall annually and with average hut floor RH of 88% and temperature of 77.8°F., is almost entirely devoid of ticks. Infested areas are those with thirty to fifty inches of rainfall annually and with hut floor RH averaging 83.3%, apparently the optimum for the tampan (consideration of ticks above the floor level, in niches with different RH, or seeking certain conditions with greater or lesser RH within the huts is not attempted). The tick-free hinterland receives about 35 inches of rainfall annually; here the hut floor RH is 79% and the average temperature 78.4°F. (cf. pages 137,156 and 157).

Clearly, this study represents the first generalized attempt to correlate tick infestation with climatic factors and tribal customs and habits. The incidence of spirochete-infected ticks is also noted. It should be of some significance to determine just how far ticks will endeavor to seek out niches with varying microclimates in an infested structure and what the optimum and threshold conditions are.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

SCHULZE (1955). Discussion of metabolic products.

LOVETT (1956). Somaliland. Summary: "Tick-borne relapsing fever, formerly common, has been eradicated in the Somaliland Protectorate by planned and systematic destruction of the vector, O. moubata, by a programme of spraying of all human dwellings with a water dispersible preparation of gammexane (P.520). The last indigenous case was seen in September, 1952. It is considered that the danger of reintroduction of the disease is small as O. moubata tend to pass their lives in or near their hatching place, with little tendency for dissemination, so that they are unlikely to become re-established in the settlements that have been cleared by spraying." Whether this surmise is sustained by future experience will be interesting to which for. *O. savignyi* is considered of no epidemiological significance and the indoor and outdoor habitats of the two species are strictly localized in Somaliland, except for the soil under one large shade tree in town, which yielded large numbers of *O. moubata*. Persons sleeping under this tree contracted relapsing fever from the bites of *O. moubata*.

ORNITHODOROS SAVIGNYI

FRANCHINI (1927X). Ethiopia, common in eastern lowlands.

GRIMALDI (1934). Libya, Eritrea, Ethiopia, and Somalia; records.

TENDEIRO (1955). Mozambique. Unsubstantiated review of previous reports from colony.

SCHULZE (1955). Discussion of metabolic products.

LOVETT (1956). Somaliland. See *O. moubata* above.

ORNITHODOROS THOLOZANI

WILLCOCKS (1922). Egypt. Introduction of nymphs into Cairo among hair on humps of camels from Sinai. Specimens seen by HH in British Museum (Natural History).

AMBLYOMMA COHAERENS

HOSTS (page 213). Uganda. A ♂ specimen from an elephant, West Nile Province, seen in Veterinary Service collection, Entebbe.

AMBLYOMMA LEPIDUM

GRIMALDI (1934). Eritrea, Ethiopia, and Somalia; records.

AMBLYOMMA MARMOREUM (group)

GRIMALDI (1934). Somalia and Ethiopia; records.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

THEILER (Correspondence). Preliminary study of a large amount of African material indicates that populations in the Sudan may be referrable to _A. schlottkei_ Schulze, 1932(A), originally described from two males without host data from Tanganyika.

AMBLYOMMA NUTTALLI

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

LOVERIDGE (Correspondence). Cf. _Pelusios s. sinuatus_ as a host (last paragraph, page 235). This aquatic turtle suns itself on logs and must be an exceedingly uncommon host of ticks

AMBLYOMMA POMPOSUM

AMBLYOMMA THOLLONI

AMBLYOMMA RHINOCEROTIS

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

SCHULZE (1955). Discussion of metabolic products of _A. rhinocerotis_.

AMBLYOMMA VARIEGATUM

GRIMALDI (1934). Eritrea, Ethiopia, and Somalia, records; that from Hodeida, Yemen, undoubtedly from cattle brought for slaughter or mislabelled locality.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

Presence of _Amblyomma_ ticks in Europe (cf. page 266). Specimens from southern France are no less unusual than that of the South African species, _A. hebraeum_, from a cow in southern Bulgaria (Pavlov and Popov 1951). This tick is presumed to have arrived in Europe as an immature stage on a migrant bird. Such individuals probably seldom if ever survive the winter or find mates.

APONOMMA EXORNATUM

APONOMMA LATUM

TENDEIRO (1955). Mozambique. Review of previous reports on both species from colony.

BOOPHILUS ANNULATUS

SAMPAIO & FAIA (1952A,B) and SAMPAIO, DA CRUZ, & FAIA (1952,1953). Portugal. Boutonneuse fever (R. conorii). The first two papers give laboratory findings and generalized remarks on increasing incidence and geographical distribution of disease in Portugal. In the third, a strain of the rickettsia from Boophilus ticks is reported; the authors believe that these ticks may play a role in transmitting the organism to human beings. The last is a brief statement that the rickettsia is transmitted by the bite of R. sanguineus and has been isolated from Boophilus ticks that had been in the laboratory for two years. [The significance of this finding would appear to be more in the line of a reservoir host than a vector - HH].

BOOPHILUS DECOLORATUS

LAHILLE (1914). Argentina. Two females, presumably this species, found on camels brought to Buenos Aires from the Canary Islands. These may form the basis of Minning's (1934) record, though it cannot be determined whether or not Minning examined the material.

GRIMALDI (1934). Eritrea, collecting locality. Not listed from Ethiopia or Somalia.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

SCHULZE (1955). Discussion of metabolic products.

BOOPHILUS MICROPLUS

HITCHCOCK (1955). Australia. Life cycle (cf. page 321). Details of cycle on hosts.

TENDEIRO (1955). Mozambique. As *B. fallax*: review of previous reports from colony.

DERMACENTOR C. CIRCUMGUTTATUS

VAN VAERENBERGH (1954). Belgian Congo. Record of specimens.

TENDEIRO (1955). Mozambique. Review of previous reports from colony. Subspecies here is *cunhasilvae*.

DERMACENTOR RHINOCERINUS

GRIMALDI (1934). Somaliland. Obbia, collecting locality.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

HOSTS (page 335): One male from cattle, locality unstated, in Uganda; seen in collections (Number 309) of Uganda Veterinary Service, Entebbe.

HAEMAPHYSALIS ACICULIFER

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

MOREL, P. (1956 correspondence). French West Africa. Occurs in Senegal across the east point of Gambia, on bushbuck, reedbuck, oribi, gray mongoose, and civet.

HAEMAPHYSALIS HOODI HOODI

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

MOREL, P. (1956 correspondence). French West Africa. On *Centropus senegalensis* at Gorom (50 km. from Dakar), Mbour (100 km. from Dakar on Atlantic coast), and Barmako (French Sudan). On *Francolinus bicalcaratus* at Barmako and Bouake (Ivory Coast). On *Ptilostomus afer* at Gorom. All stages of this tick on these birds.

HAEMAPHYSALIS HOUYI

MOREL, P. (1956 correspondence). French West Africa. On *Euxerus erythropus* at Nioro, French Sudan (adults and nymphs), and at Massakori, Tchad, about forty kilometers east of Lake Tchad (adults).

HAEMAPHYSALIS LEACHII LEACHII

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

HAEMAPHYSALIS LEACHII MUHSAMI

TENDEIRO (1935). Mozambique. Review of previous reports from colony (as *H. leachii indica*).

HYALOMMA DETRITUM and *H. SCUPENSE*

OLENEV (1931B). USSR. As *H. detritum rubrum*: description. ?As *H. volgense* and *H. uralense*: notes (see page 407). As *H. verae*: description (see page 407).

MARKOV, KURCHATOV, & MIRZABEKOV (1939). USSR. *H. detritum*, transmission of theilerosis in zebu cattle.

MARKOV & BERNADSKAIA (1939). USSR. *H. detritum*, ability of males to transmit theilerosis, in spite of the slight amount of blood they imbibe, to zebu cattle after having fed on infected hosts in immature stages.

KURCHATOV & KALMYKOV (1934). USSR. As *H. volgense*: distribution (see page 407).

DEMIDOVA (1942). USSR, Uzbekistan. As H. volgense: gives an account of methods of grazing and quartering cattle in Uzbekistan and importance of knowing where ticks seek shelter around buildings and farmyards due to their importance in transmission of human and animal diseases. A few engorged females found in cracks in walls 10 to 15 cm. above ground. See also H. excavatum, page

BARBETTI (1943). Yugoslavia. H. scupense, presence in southern Croatia. No other Hyalomma species listed.

GALUZO & L'VOVA (1945). USSR. H. detritum

For review of other reports on this tick by Galuzo, see page 411.

An ecological study in the Gissarian Valley to determine the fate of engorged females that drop from cattle in various situations and the effect of environmental factors on time of hatching, this field study merits careful attention. Although cattle wander over a variety of biotopes, H. detritum is encountered in only certain of these. In the field it is difficult to discover more than an occasional engorged female on the ground, even when pastures are dug up, manure is scattered, and grass is pulled out by the roots. Earlier studies, aimed at determining whether females detach from the host during the day while cattle are in the field or at night when they are confined, had shown that engorged females fall to the ground at any time of the day or night. Females might be expected to find suitable niches for hiding, preoviposition resting, and egg laying in grass roots, rodent burrows, reptile haunts, "insect nests", cracks and crevices in the soil, or under cakes of cow dung, lumps of earth, stones, grass bedding, or the like. Observations preliminary to the present experiment showed that when the temperature is particularly high (from 35°C. to 40°C.) and the sunlight extremely strong, females leaving the host immediately crawl into any shaded place and, if possible, burrow into the soil or hide in cracks or crevices. Females that depart their host in the evening crawl slowly over the soil until they find a crack or crevice. This they enter as deeply as the size of their body will permit. They may pass one apparently suitable niche or enter it and depart again in search of another. Rodent burrows, grass roots, or spaces under cow dung or stones are not chosen in preference to cracks in soil or under grass bedding. Oviposition commences from ten to fourteen days after leaving the host.

To observe the effect of the environment of niches in various biotopes on oviposition and the life cycle, engorged females were placed in each conceivable type of situation (in test tubes 10 cm. long, 2 to 3 cm. in diameter; into one end four reeds 10 cm. in length were placed and cheesecloth wrapped around them, the opposite end plugged with cotton; cheesecloth end placed down).

1. Northern slopes of hills, without roots, i.e. ploughed or overgrazed, no wild or cultivated vegetation; where untouched a variety of vegetation persists (scientific names given). Two tubes containing engorged females were placed in cracks in soil, two in "insect nests," one in a rodent burrow, four under grass roots, and two under a cake or cow dung.

2. Southern slopes of hills, which are considerably steeper than northern slopes and covered by a thinner layer of loess but with more vegetation near the summit; little cultivated or not at all; annual grasses with many xerophilic perennials; almost no cracks in soil, rodent burrows, or "insect nests". Here the only place in which a female may hide is in shallow interstices of annual grass roots; three tubes were placed in this situation.

The remainder of the experiment was undertaken in an irrigated part of the valley, a weakly undulating plain of river deposits and mostly under cultivation.

3. Mountain steppe (in lower part of valley); neglected weed patches of different age. The only hiding places for ticks are in cracks in soil and under grass bedding; four tubes placed in each of these situations.

4. Irrigated, cultivated plots, rice, melons, etc.; previously used melon field now deserted and overgrown by weeds utilized for experiment; five tubes placed in cracks of soil, two tubes under roots of grass. Owing to frequent irrigation, these were the only situations in which ticks could survive.

5. Banks of irrigation ditches; these are numerous and covered by grasses and other plants; three tubes placed under bedding of dead vegetation among roots.

6. Cattle sleeping places on north slopes of hills; lacking vegetation, soil cracks, or stones, but with cattle dung mixed with loess dust; only place for females is powdered mixture of loess and cow dung; three tubes placed here and one under an entire cake of cow dung.

Results: in tubes in cracks in soil in any situation larvae hatched most quickly (37 to 50 days). Among grass roots in irrigated valleys and meadow steppes, larvae hatched in 68 or 69 days. Females in all other situations perished without ovipositing.

The microclimate of these niches was determined as follows:

Places of Observation	Place of Issue	Average 24 hourly		Maximum		Minimum		Duration of embryonic development in days
		temperature of air	relative humidity	temperature	relative humidity	temperature	relative humidity	
Meadow-steppe	Cracks	26.0	72	38.6	100	20.0	50	47
Different aged deposits	Herbage	22.2	75	30.9	100	13.0	34	69
Irrigated plot of valley	Cracks	24.6	69	33.7	89	19.0	39	50
	Herbage	24.0	64	40.0	95	14.5	32	68
Northern hill slope	Cracks	27.1	44	35.0	75	22.2	33	37
	Herbage	25.5	32	35.0	57	19.2	10	eggs perished
	Burrow	27.6	63	33.9	80	24.1	40	40
Southern hill slope	Herbage	27.2	42	45.3	60	19.0	27	♀♀ perished

Temperature was ascertained by means of a mercury thermometer or, in deeper niches, by a Strelmikov thermocouple. Humidity was determined by Buxton's dew point device. Observations were made twice a month every two hours of the day from 24 July to 6 September.

On northern hill slopes, air temperature in soil cracks fluctuated from 22°C. to 28°C. in one day but in a Meriones burrow on the same slope only from 23.5°C. to 26.0°C. In the morning, RH was maximum (54%), at 1300 minimum (40%). In these places, hatching was most rapid.

In tubes on the soil surface among herbage, on southern hill slopes, in which females died, air temperature before sunrise was 19.0°C. but at midday 45.3°C. RH varied from 27% at 1100 to 60% at 2300.

In certain soil cracks where RH fell to extreme midday lows, (10 or 15%), eggs perished.

Tubes among grass roots in mountain steppes and in irrigated plots, in which larvae hatched more slowly than in those in soil cracks, experienced daily temperatures ranging from 13.5°C. to 29.0°C. in the former biotope and from 14.5°C. to 31.5°C. in the latter. RH in the former varied from 34% to 100%, in the latter from 32% to 95%. A number of other data are provided, but these are the high points and indicate the overall planning, methods, and results of the experiment. [Translated copies of the entire paper may be obtained from NAMRU-3, Cairo. The translation contains certain irregularities that may slightly modify some of the above statements but the general approach is of interest.]

SCHULZE (1950B). France. As H. steineri enigkianum subsp. nov.: includes description and illustration of male with misformed capitulum.

ABRAMOV, TSAPRUN & LEBEDEV (1950). USSR. H. detritum, importance as transmitter of equine piroplasmosis.

PERVOMAISKY (1954). USSR. H. scupense, morphological variation.

GANIEV (1954). USSR. H. detritum and H. scupense, short ecological notes from Ural District middle stream.

SURBOVA (1955). Bulgaria. H. scupense, distribution, biology, ecology, epidemiology. (Not translated).

GAJDUSEK (1956). USSR. Uzbekistan hemorrhagic fever. H. detritum feeds on man and is considered a possible vector of virus; organism has been isolated from this tick; brief review of host data.

HYALOMMA DROMEDARII

cf. page 440. USSR. H. turkmeniense is included under H. excavatum on the basis of Delpy's (1949B) surmise that it may be a synonym of H. excavatum. Pomerantzev (1950), however, considers H. turkmeniense to be a synonym of H. dromedarii (= H. asiaticum).

FRANCHINI (1927X). Libya. Collected at Giarabub.

OLENEV (1931B). USSR. As H. dromedarii asiaticum: description. As H. pavlovskyi: note (= ?H. excavatum). As H. kozlovi: description; considered by Pomerantzev (1950) as a subspecies of H. asiaticum.

GRIMALDI (1934). Libya, Somalia, and Yemen. H. dromedarii, collecting localities.

PERVOMAISKY (1950B). USSR. H. dromedarii males mate with female H. anatolicum excavatum, which act as unfertilized females remaining on the host for a month, taking little blood, and depositing only a few sterile eggs [see also Pervomaisky (1954)].

PERVOMAISKY (1954). USSR. Description of variation in morphology summarized as follows: Most males reach 5.8 mm. in length, females 6.1 mm. In average and large males common variables are width of the middle festoon and size and number of subanal shields (division or fragmentation of subanal shields is rare in material in the present collection and appears to be a localized phenomenon - HH). In minute males, 1.5 mm. in length, great changes occur in the adanal shields, which are rounded posteriorly and laterally; the accessories tend to be obsolete, and subanal shields fail to develop (See Hyalommina, pages 520 to 522). Large females are typical of the species but small females have smooth cervical grooves, narrow tail of spiracular plate, and unbanded legs.

H. asiaticum asiaticum and H. asiaticum caucasicum (both considered as synonyms of H. dromedarii by Delpy - HH) are here considered as separate geographical races with distinct morphological characteristics. Under experimental conditions they mate readily and produce fertile progeny. Male H. a. asiaticum vary from 2.5 mm. to 7.0 mm. in length and from 1.2 mm. to 4.0 mm. in width. Their critical characters are minute punctations combined with large punctations (both sparse); wide white parma; strongly concave basis capituli; and very narrow tail of spiracular plate. In every lot of H. a. asiaticum, one encounters specimens grading from this subspecies to H. a. caucasicum, males of which measure from 2.5 mm. to 6.0 mm. inlength and from 1.2 mm. to 4.0 mm. in width and average 0.5 mm. smaller than those of H. a. asiaticum. Scutal punctations of the two subspecies are similar, on small males of both only minute punctations may be present. The fusion of festoons of H. a. caucasicum is variable; however, the tail of the spiracular plate is wide and the tarsal pads are large, these characters vary but little. Females of H. a. caucasicum differ from females of H. a. asiaticum not only by smaller size but chiefly by larger tarsal pads and absence of rings on legs; the width of the tail of the spiracular plate may be either like that of H. a. asiaticum or wider.

Parthenogenetic females of H. dromedarii give rise to many deformed larvae, those that survive are all females not outwardly distinguishable from normal specimens. Both sexes are represented when F_1 females are mated with males.

NOTE. Yugoslavia. In various lists of Yugoslavian ticks presented by Oswald (see Bibliography) H. dromedarii or synonyms of this species are not included. The possibility that material mentioned in the following two papers refer to a different species in this genus must be considered. Specimens have been requested from Yugoslavian workers.

MIKACIC (1952 and 1949). Yugoslavia. H. dromedarii present in Adriatic Islands on domestic animals in spring and early summer (1949). Relation to piroplasmosis (1952).

CVJETANOVIC (1953). Yugoslavia. Tick reservoirs in an epidemic of Q fever at Ogulin believed to be R. sanguineus and H. dromedarii. Epidemic commenced at height of spring when sheep, which were the source of human infection, were most heavily infested by these two species, along with fewer numbers of R. bursa and H. punctata. Patients had no history of tickbite.

HYALOMMA EXCAVATUM

OLENEV (1931B). USSR. As H. savignyi armenorium: Note (synonymy uncertain). As H. anatolicum: Notes.

MARKOV, KURCHATOV, & MIRZABEKOV (1939). USSR. As H. savignyi (may refer to H. marginatum): transmission of theilerosis in zebu cattle.

SERDYUKOVA (1941). USSR. As H. anatolicum excavatum: spirochetes of Central Asiatic relapsing fever can be transmitted to guinea pigs by inoculation of emulsified infected ticks up to 24 hours after having been taken from infected animals. Similar results obtained with H. marginatum, D. pictus, and D. marginatus. See also H. marginatum, page

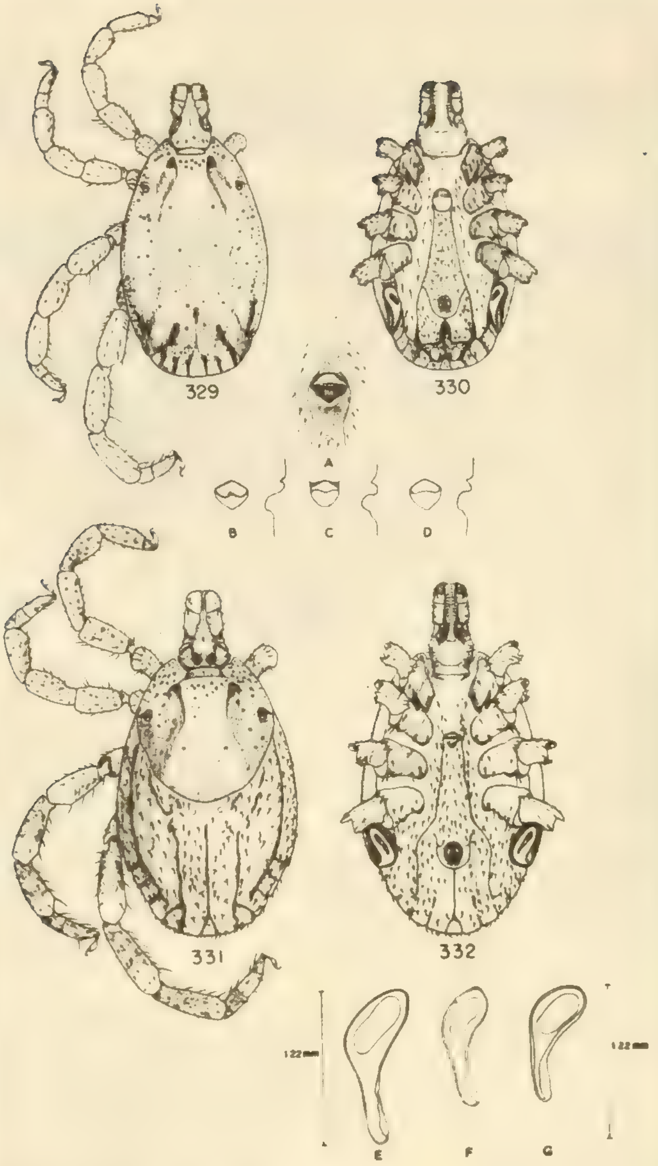
DEMIDOVA (1942). USSR, Uzbekistan. As H. savignyi (see also H. detritum, page 872): remarks appear to apply to H. excavatum rather than to H. marginatum, but this is not certain. All stages of ticks found in cracks of buildings from level of ground to roofs of sheds where cattle sleep; also in holes bored by insects in walls, cracks in poles, and under piles of corn beside stalls. Outside these buildings, numerous males and females were found up to above the height of a man under the loose bark of acacia trees but none were observed in a nearby cracked wooden feeding trough. In other localities, some were collected under plaster but numerous unengorged adults of both sexes sheltered in cracks in walls and under manure as well as in pole holes excavated by wood boring beetle larvae and under rags on poles supporting the shed. In a borrow pit in which cattle slept, ticks were found in cracked walls of the pit, under turf, etc.

PERVOMAISKY (1950B). USSR. As *H. anatolicum excavatum*: mating with *H. marginatum*, gynandromorphs. See *H. marginatum*, page , also *H. dromedarii* above, and Pervomaisky (1954).

PERVOMAISKY (1954). USSR. Breeding experiments demonstrate that progeny of *H. a. anatolicum* may in part resemble *H. a. excavatum* and that progeny of *H. a. excavatum* may in part resemble *H. a. anatolicum*. Critical characters of both subspecies described. Results obtained from parthenogenetic oviposition are similar to those described above for *H. dromedarii*.

Mosaic gynandromorphs (*H. a. anatolicum*), after feeding and mating with males of the same species, give rise to normal males and females. (There follow some remarks in support of genetic theories in vogue in the USSR at the time this was written. Similar remarks occur in this author's 1950B paper). Variations, deformities, survival in spite of physical damage, etc., are discussed in some detail.

CHUMAKOV (1954). USSR. As *H. anatolicum*: isolation of Q fever (*C. burnetii*) from specimens in Central Asia.



Figures 329 and 330, ♂, dorsal and ventral views.
Figures 331 and 332, ♀, dorsal and ventral views.

A, ♀ genital area. B to D, ♀ genital area, outline and profile, unengorged and unmated. E to G, spiracular plates of (E) "H. sp. no.2," (F) H. excavatum, and (G) "H. sp. no.1."

HYALOMMA SPECIES NO. 1 NEAR EXCAVATUM
Reared Egyptian Specimens

PLATE XVIIC

HYALOMMA SPECIES NO. 1 NEAR *EXCAVATUM*

(Figures 331 to 334)

DISTRIBUTION

This species occurs in EGYPT and probably extends eastward and westward from here.

HOSTS

Adults feed on camels; immature stages on lizards, *Acanthodactylus* and *Agama*. In the laboratory, rabbits serve as host for all stages and man has been utilized to feed adults.

BIOLOGY

This is a fairly common tick locally on Egyptian desert lizards. Life cycle and other biological data will be presented subsequently (Hoogstraal, ms.).

REMARKS

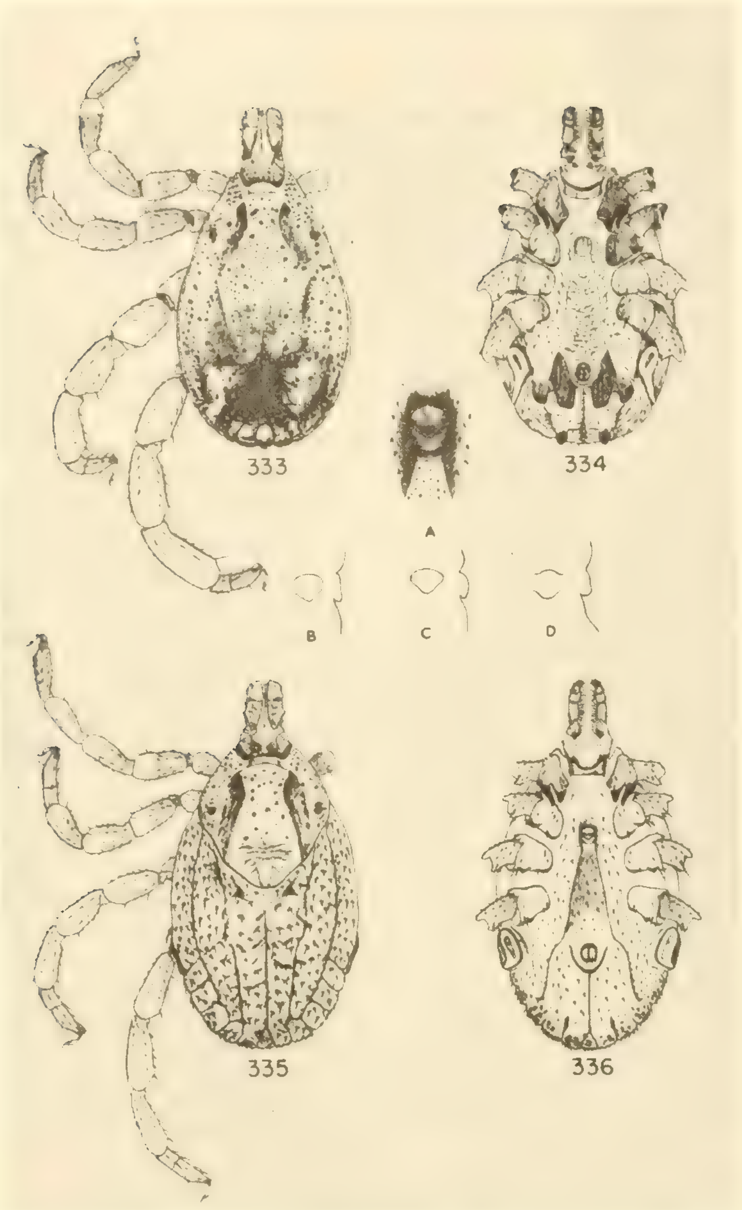
Although probably already described, we are not yet certain which name applies to this species. The male runs to *H. excavatum* in the Delpy (1949A) and in the present (page 397) keys. The female superficially resembles that of *H. detritum* but is morphologically distinct from all others. In size, both sexes are considerably larger than *H. excavatum*. Adults, reared from nymphs removed from Egyptian lizards, have produced uniform F_1 adults, thus indicating the validity of this species. All specimens are remarkably similar, a phenomenon seldom seen in this genus. However, further search of field collections and additional rearing will probably reveal more variable individuals. Means to separate this species from "*H.* species no. 2 near *excavatum*" may be found on page

IDENTIFICATION

Male. The scutum measures from 3.94 mm. to 4.37 mm. in length and from 1.95 mm. to 2.90 mm. in width; specimens with a scutum measuring less than 4.10 mm. long and 2.66 mm. wide are uncommon. [The scutum of H. excavatum measures from 3.52 mm. to 4.18 mm. long and from 2.00 mm. to 2.19 mm. wide, but seldom exceeds 3.75 mm. in length and 2.09 mm. in width.] The appearance is that of a strong hyalomma in comparison with the typical frail guise of H. excavatum. The shiny dark brown scutum is in contrast to the typically yellowish brown scutum of H. excavatum. Scutal punctations are few; minute but distinct punctations are widely scattered over the entire surface and become dense in the characteristically triangular caudal depression; large punctations number no more than those on the specimen illustrated (Figure 331) and may be even rarer. Lateral grooves are strictly confined to the posterior third of the scutum where they are deep and distinct. The caudal depression is an approximately equilateral triangle (margins curved in H. excavatum) bounded by a ridge that is not so elevated as in H. excavatum; the apex of the depression is level with the apex of the lateral grooves; the posteromedian groove is poorly developed and does not extend beyond the depression, the paramedian grooves are faint, rounded depressions extending as faint grooves to the middle of the third pair of festoons. The posterior margin of the scutum is bluntly rounded while that of H. excavatum is more narrowly rounded. The adanal shields are strong, broad, and quadrate posteriorly (Figure 332), and the subanal shields, that lie directly posterior of them,are larger than is usual in H. excavatum. The spiracular plate (Figure 332G) is distinguished from that of H. excavatum (Figure 332F) especially by the narrowly tapered, very slightly curved tail (the tail of H. excavatum is wider and curves more abruptly apically).

Female. Scutal measurements in most specimens are approximately 2.50 mm. in length and 2.38 mm. in width; the minimum is 1.95 mm. by 2.00 mm.; the maximum 2.71 mm. by 2.52 mm.; the outline is subcircular and the surface is smooth with very few, large, widely scattered punctations, thus being similar to that of H. detritum (the typical outline in H. detritum tapers more abruptly from the level of the eyes and is narrower posteriorly). The genital apron (Figure 334A to D) is similar to that of H.

truncatum and might easily be confused with it (cf. Figure 189A to D and page 503); its deeply depressed profile and wide outline is in strong contrast to the gradual slope and narrower outline in *H. detritum* and to the strongly convex profile and subcircular or more narrowly triangular outline in *H. excavatum*.



Figures 333 and 334, ♂, dorsal and ventral views.
Figures 335 and 336, ♀, dorsal and ventral views.

A, ♀, genital area. B to D, ♀, genital area outline and profile.
B, unengorged. C, partly engorged. D, fully engorged.

HYALOMMA SPECIES NO. 2 NEAR EXCAVATUM
Reared Egyptian Specimens

PLATE XVIIIC

HYALOMMA SPECIES NO. 2 NEAR *EXCAVATUM*

(Figures 335 to 338)

DISTRIBUTION

EGYPT, including Sinai, and LIBYA (H.H. collection). PALESTINE (various lots in BMNH identified as "*H. excavatum* large race", HH det.). MOROCCO (Lot 08-2-3-10-13 in BMNH, HH det.). CANARY ISLANDS (Nuttall lot 3226 in BMNH, HH det.). YEMEN (HH, ms.).

HOSTS

Known hosts of adults are camels and cattle. In Egypt, immature stages (reared to adults) have been taken from spiny mice, *Acomys russatus*, at 5000 feet altitude in Sinai; lesser gerbils, *G. g. gerbillus*, near Cairo; and fat sandrats, *Psammomys o. obesus*, in saline desert areas on the Mediterranean littoral and beside the Nile Delta.

BIOLOGY

Biological and life history data will be presented separately (HH, ms.). It is notable that in Egypt we find this species only in certain desert situations from sea level to 5000 feet elevation but never in cultivated areas.

REMARKS

"Species number 2" is a large race or species closely related to *H. excavatum* but differing from it in color and size. The size is even greater than that of "species number 1" but the color is similar.

Recently Mr. Glen M. Kohls of the Rocky Mountain Laboratory kindly sent us the Schulze collection of "*H. anatolicum*" for study. The bulk of this material conforms exactly to "*Hyalomma* species no. 2 near *excavatum*". Although a surprising mixture of other species, H. marginatum, H. rufipes, H. detritum, H. excavatum, and ticks of other genera are included in the same vials, the present species may be considered as "H. anatolicum (sensu Schulze)". It is, however, far from certain that this is the same species that contemporary Soviet workers are labelling H. anatolicum. Feldman-Muhsam (1954) states that the type specimen of H. anatolicum "seems to be lost". The true identity of this name, therefore, should be difficult to establish. She also considers H. anatolicum specimens in the Schulze collection as "within the range of variation of H. excavatum", a conclusion not corroborated by present rearing studies. Kratz (1940) also indicated that the type specimen of H. anatolicum was lost, and suggested that his mentor, Schulze, applied this name because of the frequency of this species in collections from Anatolia. It is obvious that the complicated problem of identity and of species and subspecies related to the present form will require a considerable amount of study before valid and firm conclusions can be drawn. Typical specimens of "H. anatolicum (sensu Schulze)" in the Schulze collection are from Macedonia, Anatolia, Skyros and Thassos Islands (Greece), Egypt, and Rio de Oro. A male from Kabete, Kenya, is also included; this range is difficult to explain, except on the basis of accidental introduction, and bears further investigation. Hosts of typical specimens are cattle, horses, camels, sheep, and an antelope (Rio de Oro).

The presence of this species in the northwestern area of Africa appears well established by reason of representatives from Morocco and Canary Islands in British Museum (Natural History) collections, from Rio de Oro in the Schulze collection (Rocky Mountain Laboratory), and from Libya in the HH collection.

IDENTIFICATION

Male. The scutum measures from 4.28 mm. to 5.12 mm. in length and from 2.66 mm. to 3.52 mm. in width, thus being considerably larger than H. excavatum (for measurements, see page 451). It is colored as in "species number 1" and slightly more punctate than either of the other two species; the caudal depression is more rugose and more densely furnished with mixed, contiguous punctations than in H. excavatum but its characteristic outline is the same in both species and pronounced elevated ridges border it. Lateral grooves are like those of H. excavatum, but may appear to be continued slightly more anteriorly due to the presence of several large punctations in line with them. The spiracular plate is very slightly larger than that of H. excavatum but otherwise similar to it.

Female. The scutum measures from 2.09 mm. to 2.61 mm. in length and from 2.04 mm. to 2.42 mm. in width, thereby exceeding the size of that of the largest specimen of H. excavatum. Specimens of the present species measuring less than 2.23 mm. by 2.14 mm. are rare; 2.33 mm. by 2.23 mm. is a common ratio. The genital apron is like that of H. excavatum but the scutum is colored as in "species number I" and is slightly more punctate than that of the other two species.

HYALOMMA MARGINATUM

OLENEV (1931B). USSR. As H. marginatum, H. marginatum olenevi, and H. marginatum subsp.: descriptions and notes.

KURCHATOV & KALMIKOV (1934). USSR. As H. marginatum balcanicum: distribution records from 1932.

KURCHATOV (1935). USSR. H. marginatum, collecting records.

KURCHATOV (1939B). USSR, Crimea. H. marginatum. Details of life cycle, seasonal incidence, and host preferences conform to those of other authors and of this author in other papers. Additional interesting facts are also provided. In laboratory rearing, the length of the life cycle is in direct proportion to temperature range (7°C. to 37°C.) but the length of life (? of unfed ticks - ? stage) is in inverse proportion to temperature. Temperatures of from 7°C. to 10°C. and 42°C. are unfavorable; the range from 22°C. to 27°C. is most favorable with relative humidity from 75 to 100%. Engorged nymphs tolerate any relative humidity from zero to 100% and temperature from 7°C. to 42°C.; in this respect they exceed other stages. Larvae and nymphs are most active in Crimean foothills during the summer-autumn period in the morning and evening (24°C. to 30°C., RH 50% to 75%). In temperatures over 30°C., most ticks hide in shady places and some burrow into the soil. At night temperatures below 21°C. or 22°C. and also with high relative humidity and strong winds almost no tick activity is noticed. The northern limits where this tick is common is from 46°C. to 49°C. northern latitude (annual isotherm 9°C.). Cattle are rarely infested in summer in open semi-deserts and deserts. Most heavily infested areas are lowlands and foothills of steppes, forested steppes, and low mountain forest zones. High mountain belts are rarely infested. The fact that immature stages attack migrating birds may account for finding this tick rarely in northern latitudes.

MARKOV, ABUSALIMOV, & DZASOKHOV (1939). USSR. As H. marginatum; epizootic piroplasmosis of swine; transmission not achieved.

KURCHATOV (1940G). USSR. H. marginatum; an extensive review of biological and ecological information; not yet translated.

SERDYUKOVA (1941). USSR. As H. marginatum. See H. excavatum page 878. Also: Transovarial transmission of spirochetes does not occur, whether when attempted by injection of emulsified eggs or when F_1 larvae or nymphs from infected females are allowed to feed on guineapigs.

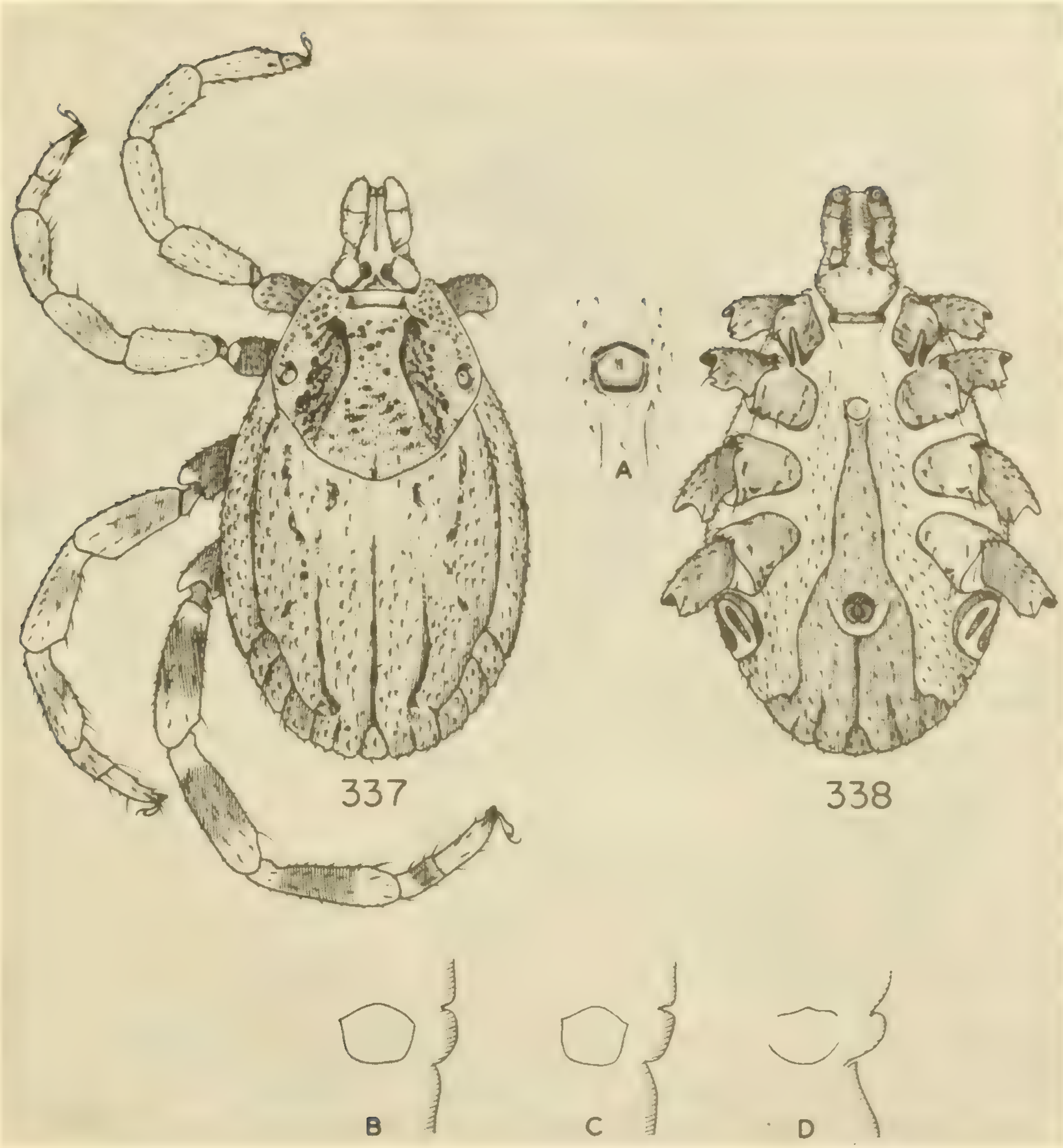
DEMIDOV, STARUKHIN, & DMITRIEV (1944). USSR. H. marginatum infests stabled horses in North Caucasus during the winter and may infect them with Nuttallia equi at that time.

ABRAMOV (1949). USSR. H. marginatum in relation to equine piroplasmosis (P. caballi).

ABRAMOV, TSAPRUN, & LEBEDEV (1950). USSR. Importance of H. marginatum as transmitter of equine piroplasmosis.

PERVOMAISKY (1950B). USSR. As H. p. plumbeum: females mated with males of H. anatolicum excavatum feed normally, become enlarged, and lay normal quantity of eggs, which are infertile. When male H. p. plumbeum fertilize female H. anatolicum excavatum, from 20% to 100% of the eggs are fertile; the majority of F_1 females have maternal traits, the majority of the F_1 males have combined maternal and paternal traits. When "extremely normal" F_1 males and females were mated, the progeny consisted of 61 gynandromorphs in a batch of 435 individuals /see also R. sanguineus, page 910, and Pervomaisky (1954)./

PERVOMAISKY (1954). USSR. As H. p. plumbeum: males vary from 3.2 mm. to 6.3 mm. in length and from 1.8 mm. to 3.6 mm. in width. Three types of scutal punctations are observed on individual specimens, (1) most common, numerous, evenly distributed minute among large, (2) common, numerous minute, (3) on small males, minute and large mixed. The middle festoon is narrow, the tail of the spiracular plate is wide, and the inner margin of the adanal shield is slightly extended. The female size is quite variable and scutal punctation varies as among males, but diagnostic characters are "relatively constant."



Figures 337 and 338, ♀, dorsal and ventral views.

A, ♀, genital area. B to D, ♀, genital apron, outline and profile. B and C, unengorged. D, engorged.

<u>HYALOMMA</u> <u>SCHULZEI</u>
Eastern Desert, Egypt
See pages 524 to 526

PLATE XIXC

SURBOVA (1955). Bulgaria. As *H. p. plumbeum*: distribution, biology, ecology, epidemiology. (Not translated).

SERDYUKOVA (1955). USSR. As *H. plumbeum*: larva illustrated and compared with those of other genera.

TARASEVICH (1955). USSR. As *H. p. plumbeum*: vector of Q fever (*R. burnetii*).

HYALOMMA RUFIPES

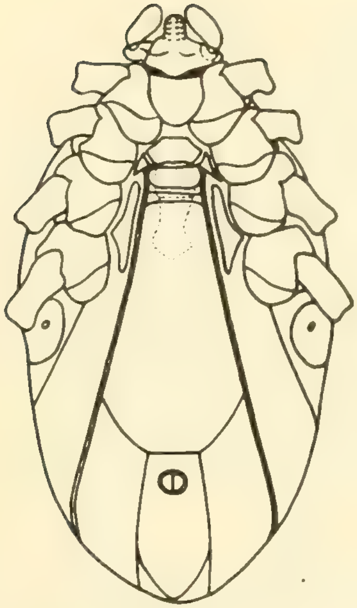
DAUBNEY (1944). Kenya. Morphology and biology under study.

HYALOMMA TRUNCATUM

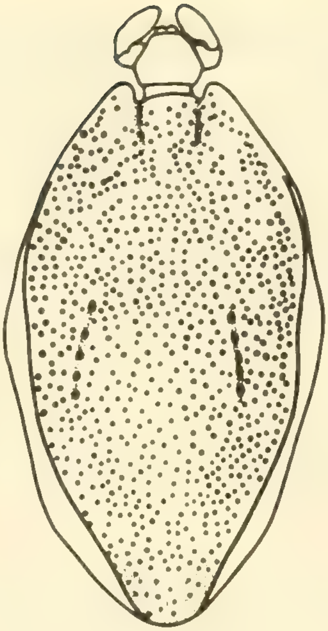
WALKER, J. B. (Correspondence). Kenya. Life cycle. At Muguga, when all stages were fed on the ears of rabbit, the life cycle was the two host type. Miss Walker believes that the type of host to which the larva attaches influences the number of hosts involved in the life cycle. The following data were obtained when nonfeeding stages were maintained at 25°C. to 27°C.

PERIOD	DAYS
Preoviposition	5
Oviposition to hatching	28
Larvae feed and molt; nymphs feed on same animal	15 to 23
Nymphal premolting period	17
Adult prefeeding period	7 to 17 or more

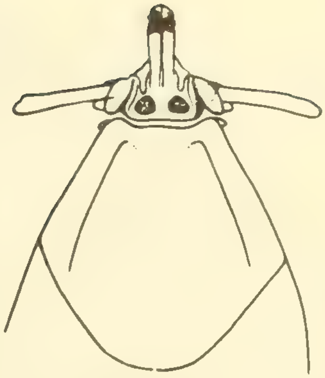
Disease relations: Experimentally, East Coast fever (*Theileria parva*) develops and is transmitted by *H. truncatum* (experiments by Dr. S. F. Barnett and Mr. K. P. Bailey). Inasmuch as immature stages do not normally feed on bovines, transmission in nature is rare.



339



340



341

Figures 339 and 340, ♂, dorsal and ventral views
Figure 341, ♀, dorsal view

IXODES ALLUAUDI
(After Theiler 1941)

PLATE C

IXODES ALLUAUDI Neumann, 1913.

(Figures 339 to 341)

THE SHREW RUSSET TICK

L	N	♀	♂	EQUATORIA PROVINCE RECORD			
	1			Kipia	*Crocidura* sp.	Jan	(BMNH)

This nymph was taken at 8000 feet elevation in the Imatong Mountains from the tail of an unidentified *Crocidura* shrew. It is specimen number 1950.3-20-42 in British Museum (Natural History) collections and has recently been identified by Arthur (1956 correspondence).

DISTRIBUTION

Ixodes alluaudi is known only from the Imatong Mountains of the Sudan, highland forests and alpine meadows of Tanganyika, Kenya, and several localities in Basutoland and the Union of South Africa. Intervening populations undoubtedly have been overlooked.

EAST AFRICA: SUDAN (Not previously recorded. Arthur, ms.). TANGANYIKA (Neumann 1913). KENYA (Arthur, ms.).

SOUTHERN AFRICA: UNION OF SOUTH AFRICA (Theiler 1941. Arthur, ms.). BASUTOLAND (Arthur, ms.).

HOSTS

The species of the Sudan host is not known. *Crocidura* shrews recorded from the Imatong Mountains during the present study are *C. hildegardeae phaios* and *C. nyansae toritensis* (common), both of which are described as new subspecies (Setzer 1956). The host of Neumann's material was not stated.

From Theiler's (1941) study of South African data it appears that the red shrew, C. flavescens, may be the true host and infestation of other rodents and insectivores is incidental. These hosts are the vlei or groove-toothed rat, Otomys irroratus subsp.; the four-striped grass mouse, Rhabdomys pumilio subsp.; Brant's gerbil, Tatera brantsi maecalinus; Lobengula's gerbil, T. lobengulae subsp.; and the Eastern Province golden-mole, Amblysomus hottentotus subsp. Thirteen collections were made from red shrews and twelve from other hosts. Collections from red shrews also contained the most specimens. Arthur (ms.) records the same hosts and adds Cryptomus capensis.

BIOLOGY

Life Cycle

"Probably a three host tick; adults, nymphs, and larvae invariably have been collected separately except for two records from Brant's gerbil when adults and nymphs were taken together" (Theiler 1941).

Ecology

The fact that the few specimens known from the Sudan and Tanganyika were taken in highland forests or alpine zones is of some interest. In southern Africa this altitudinal distribution is not so restricted.

The red shrew frequents runways made by rodents in long grass beside streams and rivers. In drier areas, this tick is taken in the smaller and shorter runways of other rodents associated with bunches of grass at the base of thorn bushes and other shrubs. Red shrews also inhabit the underground nesting burrows abandoned by rodents (Theiler 1941).

REMARKS

Theiler (1941) has made an extensive study of the morphological features of this species to show its exceptionally primitive characters. This report should be studied by anyone interested in tick morphology or phylogeny.

IDENTIFICATION

The following notes are a brief abstract of Theiler's (1941) descriptions, which also include those of the larva and nymph. Arthur (ms.) also redescribes this species; his manuscript is not available at the time this is written but he has (correspondence) confirmed the accuracy of Theiler's description and of this summary.

Male. This is a small light brown tick with slender legs. The scutum, approximately twice as long as wide and sharply pointed at both ends, bears fine, evenly distributed punctations posteriorly and coarser punctations anterolaterally. Cervical grooves are vaguely indicated. The short, converging palpi, which overlap the short, blunt hypostome, are borne on a lateral projection of the basis capituli. The ventral plates and coxae are most distinctive (Figure 340).

Female. Palpi are narrow and elongate but also borne on a lateral projection from the basis capituli. The scutum is widest just posterior of midlength and abruptly converging posteriorly; its faintly reticulate surface bears a few medium size punctations and scattered hairs; cervical grooves are absent; lateral grooves are fine. Ventrally, genital grooves are long, straight, divergent; anal grooves are truncate anterior of the anus, thence long and subparallel tending to converge distally.

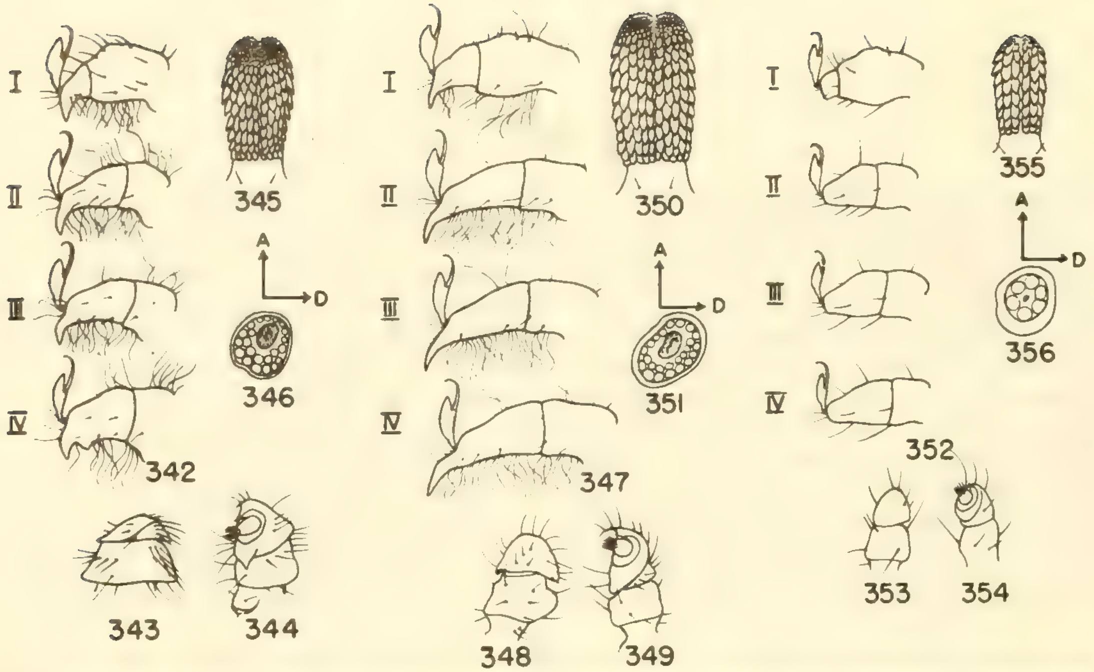
IXODES RASUS

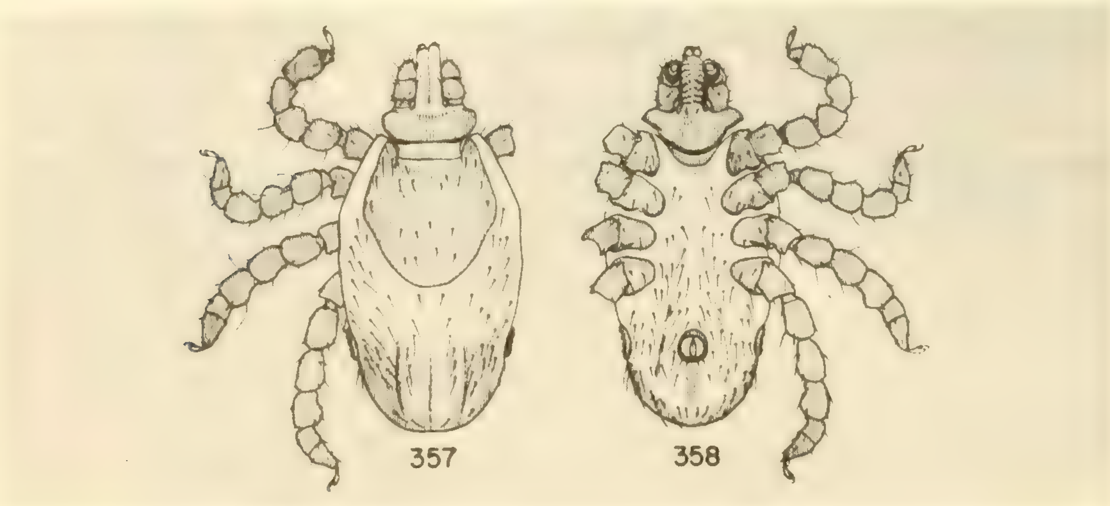
ARTHUR (1956 correspondence). Preliminary study of a large amount of material referrable to this name reveals that five species with closed circular or pointed anal grooves are involved. Incidentally, Neumann's type material, from hyrax has pointed anal grooves. Rio Muni specimens especially are easily distinguishable from all others. Neumann's material from Togo (Berlin Museum), now at Toulouse, is I. oldi, although Neumann had identified it as I. rasus. What Nuttall considered as I. rasus is a new species that is now being described. Schulze's descriptions of the I. rasus group are very vague and it is difficult to associate his so-called subspecies with available material. I. rasus and related species are no more variable than other Ixodes species and are easily separated once adequate criteria have been established.

N.B. The exact status of the pair of specimens illustrated herein (Figures 222 to 225) and of the single male from the Sudan (page 550) has not yet been determined.

IXODES SCHILLINGSI

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

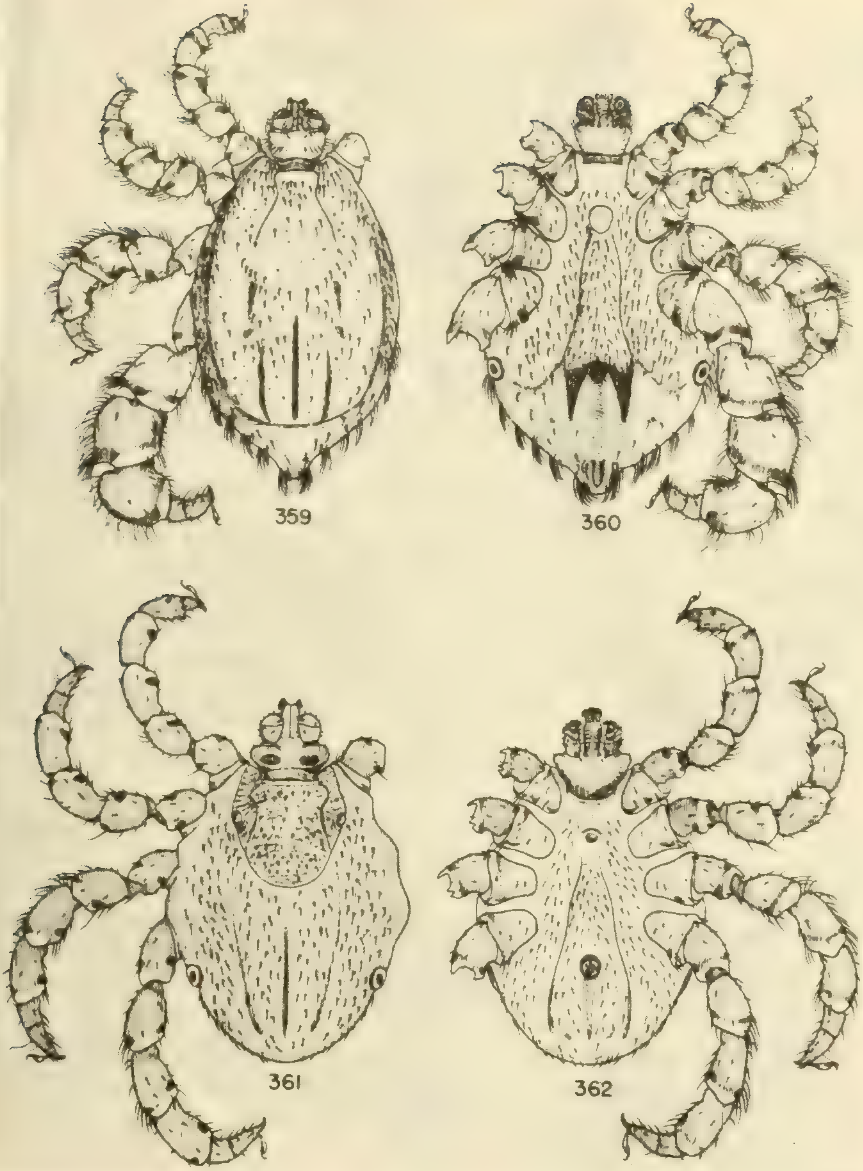




Figures 342 to 346, ♂; 347 to 351, ♀; 352 to 358, nymph.
Figures 342, 347, and 352, legs I to IV.
Figures 343, 344, 348, 349, 353, and 354, palpi, dorsal and ventral views.
Figures 345, 350, and 355, hypostome, ventral view.
Figures 346, 351, and 356, spiracular plates.
Figures 357 and 358, nymph, dorsal and ventral views.

MARGAROPUS REIDI SP. NOV.
Sudan Paratypes

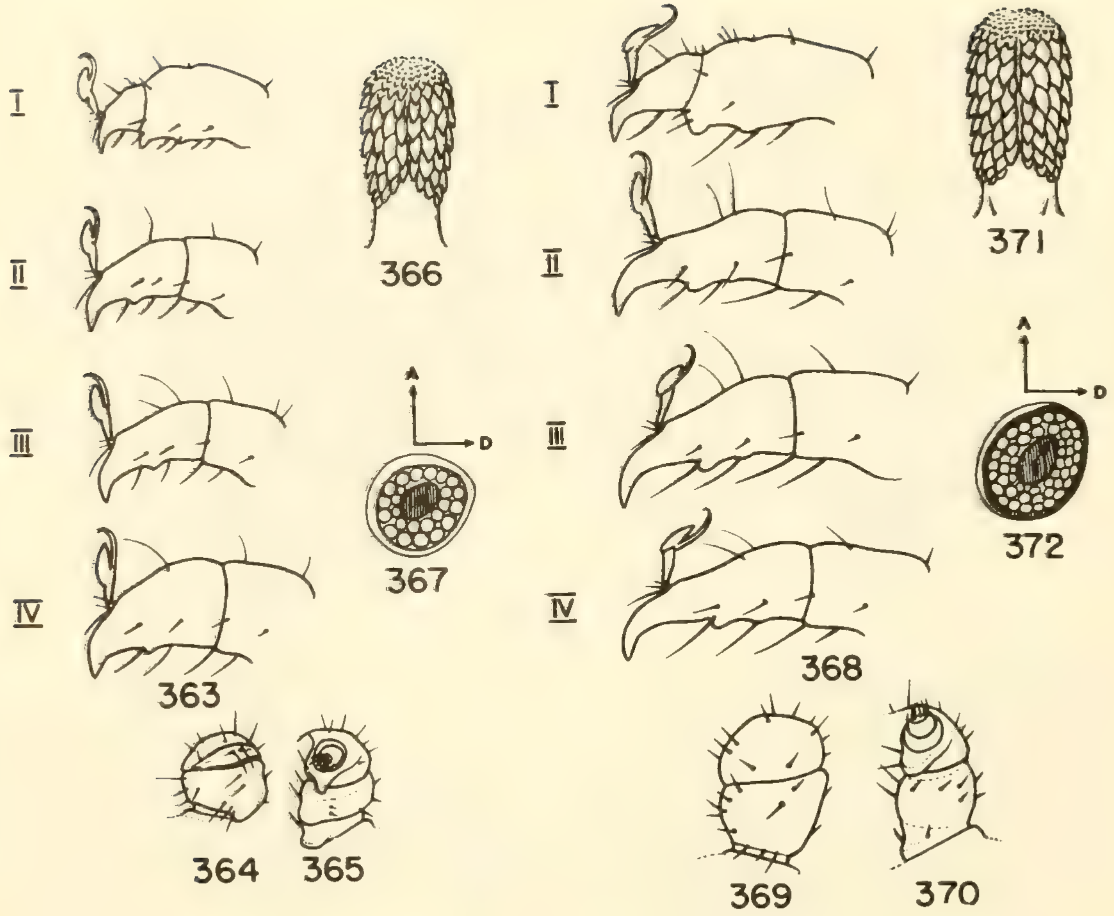
PLATE CI



Figures 359 and 360, ♂, dorsal and ventral views
Figures 361 and 362, ♀, dorsal and ventral views

MARGAROPUS WINTHEMI
South African Specimens
from Dr. G. Theiler

PLATE CII



Figures 363 to 367, ♂. Figure 363, tarsi I to IV.
Figures 364 to 365, palpi, dorsal and ventral views.
Figure 366, hypostome, ventral view.
Figure 367, spiracular plate.

Figures 368 to 372, ♀. Figure 368, tarsi I to IV.
Figures 368 and 370, palpi, dorsal and ventral views.
Figure 371, hypostome, ventral view.
Figure 372, spiracular plate.

<u>MARGAROPUS</u> <u>WINTHEMI</u>

South African Specimens from Dr. G. Theiler

PLATE CIII

MARGAROPUS WINTHEMI Karsch, 1879(B).

(Figures 359 to 372)

THE WINTER HORSE TICK or

THE SOUTH AFRICAN BEADY-LEGGED TICK

NOTE: This non-Sudanese species is treated herein in order to provide comparative data for M. reidi sp. nov. and because it is necessary to modify our concepts of the genus Margaropus. Data concerning this tick have not been reviewed in detail since Donitz (1910B).

DISTRIBUTION

The winter horse tick occurs only in localized areas of the Union of South Africa and Basutoland. This species has been introduced into Southern Rhodesia and Madagascar but populations do not appear to have become established. Frequent literature references to this as a South American tick are incorrect.

[SOUTHERN AFRICA: UNION OF SOUTH AFRICA: Specimen stated to have originated from "Valparaiso", Winthem legit; no further data; assumed (HH) to be South Africa: Karsch (1879B). Type specimen examined and stated to be misformed M. microplus: Neumann (1901); refuted by Donitz (1907B). Without species name: Orpen (1904). As Rhipicephalus species B: Lounsbury (1905). As M. lounsburyi: Neumann (1907B,1911). As Rhipicephalus phthirioides sp. nov.: Cooper and Robinson (1907). As M. winthemi: Donitz (1907B,1910B). As M. lounsburyi: Howard (1908). As M. winthemi: Bedford (1920,1926,1927,1932B, 1934). Jack (1921,1928,1937). Cowdry (1925C,1926A,1927). du Toit (1942B,1947A). Theiler and Salisbury (1956). BASUTOLAND: Howard (1908). Bedford (1920,1926,1927,1932B). Theiler and Salisbury (1956).]

[SOUTHERN RHODESIA: Introduced from South Africa but not known to be established in Southern Rhodesia: Jack (1921,1928, 1937,1942). MADAGASCAR: Introduced but not known to be established. Hoogstraal (1953E).7

HOSTS

All authors who mention hosts and Theiler (correspondence) state that horses are most commonly attacked and, to a lesser extent, cattle and sheep. Wild hosts have not been reported.

BIOLOGY

Life Cycle

This tick has not been reared in the laboratory but Lounsbury and Howard have observed that it is a single host tick that required from 186 to 201 days "from adults to hatching of larvae" at Capetown. This winter tick probably undergoes only a single generation annually.

Ecology

Veld horses become very badly covered during winter but few of these ticks are seen in summer (Howard 1908). Eighty percent of available records for *M. winthemi* are for winter months, May to August. This species does not occur in warm or in moist areas but is found, frequently at high altitudes, in many localities having more than ninety days of frost and less than thirty inches of annual rainfall (Theiler and Salisbury 1956).

REMARKS

M. winthemi and *M. reidi* sp. nov. are the only species described in this genus. They occur in widely separated, restricted areas of Africa, within the Ethiopian Faunal Region, and differ considerably in ecological requirements. It is of interest that *M. winthemi* has been collected only from horses and other domestic animals and *M. reidi* sp. nov. only from giraffes.

Long known as the Argentine horse tick because the source of the original specimen was stated to be Valparaiso, this tick has never been reported from South America. Why Valparaiso has been referred to Argentina and not to Chile is uncertain. As early as 1907, Dönitz questioned the South American origin of this species, remarks that were overlooked by most subsequent writers. According to Dönitz (1910B), Winthem was a Hamburg dealer (presumably in zoological specimens - HH).

Symbiotes were not discovered in M. winthemi by Cowdry (1925C, 1926A,1927).

Schulze (1938A) mentioned this species in his study of adult development within nymphs and in his 1943B study. Jakob (1924) included M. winthemi in his study of tick genera as have all authors who have discussed this subject. Because of its remarkable appearance, this species has been widely illustrated and discussed, usually largely incorrectly.

The first reference to this tick in South African literature (Theiler, correspondence) is that of Orpen (1904): "It is commonly believed here that there are no ticks in the Barkly East district, or only such as are brought in by transport cattle during the Summer and that ticks will not survive the severity of our winter hosts. I may state that last Winter I found many ticks upon our veld fed horses and that this winter they are worse, in a troop of about seventy mares and foals, many animals are fairly covered with ticks. We have had severe frosts since the beginning of April and the mountains are white with snow. This would lead one to conclude that given the protection and the warmth of an animal's body these ticks will live through any New England (Barkly East district) winter. (It is noticeable that the variety found on our horses remain upon them when molting)".

The original description of the genus, translated from German, is as follows: Margaropus gen. nov. Body slender, longer than wide, sides slightly sinuously rounded, the posterior margin on each side bearing three small, pointed hairtufts. The second and third pairs of legs are normal (the first pair is lacking), the fourth has very large, flat, sharply separated, almost circular segments. Type species: M. winthemi sp. nov.

The count of three pairs of pointed hair tufts noted by Karsch for *M. winthemi* was probably due to the dry, greasy, rubbed condition of the specimen. Fresh specimens bear six pairs of posterior hair tufts; these are not pointed.

Subsequently, the generic description of *Margaropus* presented by most writers has included the statement that the adanal shields are joined anteriorly, a fact true for *M. winthemi*, though difficult to discern in many specimens, but not true for *M. reidi* sp. nov.

The genus may be redefined as follows: Males with expanded leg segments that are more or less deeply separated from each other (partially noncontiguous); adanal shields arising at level of coxa IV and extending posterior of anus; tarsi elongate, narrow, tapering, with a large, apical, hooklike projection; palpi intermediate between those of *Boophilus* and *Rhipicephalus*, not ridged as in former genus; integument with conspicuous hairs posteriorly; with eyes (may be indistinct in *M. winthemi*); unornamented. Females with leg segments not greatly widened but other leg characters similar to those of male. Palpi intermediate between those of *Rhipicephalus* and *Boophilus*. Eyes distinct.

DISEASE RELATIONS

Although circumstantially associated with babesiosis, *Babesia bigemina*, no actual relation of this tick to any pathogenic organism has been demonstrated.

IDENTIFICATION

MALE: Length overall up to 3.7 mm., width 2.5 mm.; color reddish brown; outline oval with integument bulging beyond scutum laterally and posteriorly; with caudal protrusion when engorged.

Capitulum: *Basis capituli* approximately twice as wide as long, lateral margins curved, basal margin concave; bearing a horizontal row of eighteen to twenty hairs at level of midlength; ventrally with straight posterior and lateral margins, the latter converging basally. Palpi: Overall length and width of each palpus approximately equal dorsally; segment I just barely visible dorsally, longer ventrally; segment 2 quadrate with a slight angular projection at the inner basal juncture, length one-third greater than that of segment 3; segment 3 compressed, semicircular, with broadly pointed outline distally; ventrally segment 3 with a broadly triangular retrograde spur. Hypostome twice as long as wide, apex rounded with a slight medial notch and with distinct corona; dentition 4/4, with five or six denticles in inner files increasing to nine or ten denticles in outer files.

Scutum: Outline slightly convex laterally, more acutely converging anteriorly, bluntly rounded posteriorly; two-thirds as wide as long. Posteromedian groove shallow, narrow, elongate; paramedian grooves similar but shorter; cervical grooves convergent anteriorly, thence divergent for three-fourths of their length, extending one-third of scutal length. Hairs on scutum pale, shorter than lateral hairs; numbering about twelve in each scapular area and about twenty anteriorly between the cervical grooves; a row in place of the outline of the female scutum; others scattered in irregular lines on posterior half of scutum; a few rows of longer hairs on integument beside scutum, those posterior of the spiracular plates forming six pairs of longer hair tufts each clump of which consists of five to ten hairs. Eyes extremely indistinct; small, flat, situated on lateral margin at the level of coxa II.

Spiracular plate subcircular, with two rows of large goblets encircling the aperture. Genital aperture situated at level of anterior half of coxae II; outline broadly rounded anteriorly, gradually converging laterally, bluntly angled posteriorly. Genital grooves mildly undulating from aperture to anus, thence widely divergent to spiracular plates. Preanal shield with broadly to narrowly rounded anterior margin, situated between genital grooves from level of posterior half of coxae IV to anus, projecting beside anus as two tapering, narrowly pointed, robust spurs (adanal shields); accessory shields absent. Hairs on integument between genital grooves and coxae arranged in three irregular rows extending from level of coxa I to spiracular plate;

about five irregular rows within genital grooves; two irregular rows of widely spaced hairs between level of anus and posterior margin. Ventral hook situated medially at posterior margin, on caudal protrusion of engorged specimens, articulated to body basally, free from base to apex; twice as long as wide; anterior margin straight; lateral margins parallel, posterior margin bluntly rounded.

Legs: Coxae equidistant from each other, almost contiguous; outline of each with rounded junctures, I and IV subtriangular, II and III subquadrate; IV with a slight, indistinct blunt spur posteriorly near the outer margin; I with a similar spur and a slightly raised ridge at the apical juncture; coxa I without a pointed dorsal projection visible from above. Free segments of legs I and II subequal, those of III slightly larger, those of IV enormously widened; segments partially joined giving legs a "beaded" appearance especially on legs III and IV; constriction between first and second segment of each leg especially narrow; several conspicuous irregular rows of long pale hairs on dorsal surface of each segment, forming tufts at apex of segments on III and IV; an apical row of hairs encircling most segments, a few lateral and ventral hairs also present. Tarsi clawlike, with a narrowly pointed apex and small subapical spur ventrally; claws articulated dorsally and subapically, strongly recurved around pads.

FEMALE: Notably differing from male in that free segments of legs, while robust, are not greatly enlarged; also lacking a ventral hook and conspicuous lateral hairs and hair tufts. Other characters recall those of the male.

Length of engorged specimens reaching 6.6 mm.; width 3.9 mm.; color, when unengorged, yellowish.

Capitulum: Basis capituli three times as wide as long, lateral margins strongly convex, posterior margin very slightly concave; porose areas large, ovate, situated directly posterior of each palpus; ventral outline similar to that of male but with lateral margins more acutely angled. Palpi slightly longer than wide; larger than those of male; segment 3 approximately three-fourths as long as segment 2; apex subcircular; ventrally segment 3 with a very slight ridge in place of the retrograde spur of the male. Hypostome larger than that of male and with seven or eight denticles in inner files and ten or eleven denticles in outer files; otherwise similar to that of male.

Scutum: Length-width ratio approximately equal, lateral margins gradually tapering from scapulae to eyes and from eyes to bluntly rounded posterior margin. Eyes oval, slightly arched, more distinct and larger than in male, situated on lateral margin at widest point of scutum. Cervical grooves curved around eyes and extending to posterolateral margin distally; delineating a broad median, slightly shagreened field bearing widely scattered, short hairs.

Spiracular plate subcircular, with three rows of large goblets encircling the aperture. Genital aperture shield shaped, in same position as in male. Genital grooves similar to those of male to level of anus, where they continue as slightly convex grooves extending almost to the posterior margin of the body. Hairs in lines similar to those of male except that these lines extend almost to posterior margin of body; hairs laterally only slightly longer and denser than ventrally.

Legs robust but not markedly modified. Coxae similar to those of males except that they are wider in relation to length and the spurs and ridges are even more reduced. Free segments with marked constriction between first and second segment similar to that of males. Tarsi longer and narrower in comparison to those of males but otherwise similar; claws and pads similar to those of males.

NYMPH and LARVA: Undescribed.

RHIPICEPHALUS APPENDICULATUS

DAUBNEY (1942). Kenya. Infection with T. parva; brief mention of research published elsewhere.

DAUBNEY (1944). Kenya. Transmission of T. parva by R. pravus like that in R. appendiculatus under experimental conditions. Transmission of Nairobi sheep disease.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

THEILER (1956 correspondence). Additional host records in Onderstepoort collection. Number of collections indicated in parenthesis. These data add significantly to our knowledge of hosts, especially of immature stages, of the brown ear-tick. Recall that immature stages are also very common on domestic animals but that these records are not listed in the present study.

Adult Hosts

Antelopes: Impala from Zululand (2), and from Mozambique (3). Duikerbok (3) and duiker (1) from Zululand. Springbok (1) from South Africa. Reedbuck (3), bushbuck (2), waterbuck (1), and nyala (1); all from Zululand; also waterbuck (1) from Uganda. Kudu from Zululand (2), Northern Rhodesia (2), Mozambique (1), and Ngamiland (2).

Buffalo: From Zululand (2) and Uganda (1).

Carnivores: Lion from Transvaal (3) and Northern Rhodesia (1). Leopard from Transvaal (2), Mozambique (1), Northern Rhodesia (1), and Kenya (1). Cheetah from Southwest Africa (1). Striped hyena from Southern Rhodesia (1) and Tanganyika (1).

Pigs: Warthog from Zululand (3) and Uganda (1). Bushpig from Zululand (1) and Ngamiland (2).

Hares and rats: Rattus rattus from Uganda (1). Hare from South Africa (1).

Nymphal Hosts

Antelopes: Reedbuck from Zululand (1). Red duiker from Zululand (1). Blue duiker from South Africa (1). Duiker from Zululand (2) and South Africa (3). Waterbuck from Zululand (1) and South Africa (2). Impala from Zululand (1) and South Africa (1). Hartebeest from Northern Rhodesia (1). Lechwe (1) and greater kudu (1) from Northern Rhodesia.

Zebra: From Northern Rhodesia (1).

Carnivores: Big-eared fox from Kenya (1). Jackal from Transvaal (1) and Northern Rhodesia (1). Genet from Zululand (1). Banded mongoose from Uganda (1). Gray mongoose from Uganda (1). Uganda wildcat from Uganda (1).

Primates: Chacma baboon from Transvaal (4) and guenon monkey from Zululand (1) and South Africa (1).

Pigs: Warthog from Zululand (2). Bushpig from Transvaal (1). Giant forest pig from Belgian Congo (1).

Hares: *Lepus* spp. exceptionally heavily infested in Eastern Province, South Africa. *Pronolagus ruddi* from South Africa (1).

African porcupine: From Transvaal (2).

Cane rats: *Tryronomys swinderianus variegatus* from Nyasaland (1) and Southern Rhodesia (1).

Bush squirrels: *Paraxerus* from Southwest Africa (2) and Southern Rhodesia (2).

Rodents: *Mastomys coucha* from Zululand (1). *Rhabdomys pumilio* from South Africa (4).

Elephant shrews: From Tanganyika (1) and *Petrodromus* from Tanganyika (1).

Hedgehogs: From Transvaal (1).

Larval Hosts

Antelopes: Bushbuck (3) and blue duiker (1) from South Africa.

Primates: Chacma baboon from Transvaal (4). Galago from Zululand (1).

Carnivores: Banded mongoose from Uganda (1), Zululand (1), and South Africa (1). Genet from Zululand (1).

Rodents: Tatera gerbil from Southern Rhodesia (1). Groove-toothed rat (*Otomys irroratus*) from South Africa (1). Mouse (*Leggada minutoides*) from South Africa (2).

Elephant shrews: *Elephantulus myurus* from Southern Rhodesia (1).

Hares: *Lepus* spp. exceptionally heavily infested in Eastern Province, South Africa.

RHIPICEPHALUS COMPOSITUS

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

RHIPICEPHALUS CUSPIDATUS

GRIMALDI (1934). Ethiopia. Said to be present at Eil Nogal. This is considered a questionable identification; see page 631.

THEILER (ms.). Description of both sexes; review of data. Belgian Congo material from Ozeguru (Nizi) seen in addition to localities mentioned on page 631.

RHIPICEPHALUS DISTINCTUS

TENDEIRO (1955). Mozambique. Review of previous report from colony.

RHIPICEPHALUS E. EVERTSI

GRIMALDI (1934). Yemen (Hodeida, erroneous locality or based on cattle brought for slaughter). Eritrea, collecting localities. Not listed from Ethiopia and Somalia.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

RHIPICEPHALUS LONGUS

RHIPICEPHALUS MÜHLENSI

TENDEIRO (1955). Mozambique. Review of previous reports concerning both species from colony.

RHIPICEPHALUS PRAVUS

DAUBNEY (1944). Kenya. As *R. neavi*: see *R. appendiculatus*, page 906. Not able to transmit Nairobi sheep disease experimentally, possibly owing to unsatisfactory feeding of ticks. Morphology and biology of tick under study.

RHIPICEPHALUS SANGUINEUS SANGUINEUS

WILLCOCKS (1922). Egypt. Presence noted.

FRANCHINI (1927X). Libya. Collected at Giarabub.

GRIMALDI (1934). Yemen, Libya, Eritrea, Ethiopia, Somalia; collecting localities.

TARTAGLIA (1939). Yugoslavia. Case of boutonneuse fever circumstantially associated with *R. s. sanguineus* because of presence of this tick on dog in home of patient.

MARKOV, ABUSALIMOV, & DZASOKHOV (1939). USSR. Epizootic piroplasmosis of swine; transmission not achieved (similar results with *H. marginatum* and *R. rossicus*).

KURCHATOV & POPOVA (1939). USSR. Ecology. Also noted that hatching larvae quickly disperse, loss of ability (of which stage not stated) to feed after lengthy starvation, preference for dogs rather than cattle (in comparison with R. bursa) or mice or rabbits (in comparison with R. rossicus and R. turanicus).

DAUBNEY (1944). Kenya. Stresses need for study of rickettsiae in this species of tick.

PERVOMAISKY (1950B). USSR. Male R. sanguineus can fertilize female R. bursa, which lay a large number of mostly fertile eggs afterwards. Mating between male R. bursa and female R. sanguineus does not result in fertile eggs. The progeny of male sanguineus - female bursa union were only females identical to R. bursa. These hybrid females, when fertilized by male R. sanguineus, gave rise to 27 gynandromorphs and 323 females (see also Pervomaisky 1954). This paper also reports Hyalomma gynandromorphs.

CVJETANOVIC et al (1953). Yugoslavia. An exceptionally interesting study of ticks including R. s. sanguineus as reservoirs in an epidemic of Q fever. See H. dromedarii, page 878.

PERVOMAISKY (1954). USSR. Study of variation in size and morphological characters; some reared material resembles R. turanicus while a proportion of the progeny of R. turanicus resemble R. sanguineus. These two species mate readily and produce fertile offspring.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

SCHULZE (1955). Discussion of metabolic products.

RHIPICEPHALUS SIMPSONI

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

RHIPICEPHALUS SIMUS SIMUS

DAUBNEY (1944). Kenya. Morphology and biology under study.

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

PAGE 733. Distribution in the Sudan. Kenisa, on the border of Bahr El Ghazal and Upper Nile Province, is a part of the latter Province.

RHIPICEPHALUS SIMUS SENEGALENSIS

TENDEIRO (1955). Mozambique. Review of previous reports from colony.

PAGE 755. Distribution in the Sudan. Kenisa, on the border of Bahr El Ghazal and Upper Nile Province, is a part of the latter Province.

RHIPICEPHALUS SUPERTRITUS

RHIPICEPHALUS TRICUSPIS

TENDEIRO (1955). Mozambique. Review of previous reports of both species from colony.

BIBLIOGRAPHY*

A

ABSUDALLAM, M. & SARWAR, M. M. (1953) Trees as habitats of the fowl tick, Argas persicus (Oken). Bull. ent. Res., 44(3):419-420.

ABRAMOV, I. V. (1949) On recurrent equine piroplasmosis. (In Russian). J. agric. Sci., Moscow, ser. g (Vet.), 26(7):18.

____________ (1955) The duration of the preservation of the causal agent of piroplasmosis of horses (Piroplasma caballi) in the ticks Hyalomma plumbeum Panzer, 1795. (In Russian). Ibid, 32(3):42-46.

ABRAMOV, I. V., TSAPRUN, A. A. & LEBEDEV, E. M. (1950) Importance of ticks as transmitter of equine piroplasmosis. (In Russian). J. agric. Sci., Moscow, ser. g (Vet.), 27(3): 12-14.

---

*This bibliography consists of 1,880 references. Abbreviations follow the World List of Scientific Periodicals, Third Edition, 1950, London. All references, unless otherwise noted, are in the writer's files at U.S. Naval Medical Research Unit Number Three, Cairo, in published or reprint form, or as photostats or printed photographs of the original. Thanks are due Miss Nellie Medzadour for assistance in obtaining literature. The United States Department of Agriculture Index-Catalogue of Medical and Veterinary Zoology has been of inestimable assistance for bibliographic work, as have been Tropical Diseases Bulletin and Review of Applied Entomology. For obtaining literature, the services of the Armed Forces Medical Library, Library of Congress, United States Department of Agriculture, UNESCO, and the National Research Council of Egypt, have been utilized and are gratefully acknowledged.

ADERS, W. M. (1912) The blood-sucking arthropods of Zanzibar harmful to man or stock. Zanzibar Gov't. Leaflet No. 2, 13 pp.

__________ (1914) Entomology in relation to public health and medicine. Med. sanit. Rep. Zanzibar (1913), pp. 76-82.

__________ (1917A) Idem. Ibid, (1916), pp. 47-49.

__________ (1917B) Insects injurious to man and stock in Zanzibar. Bull. ent. Res., 7(4):391-401.

ADLER, S. (1952) Les piroplasmoses chez les bovidés en Israel. Bull. Off. int. Epiz. I, 38:570-574.

ADLER, S. & FELDMAN-MUHSAM, B. (1946) The differentiation of ticks of the genus Hyalomma in Palestine. (In Hebrew). Refuah vet., 3(3):91-94.

____________________ (1948) A note on the genus Hyalomma Koch in Palestine. Parasitology, 39(1-2): 95-101.

"AGRICOLA" (1946) Arsenic-resistant ticks. (Letter to editor). Fmrs' Wkly, Bloemfontein, 72:55. (Also, "The Director of Veterinary Services replies." Same page).

AGRINSKY, N. (1937) On ticks as transmitters of equine nuttalliosis in Middle Asia. (In Russian, English summary). Acta Univ. Asiae med., 8-a(31), 9 pp.

ALCOCK, A. (1915) Report of the entomologist to the London School of Tropical Medicine......1914. Etc. [From RAE, B, 3(9):129 (1915)]

ALEXANDER, R. A. (1931) Heartwater. The present state of our knowledge of the disease. 17th Rep. Dir. vet. Serv. S. Afr., pp. 89-150.

ALEXANDER, R. A. & NEITZ, W. O. (1933) The transmission of louping ill of sheep by ticks (Rhipicephalus appendiculatus). Vet. J., 89:320-323.

ALEXANDER, R. A. & NEITZ, W. O. (1935) The transmission of louping ill by ticks (Rhipicephalus appendiculatus). Onderstepoort J. vet. Sci., 5(1):15-33.

ALEXANDER, R. A., MASON, J. H. & NEITZ, W. O. (1939) Studies of the rickettsias of the typhus-rocky-mountain-spotted-fever group in South Africa. I. Isolation of strains. Onderstepoort J. vet. Sci., 13(1):19-23.

ALFEEV, N. I. (1948) New abnormalities in the female Hyalomma dromedarii Koch. (In Russian). Zool. Zh., 27(3): 257-259.

__________ (1951) On the changeability of metamorphosis in ixodid ticks. (In Russian). Rev. Ent. U.R.S.S., 31(3-4):398-403.

ALLEN, G. M. & LOVERIDGE, A. (1933) Reports on the scientific results of an expedition to the southwestern highlands of Tanganyika Territory. II. Mammals. Bull. Mus. comp. Zool. Harv., 75(2):47-140.

ALUIMOV, A. Y. (1935) Relapsing fever in Persia. (In Russian), pp. 54-67, in: Parasites, Vectors, and Venemous Animals. Rec. Trav. 25th Anniv. sci. Pavlovsky 1909-34, Moskow.

AMARAL LEAL, J. & SANT'ANNA, J. F. (1909) Ornithodorus moubata in Lourenço Marques. Arch. Med. Lisboa, 2:87-88. [Not seen; year of issue 1898?]

AMERICAN GEOGRAPHICAL SOCIETY (1954) Atlas of diseases. Plate 12. World distribution of rickettsial diseases-tick and mite vectors. (See also "erratum" sheet for above map). New York.

__________ (1955) Idem. Plate 16. World distribution of spirochetal diseases. 2. Relapsing fevers (louse-borne and tick-borne). New York.

ANASTOS, G. (1950) The scutate ticks, or Ixodidae, of Indonesia. Ent. amer., 30(1-4):1-144.

ANASTOS, G. (1954) The 3rd Danish expedition to Central Asia. Zoological results 12. Ticks (Chelicerata) from Afghanistan. Vidensk. Medd. dansk. naturh. Foren. Kbh., 116:169-174.

ANDERSON, C. W. (1935) Sur la présence d'O. erraticus infecté par Sp. hispanicum dans la banlieue de Tunis. Arch. Inst. Pasteur Tunis, 24(3-4):483-492.

ANDERSON, C. W. & SICART, M. (1937) Nouveaux cas de fièvre récurrente hispano-africaine observés dans un même foyer du nord de la régence. Etude des virus isolés. Arch. Inst. Pasteur Tunis, 26(2):250-256.

ANDERSON, T. F. (1947) Tick control by gammexane. E. Afr. med. J., 24(7):259-261.

ANDERSON, T. J. (1924A) Bloodsucking insects and their allies in the Colony and Protectorate of Kenya. Kenya med. J., Supp., 14 pp.

_______________ (1924B) Ectoparasites recorded from Kenya Colony and Protectorate, with their hosts. Ibid, Supp. 2, 8 pp.

ANDRÉ, M. (1935) Les acariens figurés par Savigny dans la Description de l'Egypte. Bull. Mus. Hist. nat., Paris, 7(3): 197-200.

ANDRÉ, M. & LAMY, E. (1931) Les acariens parasites des mollusques (Notes complémentaires). J. Conchyliol., 75:322.

ANDREWS, F. W. (1948) The vegetation of the Sudan. In: J. D. Tothill, ed., Agriculture in the Sudan, Chap. IV, pp. 32-61. Oxford Press.

ANGELOVSKY, T. P. (1954) Contribution to the knowledge of the tick fauna in the people's republic of Macedonia. I. The tick fauna of the district of Skopl'e. (In Serbian, French summary). Acta vet., Belgrade, 4(2): 53-57.

ANIGSTEIN, L., WHITNEY, D. M. & MICKS, D. W. (1950A) Antibacterial factor in tick extracts. Texas Rep. Biol. Med., 8(1): 86-100.

____________________ (1950B) Antibacterial activity of a substance present in ticks (Ixodoidea) of Texas. Nature, Lond., 166:141-145.

ANNECKE, S. (1952) Relapsing fever. (Correspondence). S. Afr. med. J., 26(35):720.

ANNECKE, S. & QUIN, P. (1952) Relapsing fever in South Africa, its control. S. Afr. med. J., 26(22):455-460.

"ANXIOUS" (1943) Local shortage of dipping fluid. (Letter to editor). Fmrs' Wkly, Bloemfontein, 65:175.

ARAKIAN, A. A. & LEBEDEV, A. D. (1955) Natural foci of hemorrhagic fevers (In Russian). J. Microbiol., Moscow, 4:20-26.

ARCHIBALD, R. G. (1923) Kala-azar in the Sudan with special reference to its treatment by tartar emetic. Amer. J. trop. Med., 3(4):307-324.

ARTHUR, D. R. (1951) The capitulum and feeding mechanism of Ixodes hexagonus Leach. Parasitology, 41(1-2):66-81.

__________ (1953A) The morphology of the British Prostriata with particular reference to Ixodes hexagonus Leach. II. Ibid, 42(3-4):161-186.

__________ (1953B) The capitulum and feeding mechanism of Ixodes hexagonus Leach. II. Ibid, 42(3-4):187-191.

__________ (1953C) Ixodes theileri n. sp., with observations on species confused therewith. Ibid, 43(3-4):239-245.

__________ (1953D) Haller's organ of ticks. Entomologist, 86:23-24.

__________ (1955) Ixodes hoogstraali, a new species of tick from Yemen. Parasitology, 45(1-2):128-130.

ARTHUR, D. R. (1956A) The Ixodes ticks of Chiroptera (Ixodoidea, Ixodidae). J. Parasit., 42 [In press].

__________ (1956B) The morphology of the British Prostriata with particular reference to Ixodes hexagonus Leach. IV. Parasitology. [In press].

__________ (ms.) The genus Ixodes in Africa. [In advanced stage of preparation].

ARTJUKH, E. S. (1936) Über die Zecken der Fam. Ixodidae in der Ukr. S.S.R. (In Russian, German summary). Uchen. Zap. Vitebsk. vet.-zootekh. Inst., 3:195-200.

ASS, M. I. (1935) Zur Kenntnis der Ektoparasiten der Flossenfüssler (Pinnipedia). Eine neue Zeckenart auf dem Walross. Z. Parasitenk., 7(5):601-607.

AUDOUIN, J. V. (1827) Description de l'Egypte, ou recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française, publié par les ordres de sa majesté l'empereur Napoleon le Grand, 2d ed., 22, Zool.

__________ (1832) Lettres pour servir de matériaux à l'histoire des insectes. Première lettre, contenant des recherches sur quelques araignées parasites des genres pteropte, Caris, Argas, et Ixode, addressée à M. Leon Dufour. Ann. sci. nat. Paris, 25:401-425.

AUSTEN, E. E. (1906) Notes on an insect found by Dr. F. Creighton Wellman preying upon a tick (Ornithodoros moubata, Murray) at Benguella, Angola, W. Africa. Medicine, Detroit, 12:498-499.

__________ (1907) Idem. Pap. Amer. Soc. trop. Med., 2:15-16.

BABUDIERI, B. (1954) Survey on relapsing fever in Jordan, July-September 1954. Preliminary report. WHO (Alexandria), EM/Epid/3 (Jordan 12), mimeographed, 5 pp.

__________ (1955) Survey on relapsing fever in Jordan, July-September 1954. Final report. WHO (Alexandria), EM/Epid/3.Add.1, mimeographed, 3 pp.

BACELAR, A. (1950) Notas acerca dos aracnídeos do Ultramar Português. Coloq. Jta Invest. colon. Lisboa, 17:1-24.

BAER, J. G. (1951) Ecology of animal parasites. 224 pp. Univ. Illinois Press.

BAGSHAWE-SMITH, L. G. (1944) Arsenic-resistant tick. (Letter to editor). Fmrs' Wkly, Bloemfontein, 67:749.

BAKER, E. W. & WHARTON, G. W. (1952) An introduction to acarology. 465 pp. New York.

BALDRATI, I. (1940) La zecca dei polli (Argas persicus). La piu grave insidia dei pollai coloniali. Agricoltura colon., 34:468-472.

BALFOUR, A. (1904) Trypanosomiasis in the Anglo-Egyptian Sudan. Preliminary note. Brit. med. J. (2291), 2:1455-1456.

__________ (1906) Biting and noxious insects other than mosquitoes. Rep. Wellcome trop. Res. Lab., 2:29-50.

__________ (1907) A peculiar blood condition, probably parasitic, in Sudanese fowls. Brit. med. J. (2445), 2:1330-1333.

__________ (1908A) Piroplasmosis in the Anglo-Egyptian Sudan. Rep. Wellcome trop. Res. Lab., 3:37.

__________ (1908B) Spirochaetosis of Sudanese fowls. Ibid, 3:38-58.

BALFOUR, A. (1909) Further observations on fowl spirochaetosis. J. trop. Med. (Hyg.), 12(19):285-289.

__________ (1910) Idem. J. trop. vet. Sci., 5(2):309-322.

__________ (1911A) The infective granule in certain protozoal infections, as illustrated by the spirochaetosis of Sudanese fowls. Preliminary note. Brit. med. J. (2622), 1:752.

__________ (1911B) Idem. Ibid (2624), 1:870.

__________ (1911C) The rôle of the infective granule in certain protozoal diseases. Ibid (2654), 2:1268-1269.

__________ (1911D) Feeding experiments in fowl spirochaetosis. Lancet, 2(4):223-224.

__________ (1911E) Spirochaetosis of Sudanese fowls. Rep. Wellcome trop. Res. Lab. 4A(Med.):76-107.

__________ (1911F) Veterinary notes. Ibid, 4A(Med.):343-352.

__________ (1911G) The rôle of the infective granule in certain protozoal diseases. J. trop. Med. (Hyg.), 14(17):263-264.

__________ (1911H) Anaplasmosis in donkeys. J. comp. Path., 24(1):44-47.

__________ (1912) The life cycle of Spirochaeta gallinarum. An appreciation and a criticism of Dr. E. Hindle's recent paper. Parasitology, 5(2):122-126. (Including reply of Hindle, p. 127).

__________ (1913) A contribution to the life-history of spirochaetes. Zbl. Bakt., Abt. I, Orig., 70(3-4):182-185.

__________ (1920A) Ticks and relapsing fever. Brit. med. J. (3085), 1:97-98.

__________ (1920B) Idem. Ibid (3085), 1:235.

BANKS, N. (1908) A revision of the Ixodoidea, or ticks, of the United States. Tech. Ser. U.S. Bur. Ent., no. 15, 61 pp.

BARBER, C. A. (1895) The tick pest in the tropics. Nature, Lond. (1339), 52:197-200. [Idem, Agric. J.C.G.H., 8(16): 419-421].

BARBETTI, K. M. (1943) Le zecche della Croazia meridionale con speciale riguardo al genere Boophilus Curtice 1891. (In Serbian, Italian summary). Vet. Arch. Zagreb, 13(9):358-379.

BARBOUR, T. & LOVERIDGE, A. (1928) A comparative study of the herpetological faunae of the Uluguru and Usambara Mountains, Tanganyika Territory with descriptions of new species. Mem. Mus. comp. Zool. Harv., 50(2):87-265.

BARDEZ, (-) (1934) Contribution à l'étude de la trypanosomiase équine et bovine au Cameroun. Rev. vet. milit., 18: 457-467.

BARNARD, W. G. (1949) Animal health and industry. Rep. Livestk. agric. Dep. Swazild. 1948, pp. 8-26.

BARTOLUCCI, F. (1933) Appunti nosografici della regione di Brava. [Quoted by Franchini (1937, p.301), further details unavailable].

BARTONE, L. (1950) Raro caso di febbre bottonosa con pleurite emorragica de flebite osservato in Cirenaica. Acta med. ital., Roma, 5(8):266-270.

BEAKBANE, H. R. & WILDE, J. K. H. (1949) An investigation of the effect of gammaxane in a half-bath on hard ticks of cattle. J. comp. Path., 59(3):155-167.

BEAL, W. P. B. (1920) Report on live stock industries of the Northern Territories, Gold Coast. [MS, 27 May 1920, 97 pp. + 7 appendices]. [From R.A.E., B, 9(6):100-101 (1921) and Trop. vet. Bull., 9(1):36-50 (1921)].

BEAMENT, J. W. L. (1945) The cuticular lipoids of insects. J. exp. Biol., 21:115-131.

BEATON, W. G. (1939) Goat husbandry in northern Nigeria including a descriptive survey of the causes of mortality. Rep. vet. Dep. Nigeria, 1937, pp. 31-48.

BEAUMONT, E. (1949) Department of Veterinary Services, Kenya, annual report, 1947, 59 pp.

BEDFORD, G. A. H. (1913) A tick new to South Africa. Rep. vet. Res. S. Afr., 2:343-344 (1912).

_______________ (1917) The spinose ear tick (Ornithodoros megnini, Dugès). Local Ser. Dept. Agric. S. Afr., 18:1-6.

_______________ (1920) Ticks found on man and his domestic animals and poultry in South Africa. J. Dept. Agric. S. Afr., 1(4):317-340.

_______________ (1924A) Description of an abnormal female blue tick (Boophilus decoloratus Koch). S. Afr. J. nat. Hist., 4(5):353-355.

_______________ (1924B) The external parasites of poultry with measures for their control. J. Dept. Agric. S. Afr., 9(2):123-140.

_______________ (1925) The spinose ear tick (Ornithodoros megnini, Dugès). Ibid, 10(2):147-153.

_______________ (1926) A check-list and host-list of the external parasites found on South African Mammalia, Aves, and Reptilia. 11-12th Rep. vet. Res. S. Afr., (1):705-817.

_______________ (1927) Reprint of 1926 (supra).

_______________ (1929A) Notes on some African ticks, with descriptions of three new species. 15th Rep. vet. Res. S. Afr., (1):493-499.

BEDFORD, G. A. H. (1929B) The effect upon ticks of dipping cattle regularly at short intervals in arsenical baths. 15th Rep. vet. Res. S. Afr., (1):551-573.

________________ (1931A) Nuttalliella namaqua, a new genus and species of tick. Parasitology, 23(2):230-232.

________________ (1931B) The ectoparasites of mammals and birds and their importance. Pamphl. S. Afr. biol. Soc., 2: 1-5.

________________ (1932A) Description of Argas striatus, a new species of ticks. 18th Rep. Vet. Res. S. Afr., (1): 221-222.

________________ (1932B) A synoptic check-list and host-list of the ectoparasites found on South African Mammalia, Aves, and Reptilia. (Second Edition). Ibid, pp. 223-523.

________________ (1934) South African ticks. Part 1. Onderstepoort J. vet. Sci., 2(1):49-99.

________________ (1936) A synoptic check-list and host-list of the ectoparasites found on South African Mammalia, Aves, and Reptilia. (Supplement No. 1). Onderstepoort J. vet. Sci., 7(1):69-110.

BEDFORD, G. A. H. & COLES, J. D. W. (1933) The transmission of Aegyptianella pullorum, Carpano, to fowls by means of ticks belonging to the genus Argas. Onderstepoort J. vet. Sci., 1(1):15-18.

BEDFORD, G. A. H. & GRAF, H. (1934) Ticks, tick-borne diseases and their eradication in South Africa. Fmg. in S. Afr. (104), 9:431-434.

______________________ (1935) Idem. II. The transmitters of East Coast fever and red-water in cattle. (In Afrikaans). Ibid (106), 10:14-17,20.

______________________ (1939) Idem of 1934 and 1935, also III. Dipping against ticks. (All in English). Ibid (107), 10:65-66,68. (Reprint No. 24, 10 pp.).

BEDFORD, G. A. H. & HEWITT, J. (1925) Descriptions and records of several new or little-known species of ticks from South Africa. S. Afr. J. nat. Hist., 5:259-266.

BEDFORD, G. A. H. & WILKEN-JORDEN, T. J. (1934) Researches into dips and dipping. C. Miscellaneous. The effect of dosing aloes to tick-infected cattle. Onderstepoort J. vet. Sci., 2(1):267-269.

BEDFORD, H. W. (1939) Medical entomology (Sudan). J. trop. Med. (Hyg.), 42(20):79-80.

BEHR, H. H. (1899) A Californian tick. Canad. Ent., 31(8):229-231 [Includes reply by C. L. Marlatt, p. 231].

BELL, S. (1953) Predisposing factors in tick-borne relapsing fever in Meru district, Kenya. Trans. R. Soc. trop. Med. Hyg., 47(4):309-317.

BEKKER, P. M. (1942) Use of waste tobacco in dips. Fmg. in S. Afr. (200), 17:695-698.

__________ (1944) Tobacco extract for control of arsenic-resistant blue tick and cattle lice. Ibid (225), 19:775-780.

__________ (1945) Use of waste tobacco in dips. Ibid (226), 20:25-29.

__________ (1947) Arsenic dips still of value. Fmrs' Wkly, Bloemfontein, 74:105.

__________ (1953) A blue tick (*Boophilus annulatus decoloratus*) resistant to BHC but not to arsenic. Fmg. in S. Afr. (325), 28:119-120, 136.

BEKKER, P. M. & GRAF, H. (1946) Gammexane and DDT dips for control of arsenic-resistant blue tick. Fmg. in S. Afr. (243), 21:361-366.

BEKKER, P. M. & KOCH, P. (1943) Growing tobacco for dipping purposes, with special reference to the resistant blue tick. Fmg. in S. Afr. (211), 18:755-758.

BEKKER, P. M., GRAF, H., MALAN, J. R. & VAN DER MERWE, S. W. (1949) Die vergelykende waarde van arseen, BHC en D.D.T. indien gebruik in dipbakke teen bosluise op beeste. (English summary). J. S. Afr. vet. med. Ass., 20(3):110-124.

BEQUAERT, J. C. (1919) L'Ornithodorus moubata dans le Nord-Est du Congo Belge. Bull. Soc. Path. exot., 12(8):517-520.

______________ (1930A) Entomology. Medical and economic entomology. In: R. P. Strong, ed., The African Republic of Liberia and the Belgian Congo (based on the observations made and materials collected during the Harvard African Expedition 1926-1927. Contr. Dep. Trop. Med. & Harv. Inst. trop. Biol. Med., (5), 2:797-1001.

______________ (1930B) Ticks collected by the American Museum Congo Expedition 1909-1915, with notes on the parasites and predacious enemies of these arthropods. Amer. Mus. Novit. No. 426, 12 pp.

______________ (1931) Synopsis des tiques du Congo Belge. Rev. Zool. Bot. afr., 20(3):209-251.

______________ (1932) On the ornate nymphs of the tick genus Amblyomma (Acarina:Ixodidae). Z. Parasitenk., 4(4):776-783.

BEQUAERT, M. (1913) Onze huidge kennis van de Belgische grotten fauna. Hand. 17 nat.-en geneesk. Congr. Gent, pp. 168-177.

BERGE, T. O. & LENNETTE, E. H. (1953) World distribution of Q fever: human, animal and arthropod infection. Amer. J. Hyg., 57(2):125-143.

BERGSMA, S. (1928) Relapsing fever in Abyssinia. J. trop. Med. (Hyg.), 31(22):289-290.

__________ (1929) Idem. Trans. R. Soc. trop. Med. Hyg., 22(4): 381-384.

BERNADSKAIA, Z. M. (1938) Study of tick biology under sandy desert conditions. (In Russian, English summary). Trud. Uzbekist. nauch.-issled. Vet. op. Stants. Narkom. UzSSR (10) pp. 18-35.

__________ (1939A) The biology of the tick Hyalomma savignyi Gerv. (In Russian, English summary). Ibid, (11), 2:15-27.

__________ (1939B) On the morphology of larvae and nymphs of Hyalomma ticks Koch. (In Russian). Ibid, (11), 2:31-36.

__________ (1939C) A case of parasitism on ixodiid ticks. (In Russian). Ibid, (11), 2:28-30.

__________ (1943) Microorganism of rickettsial type in the larvae of the tick Hyalomma savignyi. (Abstract). (In Russian). J. agric. Sci., Moscow, Ser. g (Vet.), 20(2):32.

BÉROS, G. & BALOZET, L. (1929) Fièvre éxanthématique d'été au Maroc. Bull. Soc. Path. exot., 22(8):712-728.

BERRI, P. (1953) La febbre esantematica del Mediterraneo. Minerva Med., Roma, 44, 2(86):1202-1209.

BERTAZZI, C. G. (1952) Schemi di terapia della febbre ricorrente africana dell'altopiano etiopico. Acta med. ital., Roma, 7(3):57-62.

BERTRAM, D. S. (1939) The structure of the capitulum in Ornithodoros: a contribution to the study of the feeding mechanism in ticks. Ann. trop. Med. Parasit., 33(3-4): 229-253.

BEVAN, L. E. W. (1910) African coast fever. Rhod. Agric. J., 8(1):33-40.

____________ (1912) The anaplasmoses of cattle. Ibid, 9(4): 520-529.

____________ (1915) African coast fever. Ibid, 12(4):468-483.

____________ (1915X) Ticks and the animal diseases. Ibid, 12(6):766-784.

____________ (1919) Inoculation of cattle against red-water and gallsickness. Bull. Dep. Agric. Rhod. 316, 10 pp.

____________ (1920A) Report of the veterinary bacteriologist. Rep. vet. Surg. S. Rhod. 1919, pp. 9-17.

____________ (1920B) African coast fever (revised). Rhod. agric. J., 17(2):118-129.

____________ (1927) African coast fever. Ibid, 24(6):649-652.

BINNS, H. R. (1950) East African Veterinary Research Organization, annual report, 1949, 12 pp. (mimeographed).

__________ (1951) Ibid, 1950, 37 pp. Nairobi.

__________ (1952) Ibid, 1951, 24 pp.

BIRULA, A. (1895) Ixodidae novi vel parum cogniti Musei Zoologici Academiae Caesareae Scientiarum Petropolitinae. Bull. Acad. Sci. St.-Pétersb., Ser. 5, 2(4):353-364.

BISHOPP, F. C. & TREMBLEY, H. L. (1945) Distribution and hosts of certain North American ticks. J. Parasit., 31(1): 1-54.

BLACKLOCK, D. B. (1912) The resistance of Ornithodorus moubata to various sheep-dips. Ann. trop. Med. Parasit., 6(4):429-433.

BLAGOVESHCHENSKY, D. I. (1948) Hymenopterous parasite of ticks of the family Ixodidae. (In Russian). Parazitol. Sborn. Zool. Inst. Akad. Nauk. SSSR, 9:115-124 (1947).

BLAGOVESHCHENSKY, D. I. & SERDYUKOVA, G. V. (1946) The action of chemical substances on pasture ticks. (In Russian). Izv. tadzhiks. Fil. Akad. Nauk. SSSR, 6:77-89.

BLAIZOT, L. (1910) Bull. Inst. Pasteur, __( ):316 [Not seen].

BLANC, G. (1910) Sur la terminaison du tube digestif des Ixodidae. Bull. Soc. Zool. Fr., 35(10):219-225.

________ (1951) Rickettsia (Coxiella) burnetii (Derrick) au Maroc et accessoirement en Algerie et en Afrique équatoriale. Etude expérimentale. Rev. belge Path., 21(1):17-36.

BLANC, G. & BRUNEAU, J. (1948) Comportement du virus de la pneumophatie du cobaye chez quelques arthropodes piqueurs. C. R. Acad. Sci. Paris, 227(5):375-376.

________________ (1949) Un reservoir de virus de la Q fever en Algérie, la tique bovine "Hyalomma mauritanicum". Bull. Acad. nat. Med., 133(5-6):115-117.

________________ (1953) Entretien dans la nature de Coxiella burnetii par l'association du lapin de garenne Oryctolagus cuniculus (L.) et de la tique Hyalomma excavatum C.L.K. C. R. Acad. Sci. Paris, 237(11):582-584.

________________ (1954) Etude d'une association biologique: lapin de garenne-arthropodes piqueurs dans la forêt de Nefifik, près Casablanca. Présence de virus pathogènes pour l'homme. Les raisons de leur inocuité. Bull. Acad. Nat. Med., B (ser. 3), 138(27-28):453-456.

________________ (1955) Ornithodores et coxiellose (Q. fever). C. R. Acad. Sci. Paris, 240:129-131.

BLANC, G. & CAMINOPETROS, J. (1931) Quelques expériences sur la transmission du kala-azar par la tique du chien Rhipicephalus sanguineus. C. R. Soc. Biol. Paris, 107(26): 1493-1495.

BLANC, G. & MAURICE, A. (1950) Présence d'Ornithodorus coniceps a Si Allal Tazi. Rapp. Inst. Pasteur Maroc, 1949, pp. 9-10.

BLANC, G., BRUNEAU, J. & CHABAUD, A. (1950A) Présence de Rickettsia (Coxiella) burneti chez des tiques de l'espèce Amblyomma variegatum recueillies en Afrique Equatoriale française. C. R. Acad. Sci. Paris, 230(5):474-475.

______________________________ (1950B) Quelques essais de transmission de la toxoplasmose par arthropodes piqueurs. Ann. Inst. Pasteur, 78(2):277-280.

______________________________ (1951) Idem. Arch. Inst. Pasteur Maroc, 4(4):298-303.

BLANC, G., GOIRAN, E. & BALTAZARD, M. (1937) Observation de deux cas de fièvre boutonneuse à Conakry (Guinée française) et découverte, chez les rhipicéphales de la région du chalcidien parasite Hunterellus hookeri. Arch. Inst. Pasteur Maroc, 1(4):667-676.

______________________________ (1938) Idem. Bull. Soc. Path. exot., 31(1):23-28.

BLANC, G., MARTIN, L. A., & BRUNEAU, J. (1949) Q fever expérimentale de quelques animaux domestiques. Ann. Inst. Pasteur, 77(2):99-107.

BLANC, G., MARTIN, L. A. & MAURICE, A. (1946) Sur une rickettsia isolée de tiques dans le Sud marocain. Son identité probable avec R. burneti agent de la Q fever. Note. C. R. Acad. Sci. Paris, 223(11):438-439.

______________________________ (1947A) Le mérion (Mériones shawi) de la région de Goulimine est un réservoir de virus de la Q fever marocaine. Note. Ibid, 224(23):1673-1674.

______________________________ (1947B) Présence du virus de la Q fever dans le Maroc meridional. Bull. Acad. Nat. Med. Paris, 1947(7-8):138-143.

BLANC, G., NOURY, M. & FISCHER, M. (1933) Sensibilité de l'écureuil de Getulie (Atlantoxerus getulus) au virus de la fièvre boutonneuse. C. R. Soc. Biol. Paris, 113(20):357-358.

BLANC, G., BRUNEAU, J., MARTIN, L. A. & MAURICE, A. (1948) Quelques donnée nouvelles sur le virus de la Q fever marocaine. C. R. Acad. Sci. Paris, 226(7):607-608.

BLANCHARD, M. (1913) Epidémie de spirochétose humaine à Bikié (Congo français). Bull. Soc. Path. exot., 6(8):559-560.

__________ (1914) Epidémie de fièvre récurrente à Bikié. Ann. Hyg. Med. colon., 17(1):81-86.

BLANCHARD, M. & LAIGRET, J. (1924) Recherches sur la transmission d'Onchocerca volvulus par divers parasites hématophages. Bull. Soc. Path. exot., 17(5):409-417.

BLANCHARD, R. (1909) L'Argas reflexus et les maladies infectieuses. Bull. Soc. ent. Fr., (14):238-241.

BLOMEFIELD, L. C. (1954) A small capacity dipping tank. Fmg. in S. Afr. [Reprint No. 61, 3 pp.].

BODENHEIMER, F. S. (1934) Ecological studies on some ticks. Parasitology, 26(4):489-495.

__________ (1937) Prodromus Faunae Palestinae. Essai sur les éléments zoogéographiques et historiques du sud-ouest du sous-regne paléarctique. Arachnoidea (including 23 species of ticks with their hosts). Mem. Inst. Egypt, 33:1-286. [cf. pp. 244-245].

BODENHEIMER, F. S. & THEODOR, O. (1929) Beobachtungen über hygienisch wichtige Insekten des Sinai. In: Ergebnisse der Sinai-Expedition, 1927 der hebräischen Universität Jerusalem, 142 pp. Leipzig. [cf. pp. 37-39].

BOETGGER, C. R. & REICHENBACH-KLINKE, H. H. (1955) Gesundheitsstörungen des Menschen durch den Befall mit Taubenzecken (Argas columbarum Shaw). Z. angew. Zool., 1:15-21.

BOGORODITSKY, A. V. & BERNADSKAIA, Z. M. (1938) New theileriose transmitters of big horned cattle and fighting measures against them. (In Russian, English summary). Trud. Uzbekist. nauch.-issled. Vet. op. Stants. Narkom. UzSSR, (10):3-17.

BONÉ, G. J. (1943) Recherches sur les glandes coxales et la régulation du milieu interne chez l'Ornithodorus moubata Murray (Acarina, Ixodidae). Ann. Soc. Zool. Belg., 74:16-31.

BORTHWICK, J. D. (1918) Veterinary division. Rep. Dep. Agric., S. Afr., 1916-1917, pp. 29-38.

BORZENKOV, A. K. & DONSKOV, G. D. (1933) The experimental infection of the tick Hyalomma volgense P. Schulze and E. Schlottke. 1929, with plague. (In Russian, English summary). Rev. Microbiol. Saratov, 12(1):25-30.

BOUET, G. (1909) Spirillose des poules au Soudan français. Bull. Soc. Path. exot., 2(6):288-291.

BOURLAY, R. (1909) Notes on fowl ticks. Fmrs' Bull. Transv. Dep. Agric. No. 61, pp. 4-8.

BOUVIER, G. (1945) Quelques questions d'entomologie vétérinaire et lutte contre certains arthropodes en Afrique tropicale. Acta trop. Basel, 2(1):42-59.

BRASSEY-EDWARDS, H. H. (1930) Annual report of the chief veterinary officer. Rept. Dept. Agric. Kenya, 1929, pp. 97-173.

__________ (1932) Annual report of the deputy director (animal industry) and chief veterinary officer. Ibid, 1931, pp. 213-287.

__________ (1933) Part III. Animal industry. Ibid, 1932, pp. 184-270.

__________ (1937) Division of animal industry. Ibid, 1936, 1:114-175.

BRECHER, G. & WIGGLESWORTH, V. B. (1944) The transmission of Actinomyces rhodnii Erikson in Rhodnius prolixus Stål (Hemiptera) and its influence on the growth of the host. Parasitology, 35(4):220-224.

BREIJER, H. G. (1915) Notes on the Maputaland expedition (27th May to 3rd July, 1914). Ann. Transv. Mus., 5(2):111-115.

BRETT, G. A. (1939) On the period of survival of the egg, larva, and first nymph stages of the argasid tick Ornithodorus moubata, Murray, at different relative humidities. Bull. ent. Res., 30(2):247-253.

BRIGHENTI, D. (1935) L'Argas reflexus Fab. come parassita dell' uomo. Bull. Zool. agr. Bachic. Turin, 6(1-3):219-225.

BROWNING, E. (1950) "Baby tortoise" or tortoise tick. Ill. London News (5810), 217:329.

BROWNING, T. O. (1954A) On the structure of the spiracle of the tick, Ornithodoros moubata Murray. Parasitology, 44(3-4):310-312.

______________ (1954B) Water balance in the tick Ornithodoros moubata Murray, with particular reference to the influence of carbon dioxide on the uptake and loss of water. J. exp. Biol., 31(3):331-340.

BRUCE, D., HAMERTON, A. E., BATEMAN, H. R. & MACKIE, F. P. (1910) "Amakebe", a disease of calves in Uganda. Rep. Sleep. Sickn. Comm. roy. Soc. No. 10, pp. 86-103.

BRUCE, D., HAMERTON, A. E., BATEMAN, H. R. & BRUCE, Lady (1911) Distribution of ticks in Uganda. Ibid, No. 11, pp. 228-243.

BRUMPT, E. (J.A.) "Brumpt's Précis." See 1910, 1913, 1922, 1927, 1936, and 1949.

BRUMPT, E. (J.A.) (1901) Notes et observations sur les maladies parasitaires. [Première série]. Arch. Parasit. Paris, 4(4):563-580.

__________ (1908A) Existence de la fièvre des tiques en Abyssinie. Quelques mots sur la biologie de l'*Ornithodoros moubata*, acarien qui détermine cette spirochétose. Bull. Soc. Path. exot., 1(7):432-436.

__________ (1908B) Transmission du *Spirochaeta duttoni* par l'*Ornithodorus savignyi*. Transmission du *Spirochaeta duttoni* et du *Spirochaeta gallinarum* par l'*Ornithodorus moubata*, non transmission des spirochètes de la fièvre récurrente américaine et algérienne par ce même parasite. Ibid, 1(9):577-579.

__________ (1909A) Existence d'une spirochétose des poules à *Spirochaeta gallinarum* dans le pays Somali. C. R. Soc. Biol. Paris, 67(26):174-176.

__________ (1909B) Sur une nouvelle spirochétose des poules du Sénégal produite par *Spirochaeta neveuxi* n. sp. Bull. Soc. Path. exot., 2(6):285-288.

__________ (1910) Précis de Parasitologie. 915 pp., Paris.

__________ (1913) Idem. 2nd. ed., 1011 pp., Paris.

__________ (1919) Transmission de la piroplasmose canine tunisienne par le *Rhipicephalus sanguineus*. Bull. Soc. Path. exot., 12(10):757-764.

__________ (1920) Les piroplasmes des bovidés et leurs hôtes vecteurs. Ibid, 13(6):416-460.

__________ (1921) Comment améliorer notre bétail colonial. Rev. Hist. nat. appl., 1ère partie, 2(7):205-216.

__________ (1922) Précis de Parasitologie. 3rd. ed., 1216 pp., Paris.

__________ (1923) Les theilerioses mortelles du basin Méditerranéen sont dues à *Theileria mutans*. Ann. Parasit. hum. comp., 1(1):16-53.

BRUMPT, E. (J.A.) (1924) Au sujet du rôle pathogène de l'*Argas persicus*. Rev. Hist. nat. appl., lère partie, *5*(7): 209-220.

______________ (1927) Précis de Parasitologie. 4th ed., 1452 pp., Paris.

______________ (1930A) Transmission de la fièvre exanthématique de Marseille par la tique méridionale du chien (*Rhipicephalus sanguineus*). C. R. Acad. Sci. Paris, *191*(19): 889-891.

______________ (1930B) Parasitisme latent de l'*Ixodiphagus caucurtei* chez les larves gorgées et les nymphes à jeun de divers ixodinés (*Ixodes ricinus* et *Rhipicephalus sanguineus*). *Ibid*, *191*(22):1085-1087.

______________ (1934) Le gynandromorphisme chez les ixodinés. Un curieux cas obtenus dans un élevage d'*Amblyomma dissimile*. Ann. Parasit. hum. comp., *12*(2):98-104.

______________ (1936) Distribution géographique et rôle en pathologie humaine de l'*Ornithodorus savignyi*. *Ibid*, *14*(6):640-646.

______________ (1936X) Précis de Parasitologie. 5th ed. 2 vols., Paris.

______________ (1938A) Présentation de préparations microscopiques. Transmission expérimentale d'un trypanosome, parasite de la cavité générale d'*Hyalomma pusillum*, à diverses éspèces de tiques. Bull. Soc. Path. exot., *31*(1):42-43.

______________ (1938B) Identification des piroplasmes du chien du type *Piroplasma canis*. Transmission de la souche Française par la tique Sud-africaine *Haemaphysalis leachi*. Faible valeur des épreuves d'immunité croisée dans les piroplasmoses. Ann. Parasit. hum. comp., *16*(2): 97-116.

BRUMPT, E. (J.A.) (1938C) Formes évolutives d'Haemogregarina mauritanica chez la tique Hyalomma syriacum. Ibid, 16(4):350-361.

_______________ (1938D) Parasite coelomique (Coelomoplasma hyalommae n.g. n. sp.) de la tique Hyalomma syriacum parasite de la tortue terrestre Testudo maurtanica. Ibid, 16(4):362-363.

_______________ (1938E) Protozoaire coelomique (Coelomoplasma rhipicephali n. sp.) transmis héréditairement, parasite de la tique Rhipicephalus bursa. Ibid, 16(4): 364-368.

_______________ (1949) Précis de Parasitologie. 6th ed. 2 vols., Paris.

BRUMPT, E. & CHABAUD, A. G. (1947) L'infestation par des ixodinés provoque-t-elle une immunité chez l'hôte? I. Note préliminaire. Ann. Parasit. hum. comp., 22(5-6):348-356.

BRUMPT, E. & FOLEY, G. (1908) Existence d'une spirochétose des poules à Spirochaeta gallinarum, R. Bl., dans le Sud Oranais. Transmission de cette maladie par Argas persicus. C. R. Soc. Biol. Paris, 65(26):132-134.

BRUNS, A. (1937) Ueber Rückfallfieber in Abessinien. Arch. Schiffs-u. Tropenhyg., 41(3):343-348.

BUCHNER, P. E. C. (1926) Studien an intrazellularen Symbionten. VI. Zur Acarinen - Symbiose. Z. Morph. Ökol. Tiere, 6(3):625-644.

BÜCK, G. (1935) Les tiques à Madagascar et les maladies qu'elles inoculent aux animaux domestiques de la Grande Ile. Rev. agric. Maurice, 84:196-209.

________ (1940) A propos des piroplasmoses des équidés à Madagascar. Bull. Soc. Path. exot., 33(2):86-89.

________ (1948A) Tiques des animaux domestiques à Madagascar. Bull. agric. Tananarive, 1(4):3-11.

BÜCK, G. (1948B) Existence d'*Ornithodorus megnini* Dugès à Madagascar. Bull. Soc. Path. exot., 41(7-8):567-568.

_______ (1948C) Note sur les tiques des animaux domestiques de Madagascar. Commun. Soc. Sci. méd. Madagasc., Feb. 1948, 2 pp.

_______ (1949) Tiques des animaux domestiques à Madagascar. Arch. Inst. Pasteur Tananarive. (Ann. Rept. 1948), pp. 60-63.

BÜCK, G. & LAMBERTON, G. (1946) Piroplasmose canine à Madagascar. Bull. Soc. Path. exot., 39(7-8):283-285.

BÜCK, G. & METZGER, (-) (1940) Note sur la babesiellose à *Babesiella berbera* chez les zébus, des métis-limousins, et des limousins purs à Madagascar. Bull. Soc. Path. exot., 33(2):89-93.

BÜCK, G. & RAMAMBAZAFY, (-) (1950) Premier cas de nuttaliose naturelle signalée à Madagascar. Bull. Soc. Path. exot., 43(1):43-44.

BURGDORFER, W. (1951) Analyse des Infektionsverlaufes bei *Ornithodorus moubata* (Murray) und der natürlichen Uebertragung von *Spirochaeta duttoni*. Acta trop., Basel, 8(3):194-262.

BURGDORFER, W. & DAVIS, G. E. (1954) Experimental infection of the African relapsing fever tick, *Ornithodoros moubata* (Murray), with *Borrelia latychevi* (Sofiev). J. Parasit., 40(4):456-460.

BUSVINE, J. R. (1955) The development of resistance to insecticides. Rep. 6th Commonw. Ent. Conf. (London, 1954), pp. 60-65.

BUSVINE, J. R. & BARNES, S. (1947) Observations on mortality among insects exposed to dry insecticidal films. Bull. ent. Res., 38(1):81-90.

BUSVINE, J. R. & NASH, R. (1953) The potency and persistence of some new synthetic insecticides. Bull. ent. Res., 44(2):371-376.

BUTTNER, A. (1949) Refixation accidentelle d'un mâle de *Hyalomma excavatum* sur l'homme. Ann. Parasit. hum. comp., 24(1-2): 186-187.

BUXTON, P. A. (1932) Climate in caves and similar places in Palestine. J. Anim. Ecol., 1:152-159.

____________ (1933) The effect of climatic conditions upon populations of insects. Trans. R. Soc. trop. Med. Hyg., 26(4): 325-364.

CAFFREY, P. J. (1926) Relapsing fever in northern Nigeria. Some observations. Trans. R. Soc. trop. Med. Hyg., 20(3): 195-197.

CALMAN, W. T. (1905) Ornithodorus savignyi var. caecum (sic). J. trop. Med. (Hyg.), 8(8):124.

CAMPANA, Y. (1947) Schizomelies spontanées et expérimentales chez les Ixodoidea. Ann. Parasit. hum. comp., 22(1-2): 53-62.

CAMPANA-ROUGET, Y. (1950) La tératologie des tiques. Thése Sciences, Paris, 14 Dec. 1950. [In press].

__________ (1954) Mue et croissance chez les Ixodoidea. Bull. Mem. Ec. prep. Med. Pharm. Dakar (1952-1953), 1:213-239.

CARMICHAEL, J. A. (1934) Annual report of the veterinary pathologist, Entebbe. Ann. Rep. Vet. Dep. Uganda, 1933, pp. 29-45.

__________ (1940) Research. Ibid, 1939, pp. 18-21.

__________ (1942) The chemotherapy of Babesia canis infections. E. Afr. med. J., 19(3):96-99.

CARPANO, M. (1912) La febbre della costa nella Colonia Eritrea. Note biologische e morfologische sulla "Theileria parva". Clin. vet., Milano, 35(19-22):821-862.

__________ (1929A) Piroplasmosis in Egyptian fowls (Egyptianella pullorum). Bull. 86, Tech. and Sci. Serv., Vet. Serv., Minist. Agric. Egypt, 7 pp.

__________ (1929B) Sulla piroplasmosi dei volatili domestici determinata dalla Aegiptianella (sic) pullorum. 2a nota. Clin. vet. Milano, 52(6-8):475-476. [Ibid, (In French), Ann. Parasit. hum. comp., 7(5):365-366].

CARPANO, M. (1935) Sur un nouveau microparasite du type Grahamella-Rickettsia, observé chez les poulets (Grahamella gallinarum). Ann. Parasit. hum. comp., 13(3):238-242.

__________ (1936) Sur des microorganismes du type Rickettsia observés chez ixodes en Egypte (1). Ibid, 14(5):417-422.

CARRÉ, C. (1909) Note sur des larves d'Argas qui attaquent les poules en Perse. Bull. Soc. cent. Méd. vét., 63:172-173.

CATANEI, A. (1929) Sur un essai de transmission du spirochéte des poules par Ornithodorus savignyi. C. R. Soc. Biol., Paris, 100(12):1018-1019.

CATANEI, A. & PARROT, L. M. (1926) Sur le virus de la spirochétose aviare en Algérie et sur la longue durée de sa conservation chez Argas persicus. Bull. Soc. Path. exot., 19(6):419-421.

CAVACEPPI, L. (1950) Revisione sistematica della zecche in Italia (I Nota).Riv. Parassit., 11(2):109-111.

CAVAZZI, G. (1943) Segnalazione di cinque casi di febbre bottonosa sull'altopiano Etiopico. Boll. Soc. ital. Med., Sez. Eritrea, 3(2):5-9.

CHABAUD, A. G. (1950A) Sur la nutrition artificielle des tiques. Ann. Parasit. hum. comp., 25(1-2):42-47.

__________ (1950B) L'infestation par des ixodinés provoque-t-elle une immunité chez l'hôte? (2e note). Ibid, 25(5-6):474-479.

CHABAUD, A. G. & CHOQUET, M. T. (1953) Allométrie des variants sexuels chez les Ixodidae. Arch. Zool. exp. gen., 89(4):139-146.

CHALON, G. (1923) Présence d'Ornithodoros savignyi (Audouin) à Ouargla (Sahara algérien). Bull. Soc. Path. exot., 16(10):741-742.

CHAMBERS, F. & SMITH, J. (1914) Immunisation of imported cattle against Northern Rhodesian piroplasmosis and anaplasmosis. J. comp. Path., 27(2):155-171.

CHARRIER, H. (1925) Ixodes de la région de Tanger. Bull. Soc. Path. exot., 18(6):469-470.

CHARTERS, A. D. (1946) Tick-typhus in Abyssinia. Trans. R. Soc. trop. Med. Hyg., 39(4):335-342.

CHATTON, E. & BLANC, G. (1916A) Cryptoplasma rhipicephali, n.g., n. sp., protiste endoparasite de la tique, Rhipicephalus sanguineus, du gondi (Ctenodactylus gundi). C. R. Soc. Biol. Paris, 79(3):134-138.

________________ (1916B) Un pseudo-parasite Cryptoplasma rhipicephali Chatton et Blanc. Ibid, 79(10):402.

________________ (1917) Notes et réflexions sur le toxoplasme et la toxoplasmose du gondi (Toxoplasma gundii, Nicolle et Manceaux, 1909). Arch. Inst. Pasteur Tunis, 10(1-2):1-40.

________________ (1918) Prédilection du Rhipicephalus sanguineus pour le gondi. Son rôle probable de vecteur de la toxoplasmose. Ibid, 10(4):281-282.

CHERRY, J. K. T. (1955) The prevention and treatment of tick-borne relapsing fever with special reference to aureomycin and terramycin. Trans. R. Soc. trop. Med. Hyg., 49(6):563-573.

CHODZIESNER, M. (1924) Beiträge zur Kenntnis der Zecken mit besonderer Berücksichtigung der Gattung Hyalomma Koch. Zool. Jb. Abt. 1, 47(4-6):505-572.

CHORLEY, T. W. (1943) An unusual occurrence of Ornithodoros moubata (Arachnida). Proc. R. Ent. Soc. Long. (A), 18(4-6):27.

CHOW, C. Y., THEVASAGAYAM, E. S. & THARUMARAJAH, K. (1954) Insects of public health importance in Ceylon. Rev. Ecuator. ent. Parasit., 2(1-2):105-150.

CHRISTIANSEN, M. (1934) Argas reflexus Latreille (Duemiden) i Danmark. Maanedsskr. Dyrlaeg., 46(1):6-15.

CHRISTOPHERS, S. R. (1906) The anatomy and histology of ticks. Sci. Mem. med. sanit. Dept. India, n.s. (23), 55 pp.

__________ (1907A) Preliminary note on the development of Piroplasma canis in the tick. Brit. Med. J. (2402), 1:76-78.

__________ (1907B) The sexual cycle of Leucocytozoon canis in the tick. Sci. Mem. med. sanit. Dept. India, n.s., (28), 11 pp.

__________ (1907C) Piroplasma canis and its life cycle in the tick. Ibid, (29), 83 pp.

__________ (1912A) The development of Leucocytozoon canis in the tick with a reference to the development of Piroplasma. Parasitology, 5(1):37-48.

CHRISTY, C. (1903A) "Tick fever" in man. Thomp. Yates Labs. Rep., n.s., 5(1):187-188. [Note by R. I. Pocock, pp. 188-189].

__________ (1903B) Ornithodorus moubata, and tick fever in man. Brit. Med. J. (2229), 2:652-653 [Note by L. W. Sambon, pp. 653-654, and by R. I. Pocock, p. 652].

__________ (1904) Tick fever. (Letter to editor). Ibid (2295), 2:1726.

CHUMAKOV, M. (1948A) Results of the study made on Omsk hemorrhagic fever (01) by an expedition of the institute of neurology. (In Russian). Bull. Acad. med. Sci., Moscow, 2:19-26.

__________ (1948B) Crimean hemorrhagic fever. (In Russian). In: Smirnov, E. I., ed., Encyclopedia of military medicine, 3:268-271.

__________ (1954) Queensland fever - a zoönotic rickettsiosis of man and animals. (In Russian). J. agric. Sci., Moscow, ser. g (Vet.), 31(9):26-32.

CHUMAKOV, M. P., PETROVA, S. P. & SONDAK, V. A. (1945) Study of encephalitis caused by ultraviruses. Communication VII. Artificial adaptation of the viruses of the tick-borne and Japanese encephalitis to different species of ticks of the family Ixodidae. (In Russian). Med. Parasit., Moscow, 14(1):18-24.

CIUREA, I. & STEPHANESCOU, T. (1929) Argas persicus comme parasite de l'habitation humaine. Bull. Soc. roum. Derm. Syph., 2, 4 pp. reprint.

CLARK, E. M. (1937) Report on relapsing fever in Burao. Ann. med. (sanit.) Rep., Somalild., 1936, Append. 2, pp. 57-66.

CLARK, R. (1933) Observations on sweating sickness in northern Zululand. J. S. Afr. vet. med. Ass., 4(1):10-20.

________ (1938) A note on paralysis in lambs caused apparently by Rhipicephalus evertsi. Ibid, 9(3):143-145.

CLASTRIER, J. (1936) Contribution à l'étude de la pathologie de l'Aurès [Algerie]. Arch. Inst. Pasteur Alger, 14(4): 449-557.

CLIFFORD, H. C. (1954) Spraying of cattle as a method of control of cattle ticks and its field application in Ankole District of Uganda. Trop. Agriculture, Trin., 31(1): 19-26.

CLUVER, E. H. (1939) Infectious and preventable diseases. Rep. Dep. publ. Hlth. S. Afr., 1938-1939, pp. 32-69.

________ (1944) Annual report of the South African Institute for Medical Research, Johannesburg, 1943, 47 pp.

________ (1947) Idem, 1946, 55 pp.

COGHILL, N. F., LAWRENCE, J. & BALLANTINE, I. D. (1947) Relapsing fever in Cyrenaica. Brit. Med. J. (4505), pp. 637-640.

COLAS-BELCOUR, J. (1928) Note sur Ornithodorus normandi, ses caractères différentiels et sa biologie. Arch. Inst. Pasteur Tunis, 17(1):35-39.

———— (1929A) Ponte et éclosion des ornithodores: leur élevage. Ibid, 18(1):43-49.

———— (1929B) Présence d'Ornithodorus coniceps en Tunisie. Ibid, 18(3-4):265-267.

———— (1929C) Sur l'identité d'Ornithodorus erraticus Lucas et d'Ornithodorus marocanus Vélu. C. R. Acad. Sci., 189(27):1316-1318.

———— (1930) Sur l'identite d'Ornithodorus erraticus Lucas et d'O. marocanus Vélu. Arch. Inst. Pasteur Tunis, 19(1):1-12.

———— (1931) Notes sur la faune parasitologique des Oasis de Tozeur et Kebili. Ibid, 20(1):66-72.

———— (1932) Contribution à l'étude de Rhipicephalus (Pterygodes) fulvus Neumann et de sa biologie. Ibid, 20(4):430-443.

———— (1933A) Sur une nouvelle larve d'ornithodore nord-africaine. Ibid, 22(4):505-508.

———— (1933B) Contribution à l'étude de la biologie de l'Argas vespertilionis Latr. Bull. Soc. Path. exot., 26(7):937-940.

———— (1935) Evolution post-embryonnaire et mues de l'Ornithodorus erraticus. Ibid, 28(7):604-606.

———— (1941) Sur le cycle évolutif de deux ornithodores de grande taille, Ornithodorus canestrinii Birula 1895 et O. delanoei Roubaud et Colas-Belcour 1931. C. R. Soc. Biol. Paris, 212(12):512-514.

COLAS-BELCOUR, J. & GRENIER, P. (1942) Sur un ixodiné peu connu, Ixodes lunatus Neumann 1907, ectoparasite des rats malgaches. Bull. Soc. Path. exot., 35(1-2):54-65.

COLAS-BELCOUR, J. & MILLOT, J. (1948) Contribution à l'étude des ixodides de Madagascar. Sur une variété nouvelle de Haemaphysalis hoodi. Parasitisme humain par un Boophilus. Ibid, 41(5-6):384-388.

COLAS-BELCOUR, J. & RAGEAU, J. (1951) Tiques de Tunisie: Ixodines. Arch. Inst. Pasteur Maroc, 4(4):360-367.

COLAS-BELCOUR, J. & VERVENT, G. (1949) Essai de transmission de Spirochaeta (Borrelia) hispanica par l'Ornithodorus delanoei Roubaud et Colas-Belcour, 1931. Bull. Soc. Path. exot., 42(9-10):447-448.

COLAS-BELCOUR, J., NEEL, R. & VERVENT, G. (1952) Contribution à l'étude de la transmission du spirochète de la fièvre récurrente malgache (Borrelia duttonii) par les Ornithodorus moubata de même origine. Bull. Soc. Path. exot., 45(1):69-78.

COLES, J. D. W. A. (1933) Mortality in fowls due to Aegyptianella pullorum. Onderstepoort J. vet. Sci., 1(1):9-14.

________________ (1945) Parasites of fowls. Fmg. in S. Afr. (235), 20:629-637.

COLLEN, G. (1943) Tampan control. Fmrs' Wkly, Bloemfontein, 65:1164.

COMTE, C. & BOUQUET, (-) (1908) Arch. Inst. Pasteur Tunis, __( ):163. [Not seen].

CONDORELLI-FRANCAVIGLIA, M. (1913) Parassitismo da Rhipicephalus sanguineus (Latr.) nell'orecchio umano. Boll. Acad. gioenia, 2.s. 28:11-13.

CONNAL, A. & COGHILL, H. S. (1917) Medical entomology. Rep. med. Res. Inst., Nigeria, 1916, pp. 26-28.

COOK, A. R. (1904) Relapsing fever in Uganda. J. Trop. Med. (Hyg.), 7(2):24-26.

COOLEY, R. A. (1929) A summary of tick parasites studies. S. Afr. J. nat. Hist., 6(4):266-272.

__________ (1930) The Montana tick parasite expedition to Africa. Science n.s. (1842), 71:419-420.

__________ (1934) A search for tick parasites in South Africa. Onderstepoort J. vet. Sci., 3(1):23-42.

__________ (1946) The genera Boophilus, Rhipicephalus, and Haemaphysalis (Ixodidae) of the New World. Nat. Inst. Hlth. Bull. 187, 54 pp.

COOLEY, R. A. & KOHLS, G. M. (1928) Egg-laying of Ixodiphagus caucurtei du Buysson in larval ticks. Science n.s. (1748), 117:656.

____________________ (1934) A summary on tick parasites. Proc. 5th Pan-pacific Sci. Congr., 5:3375-3381.

____________________ (1944) The Argasidae of North America and Cuba. Amer. Midl. Nat. Monogr. 1, 152 pp.

COOPER, F. A. (1947) New discoveries in parasite control. End of arsenic-resistant tick in sight. Fmrs' Wkly, Bloemfontein, 73:83.

__________ (1953) Dipping is still the best. Fmr & Stk-Breed. (3298), 67:54-55.

COOPER, G. H. (1944) Prevention of disease in poultry. Rhod. Agric. J., 41(2):68-72.

COOPER, W. F. & ROBINSON, L. E. (1907) Note on a new South African tick, Rhipicephalus phthirioides, sp. n. J. Linn. Soc. (Zool.) (195), 30:35-38.

COOPER, W. F. & ROBINSON, L. E. (1908) On six new species of Ixodidae, including a second species of the new genus Rhipicentor N. and W. Proc. Camb. phil. Soc., 14(5): 457-470.

COOREMAN, J. (1948) Acari (Hydrachnellae exclus). Exploration du Parc National Albert. Mission H. Damas (1935-1936). Fasc. 14, 26 pp.

__________ (1951) Etudes biospéologiques. 34(1). Acariens de Transylvanie. Bull. Inst. Sci. nat. Belg., 27(42):1-15.

__________ (1954A) Notes sur quelques acariens de la faune cavernicole. Ibid, 30(34):1-19.

__________ (1954B) Acariens recueillis dans les grottes de l'Ariège. Notes Biospéol., 9:179-182.

CORNELL, R. L. (1936) Report on the work of the veterinary laboratory, Mpwapwa. Rep. Dep. vet. Sci. Tanganyika, 1935, pp. 18-21.

CORNWALL, J. W. & PATTON, W. S. (1914) Some observations on the salivary secretion of the commoner bloodsucking insects and ticks. Indian J. med. Res., 2(2):569-593.

CORRESPONDENCE (1919) Tiques et spirochétose dans le bassin du Congo. Bull. Soc. Path. exot., 12:290.

CORSON, J. F. (1916) Entomological and other specimens collected in the northern territories, chiefly in the districts of Wa and Lorha. Rep. Accra Lab., 1915, pp. 30-35.

CORSON, J. F. & INGRAM, A. (1923) Rep. med. Dep. Gold Cst., 1922-1923, pp. 28-29, 65-77. [Quoted by Leeson (1953)].

COURDURIER, J., BUCK, G. & QUESNEL, J. J. (1952) Recherches sur la "Q fever" à Madagascar. 1ère note; recherches sérologiques. Bull. Soc. Path. exot., 45(5):602-604.

COWDRY, E. V. (1923) The distribution of Rickettsia in the tissues of insects and arachnids. J. exp. Med., 37(4):431-456.

COWDRY, E. V. (1925A) Studies on the etiology of heartwater. I. Observations of a rickettsia, Rickettsia ruminantium (n. sp.) in the tissues of infected animals. J. exp. Med., 42(2):231-252.

__________ (1925B) Idem. II, Rickettsia ruminantium (n. sp.) in the tissues of ticks transmitting the disease. Ibid, 42(2):253-274.

__________ (1925C) A group of microorganisms transmitted hereditarily in ticks and apparently unassociated with disease. Ibid, 41(6):817-830.

__________ (1926A) Idem. 11-12th Rep. vet. Res. S. Afr., Pt. 1, pp. 147-158.

__________ (1926B) Cytological studies on heartwater. I. The observation of Rickettsia ruminantium in the tissues of infected animals. Ibid, pp. 161-177.

__________ (1926C) Idem. II. Rickettsia ruminantium in the tissues of ticks capable of transmitting the disease. Ibid, pp. 181-196.

__________ (1927) [Reprint of 1926A. Pretoria].

COWDRY, E. V. & DANKS, W. B. C. (1933) Studies on East Coast fever. II. Behavior of the parasite and the development of distinctive lesions in susceptible animals. Parasitology, 25(1):1-63.

COWDRY, E. V. & HAM, A. W. (1930) The life cycle of the parasite of East Coast fever in ticks transmitting the disease. (Preliminary note). Science (1870), 72:461-462.

__________ (1932) Studies on East Coast fever. I. The life cycle of the parasite in ticks. Parasitology, 24(1):1-49.

COX, H. R. (1952) The spotted fever group. In: T. M. Rivers, ed., Viral and rickettsial infections of man, pp. 611-637. 2d. ed., Philadelphia, London, Montreal.

CRAWFORD, M. (1937) Report of the government veterinary surgeon for 1936, Ceylon, 16 pp.

CROSS, H. E. & PATEL, P. G. (1922) A note on Argasidae found in the Punjab. Vet. Bull. Dep. Agric. Punjab, No. 9, 13 pp.

CULLINAN, E. R. (1946) Medical disorders in East Africa. Trans. R. Soc. trop. Med. Hyg., 39(5):353-372.

CUNLIFFE, N. (1913) The variability of Rhipicephalus pulchellus (Gerstäcker, 1873), together with its geographical distribution. Parasitology, 6(2):204-216.

__________ (1914A) Rhipicephalus sanguineus: variation in size and structure due to nutrition. Ibid, 6(4):372-378.

__________ (1914B) Observations on Argas brumpti, Neumann. Ibid, 6(4):379-381.

__________ (1921) Some observations on the biology and structure of Ornithodorus moubata, Murray. (Together with a note on the external characters which serve to differentiate the sexes, by G. H. F. Nuttall). Ibid, 13(4):327-347.

__________ (1922) Some observations on the biology and structure of Ornithodorus savignyi, Audouin. Ibid, 14(1):17-26.

CURSON, H. H. (1928) Metazoan parasites from Zululand. S. Afr. J. nat. Hist., 6(3):181-187.

CURTICE, C. (1892) The cattle tick. Bull. Tex. agric. Exp. Sta., 24:237-252.

CVJETANOVIC, B., FALISEVAC, J., MIHALJEVIC, F., KOZMAR, D., TOPOLNIK, E. & VESENJAK-ZMIJANAC, J. (1953) Q fever epidemic at Ogulin in 1952 and its occupational features. (In Serbian, English summary). Arh. hig. rada (Zagreb), 4(1):14-32. [Reprint at hand; year of publication not certain].

DA COSTA LIMA, A. (1915) O chalcidideo Hunterellus hookeri, Howard, parasita do carrapato Rhipicephalus sanguineus Latreille, observado no Rio de Janeiro. Rev. Vet., Rio de J., 5(4): 201-203.

DA FONSECA, F., PINTO, M. R., COLAÇO, A. F., OLIVEIRA, J., BRANCO, F., DA GAMA, M. M., SOARES FRANCO, J., & LACERDA, M. T. (1951) Febre Q em Portugal. Epidemiologia da doença. Clin. Contem. Rev. Med. Cirurg., Lisboa, 5(1):1-23.

DALY, L. L. (1950) Some veterinary problems of the state veterinarian in Natal. J. S. Afr. vet. med. Ass., 21(4):141-154.

D'ARCES, P. J. (1952) Les piroplasmoses bovines en Algérie. Bull. Off. int. Epizoot., 38:558-569.

DAS, R. S. (1939) The cytoplasmic inclusions in the oogenesis of Rhipicephalus sanguineus (Latreille). Z. Zellforsch., 30(1):36-51.

DASGUPTA, B. (1955) A note on the campaniform sense-organs in Hyalomma savignyi. Proc. 42nd Indian Sci. Congr. Part 3 (abstracts), p. 287.

DASGUPTA, B. & RAY, H. N. (1955) Observations on rickettsia-like bodies in Hyalomma savignyi. Ibid, pp. 287-288.

(DA) SILVA LEITÃO, J. L. (1945) Piroplasma caballi (Nuttall et Strickland, 1910) em Portugal. Repos. Lab. Pat. vet., Lisboa, 6(1):145-151.

DAUBNEY, R. (1927) Bovine lymphangitis or tropical actinomycosis. J. comp. Path., 40(3):195-216.

__________ (1930A) Natural transmission of heart-water of sheep by Amblyomma variegatum (Fabricius 1794). Parasitology, 22(2):260-267.

__________ (1930B) Heartwater (Rickettsia ruminantium). Rep. Dep. Agric. Kenya, 1929, pp. 325-332.

DAUBNEY, R. (1933) Report of the chief veterinary research officer. Rep. Dep. Agric. Kenya, 1932, pp. 271-291.

__________ (1934) Idem. Ibid, 1933, pp. 348-381.

__________ (1936A) Idem. Ibid, 1934, 3:2-32.

__________ (1936B) Idem. Ibid, 1935, 2:130-162.

__________ (1937) Idem. Ibid, 1936, 2:55-100.

__________ (1939) Research. Rep. vet. Dep. Kenya, 1938, pp. 69-91.

__________ (1942) Rep. vet. Dep. Kenya, 1941, 16 pp.

__________ (1944) Ibid, 1943, 15 pp.

__________ (1946) Ibid, 1944, 23 pp.

DAUBNEY, R. & HUDSON, J. R. (1931A) Nairobi sheep disease. Parasitology, 23(4):507-524.

__________ (1931B) Idem. Rep. Dep. Agric. Kenya, 1938, pp. 127-132.

__________ (1933) Rift Valley fever. E. Afr. med. J., 10(1):2-19.

__________ (1934) Nairobi sheep disease: natural and experimental transmission by ticks other than *Rhipicephalus appendiculatus*. Parasitology, 26(4):496-509.

DAUBNEY, R. & SAID, M. S. (1951) Egyptian fever of cattle. The transmission of *Theileria annulata* (Dzchunkowsky & Luhz 1904) by *Hyalomma excavatum* Koch, 1844. Ibid, 41(3-4): 249-260.

DAVEY, J. B. & NEWSTEAD, R. (1921) Mosquitoes and other blood-sucking arthropods of the Upper Shiri River, Nyasaland. Ann. trop. Med. Parasit., 15(4):457-462.

DAVIS, G. E. (1947) A note on the larval stage of the argasid tick Ornithodoros moubata (Murray) 1877. J. Parasit., 33(6): 495-496.

__________ (1951) Parthenogenesis in the argasid tick Ornithodoros moubata (Murray, 1877). Ibid, 37(1):99-101.

__________ (1955) The endemic relapsing fevers. Chapter 28, pp. 552-565, in: Hull et al, Diseases transmitted from animals to man. Springfield, Illinois.

DAVIS, G. E. & BURGDORFER, W. (1954) On the susceptibility of the guinea pig to the relapsing fever spirochete Borrelia duttonii. Bull. Soc. Path. exot., 47(4):498-501.

DAVIS, G. E. & HOOGSTRAAL, H. (1954) The relapsing fevers: A survey of tick-borne spirochetes in Egypt. J. Egypt. publ. Hlth. Ass., 29(5):139-143.

__________ (1955) Idem. Atti 6th Congr. int. Microbiol. (Rome, 1953), 5(Sez.13):24-25.

__________ (1956) Studies on the biology of the relapsing fever spirochete, Borrelia persica, recovered from the argasid ticks, Ornithodoros tholozani, collected in the Western Desert Governorate, Egypt; with comments on the distribution and ecology of the tick vector. Ann. Parasit. hum. comp. [In press].

DAVIS, G. E. & MAVROS, A. J. (1956A) Observations on the biology of Ornithodoros d. delanoëi Roubaud and Colas-Belcour, 1931 (Ixodoidea, Argasidae). Bull. Soc. Path. exot. [In press].

__________ (1956B) Observations on the biology of Argas brumpti Neumann, 1907 (Ixodoidea, Argasidae). Bull. Soc. Ent. Egypte, 40. [In press].

__________ (1956C) Concerning the life cycle of Ornithodoros coniceps (Canestrini, 1890) (Ixodoidea, Argasidae). J. Egypt. publ. Hlth. Ass., 31(1):55-59.

DAVIS, G. E. & MAVROS, A. J. (1956D) Observations on the biology of Ornithodoros foleyi Parrot, 1928 (Ixodoidea, Argasidae). J. Egypt. publ. Hlth. Ass., [In press].

DE ALMEIDA, C. & REBELO, F. (1928) Os trabalhos das missoes do sono estabelecidas nos distritos do Congo e Zaire, em 1923. Rev. méd. Angola, 5:9-92 (1927).

DE BEAUREPAIRE ARAGÃO, H. (1936) Ixodidas brasileiros e de alguns paizes limitrophes. Mem. Inst. Osw. Cruz., 31(4):759-844.

DE BUEN, S. (1926) Note préliminaire sur l'épidémiologie de la fièvre récurrente espagnole. Ann. Parasit. hum. comp., 4(2):185-192.

DECARY, R. (1950) La faune Malgache, son rôle dans les croyances et les usages indigènes. 236 pp., Paris.

DE CHARMOY, D. d'E. (1914) Summary of investigations on insect pests during the five months. Mauritius Dept. Agric., Div. Entom., 2 pp.

__________ (1915) Report of the Division of Entomology. Rep. Dep. Agric. Mauritius, 1914. [From RAE, B, 3:221 (1915)].

__________ (1925) La tique des oiseaux de basse-cour, Argas persicus. Rev. agric. Maurice, (20):412-413.

DE GEER, C. (1778) Mémoire pour servir à l'histoire des insectes, 7. 950 pp. Stockholm. [Ticks: pp. 98-106, Pl. V and VI].

DE GREEF, G. (1919) Monographie agricole de la région de l'Urundi (Ancienne Province de l'Afrique orientale allemande). Chap. vii. Etat sanitaire des troupeaux. Bull. agric. Congo belge, 10(1-4):65-69.

DE JESUS, Z. (1939) Resistance of the larvae of the common dog tick and their behavior on the human skin. Philipp. J. Sci., 6(1):55-60.

DELANOË, P. (1923) De la spirochétose des oies dans le cercle des Doukkala. Bull. Soc. Path. exot., 16(8):582-587.

DELANOË, P. & LELAURIN, A. P. (1923) Infestation massive d'un élevage de poulets par la puce chique: *Sarcopsylla gallinacea* Westwood, 1875. Bull. Soc. Path. exot., 16(8): 593-594.

DELL, V. (1943) The blue tick and its resistance to dipping. (Letter to editor). Fmrs' Wkly., Bloemfontein, 65:886. [The director of veterinary services replies. Same page].

DELPY, L. P. (1936) Notes sur les ixodidés du genre *Hyalomma* (Koch). Ann. Parasit. hum. comp., 14(3):206-245.

________ (1937A) Idem. II. *Hyalomma schulzei* Olenev 1931. Ibid, 15(5):419-430.

________ (1937B) Description de *Hyalomma dromedarii* (Koch 1844). Morphologie de la larve et de la nymphe. Ibid, 15(6): 481-486.

________ (1937C) Les theilérioses bovines en Iran. Arch. Inst. Pasteur Alger., 15(2):255-264.

________ (1938) Morphologie et disposition des stigmates respiratoires chez les larvas hexapodes des Ixodidae. Bull. Soc. Path. exot., 31(4):298-300.

________ (1946A) Révision, par des voies expérimentales, du genre *Hyalomma* C. L. Koch 1844 (Acarina, Ixodoidea. Note préliminaire). Ann. parasit. hum. comp., 21(5-6): 267-293.

________ (1946B) Nouvelles recherches sur la theileriose bovine pathogène en Iran. Arch. Inst. Hessarek, (4):79-107.

________ (1947A) Idem. IV. Transmission de la theilériose par les *Hyalomma*. Ibid, (5):14-32.

DELPY, L. P. (1947B) I. Ornithodorus tholozani persepoliensis (var. n.). II. Presence en Iran d'Argas reflexus (Fabr. 1793). Bull. Soc. Path. exot., 40(5-6):176-178.

__________ (1949A) Révision par des voies expérimentales du genre Hyalomma C. L. Koch 1844 (2e partie). Ann. Parasit. hum. comp., 24(1-2):97-109.

__________ (1949B) Essai critique de synonymie du genre Hyalomma C. L. Koch 1844 depuis Linné, 1758. Ibid, 24(5-6):464-469.

__________ (1949C) Recherches effectuées en Iran sur Theileria annulata Dschunkowsky et Luhz, et sa transmission dans les conditions naturelles ou expérimentales. Bull. Soc. Path. exot., 42(5-6):285-294.

__________ (1952) Role des Hyalomma dans la transmission de la theileriose bovine. Biologie et taxonomie des espèces en cause. Rep. 14th Int. Vet. Congr. (Longon 1949), 2:89-94.

DELPY, L. P. & GOUCHEY, S. H. (1937) Biologie de Hyalomma dromedarii (Koch 1844). Ann. Parasit. hum. comp., 15(6):487-499.

DELPY, L. P. & KAWEH, M. (1937) Transmission de Bacillus anthracis à l'homme par Argas persicus Oken, 1818. Rev. Path. comp. (495), 37:1229-1234.

DE MEILLON, B. (1940) Entomology. Rep. S. Afr. Inst. med. Res., 1939, pp. 30-37.

__________ (1942) A toxin from the eggs of South African ticks. S. Afr. J. med. Sci., 7(4):226-235.

__________ (1946) Effect on some blood-sucking arthropods of gammexane when fed to a rabbit. (Correspondence). Nature, 158:839 (reprint).

DE MEILLON, B. (1949) The relationship between ectoparasite and host. IV. Host reactions to the bites of arthropods. Leech, pp. 43-46 (reprint).

DE MEILLON, B. & GOLBERG, L. (1947A) Preliminary studies on the nutritional requirements of the bedbug (Cimex lectularius) and the tick Ornithodorus moubata Murray. J. exp. Biol., 24(1-2):41-63.

_______________ (1947B) Development of Ornithodorus moubata on normal and thiamin-deficient rats. Nature (4031), 159:171.

DE MEILLON, B., THORP, J. M. & HARDY, F. (1947) The relationship between ectoparasite and host. I. The development of Cimex lectularius and Ornithodorus moubata on riboflavin deficient rats. S. Afr. J. med. Sci., 12(3):111-116.

_______________ (1948) Idem. II. A. The development of Cimex lectularius reared on rabbits receiving various substances by intravenous injection and by mouth. B. The development of Cimex lectularius reared on protein-deficient rats. Ibid, 13(1):1-9.

DE MEZA, J. (1918A) The common ticks of Nyasaland with some special notes on the anatomy and biology of ticks in general. Bull. Dep. Agric. Nyasald., 1:3-32.

_______________ (1918B) Report of the acting senior veterinary officer. Rep. Dep. Agric. Nyasald., 1918, pp. 18-19.

DEMIDOV, N. G., STARUKHIN, P. Ya. & DMITRIEV, G. N. (1944) Investigations on parasitic ixodid ticks and hemosporidioses of horses in North Caucasus. (Abstract). (In Russian). J. agric. Sci., Moscow, ser. g (Vet.), 21(8-9):22.

DEMIDOVA, M. O. (1942) The role of (cattle) lodgings as a dwelling place for ixodid tick vectors of haemosporidiosis. (In Russian). J. agric. Sci., Moskow, ser. g (Vet.), 18(10): 32-34.

DE OLIVEIRA, M. R. (1915) (Report of the Chief of the Veterinary Service for 1913). Bol. Repart. Agric. Moçambique, (19-21):223-260.

_______________ (1915) Carracas. Ibid, 3. s., (1-3):41-50.

DE PRADA, J. (1949) La fiebre "Q" en España. Med. colon., 14(5): 471-495.

DE PRADA, J., GAY, B. & LLORENTE, A. (1950) Primer caso de fiebre "Q" en Espana. Med. colon., 15(2):131-135.

DE PRADA, J., GIL COLLADO, J. & MINGO ALSINA, J. L. (1951) Tres ixodidos Españoles vectores de enfermedades rickett-siales. Trabajos de la Jefatura Provincial de Sanidad de Burgos, 35 pp.

DE RUDDERE, (-) (1917) La fièvre récurrente spirillaire et son traitement aux troupes de l'Est Africain Allemand. Arch. méd. belges, 70(8):710-713.

DESAI, D. K. (1952) Veterinary division. Rep. Dep. Agric. Sey-chelles, 1951, pp. 8-14.

DES LIGNERIS, M. J. (1940) Can tumors be transmitted by a vector? Rep. S. Afr. Inst. med. Res., 1939, p. 13.

DESPORTES, C. (1938) A propos d'une nymphe monstrueuse de Hyalomma mauritanicum Senevet. Ann. Parasit. hum. comp., 16(1):11-16.

DESPORTES, C. & CAMPANA, Y. (1946) Sur Ornithodorus tholozani (Laboulbène et Mégnin 1882) et sur les ornithodores de l'Asie centrale et mineure. Ann. Parasit. hum. comp., 21(1-2):74-88.

DEZEST, G. (1953) Les fièvres boutonneuses du Cameroun sont graves. Bull. Soc. Path. exot., 46(3):353-358.

DICK, G. W. A. & LEWIS, E. A. (1947) A rickettsial disease in East Africa transmitted by ticks (Rhipicephalus simus and Haemaphysalis leachi). Trans. R. Soc. trop. Med. Hyg., 41(3):295-326.

D'IGNAZIO, C. & MIRA, M. G. (1949) Ricerche epidemiologiche in alcuni territori di Etiopia. Arch. ital. Sci. med. colon., 30(7-8):97-141.

DINNICK, J. & ZUMPT, F. (1949) The integumentary sense organs of the larvae of Rhipicephalinae (Acarina). Psyche, 56(1): 1-17.

DIXON, R. W. (1914) East Coast fever. Its prevention and eradication. Agric. J. Un. S. Afr., 7(6):841-852.

DIXON, R. W. & SPREULL, J. (1898) Tick experiments. Agric. J. C. G. H., 13(11):691-695.

DODD, S. (1921) Tick paralysis. J. Comp. Path., 34(4):309-323.

DONALDSON, A. W. H. (1926) Report on relapsing fever at Oadweina. med. (sanit.) Rep. Somalild, 1925, pp. 29-32.

DONATIEN, A. L. (1925) Les maladies microbiennes des animaux domestiques en Algérie. Etat actuel de nos connaissances. Rev. gen. Méd. vét. (398), 34:65-77.

DONATIEN, A. & LESTOQUARD, F. (1935) Existence en Algérie d'une Rickettsia du chien. Bull. Soc. Path. exot., 28(6): 418-419.

______________ (1936A) Recherches sur Rickettsia canis comparaison avec Rickettsia conori. Ibid, 29(10): 1052-1056.

______________ (1936B) Rickettsia bovis, nouvelle espèce pathogène pour le boeuf. Ibid, 29(10):1057-1061.

______________ (1937) Etat actuel des connaissances sur les rickettsioses animales. Arch. Inst. Pasteur Alger, 15(2):142-187.

DÖNITZ, W. (1905) Die Zecken des Rindes als krankheitsüberträger. S. B. Ges. naturf. Fr. Berl., (4):105-134.

______ (1906) Über afrikanische Zecken. Ibid, (5):143-148.

DÖNITZ, W. (1907A) Insectes propagateurs de maladies, et en particulier, des tiques. Rev. Hyg. Police sanit., 29(9-10): 849-850.

__________ (1907B) Die Texasfieberzecke, Boophilus annulatus, und das Ixodinengenus Margaropus. S. B. Ges. naturf. Fr. Berl., (6):187-192.

__________ (1907C) Die wirtschaftlich wichtigen Zecken mit besonderer Berücksichtigung Afrikas. 127 pp., Leipzig.

__________ (1909) Uber das Zeckengenus Amblyomma. S. B. Ges. naturf. Fr. Berl., (8):440-482.

__________ (1910A) Zwei neue afrikanische Rhipicephalusarten. Ibid, (9):275-280.

__________ (1910B) Die Zecken Südafrikas. In: Schultze, Leonhard: Zool. u. Anthropol. Ergeb. einer Forschungsreise im westl. u. zentral Sudafrika. 4, 3 Lief. Denkschr. med.-naturw. Ges. Jena, 16:397-494, (pp. 27-124).

DONOVAN, C. (1913) Kala-azar, its distribution and the probable modes of infection. Proc. 3rd. meeting Gen. Malar. Comm., Madras, Nov. 1912, pp. 213-214.

DOUGLAS, J. R. (1943) The internal anatomy of Dermacentor andersoni Stiles. Univ. Calif. Publ. Ent. 7(10):207-272.

DOWSON, J. (1895) Poisonous tick. Brit. Med. J. (1796), 1:1201. [Note by R. I. Pocock, same page].

DRAKE-BROCKMAN, R. E. (1913A) Ticks and relapsing fever in Somaliland. Reports to the Colonial Office, dated 6th April and 16th April 1913. [From RAE, B, 1(6):115 (1913)].

__________________ (1913B) On the occurrence of an epidemic of relapsing fever in Bulhar, British Somaliland. J. Lond. Sch. trop. Med., 2(2):195-199.

__________________ (1914) Reports on an outbreak of relapsing fever among the Camel Constabulary in Somaliland. Report to the Colonial Office. [From RAE, B, 3(5):72 (1915)].

DRAKE-BROCKMAN, R. E. (1915A) Some notes on the bionomics of Ornithodorus savignyi in British Somaliland. Bull. ent. Res., 6(2):195-196.

__________ (1915B) On an epidemic of African tick fever among the troops in British Somaliland. Trans. R. Soc. trop. Med. Hyg., 8(7):201-211.

__________ (1920) Ticks and relapsing fever. (Correspondence). Brit. Med. J. (3086), 1:273.

DUBOIS, A. (1931) Pluralité des souches chez Spirochaeta duttoni. C. R. Soc. Biol., 106(13):1294-1297.

__________ (1949A) Pluralité des souches de Sp. duttoni dans une région limitée. Ann. Soc. belge Méd. trop., 29(1):15-17.

__________ (1949B) Le development de la médecine expérimentale au Congo Belge. 159 pp. Brussels.

DU BUYSSON, R. (1912) Un hyménoptère parasite des ixodes. Arch. Parasit., Paris, 15(2):246-247.

__________ (1924) 1. Recherches synonymiques sur Argas reflexus Fabr. (verus) et Ixodes marginatus Fabr. (verus). II. Simples aperçus sur la parasitologie chez l'homme et les animaux. Bull. Soc. Sci. nat. Nîmes, 43:93-98 (1921-1923).

DUNCAN, J. T. (1926) On a bactericidal principle present in the alimentary canal of insects and arachnids. Parasitology, 18(2):238-252.

DUNLOP, J. L. (1920) Ticks and relapsing fever. Correspondence. Brit. Med. J. (3086), 1:27.

DU PLESSIS, C. (1932) Blow-lamp control of poultry pests. Fmg. in S. Afr., 6:433, 437, (reprint No. 1).

DURAND, P. (1931) Rhipicephalus sanguineus et virus de la fievre boutonneuse de Tunisie. C. R. Acad. Sci. Paris, 192(14): 857-859.

DURAND, P. (1932A) Le chien réservoir de virus de la fièvre boutonneuse. Ibid, 194(10):918-919.

_________ (1932B) Rôle du chien comme réservoir de virus dans la fièvre boutonneuse. Arch. Inst. Pasteur Tunis, 21(2):239-250.

DURAND, P. & CONSEIL, E. (1930) Transmission expérimentale de la fièvre boutonneuse par Rhipicephalus sanguineus. C. R. Acad. Sci. Paris, 190(21):1244-1246.

_________________________ (1931) Idem. Arch. Inst. Pasteur Tunis, 20(1):54-55.

DU TOIT, P. J. (1928) A note on the longevity of the brown tick. Rhipicephalus appendiculatus. S. Afr. J. Sci., 25: 288-290.

_____________ (1931) Immunity in East Coast fever. 17th Rep. vet. Res. S. Afr., pp. 3-25.

_____________ (1948) Some outstanding veterinary problems in South Africa. Rep. roy. Soc. Emp. Scient. Conf. (London, 1946), 1:389-395.

DU TOIT, P. J. & VILJOEN, P. R. (1929) Dipping as a method of eradicating East Coast fever. 15th Rep. vet. Res. S. Afr., pp. 33-66.

DU TOIT, R. (1942A) External parasites of sheep. II. Lice and ticks. Fmg. in S. Afr. (193), 17:251-259. (reprint No. 22, 14 pp.).

__________ (1942B) Ticks and tick borne diseases. Part I. The Argasidae and Ixodidae. Ibid (198), 17:549-556, 587.

__________ (1942C) Idem. Part II. Control measures. Ibid (200), 17:699-713. /1942B and C also reprinted in Afrikaans and in English, 23 pp./.

__________ (1947A) Idem. Part I. The Argasidae and Ixodidae. Ibid (252), 22:408-423.

DU TOIT, R. (1947B) Ticks and tick-borne diseases. Part II. Control measures. Fmg. in S. Afr. (254), 22:425-431. [1947A and B also reprinted, No. 27, in English, 23 pp.].

__________ (1948) Arthropod pests of animals and their control in the Union of South Africa. Rep. roy. Soc. Emp. Scient. Conf. (London, 1946), 2:657-659.

DU TOIT, R. & MÖNNIG, H. O. (1942) An unusual site of attachment for ticks. J. S. Afr. vet. med. Ass., 13(3): 79-80.

DU TOIT, R., GRAF, H. & BEKKER, P. M. (1941) Resistance to arsenic as displayed by the single host blue tick Boophilus decoloratus (Koch) in a localized area of the Union of South Africa. Preliminary report. Ibid, 12(2):50-58.

DUTT, M. K. (1952) Chromosome studies on parasitic ticks, Rhipicephalus sanguineus Latreille and Hyalomma aegyptium Newmann. Proc. 38 Indian Sc. Cong. (Bangalore, 1951), (3):234.

DUTTON, J. E. & TODD, J. L. (1905A) The nature of human tick fever in the eastern part of the Congo Free State. With notes on the distribution and bionomics of the tick and an appendix on the external anatomy of Ornithodoros moubata by Robert Newstead. Mem. Lpool Sch. trop. Med., 17, 18 pp. [Idem. Thomp. Yates Labs Rep., n.s., 6(2):103-128].

__________ (1905B) The nature of tick fever in the eastern part of the Congo Free State. Brit. Med. J. (2341), 2:1259-1260.

E

EAST COAST FEVER AND ITS ERADICATION (1921) J. Dep. Agric. S. Afr., 3(6):515-521.

EDMONDS, C. R. & BEVAN, L. E. W. (1914) Some notes on the systematic dipping of stock. Rhod. agric. J., 11(7):988-1003.

"EGRET" (1938) Egret and tick. (Letter to editor). Fmrs' Wkly, Bloemfontein, 55:1741.

EICHLER, W. (1948) "Artspezifität" bei Räudemilben und anderen Ektoparasiten. Zbl. Bakt. Abt. 1, Orig. 152(8):599-604.

EL DARDIRY, A. H. (1945) Studies on avian spirochaetosis in Egypt. Minist. Agric. Egypt. Bull. 243; 48 pp.

ELIZONDO LANGAGNE, A. (1947) Fiebre manchada. Bol. Serv. Hig. rur. Med. Social Comarca Lagunera, 1(1):53-68.

ELMASSIAN, M. (1910) Sur les glandes salivaires chez quelques especes de tiques. Arch. Zool. exp. gen. Ser. 5, 5: 379-419.

ENIGK, K. (1943) Die Überträger der Pferdepiroplasmose, ihre Verbreitung und Biologie. Arch. wiss. prakt. Tierheilk., 78(3):209-240.

________ (1947) Zur Kenntnis der Zeckenfauna von Süd- und Osteuropa. Mh. VetMed., 2(5):75-81.

________ (1948) Die Wirkung neuartiger Insektizide auf Milben. I. Mitteilung: Laboratoriumsversuche. Dtsch. tierärztl. Wschr., 55(5-6):40-43, (7-8):51-56.

ENIGK, K. & GRITTNER, I. (1952) Die Excretion der Zecken. Z. Tropenmed. u. Parasit., 4(1):77-94.

________________ (1953) Zur Zucht und Biologie der Zecken. Z. Parasitenk., 16(1):56-83.

ENTOMOLOGICAL REPORTS (1916) Rep. med. Dep., S. Leone, 1914, London, 1915, pp. 51-53.

ERASMUS, L. D. (1952) Regional tick paralysis. Sensory and motor changes caused by a male tick, genus *Hyalomma*. S. Afr. med. J., 26(50):985-987.

EVANS, J. T. R. (1952) Report of the assistant director (research). Rep. Sudan vet. Serv., 1951-52, pp. 18-28.

EVANS, S. A. (1935) Routine work of Mpwapwa laboratory and some research notes. Rep. Dep. vet. Sci. Tanganyika, 1934, pp. 20-26.

F

FABRICIUS, J. C. (1794) Entomologia systematica, emendata et aucta, secundum classes, ornides, genera, species adjectis synonimis, locis, observationibus, descriptionibus, 4, 472 pp. Hafniae.

FAHMY, M. A. M. (1952) New records of ecto and endoparasites of chickens in Egypt with special reference to the taxonomy of Subulura brumpti. J. Parasit., 38(2):184.

FAIN, A. (1949) Contribution à l'étude des Arthropodes piqueurs dans le territoire de Banningville (Régions du Bas-Kwango et Bas-Kwilu). Rev. Zool. Bot. afr., 42(2): 175-182.

FALCONE, G. (1952) Le complicazioni oculari nella febbre ricorrente da zecca in Somalia. (Estratto Atti I. Congr. Interregion. Estafricano, Asmara). Boll. Soc. ital. Med., Sez. Eritrea. Special number, pp. 319-333.

FELDMAN-MUHSAM, B. (1947) Resistance of larvae and nymphs of Hyalomma savignyi Gerv. to various conditions of temperature and humidity. Parasitology, 38(3):111-115.

________ (1948) On larvae and nymphs of some species of Palestinian Hyalomma. Ibid, 39(1-2):138-147.

________ (1949) Hibernation of Hyalomma savignyi (Ixodidae) in Palestine. Bull. ent. Res., 40(2):305-306.

________ (1950) On some abnormalities in Hyalomma savignyi. Parasitology, 40(1-2):93-95.

________ (1951A) On the longevity of fasting ticks, Hyalomma savignyi, Gerv. Ibid, 41(1-2):63-65.

________ (1951B) The value of the female genital aperture for specific diagnosis in the genera Amblyomma and Dermacentor. Bull. Res. Counc. Israel, 1(1-2):164.

FELDMAN-MUHSAM, B. (1951C) A note on East Mediterranian (sic) species of the genus *Haemaphysalis*. Bull. Res. Counc. Israel, *1*(3):96-107.

______________ (1952A) On the identity of *Rhipicephalus sanguineus* Lat. *Ibid*, *2*(2):187-194.

______________ (1952B) Some new taxonomic characters for specific diagnosis of Ixodidae. Trans. 9th Int. Congr. Ent. (Amsterdam, 1951), *1*:947-949.

______________ (1953) The identity of *Rhipicephalus sanguineus* in the U.S.A. J. Parasit., *39*(6):670.

______________ (1954) Revision of the genus *Hyalomma*. I. Description of Koch's types. Bull. Res. Counc. Israel, *4*(2):150-170.

FENG, L. C. & CHUNG, H. L. (1938) The effect of temperature on the development of *Spirochaeta duttoni* in *Ornithodorus moubata*. Chin. med. J., Suppl. 2, pp. 555-562.

FERRO-LUZZI, G. (1948) Studio sulle malattie del gruppo del dermotifo in Eritrea. Boll. Soc. ital. Med., Sez. Eritrea, *8*(3-4):110-145.

FIASSON, R. (1943A) Notes sur les parasites animaux du Haut-Apure (Venezuela). Rev. Sci. méd. Afr. franc. lib., *2*(2): 125-151.

__________ (1943B) Contribution à l'étude des arthropodes vulnérants du Moyen-Congo. *Ibid*, *2*(3):257-282.

__________ (1949) Contribución al estudio de los acaros de Venezuela. Rev. grancolomb. Zootec., *3*(7-9):567-588.

FIEDLER, O. G. H. (1952) The lethal effect of some insecticides on the B.H.C.-resistant blue tick, *Boophilus decoloratus* Koch. Onderstepoort J. Vet. Res., *25*(4):65-67.

______________ (1953) A new African tick parasite, *Hunterellus theilerae* sp. nov. *Ibid*, *26*(1):61-63.

FIELDING, J. W. (1926) Australasian ticks. Serv. Publ. Dep. Hlth Aust. trop. Div., 9:114 pp.

FINDLAY, G. M. & ARCHER, G. T. L. (1948) The occurrence of tick-borne typhus in West Africa. Trans. R. Soc. trop. Med. Hyg., 41(6):815-818.

FINDLAY, G. M. & ELMES, B. G. T. (1947) Typhus in Northern Nigeria. II. Laboratory investigations. Trans. R. Soc. trop. Med. Hyg., 41(3):339-352.

FINLAYSON, M. H., GROBLER, J. M. & SMITHERS, R. (1940) Studies in South African rickettsiosis. I. A tick-borne rickettsiosis isolated from Hyalomma aegyptium. S. Afr. J. med. Sci., 5(3):41-45.

FLAMAND, (-) (1928) [A propos des kimputus.] Rev. Zool. Bot. afr., 16(4):68.

FLEGONTOVA, A. A. (1938) Les scarabées du genre Staphylin comme régulateurs de la quantité de puces dans les terriers des spermophiles Citellus pygmaeus Pall. (In Russian, French summary). Rev. Microbiol., Saratov, 16(1-2): 135-152.

FLETCHER, T. B. (1916) Report of the imperial pathological entomologist. Rep. agric. Res. Inst. Pusa, 1915-16, pp. 78-84.

FLOYD, T. M. & HOOGSTRAAL, H. (1956) Isolation of Salmonella from ticks in Egypt. Amer. J. trop. Med. Hyg., 5(2):388-389.

FOLEY, H. (1929) Sur divers arthropodes piqueurs observés au cours de la mission du Hoggar. Bull. Soc. Hist. nat. Afr. N., 20(2):47-54.

FONTOURA DE SEQUEIRA, L. A. (1936) Quelques considerations sur un cas de fièvre exanthématique de la Guinée portugaise. Rev. Med. Hyg. trop., 28(4):210-217.

FORD, T. A. (1919) Notes on veterinary practice in the West Indies and the Malay States. Vet. J., 75(8):45-54.

FOTHERINGHAM, W. & LEWIS, E. A. (1937) East Coast fever; its transmission by ticks in Kenya Colony. Hyalomma impressum near planum P. Sch. as a vector. Parasitology, 29(4):504-523.

FOX, I. (1950) The brown dog-tick on rats in Puerto Rico. J. econ. Ent., 43(5):722-723.

FRANCHINI, G. (1925) Brevi note di entomologia sulla Somalia e sulla Eritrea. Pathologica (404), 17:494-495.

__________ (1926A) Osservazioni entomologiche sulle colonie Italiane. Nota IIa. Ibid (415), 18:246-247.

__________ (1926B) Su di una tripanosomiasi dei cammelli a Giarabub in Cirenaica. Nota preventiva. Ibid (419), 18:481.

__________ (1927) Ixodidi delle colonie italiane dell'Africa del Nord e dell'Africa orientale. Arch. ital. Sci. med. colon., 8(10):555-558.

__________ (1927X) III Nota di entomologia sulle colonie italiane. Ibid, 8(7):363-366.

__________ (1928) Nuovo osservazioni di entomologia nelle colonie italiane. Ibid, 9(10):579-580.

__________ (1929A) Sulla distribuzione degli ixodidi (Ixodoidea) nella nostre colonie. Cirenaica. Ibid, 10(1):2-7.

__________ (1929B) Distribuzione delle Ixodoidea nelle colonie Italiane-Tripolitania. Ibid, 10(2):49-52.

__________ (1929C) Distribuzione degli ixododi [sic] (Ixodoidea) nelle nostre colonie. Somalia (Oltre Giuba compreso). Ibid, 10(3):131-135.

FRANCHINI, G. (1929D) Distribuzione degli Ixodidi nelle nostre colonie. Eritrea. Arch. ital. Sci. med. colon., 10(11):540-543.

________ (1929E) Ixodidi delle colonie Italiane dell'Africa del Nord e dell'Africa Orientale. C.R. 10 Int. Congr. Zool. (Budapest, 1927), (2):1139-1141.

________ (1930) Distribuzione degli ixodidi nello Jemen (Arabia meridionale). Reporto di spirochete nei pidocchi della città di Sana. Arch. ital. Sci. med. colon., 11(8):449-452.

________ (1932A) Ornithodoros della Colonie Italiane del Nord Africa. Specie, località dove somo state riscontrate e malattie che transmettono. Ibid, 13(8): 449-453.

________ (1932B) Febbre ricorrente nell'Africa del Nord Italiane. Febbre a lesioni cutanee causate da puntura di zecche. Ibid, 13(?):621-629.

________ (1933A) Les ornithodores des colonies italiennes de l'Afrique du nord, espèces, localités ou ils ont été rencontrés, maladies qu'ils transmettent. C.R. 5 Int. Congr. Ent. (Paris, 1932), 2:707-710.

________ (1933B) Risposta al lavoro del Prof. Zavattari, direttore dell'Instituto di anatomia e fisiologia comparata nell'Università di Pavia, apparso nel Giornale italiano di malattie esotiche e tropicali ed igiene coloniale N. 12-31 dicembre 1932 - A. XI. Arch. ital. Sci. med. colon., 14(1):16-20.

________ (1933C) Ancora sull'Ornithodorus moubata della Tripolitania. Ibid, 14(10):628-631.

________ (1933D) Fièvre récurrente dans l'Afrique italienne du nord. Lésions cutanées et fièvre causées par les piqures de tiques. Rapp. Congr. int. Hyg. Med. Méditerr. (Marseille, 1932), 1:422-431.

FRANCHINI, G. (1934A) A proposito di un articolo del Dr. J. Colas-Belcour "Sur une nouvelle larve d'Ornithodorus nord-africaine." Arch. ital. Sci. med. colon., 15(3):219-221.

__________ (1934B) A proposito di un articolo del Prof. Zavattari "Sull' asserita presenze dell'Ornithodorus moubata in Libia e sull'asserita conseguente presenza in Libia della febbre ricorrente da Spirochaeta duttoni". Ibid, 15(5): 360-363.

__________ (1935A) Sur les spirochétoses récurrentes dans l'Afrique italienne du nord. Med. Parasit. Moscow, 4(1):140-141.

__________ (1935B) L'Ornithodorus savignyi della Cirenaica trasmette la febbre ricorrente africana da Spirocheta di Dutton. Arch. ital. Sci. med. colon., 16(6):403-406.

__________ (1935C) Le colonie italiane dell'Africa Orientala dal punto di vista sanitario ed igienico. Ibid, 16(7): 485-506.

__________ (1937) Le febbre ricorrenti nelle nostre colonie africaine. Ibid, 18(n.s.2)(4):293-308.

FRANCHINI, G. & CADEDDU, A. (1927) Su di una trypanosomiasi dei cammelli a Giarabub in Cirenaica. (Seconda nota). Arch. ital. Sci. med. colon., 8(4):191-193.

FRANCHINI, G. & TADDIA, L. (1930) Febbre da puntura di zecche in Cirenaica causata dalla Ornithodorus Franchinii (n. sp.). Arch. ital. Sci. med. colon., 11(8):453-458.

FRICK, G. (1936) Das Zeichnungsmuster der Ixodiden. Versuch der Analyse einer Teirzeichnung. Z. Morph. Ökol. Tiere, 31(3):411-430.

FULLER, C. (1899) The common blue tick of Cape Colony and its relationship to the redwater ticks of North America and Australia. Agric. J. C. G. H., 14(6):363-369.

GADOLA, A. (1948) Zootecnia profilassi e igiene zootecnica in Africa orientale. Parte seconda. 511 pp. Rome. [Parte prima 1947].

GAJDUSEK, D. C. (1953) Acute infectious hemorrhagic fevers and mycotoxicoses in the Union of Soviet Socialist Republics. Army Med. Serv. Grad. School Med. Sci Publ. No. 2, 140 pp. Washington, D.C.

____________ (1956) Hemorrhagic fevers in Asia: a problem in medical ecology. Geogr. Rev., 46(1):20-42.

GALLI-VALERIO, B. (1909A) Recherches sur la spirochétiase des poules de Tunisie et sur son agent de transmission: *Argas persicus* Fischer. Zbl. Bakt. Abt. 1, Orig., 50(2):189-202.

____________ (1909B) Notes de parasitologie et de technique parasitologique. *Ibid*, 51(5):538-545.

____________ (1910) *Idem*. *Ibid*, 56(1):43-47.

____________ (1911A) *Idem*. *Ibid*, 60(5):358-363.

____________ (1911B) Recherches sur la spirochétiase des poules de Tunisie et sur son agent de transmission: *Argas persicus* Fischer. 2me. mémoire. *Ibid*, 61(6); 529-537.

____________ (1914) *Idem*. 3me. mémoire. *Ibid*, 72(6-7): 526-528.

GALUZO, I. G. (1934) Some protozoan diseases of domestic animals in Armenia. (In Russian). (Transcaucas. parasit. Exped. Armenia 1931). Trud. Sov. Izuch. proizv. Sil, Ser. Zakavkaz. (Trans. Coun. Study industr. Resources, Ser. Transcaucas.) (2):29-47.

GALUZO, I. G. (1935) Russian vectors of bovine theilerosis. (In Russian). Trav. Fil. Acad. Sci. U.R.S.S. Tadjikistan, (5):187-197.

____________ (1941) The ecological characteristics of the main representatives of the tick fauna of the Kazakh S.S.R. and the basis of control. (In Russian). Conference on Parasitological Problems, December 1939 (Moscow-Leningrad). Summaries of reports. Third conference. 13d. Akad. Nauk SSR, pp. 51-55. [See also J. agric. Sci., Moscow, Ser. g (Vet.), (3):137].

____________ (1943) The physical conditions of the development of ticks on the surface of the body of the host. Izv. kazan. Fil. Akad. Nauk SSSR, ser. a, 2:97-105.

____________ (1944) Ecological basis of the control of the vectors of theileriasis of cattle. Ibid, 3:92-109.

GALUZO, I. G. & BESPALOV, V. M. (1935) Mountain pastures as a prophylactic measure against the piroplasmosis of cattle in the Hissar Valley. (In Russian). Trav. Fil. Acad. Sci. U.R.S.S. Tadjikistan, (5):199-204.

GALUZO, I. G. & L'VOVA, V. I. (1945) Materials on the ecology of Hyalomma detritum P. Sch., 1932. (In Russian). Trav. Fil. Acad. Sci. U.R.S.S. Tadjikist., (14):131-144.

GALUZO, I. G., BOLDITZINA, K. S. & KAITMAZOVA, E. I. (1944) Ixodid ticks, the possible vectors of brucellosis. Izv. kazan. Fil. Akad. Nauk SSSR, ser. a, 3:123-137.

GAMBLE, M. (1914) A list of blood-sucking arthropods from the Lower Congo, with a vocabulary. J. Trop. Med. (Hyg.), 17(10):148-150.

GAMBLES, R. M. (1951) [Tick survey, p. 39; schedule XIX, p. 57; from Rep. vet. Dep. Nigeria, 1950-51, (other pages not seen)]

GANIEV, I. M. (1954) In regard to the fauna and ecology of ticks of the family Ixodidae in the district of Ural River middle stream. Trav. Inst. zool. Acad. Sci. U.R.S.S., 16:489-498.

GARDEN, G. (1912) East Coast fever in Nyasaland. Rep. Dep. Agric. Nyasald. 1912, pp. 31-36.

GARIBALDI, M. (1935) Distribuzione geografica degli ixodidi nelle nostre colonie dell'Africa settentrionale. Arch. ital. Sci. med. colon., 16(9):664-671.

GARNHAM, P. C. C. (1926) Susceptibility of Ornithodorus to fire. Kenya med. J., 3(9):265-266.

______________ (1947) A new blood spirochaete in the grivet monkey, Cercopithecus aethiops. E. Afr. Med. J., 24(1): 47-51 (reprint pp. 1-5).

______________ (1951) A new piroplasm from the rock hyrax. J. Parasit., 37(6):528-532.

______________ (1954) A haemogregarine in Argas brumpti. Riv. Parassit., 15(4):425-435.

______________ (1955) A haemogregarine infection of Argas brumpti (Demonstration). Trans. R. Soc. trop. Med. Hyg., 49(1):9.

GARNHAM, P. C. C. & HEISCH, R. B. (1953) On a new blood parasite of insectivorous bats. Trans. R. Soc. trop. Med. Hyg., 47(5):357-363.

GARNHAM, P. C. C., DAVIES, C. W., HEISCH, R. B. & TIMMS, G. L. (1947) An epidemic of louse-borne relapsing fever in Kenya. Trans. R. Soc. trop. Med. Hyg., 47(1):141-170.

GASPARE, L. (1933) Alcuni casi di punture di zecche del tipo Ornithodoros franchinii. Arch. ital. Sci. med. colon., 14(2):81-89.

__________ (1934) Risposta alla nota del Prof. Zavettari "Sull' asserita presenza dell'O. moubata in Libia." Ibid, 15(5):353-359.

GAUD, M. (1949) The rickettsioses in equatorial Africa. "Congolese red fever". Bull. World Hlth Org., 2(2):257-270.

MARINE BIOLOGICAL LABORATORY LIBRARY WOODS HOLE, MASS.

GAUD, M. & NAIN, M. (1935) Note sur le parasitisme du chien à Rabat par le Rhipicephalus sanguineus. Bull. Soc. Path. exot., 28(8):718-719.

GEAR, J. (1939) Complications in tick-bite fever. A survey of fifty cases. S. Afr. med. J., 13(1):35-36.

_______ (1954) The rickettsial diseases of southern Africa. A review of recent studies. S. Afr. J. clin. Sci., 5(3):158-175.

GEAR, J. & DE MEILLON, B. (1939) The common dog tick Haemaphysalis leachi as a vector of tick typhus. S. Afr. med. J., 13(24):815-816.

_______ (1941) The hereditary transmission of the rickettsiae of tick-bite fever through the common dog-tick, Haemaphysalis leachi. Ibid, 15(19):389-392.

GEAR, J. H. S. (1938) South African typhus. S. Afr. J. med. Sci., 3(4):134-160.

GEAR, J. H. S. & BEVAN, C. (1936) An outbreak of tick-bite fever. S. Afr. med. J., 10(13):485-488.

GEAR, J. H. S. & DOUTHWAITE, M. (1938) The dog tick Haemaphysalis leachi as a vector of tick typhus. S. Afr. med. J., 12(2):53-55.

GEIGY, R. (1951) Transmission de Spirochaeta duttoni par Ornithodorus moubata et evolution de diverses souches de cet agent pathogene dans la souris blanche. Atti 3. Congr. Int. Hyg. Med. Mediterr. (Palermo, 1951) 10 pp. (reprint).

GEIGY, R. & BURGDORFER, W. (1951) Unterschiedliches Verhalten verschiedener Stämme von Spirochaeta duttoni in der weissen Maus. Acta trop. Basel, 8(2):151-154.

GEIGY, R. & MOOSER, H. (1955) Studies on the epidemiology of African relapsing fever in Tanganyika. J. trop. Med. (Hyg.), 58(9):199-201.

GERICKE, A. M. M. & COLES, D. (1950) The poultry industry in South Africa. African Reg. Scient. Conf. (Johannesburg, 1949), 2:263-266.

GERSTÄCKER, A. (1860) Argas reflexus Latr., ein neuer Parasit des Menschen. Virchows Arch., 19(5-6):457-470.

——— (1873) Gliderthiere (Insekten, Arachniden, Myriapoden und Isopoden) 542 pp. Leipzig and Heidelberg. (Baron Carl Claus von der Decken's Reisen in Ost-Afrika, 3: Wissenschaftliche Ergebnisse 2. Abt).

GHESQUIERE, J. (1919) Note sur quelques parasites des oiseaux au Katanga. Ann. Soc. Med. Katanga, 3(4):6-7.

——— (1921A) Note sur quelques parasites des oiseaux au Congo Belge. Ann. Gembl., 27(7):239-242.

——— (1921B) Note sur quelques parasites des oiseaux de basse-cour au Congo Belge. Bull. agric. Congo belge, 12(4):727-730.

——— (1922) Ornithodorus moubata Murray au Kasai et au Sankuru. Ann. Soc. belge Med. trop., 2(2-3):277-283.

——— (1928) Contribution à l'étude des tigues [sic] du Congo Belge. Bull. Cerc. zool. congol., 5(2):64 [Suppl. to Rev. Zool. Bot. afr., 16(3) (1929)].

GIL COLLADO, J. (1936) Ácaros Ixodoideos de Cataluña y Baleares. Mus. barcin. Sci. nat. Op. X, (Ent., 11):11 pp.

——— (1937) Sur le parasitisme de quelques arthropodes de l'Espagne. C.R. 12 Int. Congr. Zool. (Lisbon, 1935), 3:2061-2064.

——— (1938) Los acaros (Ixodoideos) de España. Broteria, 7(3):99-109.

——— (1947) Hallazgo en España del Ornithodoros coniceps, Can. Rev. Sanid. Hig. públ., Madr., 21(3):229-232.

GIL COLLADO, J. (1948A) Acaros Ixodoideos de España. Can. Rev. Sanid. Hig. publ., Madr., 22(5):389-440.

______________ (1948B) Los "chinchorros" de los palomares. Bull. No. 6-48H, Min. Agric., 12 pp. Madrid.

GILLAIN, J. (1935) Note sur la présence d'Aegyptianella pullorum chez les poules au Congo Belge. Ann. Soc. belge Méd. trop., 15(3):299-300.

GILLARD, A. (1947) Un hôte indésirable et fréquent de nos poulaillers, l'Argas persicus. Rev. agric. Réunion (n.s.), 47:79-80.

__________ (1949) Les tiques et la babésiellose bovine à la Réunion. Ibid, 49:5-11.

GIORDANO, M. (1936) Uno sguardo alle attuali condizioni sanitarie dell'Eritrea. Rev. Parasit., Habana, 2(3):355-366.

__________ (1953) L'oeuvre sanitaire de la marine militaire Italienne en Somalie et organisation du centre d'études et de recherches, en collaboration avec l'Institut de Malariologie et Marchiafava de Rome. 50 pp. Ministry of Defence and Navy, Rome.

GIORDANO, M. & GIORDANO, M. D. (1935) Boutonneuse fever in Tripolitania. Arch. ital. Sci. med. colon, 16(3):101-185.

GIORDANO, M. & NASTASI, A. (1935) La febbre esantematica del littorale Mediterraneo in Tripolitania. Arch. Ital. Sci. med. colon., 16(3):1-28 (reprint).

GIRARD, H. & ROUSSELOT, R. (1945) La rickettsiose bovine a Rickettsia bovis au Soudan français. Bull. Soc. Path. exot., 38(3-4):64-77.

GIROLAMI, M. (1952) Considerazioni mediche su un viaggio nello Yemen. Arch. ital. Sci. med. trop. Parasit., 7:1-97. (reprint).

GIROUD, P. & GRJEBINE, A. (1951) Fièvres exanthématiques au Moyen Congo et toxoplasmoses. Bull. Soc. Path. exot., 44(1-2): 54-57.

GIROUD, P. (1951) Les rickettsioses en Afrique équatoriale. Bull. World Hlth Org., 4:535-546.

GIROUD, P. & JADIN, J. (1950) Essais d'isolement de souches de fièvre Q au Ruanda-Urundi du lait de vache, du cerveau de chèvres et de tiques d'animaux domestiques et sauvages. Bull. Soc. Path. exot., 43(11-12):672-673.

________________ (1954) Premiers résultats concernant le virus des Bashi isolé dans la Province du Kivu au Congo Belge. Ibid, 47(4):578-588.

________________ (1955) Le virus des Bashi. Mem. 8, n.s., Acad. R. Sci. colon., 1(5):70 pp.

GIROUD, P., JADIN, J. & REIZES, C. (1952) Nouveaux résultats concernant les fièvres exanthématiques avec ulcération ou tache noire et les toxoplasmoses au Moyen Congo. Bull. Soc. Path. exot., 44(7-8):422-424.

GOSSEL, P. (1935) Beiträge zur Kenntnis der Hautsinnesorgane und Hautdrüsen der Cheliceraten und der Augen der Ixodiden. Z. Morph. Ökol. Tiere, 30(2):177-205.

GOUZIEN, P. (1923) La fièvre récurrente dans l'Afrique Occidentale Française. Bull. Off. int. Hyg. publ., 15(6): 797-806.

GOZONY, L., HINDLE, E., & ROSS, P. H. (1914) Serological tests. 1. On the persistence of precipitins in sera stored in vitro. II. On the reactions obtained with (a) complement fixation tests and (b) precipitin tests, with the gut contents of blood-sucking arthropods. J. Hyg., Camb., 14(3):354-359.

GRAF, H. & BEKKER, P. M. (1949) Die vergelykende waardes vas bosluisdipstowwe. Landbouweekblad (1570), 31:41-42, 55.

GRAY, C. E., & ROBERTSON, W. (1902) Redwater in Rhodesia. Agric. J. C.G.H., 21(5):435-458.

GREENWAY, H. G. (1907) Fever caused by tampans. Transv. agric. J., 5:1029-1030.

GRIMALDI, V. (1934) Gli Ixodidi delle Colonie Italiane e le malattie da essi trasmesse. Arch. ital. Sci. med. colon., 15(7): 504-513.

GROBOV, A. G. (1946) On the question of carriers of the Crimean haemorrhagic fever. (In Russian). Med. parasit., Moscow, 15(6):59-63.

GUÉRIN-MÉNEVILLE, F. -E. (1829-1843) Iconographie du règne animal de G. Cuvier, ou représentation d'après nature de l'une des espèces les plus remarquables et souvent non encore figurées de chaque genre d'animaux. 4:Arachnides. 20 pp. Paris.

GUILLET, R. (1924) Fièvre récurrente à tiques à Brazzaville. Ann. Med. Pharm. colon., 22(1):77-81.

GUITEL, F. (1918) La station entomologique de la Faculté des Sciences de Rennes en 1917. Insecta, 8(85-96):177-181.

HALAWANI, A. (1946) On the transmission of relapsing fever in Egypt. J. Egypt. publ. Hlth Ass., 21(8):183-190.

HALAWANI, A., EL DINE, K. Z., & EL FIKI, A. Y. (1952) Q fever in Egypt. J. Egypt. Med. Ass., 35(5):339-346.

HAMMOND, R. A. (1954) Department of Veterinary Services, Kenya, Annual Report, 1953, 89 pp.

__________ (1955) Idem. 1954, 107 pp.

HARDMAN, J. L. (1951) Notes on ticks and tick-borne diseases in Nyasaland. [Unpublished ms. received, with permission to quote, from Director of Medical Service, Zomba].

HARGREAVES, H. (1936) Annual report of the government entomologist. Rep. med. Dep. Uganda, 1935, pp. 69-73.

HAROLD, C. T. H. H. (1929) Relapsing and mianeh fever in East Persia. J. R. Army med. Cps., 34(6):484-498.

__________ (1922) Tick fever in East Persia. (Correspondence). Ibid, 38(5):398-400.

HARRISON, E. (1928) Veterinary department. Rep. Dep. Agric. Kenya, 1927, pp. 25-35.

HARVEY, A. E. C. (1947) The care and maintenance of laboratory animals and arthropod vectors of disease. E. Afr. med. J., 24(1):58-71.

HAWKING, F. (1941) Relapsing fever: cerebrospinal fluid and therapy. J. trop. Med. (Hyg.), 44(16):104-105.

HEISCH, R. B. (1950A) Studies in East African relapsing fever. E. Afr. med. J., 27(1):1-58.

__________ (1950B) Survey of the Kerio Valley. Ibid, 27(6): 233-242.

HEISCH, R. B. (1950C) On Spirochaeta dipodilli sp. nov., a parasite of pygmy gerbils (Dipodillus sp.). Ann. trop. Med. Parasit., 44(3):260-272.

__________ (1951A) Correspondence. E. Afr. med. J., 28(7):292.

__________ (1951B) Argas boueti Roubaud and Colas-Belcour 1933, in the Northern Province of Kenya. Ibid, 28(9):354.

__________ (1952) First record of Ornithodoros erraticus (Lucas) from Uganda, with some speculations on the origin of Spirochaeta duttoni Novy and Knapp. Ibid, 29(11):477-479.

__________ (1953) On a spirochaete isolated from Ornithodoros graingeri. Parasitology, 43(1-2):133-135.

__________ (1954A) The host of Ornithodoros graingeri Heisch and Guggisberg, 1952 (sic). E. Afr. med. J., 31(1):29.

__________ (1954B) First record of Argas reflexus (Fabricius) Latreille, 1796 from East Africa. Ibid, 31(3):89-91.

__________ (1954C) Transmission experiments with Spirochaeta dipodilli Heisch, 1950. Ann. trop. Med. Parasit., 48(1):28-32.

__________ (1954D) Ornithodoros erraticus (Lucas) in ant-chat burrows. E. Afr. med. J., 31(6):264.

__________ (1954E) Ornithodoros moubata (Murray) in a porcupine burrow near Kitui. Ibid, 31(10):483.

__________ (1954F) Argas brumpti Neumann in the Kitui district of Kenya. Ibid, 31(10):483-484.

__________ (1954G) Studies in leishmaniasis in East Africa. I. The epidemiology of an outbreak of kala-azar in Kenya. Trans. R. Soc. trop. Med. Hyg., 48(6):449-469.

HEISCH, R. B. & FURLONG, M. (1954) Control of Ornithodoros moubata (Murray) by gammexane. E. Afr. med. J., 31(12):561-563.

HEISCH, R. B. & GARNHAM, P. C. C. (1948) The transmission of Spirochaeta duttoni Novy and Knapp by Pediculus humanus corporis de Geer. Parasitology, 38(4):247-252.

HEISCH, R. B. & GRAINGER, W. E. (1950) On the occurrence of Ornithodorus moubata Murray in burrows. Ann. trop. Med. Parasit., 44(2):153-155.

HEISCH, R. B. & GUGGISBERG, C. A. W. (1952) A description of Ornithodoros erraticus (Lucas) from Kenya. Ann. trop. Med. Parasit., 46(1):1-6.

____________________ (1953A) On Ornithodoros graingeri n. sp. a tick from caves in Kenya. Parasitology, 42(3-4):192-198 (1952).

____________________ (1953B) On Ornithodoros zumpti n. sp., a new tick from South Africa. Ibid, 43(1-2):136-138.

HEISCH, R. B. & HARVEY, A. E. C. (1953) The biology of Ornithodoros graingeri Heisch and Guggisberg, 1952 (sic). Parasitology, 43(1-2):131-132.

HELLER, C. (1858) Zur Anatomie von Argas persicus. S.B. Akad. Wiss. Wien, 30(16):297-326.

HELM, R. W. (1952) Report of brown dog-tick, Rhipicephalus sanguineus (Latr.) attacking humans. Ent. News, 63:214.

HENNING, M. W. (1953) Q fever. J. S. Afr. vet. med. Ass., 24:219-220, 222-224, 226-235, 237-239.

HERTER, K. (1942) Untersuchungen über dem Temperatursinn von Warmblütter-Parasiten. Z. Parasitenk., 12(5):552-591.

HERTIG, M. & WOLBACH, S. B. (1924) Studies on rickettsia-like microorganisms in insects. J. Med. Res., 44(3):329-374.

HESSE, E. (1920) Tierverschleppungen. Zool. Anz., 52(3-4):79-82.

HEWITT, J. (1920) Notes on the fauna of St. Croix Island. S. Afr. J. nat. Hist., 2(1):98-112.

HIMPE, N. E. & PIERQUIN, L. (1951) Essais de lutte contre Ornithodorus moubata moyen de Cyclotox Solvay. Ann. Soc. belge Méd. trop., 31(2):153-157.

HINDLE, E. (1911) The relapsing fever of tropical Africa. A review. Parasitology, 4(3):183-203.

__________ (1912) On the life-cycle of Spirochaeta gallinarum. Preliminary note. Ibid, 4(4):463-477 (1911).

HINDLE, E. & CUNLIFFE, N. (1914) Regeneration in Argas persicus. Parasitology, 6(4):353-371.

HINDLE, E. & DUNCAN, J. T. (1925) The viability of bacteria in Argas persicus. Parasitology, 17(4):434-446.

HINDLE, E. & MERRIMAN, G. (1912) The sensory perceptions of Argas persicus (Oken). Parasitology, 5(3):203-216.

HIRST, (A.) S. (1909) Ruwenzori expedition reports. 6. Arachnida. Trans. Zool. Soc. Lond., 19(1):57-58.

__________ (1914) On the parasitic acari found on the species of rodents frequenting human habitation in Egypt. Bull. ent. Res., 5(3):215-229.

__________ (1916) Notes on parasitic acari. J. zool. Res., 1(2):59-81.

__________ (1917) Species of Arachnida and Myriopoda (scorpions, spiders, mites, ticks and centipedes) injurious to man. Econ. Ser. Brit. Mus. (6): 60 pp.

HITCHCOCK, L. F. (1953) Resistance of cattle tick (Boophilus microplus (Canestrini) to benzene hexachloride. Aust. J. agric. Res., 4(3):360-364.

__________ (1955) Studies on the parasitic stages of the cattle tick, Boophilus microplus (Canestrini) (Acarina: Ixodidae). Aust. J. Zool., 3(2):145-155.

HOCKING, K. S. (1946) The use of "666" in the control of *Ornithodoros moubata*, Murray. E. Afr. Med. J., 23(2):50-55.

HOEPPLI, R. & FEN, L. C. (1933) Experimental studies on ticks. Chin. med. J., 47(1):29-43.

HOFFMANN, C. C. (1930) Los Argasidos de Mexico. An. Inst. Biol. Univ. Méx., 1(2):135-164.

HOLMES, J. W. E. (1953) Tick control and relapsing fever. J. R. sanit. Inst., 73(3):262-265.

HOOGSTRAAL, H. (1950) Mission malaria. Nat. Hist., N.Y., 59(2): 104-111, 140-141.

__________ (1951) Medical investigations of the United States Navy in the Anglo-Egyptian Sudan, 1948-1950. Sudan Notes, 32(2):333-337.

__________ (1952A) Notes on Egyptian ticks (Ixodoidea). I. The genus *Argas* (Argasidae) in the Cairo area. Proc. Egypt. Acad. Sci., 7:114-127 (1951).

__________ (1952B) Biological factors of ticks (Ixodoidea) of the Ethiopian Faunal Region in relation to human injury and disease. Trans. 9th Int. Congr. Ent. (Amsterdam, 1951), 1:959-963.

__________ (1952C) Yemen opens the door to progress. Nat. geogr. Mag., 101(2):213-244.

__________ (1953A) South in the Sudan. Ibid, 103(2):248-272.

__________ (1953B) *Ornithodoros salahi* sp. nov. from the Cairo citadel, with notes on *O. piriformis* Warburton 1918 and *O. batuensis* Hirst 1929 (Ixodoidea, Argasidae). J. Parasit., 39(3):256-263.

__________ (1953C) *Ornithodoros arenicolous* sp. nov. (Ixodoidea, Argasidae) from Egyptian desert mammal burrows. Ibid, 39(5):505-516.

HOOGSTRAAL, H. (1953D) On ticks (Ixodidae) of southern French Somaliland and the rediscovery of Rhipicephalus longicoxatus Neumann 1905. Ann. ent. Soc. Amer., 46(3):393-398.

__________ (1953E) Ticks (Ixodoidea) of the Malagasy Faunal Region (excepting the Seychelles). Their origins and host-relationships; with descriptions of five new Haemaphysalis species. Bull. Mus. comp. Zool. Harv., 111(2):37-113.

__________ (1954A) Ticks (Ixodoidea) and their medical relations in the Near East. J. Egypt. publ. Hlth Ass., 29(1-2):1-8.

__________ (1954B) A preliminary, annotated list of ticks (Ixodoidea) of the Anglo-Egyptian Sudan. J. Parasit., 40(3):304-310.

__________ (1954C) Noteworthy African tick records in the British Museum (Natural History) collections. Proc. ent. Soc. Wash., 56(6):273-279.

__________ (1955A) Research on arthropods and arthropod-borne diseases at U.S. Naval Medical Research Unit No. 3, Cairo, Egypt. U.S. Nav. med. Res. Unit No. 3, Inform. Bull., 22 pp. Cairo.

__________ (1955B) Bat ticks of the genus Argas (Ixodoidea, Argasidae). I. The subgenus Chiropterargas. Fieldiana: Zool., 37:579-600.

__________ (1955C) Notes on African Haemaphysalis ticks. I. The Mediterranean-littoral hedgehog parasite H. erinacei Pavesi, 1884 (Ixodoidea, Ixodidae). J. Parasit., 41(3): 221-233.

__________ (1955D) Idem. II. The ground-squirrel parasites, H. calcarata Neumann, 1902, and H. houyi Nuttall and Warburton, 1915 (Ixodoidea, Ixodidae). Ibid, 41(4): 361-373.

HOOGSTRAAL, H. (1955E) Ornithodoros d. delanoei Roubaud and Colas-Belcour, 1931 (Ixodoidea, Argasidae); its identification and distribution, incidence and habitats in Egypt. Bull. Soc. Path. exot., 48(5):734-747.

_____________ (1956A) Notes on African Haemaphysalis ticks. III. The hyrax parasites H. bequaerti sp. nov., H. orientalis N. & W., 1915 (new combination), and H. cooleyi Bedford, 1929 (Ixodoidea, Ixodidae). J. Parasit., 42

_____________ (MS) The ticks of Arabia, with special reference to the Yemen. [In preparation].

HOOGSTRAAL, H. & KAISER, M. N. (1956) Results of the NAMRU3 South-eastern Egypt Expedition 1954. III. Argas brumpti Neumann, 1907 and Ornithodoros foleyi Parrot, 1928 (Ixodoidea, Argasidae) in Egypt. Bull. zool. Soc. Egypt. [In press].

HOOGSTRAAL, H., HUFF, C. G. & LAWLESS, D. K. (1950) A malarial parasite of the African elephant shrew, Elephantulus rufescens dundasi Dollman. J. nat. Malar. Soc., 9(4):293-306.

HOOGSTRAAL, H., WASSIF, K. & KAISER, M. N. (1955) New mammal records from the western desert of Egypt. Bull. zool. Soc. Egypt., 12:7-12 (1954).

HOOKER, W. A., BISHOPP, F. C. & WOOD, H. P. (1912) The life history and bionomics of some North American ticks. Bull. U.S. Bur. Ent., No. 106, 239 pp.

HOPKINS, G. H. E. & CHORLEY, T. W. (1940) Experiments on the destruction of ticks. E. Afr. med. J., 17(2):71-80.

HOWARD, C. W. (1907) Two little known ticks of the Transvaal. Transv. agric. J., 5(19):581-584.

_____________ (1908) A list of the ticks of South Africa, with descriptions and keys. Ann. Transv. Mus., 1(2):73-172. [Idem. Fmrs' Bull. Transv. Dep. agric., No. 30, 96 pp.]

HOWARD, C. W. (1909A) A new species of Haemaphysalis from East Africa. Ann. Transv. Mus., 1(4):219-223.

____________ (1909B) A note on the copulation of ticks. Ibid, 1(4):225.

____________ (1909C) The fowl tick (Argas persicus). Fmrs' Bull. Transv. Dep. agric., No. 61, 4 pp.

____________ (1910) The fowl tick. Ill. Poult. Rec., 2(8):441-442.

____________ (1911) An experiment in fumigation of ticks. Parasitology, 4(2):164-167.

HOWELL, D. E., STILES, G. W. & MOE, L. H. (1943) The fowl tick (Argas persicus), a new vector of anaplasmosis. Amer. J. vet. Res., 4(10):73-75.

HUBBARD, C. A. (1955) Some ticks from Iraq. Ent. News, 66(7):189-191.

HUNTER, W. D. & HOOKER, W. A. (1907) Information concerning the North American fever tick with notes on other species. Bull. U.S. Bur. Ent., No. 72, 87 pp.

HURLBUT, H. S. (1956) West Nile virus infection in arthropods. Amer. J. trop. Med. Hyg., 5(1):76-85.

HUTCHINS, E. (1917) Report of the chief veterinary officer. Rep. Dep. Agric. Uganda for Year Ending 31st March 1917, pp. 27-31.

____________ (1924) Diseases of cattle. Rep. vet. Dep. Uganda, 1923, pp. 4-10.

HYND, R. S. (1945) The construction of army huts to limit infestation by Ornithodoros moubata (relapsing fever tick). E. Afr. med. J., 22(10):337-342.

INGRAM, A. (1924) *Ornithodorus moubata* Murray, in relation to relapsing fever in the Gold Coast. Ann. trop. Med. Parasit., 18(1):95-97.

IRELAND, A. W. (1948) The climate of the Sudan. In: J. D. Tothill, ed., Agriculture in the Sudan, Chap. V, pp. 62 to 83. Oxford Press.

JACK, R. W. (1910) The relationship of ticks and animal disease. Rhod. agric. J., 7(6):1487-1497.

__________ (1921) Ticks infesting domestic animals in Southern Rhodesia. Ibid, 18(4):361-367; (5):480-493.

__________ (1928) Idem. Ibid, 25(5):537-556; (6):704-716.

__________ (1931) Report of the chief entomologist. Rep. Dir. Agric., S. Rhod. 1930; pp. 65-73.

__________ (1936) Annual report of the division of entomology for the year ended 31st December, 1935. Rhod. agric. J., 33(5):329-356.

__________ (1937) Ticks infesting domestic animals in Southern Rhodesia. Ibid, 33(12):907-929.

__________ (1938) Idem. Ibid, 34(1):25-37.

__________ (1942) Idem. Ibid, 39(2):95-109, (3):202-219. (Reprint as Bull. 1205. Min. Agric. Lands, Salisbury).

JACOB, E. See JAKOB, E.

JAKOB (JACOB), E. (1924A) Die Verwandtschaftsbeziehungen der Zeckengattungen. Versuch eines natürlichen Systems auf vergleichendmorphologischer Grundlage. Parasitology, 16(3):313-316.

JAKOB, E. (1924B) Die verwandtschaft der Zeckengattungen. Idem. Z. Morph. Ökol. Tiere, 1(2):309-372.

JADIN, J. (1951A) Contribution à l'étude des intoxications alimentaires au Ruanda-Urundi. Rev. belg. Path., 21(1):8-10.

________ (1951B) Les rickettsioses du Congo Belge et du Ruanda-Urundi. 108 pp., Paris.

JADIN, J. & GIROUD, P. (1950) La fièvre Q au Ruanda-Urundi. Bull. Soc. Path. exot., 43(11-12):667-672.

__________________ (1951) Idem. Ann. Soc. belge Méd. trop., 31(2):159-177.

JADIN, J. & PANIER, E. (1953) Un virus rickettsien du type boutonneux-pourpré isolé au Ruanda-Urundi. Ann. Soc. belge Med. trop., 33(2):119-122.

JANSEN, B. C. (1952) Babesia thomasi sp. nov., an intra-erythrocytic parasite of the Cape dassie. [Procavia capensis (Pallas)]. Onderstepoort J. vet. Sci., 25(3):3-6.

JARVIS, E. M. (1918) Report on ixodic lymphangitis (German East Africa Campaign, 1916-1917) made to the A.D.V.S., Dar-es-Salaam. Vet. J., 74(2):44-53.

JASCHKE, W. (1933) Beiträge zur Kenntnis der symbiotischen Einrichtungen bei Hirudineen und Ixodiden. Z. Parasitenk., 5(3-4):515-541.

JEANNEL, R. (1926) Faune cavernicole de la France, avec une étude des conditions d'éxistence dans le domaine souterrain. 334 pp., Paris.

JEPSON, W. F. (1947) Economic control of the relapsing fever tick in African houses. Nature, Lond. (4077), 160:874.

"J.G." (1943) Paralysis and tampans. (Letter to editor). Fmrs' Wkly, Bloemfontein, 66:81. [Reply by "Poultry Specialist", same page].

JOBLING, B. (1925) A contribution to the biology of Ornithodorus moubata, Murray. Bull. ent. Res., 15(3):271-280.

JOHNSTON, J. E. L. (1916) A summary of an entomological survey of Kaduna District, Northern Nigeria. Bull. ent. Res., 7(1):19-28.

JOHNSTON, (-) (pre 1903) Uganda Protectorate. [Not seen. Quoted by Pocock (1903) in Christy (1903B)].

JOJOT, C. (1921) Le secteur de prophylaxie de la maladie du sommeil du Haut-Nyong (Cameroun). Ann. Med. Pharm. colon., 19(4): 423-442.

JORDANO BAREA, D. (1951) *Hyalomma lusitanicum algericum* Senevet, 1928 (Artropoda Ixodoidea) nuevo para la fauna española. Bol. Acad. Cienc. Córdoba, 65:105-107.

JOSHI, B. B. (1943) The tampan ticks of Marwar. Indian Fmg., 4(3):141-142.

JOWETT, W. (1910) Fowl spirochoetosis. Note on the occurrence of, at the Cape. Agric. J. C.G.H., 37(6):662-670.

JOYEUX, C. (1915) Sur quelques arthropodes récoltés en Haute-Guinée française. Bull. Soc. Path. exot., 8(9):656-659.

KAPLAN, M. M. & HULSE, E. C. (1953) Prevalence of Q fever in Europe and survey methods for its detection. Monogr. World Hlth Org., No. 19 (Advances in the control of zoonoses, etc.), pp. 175-191.

KAPUR, H. R. (1940) Transmission of fowl spirochaetosis through agents other than Argas persicus. Indian J. vet. Sci., 10(4):354-360.

KARPOV, S. P. & POPOV, V. M. (1945) The Ixodidae ticks of western Siberia as reservoirs of tularemia. Amer. Rev. Soviet. Med., 3(2):140-142.

KARSCH, F. (1878) Ueber einige von Herrn J. M. Hildebrandt im Zanzibargebiete erbeuteten Arachniden. Z. ges. Naturw. Berl., 51, 3F, (3):311-322.

__________ (1879A) Westafrikanische Arachniden gesammelt von Herrn Stabsarzt Dr. Falkenstein. Ibid, 52, 3F, (4):329-373.

__________ (1879B) Zwei neue Arachniden des Berliner Museums. Mitt. münch. ent. Ver., 3:95-96.

__________ (1879C) Uebersicht der von ihm in Mossambique gasammelten Arachniden. Mber. K. preuss. Akad. Wiss., Apr., pp. 314-338.

KAUNTZE, W. H. (1932) Section of medical entomology. Rep. med. Res. Lab., Kenya, 1931, pp. 25-29.

____________ (1934) Idem. Ibid, 1932, pp. 8, 21-27.

KEMPER, H. (1934) Die Taubenzecke, Argas reflexus, als Plageerreger in menschlichen Wohnungen. Anz. Schädlingsk, 10(12): 139-140.

KEMPER, H. & REICHMUTH, W. (1941) Die Taubenzecke als Parasit des Menschen. Z. angew. Ent., 28(2-3):507-518.

["KENYA (1928)"] Section of medical entomology (Anom.). Rep. med. Res. Lab. Kenya, pp. 114-116, Nairobi. [From RAE, B, 17(4):87 (1929)].

"KENYA VET. SERV." (1939A) Notes on animal diseases. I. Redwater and anaplasmosis. E. Afr. agric. J., 4:297-303. [Revised and reprinted 1949 and 1952].

______________ (1939B) Idem. II. East Coast fever and related diseases. Ibid, 4:381-385. [Revised, Ibid, 12(3)(1947) and 17(2)(1951), reprints, 4 pp.].

______________ (1939C) Idem. III. Piroplasmosis and anaplasmosis of animals other than cattle, and trypanosomiasis. Ibid, 4:463-468. [Reprinted with amendments, Apr. 1953].

______________ (1940) Idem. VII. Nairobi sheep disease and heartwater. Ibid, 6:39-42. [Reprinted with amendments, May 1951].

______________ (1947) See 1939B.

______________ (1949) See 1939A.

______________ (1951) See 1939B and 1940.

______________ (1952) See 1939A and 1949.

______________ (1953) See 1939C.

KERREST, J., GAMBIER, A. & BOURON, A. (1922A) La fièvre récurrente au Soudan. Bull. Soc. Path. exot., 15(5):320-331.

______________ (1922B) La fièvre récurrente en Afrique central. Bull. Acad. Med. Paris, 104:112.

KHAYYAT, S. M. & GILDER, A. A. (1947) Ovine piroplasmoses in Iraq. Trans. R. Soc. trop. Med. Hyg., 41(1):119-126.

KING, H. H. (1908) Report of economic entomology. Rep. Wellcome trop. Res. Lab., 3:201-248.

KING, H. H. (1911) Report of the entomological section of the Wellcome tropical research laboratories. Rep. Wellcome trop. Res. Lab., 4B:95-150.

__________ (1915) Preliminary notes on the life-history of Argas brumpti, Neumann. Bull. ent. Res., 6(2):191-193.

__________ (1921) The fowl tick (Argas persicus, Oken). Ent. Bull. Sudan, No. 16, 6 pp.

__________ (1926) The ticks (Ixodoidea) of the Sudan. Ibid, No. 23, 21 pp.

KIRK, R. (1938A) A laboratory study of Abyssinian louse-borne relapsing fever. Ann. trop. Med. Parasit., 32(4): 339-356.

________ (1938B) The non-transmission of Abyssinian louse-borne relapsing fever by the tick Ornithodorus savignyi and certain other blood-sucking arthropods. Ibid, 32(4): 357-365.

________ (1939) The epidemiology of relapsing fever in the Anglo-Egyptian Sudan. Ibid, 33(2):125-140.

KISHIDA, K. (1930) Notes on Japanese ticks of the genus Ixodes Latreille, 1795. (In Japanese). Lansania, 2(11):1-5.

KLEINE, F. K. & KRAUSE, M. (1932) Zur Uebertragung der Rückfallfieberspirochäten durch Zecken. Arch. Schiffs- u. Tropenhyg., 36(11):587-589.

KNOWLES, F. A. & TERRY, E. D. (1950) Prevention of tick-borne relapsing fever. E. Afr. med. J., 27(2):88-93.

KNUTH, P. (1938) Ueber meine Studienreise näch Afrika in den Jahren 1906 und 1907. Berl. tierarztl. Wschr., 1938(1):14-16; (2):30-32.

KNUTH, P. & du TOIT, P. J. (1921) Tropen-Krankheiten der Haustiere. Handbuch. Tropenkrankh. Mense 2. Aufl. 6; 889 pp. [Not seen].

KNUTH, P., BEHN, P. & SCHULZE, P. (1918) Untersuchungen über die Piroplasmose der Pferde im Jahre 1917. Z. Veterinärk., 30(6):241-264.

KOBAYASHI, H. (1925) On the animal parasites in Korea. Jap. med. World, 5(1):9-16.

KOCH, C. L. (1844) Systematische Uebersicht über die Ordnung der Zecken. Arch. Naturgesch., 10.J., 1:217-239.

KOCH, L. (1875) Aegyptische und abyssinische Arachniden gesammelt von Herrn C. Jickeli beschrieben und abgebildet. 96 pp., Nürnberg.

KOCH, R. (1903) The cattle disease in Southern Rhodesia. Transv. agric. J., 1(4):112-117.

——— (1905) Vorläufige Mitteilunger über die Ergebnisse einer Forschungsreise nach Ostafrika. Dtsch. m. Wschr., 31(47):1865-1869.

——— (1906) Ueber afrikanischen Recurrens. Berl. klin. Wschr., 43(7):185-194.

KOCHETKOV, A. V. (1935) Les tiques de la famille Ixodidae au Transoural. (In Russian, French summary). Trud. Inst. eksp. Vet. Mosk., 11:124-127.

KOHLS, G. M. (1948) Vectors of rickettsial diseases. In: Rickettsial diseases of man. Symposium A.A.A.S. (Boston, 1946), pp. 83-86.

——— (1953) Notes on the ticks of Guam, with the description of Amblyomma squamosum n. sp. (Acarina:Ixodidae). J. Parasit. 39(3):264-267.

KOHLS, G. M. & PARKER, R. R. (1948) Occurrence of the brown dog-tick in the western states. J. econ. Ent., 41(1):102.

KONE, K. (1949) Accidents mortels chez les zébus causés par des piqures d'ornithodores. Bull. Serv. Elev. Indust. anim. A.O.F., 2(1):25-26.

KORNIENKO-KONEVA, Z. P. & SHMYREVA, M. K. (1944) On the possibility of the transmission of Theileria to its own progeny by the ticks Hyalomma turkmeniense (Olenev, 1931). (In Russian). Veterinarian, Moscow, 21(4):24-25.

KORSHUNOVA, O. S. & PETROVA-PIONTKOVSKAYA, S. P. (1949A) On a virus isolated from Hyalomma marginatum marginatum Koch. (In Russian). Zool. Zh., 28(2):186-187.

__________ (1949B) On the vector of Marseilles fever. (In Russian). C. R. Acad. Sci. U.R.S.S., n.s. 68(6):1151-1153.

KOTLAN, S. (1921A) Contribution to knowledge relating to Hungary's ixodid fauna. (In Hungarian). Állatt. Közlem., 18(1-4); 33-36, 48.

__________ (1921B) The classification of the ticks of Hungary. (In Hungarian, German summary). Ibid, 20(1-4):42-50.

KRATZ, W. (1940) Die Zeckengattung Hyalomma Koch. Z. Parasitenk., 11(4):510-562.

KRUGER, J. C. (1951) New tick control methods needed to save the soil. Rhod. Fmr, 5(29):11, 23.

KRÜGER, K. (1935) Die Doppelt-Schrägstreifung bei den Muskelfasern der Zecken (Ixodidae). Z. wiss. Zool., 147(2):275-294.

KURCHATOV, V. I. (1935) L'état actuel de la question de répartition géographique de la tique Boophilus calcaratus Bir. en URSS. (In Russian, French Summary). Trav. Inst. Med. vet. exp. URSS, 11:115-123.

__________ (1939A) The biology of the vector of theileriosis, the Hyalomma tick, and conditions in Bakou. (In Russian). Sovetsk. Vet., 15(10-11):60-61.

__________ (1939B) Biological peculiarity of the tick Hyalomma marginatum Koch, vector of equine piroplasmosis. (In Russian). Ibid, 16(5):45-46.

KURCHATOV, V. I. (1940A) Prophylaxis of piroplasmosis and anti-tick measures in the winter. (In Russian). Sovetsk. Vet., 17(1):30-32.

———————— (1940B) A survey of the fauna of bloodsucking ticks of the Family Ixodoidea in the Crimea. (Abstract) (In Russian). Ibid, 17(1):32.

———————— (1940C) The outlines of the study of tick vector in accordance with problems of control of piroplasmosis. (In Russian). Ibid, 17(2-3):28-31.

———————— (1940D) Combatting ticks and insects injurious to livestock. (In Russian). Ibid, 17(11-12):26-29.

———————— (1940E) Omitted.

———————— (1940F) On the specificity of cycles of development of ticks of the family Ixodidae. Proc. Lenin Acad. agric. Sci., 2:39-42.

———————— (1940G) Contribution à la question de la biologie de l'oecologie et de la répartition de la tique *Hyalomma marginatum* - agent propagateur des piroplasmoses équines. (In Russian, French summary). J. agric. Sci., Moscow, ser. g (Vet.), 2:66-79.

———————— (1941A) Experiments in the application of pyrethrum in the control of certain ectoparasites of domestic animals. (In Russian, French summary). Ibid, 2:97-103.

———————— (1941B) Idem. (Abstract) (In Russian). Ibid, 3:138, 139.

———————— (1941C) Several means of defence against ectoparasites of domestic animals - report of invasion and infection. (In Russian). Veterinarian, Moscow, 19(1): 30-33.

KURCHATOV, V. I. & KALMIKOV, E. S. (1934) External parasites of farm stock in USSR. Their development and distribu tion. (In Russian, English summary). 80 pp., Leningrad [People's Commisariat (sic) of Agriculture. Association for Pest and Disease Control in USSR - Record Service].

KURCHATOV, V. I. & POPOVA, V. (1939) Material on biology of ticks of the genus Rhipicephalus Koch. (Abstract). (In Russian). Sovetsk. Vet., 16(5):46.

KURCHATOV, V. I. & SOKOLOV, B. D. (1940) The epizootology of Crimean mountain pastures ("Yaila") in the light of prophylaxis for piroplasmosis. (Abstract). (In Russian). Sovetsk. Vet., 17(1):35.

KURTPINAR, H. (1954) Türkiye kenelri (Ixodoidea). Morfoloji, biyoloji, konakçi, yayilişlari ve medikal önemleri. 113 pp., Ankara.

LABOULBÈNE, J. J. A. (1881) (Communication sur des Argas de Perse envoyés par le Dr. Tholozan). Ann. Soc. ent. Fr., Ser. 6, 1(16):138-139.

____________ (1882) (Communication sur le parasitisme de l'Argas reflexus). Ibid, 2(7):98-99.

LABOULBÈNE, J. J. A. & MÉGNIN, J. P. (1882A) Mémoire sur les Argas de Perse. J. Anat. Paris, 18(4):317-341.

____________ (1882B) Sur les Argas de Perse. C. R. Soc. Biol. Paris,(34) Ser. 7, 4:577.

LAHILLE, F. (1914) Nota sobre la presencia accidental en Buenos Aires de unas garrapatas del camello. Bol. Minist. Agric. B. Aires, 17(2):289-293.

LAHILLE, F. & JOAN, T. (1931) La garrapata de las gallinas. Bol. Minist. Agric. B. Aires, 30(2):89-94.

LAMBORN, W. A. (1924) Medical entomologist's report. Med. Rep. Nyasald. 1923, Appendix 1, pp. 37-39.

____________ (1927) Idem. Ibid, 1926, pp. 24-31.

____________ (1929) Idem. Ibid, 1928, pp. 35-38.

____________ (1939) Annual report of the medical entomologist. Med. Rep. Nyasald. 1938, pp. 40-48.

LAMONTELLERIE, M. (1954) Les ixodoides du sud-ouest de la France. Espèces rencontrées, agressivité, role pathogène. 145 pp., Bordeaux.

LAMOUREUX, A. (1913A) Présence d'Ornithodorus moubata dans un foyer de fièvre récurrente à la côte ouest de Madagascar. Bull. Soc. Path. exot., 6(3):146-149.

LAMOUREUX, A. (1931B) La fièvre récurrente de Madagascar. Considérations cliniques. Le spirochète dans l'organisme humain. Essai de traitement par le '606'. Bull. Soc. Path. exot., 6(7):523-533.

LANG, H. (1924) The eland and its bird sentinel. Nat. Hist., N.Y., 24:96-97.

LANGERON, M. (1912) Mission parasitologique en Tunisie (Septembre-Octobre 1911). Arch. Parasit. Paris, 15(3):442-473.

__________ (1921) Deuxiéme mission parasitologique en Tunisie Tamerza (Septembre-Octobre 1919). Arch. Insts Pasteur Afr. N., 1(4):347-382.

LARROUSE, F. (1923) Présence au Kef (Tunisie) d'une nouvelle espece du genre *Ornithodoros*: *O. normandi* n. sp. Ann. Parasit. hum. comp., 1(2):170-177.

__________ (1927) Description d'une nouvelle espèce de *Rhipicephalus* du Congo Belge, *Rhipicephalus schwetzi*, n.sp. Rev. zool. afr., 15(2):214-216.

LATREILLE, P. A. (1796) Précis des charactères génériques des insectes disposés dans un ordre naturel. 202 pp., Brive.

__________ (1802) Histoire naturelle, générale et particulière des crustacés et des insectes (etc.). V. 3, 468 pp., Paris. [Cf. p. 67-68].

LAVERAN, C. L. A. (1901) Essai de classification des hematozoaires endoglobulaires ou haemocytozoa. C.R. Soc. Biol., Paris, 53:798-801.

LAVERAN, C. L. A. & NEGRE, L. (1905) Sur un protozoaire de *Hyalomma aegyptium*. C.R. Soc. Biol., Paris, 58(21): 964-966.

LAVERAN, C. L. A. & PETTIT, A. (1910) Sur le rôle d'*Hyalomma aegyptium* L. dans la propagation d'*Haemogregarina mauritanica* Ed. et Et. Sergent. C.R. Ass. franc. Av. Sci. (38e Seance, Lille 1909) pp. 723-726.

LAVERAN, C. L. A. & VALLEE, H. P. M. (1905) Sur un cas de transmission par des ixodes de la spirillose et de la piroplasmose bovines. C. R. Acad. Sci., Paris, 140(23):1515-1517.

LAVIER, G. (1923) Ixodidés récoltés au Maroc. Ann. Parasit. hum. comp., 1(2):200-201.

LAVOIPIERRE, M. M. J. & RIEK, R. F. (1955) Observations on the feeding habits of argasid ticks and on the effect of their bites on laboratory animals, together with a note on the production of coxal fluid by several of the species studied. Ann. trop. Med. Parasit., 49(1):96-113.

LAWRENCE, D. A. (1935) Report of the director of veterinary research, Southern Rhodesia, 1934, Salisbury, pp. 1-10.

__________ (1937) Ibid, 1936, pp. 1-12.

__________ (1938A) Ibid, 1937, pp. 1-12.

__________ (1938B) Rickettsiosis in a dog. J. S. Afr. vet. med. Ass., 9(4):175-178.

__________ (1939) Report of the director of veterinary research, Southern Rhodesia, 1938, Salisbury, pp. 1-7.

__________ (1942) Tick transmission of disease. Rhodesian agric. J., 39(6):500-503. [Reprinted as Bull. 1223, Min. Agric. Lands, Salisbury].

LAWS, S. G. (1948) A biological test for assessing the acaricidal properties of DDT and "Gammexane" preparations. Bull. ent. Res., 39(2):277-279.

LE BOEUF, A. & GAMBIER, A. (1918A) Sur deux cas de spirochétose humaine observés à Brazzaville (Moyen-Congo). Bull. Soc. Path. exot., 11(5):359-364.

__________ (1918B) Le spirochétose humaine et l'Ornithodorus moubata dans la Colonie du Moyen-Congo. Ibid, 11(10):833-836.

LEES, A. D. (1946A) The water balance in Ixodes ricinus L. and certain other species of ticks. Parasitology, 37(1-2): 1-20.

__________ (1946B) Chloride regulation and the function of the coxal glands in ticks. Ibid, 37(3-4):172-184.

__________ (1947) Transpiration and the structure of the epicuticle in ticks. J. exp. Biol., 23(3-4):379-410.

__________ (1952) The role of cuticle growth in the feeding process of ticks. Proc. zool. Soc. Lond., 121(4): 759-772.

LEES, A. D. & BEAMENT, J. W. L. (1948) An egg-waxing organ in ticks. Quart. J. micr. Sci., 89(3):291-332.

LEESE, A. S. (1914) Final report for 12 months ending 31st March 1914. Colonial office, London. [From RAE, B, 2(10): 151-152 (1914).]

LEESON, H. S. (1951) The recorded distribution of the tick Rhipicephalus sanguineus (Latreille). Bull. ent. Res., 42(1):123-124.

__________ (1952) The recorded distribution of Ornithodoros moubata (Murray) (Acarina). Ibid, 43(2):407-411.

__________ (1953) Some notes on the recorded distribution of old world species of Ornithodoros (Acarina). Ibid, 44(3):517-526.

__________ (1956) Further notes on the geographical distribution of old world species of Ornithodoros (Acarina). Ibid, 46(4):747-748.

LE GAC, P. (1931) L'epidémie de fièvre récurrente au Ouadai (Tchad) 1925-1928. Ann. Méd. Pharm. colon., 29(1):148-165.

LE GAC, P. & BORJEIX, L. (1945) Premier cas de fièvre boutonneuse au Togo. Bull. Soc. Path. exot., 38(9-10):247-250.

LE GALL, R. (1943) Vue d'ensemble sur les maladies pestilentielles, endémo-épidémiques, transmissibles et sociales à Madagascar entre 1936 et 1940. Bull. Off. int. Hyg. publ., 35:417-450.

LEGG, J. (1930) Some observations on the life history of the cattle tick (Boophilus australis). Proc. roy. Soc. Qd., 41(8):121-132.

LE ROUX, L. P. (1934) Report of the assistant veterinary research officer. Rep. Dep. Anim. Hlth N. Rhod., 1933, pp. 28-71.

__________ (1937) Appendix C. Central Research Station, Mazabuka. Annual report, 1936. Rep. vet. Dep. N. Rhod., 1936, pp. 46-70.

__________ (1947) Ibid, 1946. [Not seen.]

LERUTH, R. (1931) Note préliminaire sur la faune cavernicole de la Belgique. Bull. Soc. belge Etud. Géol. et archéol., 10:88-101.

__________ (1939A) Etudes biospeologiques XII. Remarques écologiques et biologiques sur des stations visitées en Roumanie. Bull. Mus. Hist. nat. Belg., 15:1-51.

__________ (1939B) La biologie du domaine souterrain et la faune cavernicole de la Belgique. Mém. Mus. Hist. nat. Belg., 87:1-506.

LEWIS, D. J. (1953) The Tabanidae of the Anglo-Egyptian Sudan. Bull. ent. Res., 44(1):175-216.

LEWIS, E. A. (1931A) Observations on ticks and tick-borne diseases. Bull. Dep. Agric. Kenya, No. 2 of 1931, 15 pp.

__________ (1931B) A study of the ticks in Kenya Colony. The influence of natural conditions and other factors on their distribution and the incidence of tick-borne diseases. Part I. A report on an investigation into the tick problem in the Rift Valley, Kenya Colony. Bull. Dep. Agric. Kenya, No. 17 of 1931, 19 pp.

LEWIS, E. A. (1931C) Report on tick survey in Kenya Colony. Rep. Dep. Agric. Kenya, 1930, pp. 151-162.

———— (1932A) Some tick investigations in Kenya Colony. Parasitology, 24(2):175-182.

———— (1932B) A study of the ticks in Kenya Colony. The influence of natural conditions and other factors on their distribution and the incidence of tick-borne diseases. Part II. A report on an investigation into the tick problem in the Rift Valley (contd), the Uasin Gishu, and the Trans Nzoia Districts, Kenya Colony. Bull. Dep. Agric. Kenya, No. 6 of 1932, 33 pp.

———— (1933) *Rhipicephalus ayrei* n. sp. (a tick) from Kenya Colony. Parasitology, 25(2):269-272.

———— (1934) A study of the ticks in Kenya Colony. The influence of natural conditions and other factors on their distribution and the incidence of tick-borne diseases. Part III. Investigations into the tick problem in the Masai Reserve. Bull. Dept. Agric. Kenya, No. 7 of 1934, 67 pp.

———— (1939A) The ticks of East Africa. Part I. Species, distribution, influence of climate, habits, and life histories. Empire J. exp. Agric., 7(27):261-270.

———— (1939B) *Idem*. Part II. Tick-borne diseases and their control. *Ibid*, 7(28):299-304.

———— (1943) East Coast fever and the African buffalo, the eland and the bushbuck. E. Afr. agric. J., 9(2): 90-92.

———— (1946) Nairobi sheep disease; the survival of the virus in the tick *Rhipicephalus appendiculatus*. Parasitology, 37(1-2):55-59.

———— (1950) Conditions affecting the East Coast fever parasite in ticks and in cattle. E. Afr. agric. J., 16(2):65-77.

LEWIS, E. A. (1952) Recent developments in insect- and tick-borne diseases in East Africa. Rep. 14th Int. vet. Congr. (London, 1949), Sect. 1(c), 2:1-5.

LEWIS, E. A. & FOTHERINGHAM, W. (1941) The transmission of Theileria parva by ticks. Parasitology, 33(3):251-277.

LEWIS, E. A., PIERCY, S. E. & WILEY, A. J. (1946) Rhipicephalus neavei Warburton, 1912 as a vector of East Coast fever. Parasitology, 37(1-2):60-64.

LIENHART, R. & RÉMY, P. (1920) Note sur la présence en Lorraine d'Argas reflexus (Fabricius 1794) et contribution à l'étude de sa biologie. C.R. Soc. Biol. Paris, 83(26): 1155-1156.

LIPPARONI, E. (1951) Osservazioni sulla epidemiologia della febbre ricorrente in Somalia. Arch. ital. Sci. Med. trop. Parasit., 32(2):105-117.

__________ (1954) Rilievi sul nomadismo nelle sue correlazioni nosografiche ed epidemiologiche in Somalia. Ibid, 35(3):134-154.

LITTLE, A. (1919) The tampan or poultry tick. Rhod. agric. J., 16(1):42-44.

__________ (1920) The fowl tick (Argas persicus). Ibid, 17(6): 542-545.

LIVINGSTONE, D. (1857) Missionary travels and researches in South Africa, etc. 711 pp., London. [Cf. pp. 382, 383, 628, 629].

__________ (1874) The last journals of David Livingstone in Central Africa, from 1865 to his death, continued by a narrative of his last moments, etc. (By H. Waller). 2 vols, 360 pp. and 364 pp., London. [Cf. vol. II, pp. 33, 115].

LLOVÉROL, H., PHILPPE, J. & ADJOVI, P. (1942) Existence de piroplasmoses du porc en Guinée Française. Bull. Serv. Zoot. A. O. F., 5:206-209.

LLOYD, L. (1913) Report of the Entomologist. In: KINGHORN, A., YORKE, W., & LLOYD, L. Final report of the Luangwa Sleeping Sickness Commission of the British South Africa Company 1911-1912, Section VI, pp. 285-297. Ann. trop. Med. Parasit., 7(2):183-302.

________ (1915) On the association of warthog and the nkufu tick (Ornithodorus moubata). Ibid, 9(4):559-560.

LOMBARDINI, G. (1950) Osservazioni biologiche ed anatomiche sul Rhipicephalus sanguineus Latr. (Acarina, Ixodidae). Redia, 35:173-183.

LOPEZ-NEYRA, C. R. (1949) La parasitologia humana en el Marruecos español. Rev. ibér. Parasit., 9(4):373-443.

LOTOTSKY, B. V. & POKROVSKY, S. A. (1946) An experiment in the organization of a minimum complex of measures against haemosporidiasis in northern Tadzhiskistan. (In Russian). Izv. tadzhiks. Fil. Akad. Nauk SSSR, 6: 64-74.

LOTOTSKY, B. V. & POPOV, V. V. (1934) Contribution to the fauna and ecology of the blood sucking ticks of the family Ixodidae in the northeastern region of Armenia. (In Russian). Zakavkazsk. parasit. Eksped. v. Armeniyu 1931 g. (Transcaucas. parasit. Exped. Armenia in 1931) in Trud. Sov. Izuch. proizv. Sil. Ser. Zakavkaz (Trans. Coun. Study industr. Resources, Ser. Transcaucas.) (2):67-80. (Leningrad, Acad. Sci.).

LOUBSER, J. N. W. (1927) Ueber Ohrzecken (Ornithodorus megnini) bei Menschen in Süd-Afrika. Arch. Schiffs-u. Tropenhyg., 31(1):45.

LOUNSBURY, C. P. (1895) Fowl tick (letter from T. W. Parker answered by C. L. P.). Agric. J. C.G.H., 8(25):657-658.

LOUNSBURY, C. P. (1899A) Pig lice, alias "tampans." Agric. J. C.G.H., 15(4):240.

__________ (1899B) Tampans or fowl ticks. Ibid, 15(6): 421-422.

__________ (1899C) Ticks. Report of the government entomologist. Rep. Dep. Agric., C.G.H. (1898), pp. 43-46.

__________ (1900A) Tick investigations. Report of the government entomologist. Idem (1899), pp. 19-34.

__________ (1900B) Notes on some South African ticks. Proc. 12th Ann. Meeting of the Assoc. of Econ. Entomologists. Bull. U.S. Bur. Ent., No. 26, n.s., pp. 41-48.

__________ (1900C) Insect bites and the effects thereof. Canad. Ent., 32(1):17-24.

__________ (1901) Transmission of malignant jaundice of the dog by a species of tick. Agric. J. C.G.H., 19(11): 714-724.

__________ (1902A) Idem. Veterinarian, Lond. (890) 75, 4 s. (566), 48:86-95.

__________ (1902B) The plague of ticks; their destruction by oil spraying; Eastern Province experiments. Agric. J. C.G.H., 21(4):337-345.

__________ (1902C) The plague of ticks. Oil-water pumps etc. (for tick extermination). Ibid, 21(5):427-434.

__________ (1903A) A note on tick investigation. Transv. agric. J., 1(4):11-12.

__________ (1903B) The fowl tick. Studies on its life-cycle and habits. Agric. J. C.G.H., 23(3):261-273.

__________ (1903C) Ticks and African coast fever. Transv. agric. J., 2(5):4-13.

LOUNSBURY, C. P. (1904A) Ticks and malignant jaundice of the dog. J. comp. Path., 17(2):113-129.

______________ (1904B) Distribution of coast fever ticks. Agric. J. C.G.H., 25(3):268-270.

______________ (1904C) Transmission of African coast fever. Ibid, 24(4):428-432.

______________ (1904D) External parasites of fowls. Ibid, 25(5): 548-552.

______________ (1904E) Persian sheep and heartwater. Ibid, 25(2): 175-186.

______________ (1905A) Report of the government entomologist. Rep. Dep. Agric., C.G.H., June, 1904, 35 pp.

______________ (1905B) Habits and peculiarities of some South Africa ticks. Rep. Brit. Ass. Adv. Sci., Section D, S. Afr., 10 pp. [Reprint not seen. Published 1906?].

______________ (1905C) Report of the government entomologist. Rep. Dep. Agric., C.G.H., 1904, pp. 95-104. [Not seen].

______________ (1905D) Cattle dips and their value as destroyers of ticks. (Editorial). Agric. J. C.G.H., 26(3):320-321.

______________ (1905E) Tests of substances for tick destruction. Ibid, 26(3):387-395.

______________ (1906B) Habits and peculiarities of some South African ticks. Rep. Brit. Ass., (75th meeting, S. Afr., 18 Aug. 1905), pp. 282-291.

______________ (1906C) Ticks and African coast fever. Agric. J. C.G.H., 28(5):634-653.

______________ (1909) Report of the government entomologist. Rep. Dep. Agric., C.G.H. (1908), pp. 55-70.

LOVERIDGE, A. (1923A) Notes on East African mammals collected 1920-1923. Proc. zool. Soc. Lond., 4:685-739.

____________ (1923B) Notes on East African snakes, collected 1918-1923. Ibid, 4:871-897.

____________ (1923C) Notes on East African tortoises collected 1921-1923, with the description of a new species of soft land tortoise. Ibid, 4:923-933.

____________ (1923D) Notes on East African lizards collected 1920-1923, with the description of two new races of *Agama lionotus* Blgr. Ibid, 4:935-969.

____________ (1928) Field notes on vertebrates collected by the Smithsonian-Chrysler East African expedition of 1926. Proc. U.S. nat. Mus., 73(17):1-69.

____________ (1929) East African reptiles and amphibians in the United States National Museum. Bull. U.S. nat. Mus., No. 151, 135 pp.

____________ (1936A) Field notes. In: Scientific results of an expedition to rain forest regions in eastern Africa. III. Mammals, by G. M. Allen and B. Lawrence. Bull. Mus. comp. Zool., Harv., 79(3):31-125.

____________ (1936B) Scientific results of an expedition to rain forest regions in eastern Africa. V. Reptiles. Ibid, 79(5):209-337.

____________ (1942) Scientific results of a fourth expedition to forested areas in East and Central Africa. IV. Reptiles. Ibid, 91(4):237-373.

____________ (1955) "Report on Torit snakes". Sudan Notes (Not seen).

LOVETT, W. C. D. (1956) Eradication of tick-borne relapsing fever in the Somaliland Protectorate by a tick destruction programme. Trans. R. Soc. trop. Med. Hyg., 50(2):157-165.

LOWE, H. J. (1944) Annual report of Director, 1943. Dep. vet. Sci. Tanganyika. [Only copy of text seen].

LOWNDES, A. G. (1922) The pigeon tick. Nature, Lond., 110:380.

LUCAS, G. C. (1940) Procedimientos para combatir la garrapata de las gallinas, Argas persicus (Oken), 1818. Alm. Minist. Agric. B. Aires, 15:97-102.

LUCAS, H. (1846) Sur quelques espèces nouvelles d'Ixodes qui vivent parasites sur les serpens (Boa constrictor et Python sebae) et sur l'ornithorhynque (Ornithorhyncus paradoxus, Blum.). Ann. Soc. Ent. Fr., Ser. 2, 4:53-64.

LUCAS, J. M. S. (1954) Fatal anaemia in poultry caused by a heavy tick infestation. Vet. Rec., 66(39):573-574.

LUMSDEN, W. H. R. (1955) Entomological studies, relating to yellow fever epidemiology, at Gede and Taveta, Kenya. Bull. ent. Res., 46(1):149-183.

LUTTERMOSER, G. W. (1947) The white rat and guinea pig as hosts for the larvae of the brown dog-tick, Rhipicephalus sanguineus. J. Parasit., 33(6): suppl. 2:25 (abstract).

LUXMOORE, H. B. (1950) Final veterinary report on Equatoria Province. Sudan vet. Serv., Khartoum. 59 pp. [mimeographed.]

MACCREARY, D. (1945) Ticks of Delaware. With special reference to Dermacentor variabilis (Say) vector of Rocky Mountain spotted fever. Bull. Del. agric. Exp. Sta. no. 252, 22 pp.

MACFIE, J. W. S. (1915) Babesiasis and trypanosomiasis at Accra, Gold Coast, West Africa. Ann. trop. Med. Parasit., 9(4):457-494.

______________ (1916) Notes on the insects collected at Accra during the year. Rep. Accra Lab., 1915, pp. 76-79, London.

MACFIE, J. W. S. & JOHNSTON, J. E. L. (1914) A note on the occurrence of spirochaetosis of fowls in southern Nigeria. Ann. trop. Med. Parasit., 8(1):41-50.

MACKENZIE, J. W. (1920) Ticks and relapsing fever. (Correspondence). Brit. med. J. (3084), 1:200.

MACKIE, A. S. (1927) Relapsing fever in Meru. E. Afr. med. J., 3:121-122.

MACLEOD, J. (1939) The ticks of domestic animals in Britain. Emp. J. exp. Agric., 7(26):97-110.

MACNAY, C. G. (1954) New records of insects in Canada in 1952: a review. Canad. Ent., 86(2):55-60.

MALAMOS, B. (1938) Versuche mit Leishmanien. IV. Versuche der Kala-Azar Übertragung durch Zecken (Rhipicephalus sanguineus). Arch. Schiffs-u. Tropenhyg., 42(1):22-23.

MALHERBE, W. D. (1947) Rickettsia canis infection in dogs in the Pretoria district. S. Afr. J. Sci., 43:271-276.

MAMIKONIAN, M. M. (1934) Some observations on sheep piroplasmosis in sheep breeding collective farms in Alapes, Armenia, in 1931. (In Russian). Trud. Sov. Izuch. Proizv. Sil., Ser. Zakavkaz, (2):21-28.

MANETTI, C. (1920) L'allevamento del bestiame nell'Africa occidentale. I. Angola. Agricoltura colon, 14(6):257-268.

MANN, W. M. (1915) A cursorial tick. Psyche, 22(2):60.

MANSON, J. K. & THORNTON, L. H. D. (1919) East African relapsing fever. J. R. Army med. Cps, 33(2):97-116; 33(3):193-216.

MANSON-BAHR, P. (1941) The prevalent diseases of Italian East Africa. Lancet (6141), 240, 1(19):609-612.

__________ (1942) Diseases of East Africa. Ibid (6181), 242, 1(7):217.

MARCHOUX, E. & COUVY, L. (1912A) Argas et spirilles. Bull. Soc. Path. exot., 5(2):62-68.

__________ (1912B) Argas et spirochetes. Ibid, 5(10):796-798.

__________ (1913A) Idem. (Première mémoire). Les granules de Leishman. Ann. Inst. Pasteur, 27(6):453-480.

__________ (1913B) Idem. (Deuxième partie). Le virus chez l'acarien. Ibid, 27(8):620-643.

MARCQ, J. (1924) Un voyage d'études zootechniques au Congo oriental. Ann. Gembl., 30(1):1-40.

MARKOV, A. A., ABRAMOV, I. V., & DZASOKHOV, G. S. (1940) Contribution à la biologie de la tique Hyalomma volgense. (In Russian, French summary). Trud. Inst. eksp. Vet., Mosk., 15:122-125.

MARKOV, A. A., ABUSALIMOV, N. S. & DZASOKHOV, G. S. (1939) Material on epizootic piroplasmosis of swine. (Author's abstract). (In Russian). J. agric. Sci. Moscow, ser. g (Vet.), 16(5):45.

MARKOV, A. A. & BERNADSKAIA, Z. M. (1939) Experimental transmission of theileriosis of big-horned cattle by males of *Hyalomma detritum*. (Author's abstract). (In Russian). J. agric. Sci. Moscow, ser. g (Vet.), 16(5):45.

MARKOV, A. A., GILDENBLAT, A. A., KURCHATOV, V. I. & PETUNIN, F. A. (1948) A new vector of the causal agent of theileriasis of cattle (the tick *Hyalomma scupense* P. Sch.). (Abstract). (In Russian). J. agric. Sci. Moscow, ser. g (Vet.), 25(9):13.

MARKOV, A. A., KURCHATOV, V. I. & MIRZABEKOV, D. A. (1939) On the transmission of theileriosis in a hybrid zebu in Azerbaidzhan. (Author's abstract). (In Russian). J. agric. Sci. Moscow, ser. g (Vet.), 16(5):45.

MARQUES, A. (1943) Febre recorrente de carraças atipica em Xinavane (Moçambique). An. Inst. Med. trop., Lisboa, 1(1):187-197.

__________ (1944) Tick spirochaetosis or non-epidemic relapsing fever at Xinavane. S. Afr. med. J., 18(21):360-364.

MARTIAL, R. & SENEVET, G. (1921) Présence à Fez d'*Ornithodorus talaje* (Guérin-Méneville, 1849). Action pathogène sur l'homme. Bull. Soc. Path. exot., 14(1):24-26.

MARZINOWSKY, E. (1927) Du développement de l'*Haemogregarina stepanovi*. Ann. Parasit. hum. comp., 5(2):140-142.

MASON, F. E. (1915) Veterinary pathological laboratory. Rep. Vet. Serv., Min. Agric., Egypt, 1913, pp. 13-25.

__________ (1916) *Ibid*. *Idem*, 1915, pp. 28-42.

__________ (1920) *Ibid*. *Idem*, 1917, pp. 22-25.

__________ (1922A) *Ibid*. *Idem*, 1920-21, pp. 23-43.

__________ (1922B) Egyptian fever in cattle and buffaloes. J. comp. Path., 35(1):33-39.

MASON, G. E. (1921) Observations on certain external parasites found upon the New Zealand huia (Neomorpha acutirostris Gould) and not previously recorded. Trans. Proc. N.Z. Inst., 53:357-359.

MASON, J. H. & ALEXANDER, R. A. (1939) Studies of the rickettsias of the typhus-rocky-mountain-spotted-fever group in South Africa. IV. Discussion and classification. Onderstepoort J. vet. Sci., 13(1):67-76.

MASSA, F. (1936A) Contributo alla distribuzione geografica delle zecche Ornithodorus nella Somalia Italiana. G. Med. milit., 84(5):453-459.

________ (1936B) Febbre esantematica da zecche, a Mogadiscio. Ibid, 84(9):873-877.

MASSEY, A. Y. (1905) Spirillosis in Portugese West Africa. J. trop. Med. (Hyg.), 8(15):225.

________ (1908) Some ticks of Central Africa. Ibid., 11(5):70.

MATHIS, C. (1928A) Identité à Dakar du spirochète des rats, du spirochète de la musaraigne et du spirochète récurrent humain. Bull. Soc. Path. exot., 21(6):472-485.

________ (1928B) Identité du spirochète de la fièvre des tiques (Sp. duttoni) et des diverses souches de spirochètes récurrents dakarois. Ibid, 21(7):585-593.

MATHIS, C. & DURIEUX, C. (1932A) Identité, à Dakar, de Spirochaeta duttoni var. crocidurae et du spirochète infectant dans la nature Ornithodorus erraticus. Bull. Soc. Path. exot., 25(7):843-853.

________ (1932B) Idem. C.R. Acad. Sci. Paris, 194(12):1107-1109.

MATHIS, C., DURIEUX, C. & ADVIER, M. (1933) Transmission naturelle et expérimentale à l'homme du spirochète infectant dans la nature, à Dakar, la tique Ornithodorus erraticus vel marocanus. (Note préliminaire). Bull. Soc. Path. exot., 26(8):1094-1098.

MATHIS, C., DURIEUX, C. & ADVIER, M. (1934) Transmission naturelle et expérimentale à l'homme du spirochète infectant dans la nature, à Dakar, la tique: Ornithodorus erraticus vel marocanus. Ann. Inst. Pasteur Paris, 52(2):166-178.

MATTEI, A. (1933) La febbre ricorrente nella Somalia Italiana. Ann. Med. nav. colon. Anno 39, 1(1-2):49-75.

MATTHEWS, L. H. & HOBSON, A. D. (1922) The pigeon tick. Nature, Lond. (2757), 110:313.

MATTHYSSE, J. G. (1954) Report on tick-borne diseases. Govt. Printer, Lusaka, Northern Rhodesia, 28 pp.

MAURICE, G. K. (1932) The entry of relapsing fever into the Sudan. Sudan Notes, 15:97-118.

MAUZÉ, J. & MONTIGNY, G. (1954) Theilériose des bovidés en Guadeloupe. Bull. Soc. Path. exot., 47(4):504-505.

MAYER, A. & MADEL, W. (1950) Beobachtungen über das Auftreten und die Bekämpfung von Taubenzecken (Argas reflexus F.). Z. Disinfect. SchädlBekampf., B, 41(10): 3 pp. (reprint).

MAYER, M. (1918) Uber den Dauerparasitismus von Schizotrypanum cruzi bei Ornithodorus moubata. Arch. Schiffs.-u. Tropenhyg., 22(9):158-160.

MC CALL, F. J. (1924) Annual Report (1922). Rep. Dep. vet. Sci. Tanganyika. Fol. 30 pp.

MC CULLOCH, W. E. (1925) Relapsing fever in northern Nigeria, a study of 300 cases. J. Trop. Med. (Hyg.), 28(18): 332-341.

MC FARLANE, R. N. (1916) The sanitation of a small European settlement in Portugese East Africa; with notes on some of the diseases prevalent in the district. Trans. R. Soc. trop. Med. Hyg., 9(5):129-156.

MC INTYRE, G. (1939) The lungsickness campaign in the Caprivi Zipfel. J. S. Afr. vet. med. Ass., 10(1):4-12.

M.D. (1936) Typhus-like diseases in South Africa. J. trop. Med. (Hyg.), 39(12):139-140.

MEDULLA, C. (1935) Sulla dibattuta questione della presenza della ricorrente da Spironema duttoni in Cirenaica. Arch. ital. Sci. med. colon., 16(10):755-759.

MEESER, M. J. N. (1952) A preliminary survey of the endo- and ectoparasites of the impala, Aepyceros melampus. J. S. Afr. vet. med. Ass., 23(4):221-223.

MEGNIN, J. P. (1887) [Ixodes sur des boeufs algériens et marocains arrivés à l'abattoir militaire de Vincennes]. Ann. Soc. ent. Fr., ser. 5, 8(2):xci-xcii.

MEINERTZHAGEN, R. (1930) Nicoll's birds of Egypt, 2 vols., 700 pp., London.

MELLANBY, K. (1935) The structure and function of the spiracles of the tick, Ornithodoros moubata Murray. Parasitology, 27(2):288-290.

MELNIKOVA, T. G. (1953) Ixodid ticks of wild and domestic animals of the Crimean National Forest. (In Russian). Zool. Zh., 32(3):422-434.

MEMMO, G., MARTOGLIO, F. & ADANI, C. (1904) Infezioni protozoarie negli animali domestici in Eritrea (Piroplasmosi e tripanosomiasi). Ann. Igiene (sper.), n.s., 15(1):1-44.

MENNONNA, G. & MODUGNO, G. (1937) Prime osservazioni nosografiche sulla zona Ogaden-Harrarié. Arch. ital. Sci. med. colon., 18(n.s. 3;i.e. 2) (1):5-21.

MERRIMAN, G. (1911) The geographical distribution of Ornithodorus moubata (Murray, 1877). Parasitology, 4(2):168-173.

MERSKEY, C. (1947) Relapsing fever in Cullinan (Transvaal) with a short reference to penicillin therapy. Clin. Proc. Cape Town, 6(4):113-124.

METCALF, R. L. (1955) Physiological basis for insect resistance to insecticides. Physiol. Rev., 35(1):197-232.

METIANU, T. (1951) Contribution à l'étude des Ixodidés de Roumanie. Ann. Parasit. hum. comp., 26(5-6):446-463.

METTAM, R. W. M. (1932) Appendix IA (Ticks of Uganda). Ann. Rep. Vet. Dept. Uganda, 1931, p. 19.

______________ (1933) Annual report, 1932, of the veterinary pathologist, Entebbe. Ibid, 1932, p. 21-37.

______________ (1934) Turning sickness and East Coast fever. Parasitology, 26(1):150-151.

______________ (1935) Annual report of the veterinary pathologist, Entebbe. Rep. Vet. Dept. Uganda, 1934, pp. 21-30.

______________ (1940) Annual report of the veterinary pathologist. Rep. Vet. Dept. Nigeria, 1938, pp. 20-31.

______________ (1943) Laboratory. Ibid, 1941, pp. 7-10.

______________ (1947) Annual report of the veterinary laboratory. Ibid, 1945, pp. 12-20.

______________ (1948) Annual report of the veterinary laboratory, Vom. Ibid, 1947, pp. 15-24.

______________ (1950) Laboratory services. Ibid, 1948, pp. 58-79.

______________ (1951) Annual report on veterinary laboratory. Ibid, 1949-1950, pp. 32-36.

METTAM, R. W. M. & CARMICHAEL, J. (1936) Turning sickness, a protozoan encephalitis of cattle in Uganda. Its relationships with East Coast fever. Parasitology, 28(2):254-283.

MICHAEL, A. D. (1899) Acari [of Lake Urmi, Iran]. J. Linn. Soc. (Zool.) (177), 27:407.

MICKS, D. W. (1951) The laboratory rearing of the common fowl tick, Argas persicus (Oken). J. Parasit., 37(1): 102-105.

MICKS, D. W., WHITNEY, D. M. & ANIGSTEIN, L. (1951) Effect of sanguinin, an antibacterial agent from blood, on streptococcal infection in mice. Proc. Soc. exp. Biol. N.Y., 78:573-576.

MIKACIC, D. (1949) Ixodidae of the Islands of Cres and Losinj with a map of distribution of tick species in Yugoslavia. (In Hungarian, French and English summaries). Vet. arhiv. Zagreb, 19(1-2):14-32.

__________ (1952) Les piroplasmoses en Yougoslavie. (English summary). Bull. Off. int. Epiz. 1, 38:575-592.

MILLOT, J. (1948) Revue générale de arachnides de Madagascar. Mém. Inst. sci. Madagascar, Sér. A, 1(2):137-155.

__________ (1952) La faune malgache et le mythe gondwanien. Ibid, Sér. A, 7(1):1-36.

MIMIOGLU, M. (1954) Die Schildzecken (Ixodiden) der Haustiere in der Turkei. Vet. Fak. Dergis. Ankara, 1(2):20-34, plus 48 figs.

MINNING, W. (1934) Beiträge zur Systematik und Morphologie der Zeckengattung Boophilus Curtice. Z. Parasitenk. 7(1):1-43.

__________ (1935) Zur Kenntnis des Genus Boophilus Curtice I. Ibid, 7(6):719-721.

__________ (1936) Idem II. Ibid, 8(3):365-370.

MIRONOV, V. S., NABOKOV, V. A. & KACHALOVA, E. K. (1940) Derris and its insecticidal properties. (In Russian). Med. Parasit., Moscow, 9(1-2):106-108.

MITSCHERLICH, E. (1940) Farmwirtschaft in Süd-West-Afrika (Schluss). Dtsch. tierärztl. Wschr., 48(37):435-440.

_______________ (1941) Hühnerstallungen und die Bekämpfung der Hühnerzecken in Deutsch-Sudwest-und Sudafrika. Ibid, 49(3):346-348.

MOISE, R. M. R. (1938) Ricerche epidemiologiche e sperimentali sulla transmissione e patologia della febbre ricorrente in Somalia (1932-1937). Ann. Med. nav. colon., 44(7-8): 315-327.

_______________ (1950) Problemi sanitari in Somalia. Ibid, ?(5): 1-24. (Reprint).

MÖLLERS, B. (1907) Experimentelle Studien über die Übertragung des Rückfallfiebers durch Zecken. Z. Hyg. Infektkr., 58:277-286.

MÖNNIG, H. O. (1949) Veterinary helminthology and entomology. 427 pp. (3rd edition). Baltimore, Maryland.

MÖNNIG, H. O. & COLES, J. D. W. A. (1934) Parasites of fowls. Fmg. in S. Afr., 9:72-75.

_______________ (1936) Idem. Ibid, 11:482-485.

_______________ (1939) Idem. Ibid, 14:25-27.

_______________ (1940) Idem. Ibid, 15:351-354.

MONTEIRO DA COSTA, A. (1926) Relatório duma missão medico-veterinária à Guiné, em 1923. Rev. Med. Vet. Lisboa (261), 24:45-74.

MONTGOMERY, R. E. (1913) Annual report of the veterinary pathological laboratory. Rep. Dept. Agric. B.E.A., 1911-12, pp. 33-58.

_______________ (1917) On a tick-borne gastro-enteritis of sheep and goats occurring in British East Africa. J. comp. Path., 30(1):28-57.

MONTGOMERY, R. E. (1919) Insects and their relation to some diseases of stock. J. E. Afr. Ug. nat. Hist. Soc., 14: 381-400.

MOORE, W. (1912) The tick problem in South Africa. J. econ. Ent., 5(5):377-384.

MOOSER, H. & WEYER, F. (1954) Küntstliche Infektion von Läusen mit Borrelia duttoni. Z. Tropenmed. u. Parasit., 5(1): 28-45.

MOREAU, R. E. (1933) The food of the red-billed oxpecker, Buphagus erythrorhynchus (Stanley). Bull. ent. Res., 24(3):325-335.

MORRIS, J. P. A. (1933) Disease control. Rep. Dep. Anim. Hlth N. Rhod. 1932, pp. 14-24.

____________ (1934) Classification of diseases. Ibid, 1933, pp. 10-20.

____________ (1935) Idem. Ibid, 1934, pp. 6-16.

____________ (1936) Diseases of animals in Northern Rhodesia. Rep. Vet. Dept. N. Rhod., 1935, pp. 9-19.

____________ (1937) Idem. Ibid, 1936, pp. 19-29, 38.

____________ (1938) Idem. Ibid, 1937, pp. 12-22.

____________ (1939) Idem. Ibid, 1938, pp. 12-26.

____________ (1940) Idem. Ibid, 1939, pp. 9-17.

MORSTATT, H. (1913) Liste der blutsaugenden Fliegen und Zecken. Pflanzer, 9(10):507-510.

____________ (1914) Kaffeekultur, Kaffeeschädlinge und andere schädliche Insekten im Bezirk Bukoka. Ibid, 10(3): 133-144.

MOUNT, R. A. (1953) Medical mission to the Yemen, southwest Arabia, 1951. Amer. J. trop. Med. Hyg., 2(1):1-12.

MOUTIA, L. A. & MAMET, R. (1947) An annotated list of insects and acarina of economic importance in Mauritius. Bull. Dep. Agric., Mauritius, Sci. Ser. 29, 43 pp.

MUDROW, E. (1932) Über die Intrazellulären Symbionten der Zecken. Z. Parasitenk., 5(1):138-183.

MÜLLER, K. H. (The biology of the pigeon tick, A. reflexus. Inaug. Dissert. Fried. Wilh. Univ. Berlin, 40 pp. [Not seen].

MULLIGAN, E. J. (1938) Veterinary department annual report, 1937. Rep. vet. Dep. Kenya, 1937, 121 pp. [Cf. pp. 21-22, 88-89].

MULLINS, G. C. (1944) Arsenic-resistant tick. (Letter to Editor). Fmrs' Wkly., Bloemfontein, 67:556.

MURRAY, A. (1877) Economic entomology. Aptera. I. 433 pp. London.

NAJERA, L. E. (1951) Sobre nomenclatura entomologica: Ornithodoros u Ornithodorus. An. med. publ. Sante Fe, 3(1-4):185-190.

NEAVE, S. A. (1911) Report on a journey to the Luangwa Valley, northeastern Rhodesia, from July to September, 1910. Bull. ent. Res., 1(4):303-317.

_________ (1912) Notes on the blood-sucking insects of eastern tropical Africa. Ibid, 3(3):275-323.

NEEL, R., PAYET, M. & GONNET, C. (1949) La fièvre récurrente à tiques de Madagascar. Historique. Etat actuel de la question. Bull. Soc. Path. exot., 42(7-8):384-394.

NEITZ, W. O. (1939) The immunity in heartwater. Onderstepoort J. vet. Sci., 13(2):245-283.

_________ (1943) The eradication of the brown dog tick (Rhipicephalus sanguineus Ltr.) from a dog kennel. J. S. Afr. vet. med. Ass., 14(3):90-93.

_________ (1947) Die oordraging van hartwater deur Amblyomma pomposum Dönitz, 1909. S. Afr. Sci., 1(4):83.

_________ (1948) Studies on East Coast fever. Ibid, 1(7):133-135.

_________ (1950) The specific action of pamaquin on the haemotropic parasites of Theileria parva. S. Afr. J. Sci., 46(7):218-219.

_________ (1953) Aureomycin in Theileria parva infection. Nature, Lond., 171(1):34.

_________ (1954) Hyalomma transiens Schulze: a vector of sweating sickness. J. S. Afr. vet. med. Ass., 25(1):19-20.

NEITZ, W. O. & STEYN, H. P. (1947) The transmission of Babesia canis (Piana and Galli-Valerio, 1895) to the black-backed jackal [Thos mesomelas mesomelas (Schreber)], with a discussion on the classification of the piroplasms of the Canidae. J. S. Afr. vet. med. Ass., 18(1):1-12.

NEITZ, W. O., ALEXANDER, R. A. & MASON, J. H. (1941) The transmission of tick-bite fever by the dog tick Rhipicephalus sanguineus, Latr. Onderstepoort J. vet. Sci., 16(1-2): 9-17.

NEITZ, W. O. & DU TOIT, P. J. (1938) Tick-borne diseases. J. S. Afr. vet. med. Ass., 9(3):85-124.

NEMENZ, H. (1953) Ergebnisse der österreichischen Iran - Expedition 1949/50. Ixodidae. S. B. öst. Akad. Wiss., Abt. 1, 162:61-63.

NEUMANN, L. G. (1896) Revision de la famille des ixodidés. 1er mémoire, Argasines. Mem. Soc. zool. Fr., 9(1):1-44.

__________ (1897) Idem. 2e mémoire. Ibid, 10(3-4):324-420.

__________ (1899A) Idem. 3e mémoire. Ibid, 12:107-294.

__________ (1899B) Anomalies d'ixodidés. Arch. Parasit. Paris, 2(3):463-465.

__________ (1901) Revision de la famille des ixodidés. 4e mémoire. Mem. Soc. zool. Fr., 14(2-3):249-372.

__________ (1902A) Notes sur les ixodidés, I. Arch. Parasit. Paris, 6(1):109-128.

__________ (1902B) Note sur une collection d'ectoparasites recueillis en Abyssinie par M. le Baron C. von Erlanger. Ibid, 6(2):293-294.

__________ (1902C) Sur la transmission des maladies microbiennes par les ixodidés. Arch. med. Toulouse, 8(20): 457-464, (21):481-487.

NEUMANN, L. G. (1902D) La détermination des espèces en zoologie à propos des ixodidés. Mém. Acad. Toulouse, ser. 10, 2:329-338.

______ (1904) Notes sur les ixodidés, II. Arch. Parasit. Paris, 8(3):444-464.

______ (1905) Idem, III. Ibid, 9(2):225-241.

______ (1906) Idem, IV. Ibid, 10(2):195-219.

______ (1907A) Description of two new species of African ticks. Ann. trop. Med. Parasit., 1(1):115-120.

______ (1907B) Notes sur les ixodidés, V. Arch. Parasit. Paris, 11(2):215-232.

______ (1907C) Ixodidae, pp. 17-30, in: Wissen. Ergebn. schwed. Zool. Exped. Kilimandjaro, Meru, Deutsch-Ostafrikas 1905-1906 (Sjöstedt), Abt 20: Arachnoidea (2), Uppsala. [Preprint of 1910B]

______ (1907E) Note sur les Ixodidae recueillis dans des îles de l'ocean Indien par M. J. Stanley Gardiner. Trans. Linn. Soc. Lond. (Zool.) Ser. 2, 12(2):193-196.

______ (1907D) Quatre espèces nouvelles d'ixodidés. Notes Leyden Mus., 29(2):88-100.

______ (1908A) Description d'une nouvelle espèce d'ixodiné. Bull. Mus. Hist. nat., Paris, 14(7):352-356.

______ (1908B) Notes sur les ixodidés, VI. Arch. Parasit. Paris, 12(1):5-27.

______ (1908C) Idem, VII. Notes Leyden Mus., 30(1):73-91.

______ (1909) A new variety of Ixodes pilosus (Koch). Trans. roy. Soc. S. Afr., 1(1):125 (1908).

NEUMANN, L. G. (1910A) Sur quelques espèces d'Ixodidae nouvelles ou insuffisamment connues. Ann. Sci. nat. (b) Zool. Ser. 9, 12(1-3):161-176.

_____________ (1910B) Ixodidae, pp. 17-30, in: Wissen. Ergebn. schwed. Zool. Exped. Kilimandjaro, Meru, Deutsch-Ostafriaks 1905-1906 (Sjöstedt), Abt 20: Arachnoidea (2), Uppsala. [Same as 1907C].

_____________ (1910C) Sur trois types d'ixodinae de Kolenati appartenant au Musée d'Histoire naturelle de Paris. Bull. Mus. Hist. nat., Paris, 4:191-193.

_____________ (1911) Ixodidae. Tierreich, 26, 169 pp. Berlin. *

_____________ (1912) Ixodides (collected by the Swedish zoological expedition to British East Africa, 1911). Ark. Zool., 7(3):4-8.

_____________ (1913) Ixodidae, pp. 25-25, in: Voyage de Ch. Alluaud et R. Jeannel en Afrique Orientale (1911-1912), Paris.

_____________ (1914) Parasites et maladies parasitaires du chien et du chat. 348 pp., Paris.

_____________ (1916) Ixodidei (Acariens): première série. Arch. Zool. exp. gén., 55(12):517-527.

_____________ (1922) Acariens, Résultats Sci., Artic. 1st part, pp. 108-125, in: Voyage de M. le Baron M. de Rothschild en Ethiopie, etc. Paris.

NEUMANN, K. W. (1942) Die "Dorsalplatte" der Aragsidenlarven als Teil eines Atmungssystems und die angeblichen "Attempatten" der Ixodidenlarven. Z. Morph. Ökol. Tiere, 38(2):420-434.

_____________ (1943) Noch einmal: Das Tarsalorgan bei Spinturnix v. Heiden. Zool. Anz., 143(5-6):105-116.

NEWMAN, L. J. (1924) Longevity of the fowl tick (Argas persicus). J. Dep. Agric. W. Aust., Ser. 2, 1(1):48-49.

NEWSTEAD, R. (1905A) On the external anatomy of Ornithodoros moubata (Murray). [Cf. Dutton and Todd (1905A) pp. 18-26].

__________ (1905B) On the pathogenic ticks concerned in the distribution of disease in man, with special reference to the differential characters in Ornithodoros moubata. J. Trop. Med. (Hyg.), 8(16):246-247.

__________ (1905C) Pathogenic ticks concerned in the distribution of disease in man. Med. Rec., N.Y. (1816), 68(9): 360-361.

__________ (1906A) On the external anatomy of Ornithodoros moubata (Murray). Bull. Inst. Pasteur, 4(1):32-33.

__________ (1906B) On the bionomics of Ornithodoros moubata, the intermediary host of human tick fever. Proc. Ass. econ. Biol., Lond. 1(2):74-77.

NICHOLSON, F. D. (1919) Tick fever in Palestine. Brit. med. J. (3077), 2:811.

NICOLLE, C., ANDERSON, C. & COLAS-BELCOUR, J. (1927A) Sur un nouveau spirochète sanguicole pathogène (Sp. normandi) transmis par un ornithodore (Orn. normandi), hôte des terriers de rongeurs nord-africains. C.R. Acad. Sci. Paris, 185(5):334-336.

__________ (1927B) Note préliminaire sur un nouveau spirochète sanguicole pathogène (Sp. normandi), transmis par un ornithodore (Orn. normandi), hôte des terriers de rongeurs nord-africains. Arch. Inst. Pasteur Tunis, 16(3):219-221.

__________ (1928A) Sur un spirochète sanguicole nouveau (Sp. normandi), transmis par un ornithodore (Orn. normandi), hôte des terriers de rongeurs nord-africains. Ibid, 17(1):1-34.

NICOLLE, C., ANDERSON, C. & COLAS-BELCOUR, J. (1928B) Etude expérimentale du spirochète sanguicole du gondi, *Sp. gondii*. Arch. Inst. Pasteur Tunis, 17(4):310-320.

______________ (1928C) Etude expérimentale du spirochète sanguicole du gondi. C.R. Acad. Sci., Paris, 187(19):790-791.

______________ (1928D) Premiers essais d'adaptation du spirochète des poules à divers ornithodores. Ibid, 187(19):791-792.

______________ (1930) Sur le rôle d'*Ornithodorus erraticus* dans la transmission naturelle de deux groupes des spirochètes recurrents. Danger de la propagation de la fièvre recurrente hispano-marocaine à l'Algérie et la Tunisie. Arch. Inst. Pasteur Tunis, 19(1):14-15.

NICOLLE, C. & ANDERSON, C. (1927) Sur l'origine des fièvre récurrentes humaines. Bull. Inst. Pasteur, 25(15):657-665.

NICOLLE, C. & COMTE, C. (1905) Sur le rôle possible de *Hyalomma aegyptium* dans l'infection hémogrégarinienne de *Testudo mauritanica*. C.R. Soc. Biol., Paris, 58(23):1045-1046.

NICOLLE, C., BLAIZOT, L. & CONSEIL, E. (1912) Conditions de transmission de la fièvre récurrente par le pou. C.R. Acad. Sci., Paris, 155(9):481-484.

______________ (1913A) Etiologie de la fièvre récurrente. Son mode de transmission par les poux. Ann. Inst. Pasteur Paris, 27(3):204-225.

______________ (1913B) Etudes sur la fièvre récurrente. L'épidémie tunisienne de 1912 et la démonstration expérimentale de la transmission de la fièvre récurrente par les poux. Arch. Inst. Pasteur Tunis, pp. 1-30.

NIESCHULZ, O. & DU TOIT, R. M. (1937) Investigations into the transmission of horsesickness at Onderstepoort during the season 1932-1933. Onderstepoort J. vet. Sci., 8(1):213-268.

NIESCHULZ, O. & WAWO-ROENTOE, F. K. (1930) Ueber die Zucht von Zecken. Zbl. Bakt., Abt. I. Orig. 115(7-8):486-488.

NIKOLSKY, S. N. (1948) The action of DDT and BHC on ixodid ticks. (In Russian). J. agric. Sci. Moscow, ser. g (Vet.), 25(9):29-33.

NIRO, S. (1935) Gli Ixodidi delle nostre colonie dell'Africa orientale. Distribuzione geografica. Arch. ital. Sci. med. colon., 16(8):602-609.

NOBECOURT, P. & MARTIN, Mme. (1940) Un cas de fièvre exanthématique. Bull. Acad. Med., Paris, 123(3-4):72-76.

NORDENSKIÖLD, N. A. E. (1920) Spermatogenesis in Ixodes ricinus Linn. Parasitology, 12(2):159-166.

NUTTALL, G. H. F. (1910) New species of ticks (Ixodes, Amblyomma, Rhipicephalus). Parasitology, 3(4):408-416.

__________ (1911A) On the adaptation of ticks to the habits of their hosts. Ibid, 4(1):46-67. [Idem (with slight alterations) pp. 324-345 in: Nuttall et al., Ticks. A Monograph of the Ixodoidea (1911)].

__________ (1911B) On symptoms following tick-bite in man. Ibid, 4(2):89-93.

__________ (1911C) Notes on ticks. I. (1) Ixodes caledonicus description of male, together with considerations regarding the structure of the foot in male Ixodes. (2) Types of parasitism in ticks, illustrated by a diagram, together with some remarks upon longevity in ticks. (3) Regarding the loss of life in ticks occurring on wandering hosts. Ibid, 4(3):175-182.

NUTTALL, G. H. F. (1912) Notes on ticks. 2. (1) New species (Amblyomma, Haemaphysalis). (2) Ixodes putus: description of the hitherto unknown larval stage. Parasitology, 5(1):50-60.

__________ (1913A) Note on coloration in ticks. [I.] Ibid, 6(1):49-51.

__________ (1913B) Observations on the biology of Ixodidae. Part 1. Ibid, 6(1):68-118.

__________ (1913C) Notes on ticks. 3. On four new species of Ixodes. Ibid, 6(2):113-138.

__________ (1913D) Rhipicephalus appendiculatus: variation in size and structure due to nutrition. Ibid, 6(2):195-203.

__________ (1914A) Tick abnormalities. Ibid, 7(3):250-257.

__________ (1914B) Penetration of Ixodes beneath the skin. Ibid, 7(3):258-259.

__________ (1915) Observations on the biology of Ixodidae. Part 2. Ibid, 7(4):408-456.

__________ (1916) Notes on ticks. 4. Relating to the genus Ixodes and including a description of three new species and two new varieties. Ibid, 8(3):294-337.

__________ (1919) Observations on the biology of the Ixodidae. Part 3. Dealing with the behaviour of the sexes in Amblyomma hebraeum, Hyalomma aegyptium and Rhipicephalus bursa when upon the host. Ibid, 11(3-4):393-404.

__________ (1920A) On coloration in ticks. 2. Ibid, 12(1):1-6.

__________ (1920B) Regeneration of the mouthparts and legs in ticks. Argas persicus, Amblyomma hebraeum and Hyalomma aegyptium. Ibid, 12(1):7-26.

NUTTALL, G. H. F. (1921) A note on the external characters which serve to differentiate the sexes. Parasitology, 13(4): 345-347.

_______________ (1925) Acarina (Ixodidae), in: Parasitologia Mauritanica. Materiaux pour la fauna parasitologique en Mauritanie. Bull. Com. A.O.F., 8(1):100-101.

NUTTALL, G. H. F. & MERRIMAN, G. (1911) The process of copulation in *Ornithodorus moubata*. Parasitology, 4(1):39-45. *Idem*, pp. 318-323 in: Nuttall *et al*, Ticks. A Monograph of Ixodidae (1911).

NUTTALL, G. H. F. & ROBINSON, L. E. (1915) Bibliography of the Ixodidae II, in: Nuttall *et al*, Ticks. A Monograph of the Ixodoidea. 32 pp.

NUTTALL, G. H. F. & STRICKLAND, C. (1909) On the presence of an anticoagulin in the salivary glands and intestines of *Argas persicus*. Parasitology, 1(4):302-310 (1908).

NUTTALL, G. H. F. & WARBURTON, C. (1908) On a new genus of the Ixodoidea together with a description of eleven new species of ticks. Proc. Camb. phil. Soc. 14(4):392-416 (1907).

_______________ (1911) Ixodidae. Part 2, Section I. Classification. Section II. The genus *Ixodes*. pp. (i)-xix, 105-348, in: Nuttall *et al*, Ticks. A Monograph of the Ixodoidea.

_______________ (1915) The genus *Haemaphysalis*. Part 3, pp. (i)-xiii, 349-550, in: Nuttall *et al*, Ticks. A Monograph of the Ixodoidea.

_______________ (1916) Ticks of the Belgian Congo and the diseases they convey. Bull. ent. Res., 6(4):313-352.

NUTTALL, G. H. F., COOPER, W. F. & SMEDLEY, R. D. (1906) The buccal apparatus of a tick (*Haemaphysalis punctata* C. and F.). Rep. Brit. Ass. (75. Meet. S. Afr., 1905), pp. 439-441.

NUTTALL, G. H. F., COOPER, W. F. & ROBINSON, L. E. (1908A) The structure and biology of *Haemaphysalis punctata* Canestrini and Fanzago. 1. *Parasitology*, *1*(2):152-181.

____________________ (1908B) On the structure of Haller's organ in the Ixodoidea. *Ibid*, *1*(3):238-242.

____________________ (1908C) On the structure of the spiracles of a tick, *Haemaphysalis punctata*, Canestrini and Fanzago. *Ibid*, *1*(4):347-351.

NUTTALL, G. H. F., ROBINSON, L.E. & COOPER, W. F. (1911) Bibliography of the Ixodoidea, in: Nuttall *et al*, Ticks. A Monograph of the Ixodoidea. 68 pp.

NUTTALL, G. H. F., WARBURTON, C., COOPER, W. F. & ROBINSON, L.E. (1908-1926) Ticks. A Monograph of the Ixodoidea. Parts 1-4. Cambridge. (Quoted in text as: Nuttall *et al* followed by year of publication of individual part. Part 4 is Robinson 1926).

O'FARRELL, W. R. (1913A) Preliminary note on a new flagellate, Crithidia hyalommae, sp. nov., found in the tick Hyalomma aegyptium (Linnaeus 1758). J. trop. Med. (Hyg.), 16(6): 245-246.

_______________ (1913B) Hereditary infection, with special reference to its occurrence, in Hyalomma aegyptium infected with Crithidia hyalommae. Ann. trop. Med. Parasit., 7(4):545-562.

OLD, J. E. S. (1909) Contribution to the study of trypanosomiasis and to the geographical distribution of the blood-sucking insects. J. trop. Med. (Hyg.), 12(2):15-22. [Idem: J. trop. vet. Sci., 4(3):395-416].

OLENEV, N. O. (1926) On the distribution of Argas persicus Oken, in SSSR. (In Russian). Vet. Truzh., 2(12):13-14.

_______________ (1927) Sur la classification et la distribution géographique des Ixodides. (In Russian; French summary). C.R. Acad. Sci. U.R.S.S., A(14):219-224.

_______________ (1928A) Biological observations on the Persian tick (Argas persicus persicus, F.-W.). (In Russian). Pl. Prot. Leningr., 5(1):5-14.

_______________ (1928B) Sur la classification et la distribution géographique des Ixodides. II. (In Russian, species diagnosis and title in French). C.R. Acad. Sci. U.R.S.S., A(2):29-34.

_______________ (1929A) The study of the Ixodoidea of our country. (In Russian). Vestnik. Sovreum. Vet., (80-81) 5(7-8): 191-193.

_______________ (1929B) Contributions à la connaissance des Ixodides de la faune paléarctique. (In Russian, French summary). Annu. Mus. Zool. Acad. St. Pétersb., 30(2):305-314.

OLENEV, N. O. (1930) Résultats scientifiques des travaux des expéditions de 1928 et 1929 pour l'étude des parasites des animaux domestiques au Kazakstan. (In Russian). C.R. Acad. Sci. U.R.S.S., A(22):604-610.

__________ (1931A) The parasitic ticks, Ixodoidea, of the fauna of the USSR. (In Russian). Tab. anal. Faune U.R.S.S., 4: 125 pp.

__________ (1931B) Contribution to the classification and geographical distribution of the ticks (Ixodoidea). V. (In Russian). Mag. Parasit., Moscow, 2:249-261.

__________ (1931C) Zie Zecken (Ixodoidea) der Fauna Russlands. Z. Parasitenk., 4(1):126-139.

__________ (1934) Les limites septentrionales de la distribution des tiques Ixodoidea sur les continents du globe terrestre. (In Russian, French summary). Bull. Acad. Sci. U.R.S.S., (2-3):367-388.

__________ (1950) New data on the effect of poisons from higher plants on ticks and insects. (In Russian). C.R. Acad. Sci. U.R.S.S., n.s., 75(1):149-151.

OLIVIER, J. (1924) Notes sur la fièvre récurrente. Ann. Soc. belge Med. trop., 3(3):365-376.

OMER-COOPER, J. & WHITNALL, A. B. M. (1945) An arsenic-resistant tick (Boophilus decoloratus). Nature, Lond. (3963), 156:450-451.

OPPERMANN, E. (1935) Die Entstehung des Riesenspermien von Argas columbarum (Shaw) (reflexus F.). Z. mikr.- anat. Forsch., 37(4):538-560.

ORDMAN, D. (1939) An outbreak of African relapsing fever in the Cape Province. S. Afr. med. J., 13(13):491-498.

__________ (1941) The occurrence of relapsing fever and the geographical distribution of Ornithodorus moubata in South Africa. With an account of investigations carried out in the northern and eastern Transvaal. Ibid, 15(19): 383-388.

ORDMAN, D. (1943) Epidemiological observations on an outbreak of tick relapsing fever in the northern Transvaal. S. Afr. med. J., 17(11):180-182.

________ (1944A) Public health aspects of an outbreak of tick relapsing fever in non-Europeans in Kimberly. Ibid, 18(15):259-261.

________ (1944B) Relapsing fever in Graaf-Reinet. Ibid, 18(16): 272-275.

________ (1955) Relapsing fever in South Africa with a record of its occurrence in Europeans. Ibid, 29(22):518-521.

ORPEN, C. (1904) Correspondence (Margaropus winthemi). Agric. J. C.G.H., 25:92 (Lounsbury's reply, same page).

OSWALD, B. (1937) On ticks: their noxiousness and eradication. (In Serbian, English summary). Jugosl. vet. Glasn., 17(7):265-273.

________ (1938A) Lésions externes observées chez des tiques conservées au laboratoire. Ann. Parasit. hum. comp., 16(2):151-152.

________ (1938B) Revue des travaux publiés en Jugoslavia sur le problème des tiques et nouvelles recherches sur le poison de leur oeufs. Ibid, 16(6):548-559.

________ (1938C) On the species, occurrence, and distribution of Jugoslavian ticks, with special reference to southern Serbia. (In Serbian, English summary). Jugosl. vet. Glasn., 18(2):54-61.

________ (1939A) On recent results obtained in the study of Yugoslavian ticks (Ixodoidea) and some suggestions in connexion with this problem. (In Serbian, English summary). Ibid, 19(8):344-347.

________ (1939B) On Yugoslavian (Balkan) ticks (Ixodoidea). Parasitology, 31(3):271-280.

OSWALD, B. (1940) Determination of Yugoslavian (Balkan) ticks (Ixodoidea). (In Serbian, English summary). Vet. Arhiv. Zagreb, 10(6):297-304.

OUDEMANS, A. C. (1929) Kritisch historisch overzicht der Acarologie. II, 1759-1804, pp. xvii+1097. Amsterdam.

_____________ (1936) III. 430 pp. Leiden.

PAGENSTECHER, H. A. (1861) Zur Anatomie von Argas reflexus. Z. wiss. Zool., 11(2):142-155. (pl. 16, figs. 1-13).

PANDAZIS, G. P. (1947) The tick fauna of Greece. (In Greek). Epistem. Epet. Athens, Unnumbered, pp. 69-182.

PANZER, G. W. F. (1795-1796) Faunae insectorum Germanicae initia, oder Deutschlands Insecten. ... 2 Aufl.

PAOLI, G. (1916) Ixodidi raccolti nella Somalia Italiana meridionale. Redia, 11(1-2):269-297.

PARKER, R. R., DE PRADA, J., BELL, E. J. & LACKMAN, D. B. (1949) Recovery of C. burneti from H. savignyi collected in Spain. Publ. Hlth Rep. Wash., 64(50):1616-1618.

PARMAN, D. C. (1926) A brief history of the sticktight flea and the fowl tick in the United States. J. econ. Ent., 19(4):644-648.

PARROT, L. (1928) Un ornithodore nouveau du Sahara Algérien Ornithodoros foleyi n. sp. Bull. Soc. Path. exot., 21(7): 520-524.

PATERSON, A. R. (1934) Communicable diseases. Rep. med. Dep. Kenya, 1932, pp. 27-29.

PATTON, W. S. (1910) Preliminary report on a new piroplasm (Piroplasma gibsoni sp. nov.) found in the blood of the hounds of the Madras Hunt and subsequently discovered in the blood of the jackal Canis aureus. Bull. Soc. Path. exot., 3(4):274-281.

____________ (1920) Some notes on the arthropods of medical and veterinary importance in Mesopotamia, and on their relation to disease. Part V. Some miscellaneous arthropods. Indian J. med. Res., 8(2):253-256.

PATTON, W. S. & CRAGG, F. W. (1913) A textbook of medical entomology. 768 pp. Christian Literature Society for India. London, Madras, and Calcutta.

PATTON, W. S. & EVANS, A. M. (1929) Insects, ticks, mites, and venomous animals of medical and veterinary importance. I. Medical. 786 pp., Croydon.

PAVESI, P. (1883) Considerazioni sull'aracnofauna dell'Abissinia. R.C. 1st Lombardo, Ser. 2, 16(9):496-501.

_________ (1884A) Spedizione Italiana nell'Africa equatoriale; resultati zoologici. Aracnidi del regno di Scioa. Ann. Mus. Stor. nat. Genova, (1883-84), 20:90-105.

_________ (1884B) Materiali per lo studio della fauna tunisina. II. Aracnidi. Ibid, 20:446-447.

_________ (1895) Aracnidi. Ann. Mus. Stor. nat. Genova, Ser. 2, 15(35):491-537.

_________ (1898) Aracnidi raccolti nel paese dei Somali dall' ing. L. Bricchetti-Robecchi. Boll. Sci. Univ. Pavia, (1895-98), 5(2):37-46.

PAVLOV, P. (1940) Epízoozia di paralisi da zecche nelle capre in Bulgaria. Riv. Parassit., 4(4):227-232.

_________ (1942A) Ricerche sperimentali sulla tossina delle uova di Ixodinae. Ibid, 6(2):101-105.

_________ (1942B) Das Vorkommen von Theileriose in Mazedonien. Dtsch. tierärztl. Wschr., 50(43-44):458-460.

_________ (1944) Epizootologische Untersuchungen über die Piroplasmose in Bulgarien. Dtsch. tropenmed. Z., 48(1-2): 25-36.

_________ (1947) Les tiques en Bulgarie et leurs hôtes vecteurs. Bull. Soc. Path. exot., 40(3-4):95-98.

PAVLOV, P. & GEORGIEV, B. (1950) Research on the insecticides HCH, DDT, Gesarol, and Dedetex powder. 1st communication. (In Bulgarian, summaries in Russian and French). Rev. Inst. Rech. agron. Bulg., 18(1):107-118.

PAVLOV, P. & POPOV, A. (1951) Presence de la tique Amblyomma hebraeum (Koch 1844) en Bulgarie. (In Bulgarian, French summary). Bulgar. Akad. Nauk. Inst. Pos. Eksper. Vet. Med. Izv., 1:211-216.

PAVLOVSKY, E. N. (1940) Monstrosities and abnormalities in the ticks Ixodoidea. (In Russian, English summary). Mag. Parasit., Leningrad, 7:7-44 (1939).

______________ (1948) Handbook on the parasitology of man together with a treatise on the vectors of transmissible diseases. (In Russian). 5th ed. 2:527-1022.

PAVLOVSKY, E. N. & POMERANTZEV, B. I. (1934) Contribution to the question of the distribution of ticks in the pastures zone on the Western Slope of Alagez. (Transcaucas. parasit. Exped. Armenia 1931). (In Russian). Trud. Sov. Izuch. proizv. Sil, Ser. Zakavkaz, 2:49-62.

PAVLOVSKY, E. N., GALUZO, I. G. & LOTOTSKY, B. V. (1941) The system of control measures against ticks transmitting theileriasis and piroplasmosis of cattle in Tadzhikistan. (In Russian). Third Conference on Parasitological Problems. March 1941 (Moscow). Bull. Acad. Sci. U.R.S.S., pp. 48-50.

PAVLOVSKY, E. N., PERVOMAISKY, G. S. & CHAGIN, K. P. (1954) Intensity of feeding of one (species) and simultaneous feeding of two species of pasture ticks (Ixodidae) on rabbits. (In Russian). Zool. Zhur., 33(3):497-506.

PEARSE, A. S. (1929) Ecology of the ectoparasites of Nigerian rodents and insectivores. J. Mammal., 10(3):229-239.

PELLEGRINI, D. (1950) La gastro-enterite emorragica delle pecore. Boll. Soc. ital. Med. Ig. trop., 10(3-6):164-170.

PELLISIER, A. & TRINQUIER, E. (1949) Etudes sur les rickettsioses humaines et animales en Afrique Equatoriale Française. I. La fièvre rouge Congolaise, fièvre éxanthematique africaine. Bull. Soc. Path. exot., 42(11-12):565-580.

PELLISIER, A., TROQUEREAU, P. & TRINQUIER, E. (1950) Idem. II. Une rickettsiose du chien, fièvre éxanthematique animale. Ibid, 43(1-2):65-76.

PELLOUX, A. & DECOURT, P. (1949) Toxicité du S.N.P. sur Argas persicus. Bull. Soc. Path. exot., 42(5-6):187-190.

PELTIER, M., CARRIÈRE, C., JONCHÈRE, H. & ARQUIÉ, E. (1938) Premier cas de fièvre boutonneuse au Sénègal. Bull. Soc. Path. exot., 31(1):29-32.

PEREIRA, C. & DE CASTRO, M. P. (1945) Sobre um ginandromorfo de "Rhipicephalus sanguineus Latr., 1804". Arch. Inst. biol. (Def. agric. anim.) S. Paulo, 16(14):187-192.

PEREZ GALLARDO, F., CLAVERO, G. & HERNANDEZ, S. (1952) Investigaciones sobre la epidemiologia de la fiebre "Q" en España. Los conejos de monte y los lirones como reservorios de la "Coxiella burneti". Rev. Sanid. Hig. públ., Madr., 26(1-2):81-87.

PEREZ GALLARDO, F., CLAVERO, G. & VALLE, G. (1952) Epidemiología de la fiebre Q. (Nota sobre la infección experimental del perro por la C. burneti. Rev. Sanid. Hig. públ., Madr., 26(11-12):641-644.

PERVOMAISKY, G. S. (1947) Concerning the spread of parasites of pasture ticks at the sites of tick encephalitis. (In Russian). Priroda, 36(11):75-78.

__________ (1949) Parthenogenetic development in ticks of the family Ixodidae. (In Russian). Zool. Zh., 28(6):523-526.

__________ (1950A) New tick gynandromorphs of the genus Hyalomma Koch (Acarina, Ixodidae). (In Russian). Ent. Obozr., 31(1-2):113-120.

PERVOMAISKY, G. S. (1950B) Interspecific hybridisation of Ixodidae. (In Russian). C.R. Acad. Sci. U.R.S.S., n.s., 73(5): 1033-1036.

________________ (1954) Variability of pasture ticks (Acarina, Ixodidae), and their importance for systematics. (In Russian). Vsesoiuzn. Ent. Obshch. Trudy, 44:62-201.

PETRIE, P. W. R. (1939) Some experiences in south Arabia. J. Trop. Med. (Hyg.), 42(12):357-360.

PETRISHCHEVA, P. A. (1955) In regard to the prevention of diseases with natural foci in districts of virgin soil and waste land reclamation. (In Russian). J. Microbiol., Moscow, 4:8-15.

PETROVITCH, K. M. (1955) La contribution à la connaissance de la faune des tiques à l'arrondissement de Niche et les arrondissements avoisinants. (In Serbo-Croatian, French summary). Vet. Glasn., 9:99-102.

PHILIP, C. B. (1931A) Occurrence of a colony of the tick parasite Hunterellus hookeri Howard in West Africa. Publ. Hlth Rep., Wash., 46(37):2168-2172.

____________ (1931B) Découverte en Afrique occidentale d'Hunterellus hookeri Howard, parasite des ixodides. Ann. Parasit. hum. comp., 9(3):276.

____________ (1952) Tick transmission of Indian tick typhus and some related rickettsioses. Exp. Parasit., 1(2):129-142.

____________ (1954) A new locality record in Africa for the tick parasite, Hunterellus hookeri Howard. J. Parasit., 40(2): 234.

PHIPPS, J. (1950) Ornithodoros moubata Murray in Tanganyika. E. Afr. med. J., 27(12):475-482.

PIERCY, S. E. (1948) The control of dog ticks with gammexane and gamatox. E. Afr. agric. J., 13(3):157-159.

PIERQUIN, L. (1950) Relation de quelques essais concernant l'efficacité, sur Ornithodorus moubata, de trois insecticides à base de l'isomère "Gamma" de l'hexachlorure de benzène. Ann. Soc. belge Med. trop., 30(3):553-564.

PIERQUIN, L. A. & NIEMEGEERS, C. (1953) Notes sur l'élevage de Ornithodorus moubata (Murray), (Acari, Argasidae). Bull. Inst. Sci. nat. Belg., 29(45):1-6.

PIGOURY, L. (1937) Piroplasmes et piroplasmoses en Syrie et au Liban. Bull. Soc. Path. exot., 30(9):767-772.

PIJPER, A. (1934) Tick-bite fever, a clinical lecture. S. Afr. med. J., 8(15):551-556.

PIJPER, A. & CROCKER, C. G. (1938) Rickettsioses of South Africa. S. Afr. med. J., 12(17):613-630.

PIJPER, A. & DAU, H. (1933) South African tick-bite and the treatment of general paralysis. Ned. Tijdschr. Geneesk. 77, Pt. 2, (18):2030-2037.

________________ (1935) South African typhus. J. Hyg., Camb., 35:116-124.

PILLIPENKO, V. G. & DEREVIANCHENKO, R. I. (1955) A case of finding nymphs of Hyalomma plumbeum Panz., on a hare infected with tularemia organisms. (In Russian). J. Microbiol., Moscow, 4(1):63-67.

PIONTKOVSKAIA, S. P. (1949) The ticks Hyalomma marginatum Koch as carriers of rickettsia. (In Russian). Zool. Zh., 28(5):419-420.

________________ (1950) Influence of agriculture on the populations of Hyalomma marginatum marginatum Koch in the areas of field protection plantations. Ibid, 29(4):297-300.

________________ (1951) On the importance of agricultural measures for clearing tick (Hyalomma plumbeum plumbeum) habitats. (In Russian). Ibid, 30(4):319-324.

PLOWES, D. C. H. (1950) Herons and egrets. Rhod. agric. J., 47(5): 405-408.

POCOCK, R. I. (1900) On a collection of insects and arachnids made in 1895-1897 in Somaliland, with descriptions of new species. 9. Chilopoda and Arachnida. Proc. zool. Soc. Lond. 1900:48-55.

__________ (1903) [See Christy (1903B)].

POISSON, H. (1927) Prodrome d'études de parasitologie malgache. Bull. écon. Madagascar. Partie Document., 24(1):133-144. [Idem: 1927, Etud. Lab. vét. Tananarive, 1:11-22].

POISSON, H. & DECARY, R. (1930) Répartition géographique de l'Ornithodorus moubata à Madagascar. Soc. Sci. méd. Madagascar. Séance du 16 Octobre 1930. [Not seen].

POLAKOW, R. (1944) Relapsing fever in Graaff-Reinet. S. Afr. med. J., 18(16):271-272.

POLUSZYNSKI, G. (1954) Principal morphological and biological properties of ticks found in Poland. (In Polish). Postepy hig. med. doswiadcz, 8(3):3-10.

POMERANTZEV, B. I. (1934) Preliminary data on the ecology of ixodid ticks in the Arax Valley. (Transcaucas. parasit. Exped. Armenia 1931). (In Russian). Trud. Sov. Izuch. proizv. Sil. Ser. Zakavkaz., 2:63-66.

__________ (1936) The morphology of the genus Rhipicephalus Koch in connection with the construction of a natural classification of Ixodoidea. (In Russian, English summary). Mag. Parasit., Leningrad, 6:5-32.

__________ (1937) Adaptations parasitiques des tiques, Ixodoidea (Acarina). (In Russian, French summary). Bull. Acad. Sci. U.R.S.S., Math. and Nat. Sci., (4): 1423-1436.

POMERANTZEV, B. I. (1946) Les tiques (Ixodidae) de la fauna de l'URSS et des pays limitrophes. (In Russian, French summary). Tab. anal. Faunae U.R.S.S. No. 26, 28 pp.

__________ (1950) Ixodidae. In: Fauna of the USSR, 4(2): 224 pp. (In Russian). Moscow.

POMERANTZEV, B. I., MATIKASHVILY, N. V. & LOTOTZKY, B. (1940) An ecological and faunistic outline of Ixodidae ticks occurring in Transcaucasia. (In Russian, English summary). Mag. Parasit., Moscow, 7:100-133 (1939).

POPOVICI-BAZNOSANO, A. (1901) Contribution à l'étude des parasites endoglobulaires du sang des vertébrés. Bul. Soc. roum. Sci., 10(3-4):329-335.

__________ (1906) Sur l'hématozoaire de Testudo ibera (T. mauritanica, T. pusilla). C.R. Soc. Biol., Paris, an. 58, 60, 1(4):173-174.

__________ (1907) La forme mobile des hémogrégarines des chéloneens. Zool. Anz., 31(19-20):620-624.

PORTER, C. E. (1929) Notas de parasitologia. V. Sobre Argas persicus en Calama. Rev. chil. Hist. nat., 32:325-327.

POSPELOVA-SHTROM, M. V. (1932) Boebachtungen über die Biologie von Hyalomma yakimowi Ol. in Laboratoriumsbedingungen. Z. Parasitenk., 5(1):195-212.

__________ (1946) On the Argasidae system (with descriptions of two new subfamilies, three new tribes, and one new genus). (In Russian, English summary). Med. Parasit., Moscow, 15(3):47-58.

PRICE, E. G. (1948) Fighting spotted fever in the rockies. 269 pp. Helena, Montana.

PRITULIN, P. I. (1954) Transmission of brucellosis by pasture ticks Dermacentor nuttalli and Hyalomma marginatum. (In Russian). J. agric. Sci., Moscow, ser. g (Vet.), 31(7):31-33.

QUIN, C. E. & PERKINS, E. S. (1946) Tick-borne relapsing fever in East Africa. J. trop. Med. (Hyg.), 49(2):30-32.

QURESHI, S. H. (1948) On the bionomics of the fowl ticks, *Argas persicus*. Curr. Sci., 17(12):366.

RADFORD, C. D. (1931) Observations on the tick, Ornithodorus moubata Murray. Northw. Nat., 6(3):155-158.

RAGEAU, J. (1951) Ixodidés du Cameroun. Bull. Soc. Path. exot., 44(7-8):441-446.

________ (1953A) Clés pour l'identification des tiques du Cameroun. Ann. Parasit. hum. comp., 28(5-6):399-411.

________ (1953B) Note complémentaire sur les Ixodidae du Cameroun. Bull. Soc. Path. exot., 46(6):1090-1098.

RAGEAU, J. & VERVENT, G. (1953) Clé des Amblyomma d'Afrique. Ann. Parasit. hum. comp., 28(1-2):60-63.

RAMSAY, J. A. (1935A) Methods of measuring the evaporation of water from animals. J. Exp. Biol., 12:352-372.

________ (1935B) The evaporation of water from the cockroach. Ibid, 12(4):373-383.

RAO, K. N. A. (1951) A case of tick typhus in Srinagar. Indian J. med. Res., 39(3):293-296.

RAO, M. A. N. & AYYAR, L. S. P. (1931) Some observations on trypanosomiasis in Madras presidency. Indian Vet. J., 8(2):111-118.

RAY, H. N. (1950A) Hereditary transmission of Theileria annulata infection in the tick, Hyalomma aegyptium Neumann. Trans. R. Soc. trop. Med. Hyg., 44(1):93-104.

________ (1950B) Correspondence. Hyalomma aegyptium. Ibid, 44(2):236.

REGENDANZ, P. & REICHENOW, E. (1931) Ueber Zeckengift und Zeckenparalyse. Arch. Schiffs.-u. Tropenhyg., 35(5):255-273.

REICHENOW, E. (1910) Haemogregarina stepanovi. Die Entwicklungegeschichte einer Hämogregarine. Arch. Protistenk., 20(3):251-350.

__________ (1937) Ueber die Entwicklung von Theileria parva, dem Erreger des Küstenfiebers der Rinder, in Rhipicephalus appendiculatus. Zbl. Bakt., Abt. 1, Orig., 140(3-8): 223-226.

__________ (1940) Der Entwicklungsgang des Küstenfieberregers im Rinde und in der übertragenden Zecke. Arch. Protistenk., 94(1):1-56.

__________ (1941A) Die Bedeutung der Piroplasmosen für Afrika. Dtsch. tropenmed. Z., 45(3):86-91.

__________ (1941B) Zur Kenntnis des Küstenfiebers der Rinder. Dtsch. tierärztl. Wschr., 49(44):546-547, (48):594-595 [reprint combined, four unnumbered pages].

REID, E. T. M. (1955) Some observations on Glossina morsitans ugandensis Vanderplank in the Sudan. Acta Tropica, Basle, 12(3):193-221.

REITANI, U. & PARISI, E. (1923) Note cliniche su la febbre ricorrente nella Somalia Italiana. Policlinico, 30(10): 514-528.

REMENTSOVA, M. M. (1953) New carriers of brucellosis, ticks of the super-family, Ixodoidea. (In Russian). Trud. zool. Inst. Kazakst. Fil. Akad. Nauk SSSR, 1:75-83.

REMLINGER, P. & BAILLY, J. (1939) Contribution à l'étude expérimentale des accidents déterminés par la tique du chien (Rhipicephalus sanguineus). Ann. Parasit. hum. comp., 17(1):1-3.

REMY, P. (1921) De l'action des vapeurs de chloropicrine sur l'Argas reflexus Fabr. C.R. Acad. Sci., Paris, 172 (25):1619-1621.

REMY, P. (1922A) Sur le rejet de sang par les Argasidae. Arch. Zool. exp. gén., 61(1):1-16.

_______ (1922B) La saignée réflexe chez un Arachnide, l'Argas reflexus Fabr. C.R. Ass. franç. Av. Sci. (45th session, Rouen, 1921), pp. 664-671.

RICHARDSON, U. F. (1926) Research division annual report. Rep. Vet. Dep. Uganda, 1925, pp. 13-16.

_______ (1930) A suggested relationship between Theileria mutans and East Coast fever. Trans. Roy. Soc. trop. Med. Hyg., 24(3):343-346.

RIDING, D. & MACDOWELL, T. W. (1927) Preliminary notes on relapsing fever in the Anglo-Egyptian Sudan. Trans. R. Soc. trop. Med. Hyg., 20(8):524-529.

RISBEC, J. (1944) Un parasite des tiques du chien. Notes afr. (22), Apr., pp. 3-4.

ROBERTS, F. H. S. (1939) The brown dog tick (Rhipicephalus sanguineus). Qd. agric. J., 52(5):529-530.

_______ (1953) The Australian species of Aponomma and Amblyomma (Ixodoidea). Aust. J. Zool., 1(1):111-161.

ROBERTS, J. I. (1935) The ticks of rodents and their nests, and the discovery that Rhipicephalus sanguineus, Latr. is the vector of tropical typhus in Kenya. J. Hyg., Camb., 35(1):1-22.

ROBERTS, J. I. & TONKING, H. D. (1933) A preliminary note on the vector of tropical typhus in Kenya. E. Afr. med. J., 9(11):310-315.

ROBERTSON, W. (1902) Interim report upon cattle disease in Southern Rhodesia. Agric. J. C.G.H., 20(12):754-763.

_______ (1904A) Sulphur internally as a preventive against the attacks of ticks. Ibid, 25(5):588-590.

ROBERTSON, W. (1904B) African Coast fever. J. Comp. Path., 17(3): 214-221.

ROBINSON, E. M. (1923) Non-specific gall-sickness of cattle in South Africa. J. Dep. Agric. S. Afr., 6(2):137-143.

ROBINSON, E. M. & COLES, J. D. W. A. (1932) A note on *Aegyptianella pullorum* in the fowl in South Africa. Rep. vet. Res. S. Afr., 18(1):31-34.

ROBINSON, G. G. (1942A) The penetration of pyrethrum through the cuticle of the tick, *Ornithodorus moubata* Murray (Argasidae). Parasitology, 34(1):113-121.

__________ (1942B) The mechanism of insemination in the argasid tick, *Ornithodorus moubata* Murray. Ibid, 34(2): 195-198.

__________ (1942C) Fertility in the argasid tick, *Ornithodorus moubata*, Murray. Ibid, 34(3-4):308-314.

__________ (1942D) The quantitative interaction of spray fluid and active principle in determining the toxicity of a pyrethrum preparation to the argasid tick, *Ornithodorus moubata* Murray. Ann. appl. Biol., 29(3):290-300.

__________ (1943A) Cases of abnormal development in the argasid tick, *Ornithodorus moubata*. Parasitology, 35 (1-2):23-26.

__________ (1943B) The use of a plaster substratum for testing pyrethrum-oil films against *Ornithodorus moubata*, Murray (Acarina: Argasidae). Bull. ent. Res., 34(4):269-277.

__________ (1944A) Testing insecticides on the argasid tick, *Ornithodorus moubata*, Murray. Ibid, 35(2):95-99.

__________ (1944B) More cases of abnormal development in the argasid tick, *Ornithodorus moubata* Murray. Parasitology, 36(1-2):95-97.

ROBINSON, G. G. (1946) The biology of Ornithodorus delanoëi acinus Whittick, 1938. Parasitology, 37(1-2):82-84.

ROBINSON, L. E. (1912) New species of ticks (Haemaphysalis, Amblyomma). Parasitology, 4(4):478-484 (1911).

__________ (1926) The genus Amblyomma. Vol. IV in Nuttall et al: Ticks. A monograph of the Ixodoidea. 302 pp. Cambridge.

ROBINSON, L. E. & DAVIDSON, J. (1913A) The anatomy of Argas persicus (Oken, 1818). Part I. Parasitology, 6(1):20-48.

__________ (1913B) Idem. Part 2. Ibid, 6(3): 217-256.

__________ (1914) Idem. Part 3. Ibid, 6(4): 382-424.

RODHAIN, J. (1919A) Remarques au sujet de la biologie de l'Ornithodorus moubata. C.R. Soc. Biol. Paris, 82(23):934-940.

__________ (1919B) Observations médicales recueillies parmi les troupes coloniales belges pendant leur campagne en Afrique Orientale. 1914-1917. Bull. Soc. Path. exot., 12(3):137-158.

__________ (1920) Remarques au sujet de la biologie de l'Ornithodorus moubata. Ann. Soc. belge Med. trop., 1(1): 133-138.

__________ (1922A) Répartition de l'Ornithodorus moubata dans le Bas et le Moyen Congo. Ibid, 2(2-3):213-226.

__________ (1922B) La subsistance de l'Ornithodorus moubata sur des reptiles et des sauriens. Bull. Soc. Path. exot., 15(7):560-564.

__________ (1922C) L'ubiquisme parasitaire de l'Ornithodorus moubata peut-il influer sur son infection par le spirochete de Dutton? Ibid, 15(7):564-565.

RODHAIN, J. (1936) Piroplasmose d'okapi et d'eléphants dans l'Ouelle. Bull. Soc. Path. exot., 29(8):877-881.

RODHAIN, J., PONS, C., VAN DEN BRANDEN, F. & BEQUAERT, J. C. (1913) Rapport sur les travaux de la Mission scientifique du Katanga (Octobre 1910 à Septembre 1912). In: Observations concernant la fièvre recurrente africaine, Chap. 1, pp. 7-27. Brussels, Acad. Royale, Min. Colonies.

RODINO, N. (1922) Una epidemia de febbre ricorrente ad Itala nella Somalia italiana. G. Med. milit., 70(2):90-93.

ROETTI, C. (1939) Gli ixodidi dello Scioa e del Gimma. Riv. Biol. colon., 2(3):185-192.

ROHR, C. J. (1909) Estudios sobre Ixódidas do Brasil. 220 pp. Rio de Janeiro.

ROMAN, E. & NALIN, P. (1948) Invasion d'ornithodores dans une habitation humaine en Haute-Provence. Ann. Parasit. hum. comp., 23(3-4):214-219.

ROSICKY, B. (1953) Bionomio-faunistic outline of ixodid ticks in Czechoslovakia. (In Czechoslovakian). Zool. Entom. Listy, 16(2):120-130.

ROSS, P. H. (1906) Tick fever. J. trop. Med. (Hyg.), 9(5):65-69.

ROSS, P. H. & MILNE, A. D. (1904) Tick fever. Brit. med. J., (2291), 2:1453-1454.

ROSEVEAR, D. R. (1953) Checklist and atlas of Nigerian mammals with a forward on vegetation. Lagos.

ROUBAUD, E. (1916) Les porcins et la conservation des ectoparasites humains, dans les régions chaudes. Bull. Soc. Path. exot., 9(10):768-771.

ROUBAUD, E. & COLAS-BELCOUR, J. (1931) Etude sur les ornithodores, du groupe *lahorensis* dans l'Afrique du Nord. Description d'*O. delanoei* n. sp. *Ibid*, 24(10):948-957.

ROUBAUD, E. & COLAS-BELCOUR, J. (1933) Argas boueti, nouvelle espèce d'ixodidé parasite des chauve-souris au Soudan français. Parasitology, 25(4):472-477.

________________ (1936) Notes biologiques sur l'Ornithodorus delanoei. Bull. Soc. Path. exot., 29 (9):963-966.

ROUBAUD, E. & VAN SACEGHEM, R. (1916) Observations sur quelques insectes et acariens parasites du bétail au Congo Belge. Bull. Soc. Path. exot., 9(10):763-767.

ROUSSELOT, R. (1946) Identité d'un nouvel ixodiné du genre Hyalomma de l'Afrique Occidentale Française. Ann. parasit. hum. comp., 21(3-4):148-154.

________ (1948) Hyalomma brumpti Delpy 1946. Description de la larve et de la nymphe. Biologie. Ibid, 23(1-2): 31-34.

________ (1951) Ixodes de l'Afrique noir. Bull. Soc. Path. exot., 44(5-6):307-309.

________ (1953A) Notes de parasitologie tropicale. Tome I. Parasites du sang des animaux (systeme reticulo-endothelial) A.O.F. (1942-1945) Iran (1946-1947) A.E.F. (1948-1952). 152 pp. Paris.

________ (1953B) Idem. Tome II. Ixodes. 135 pp.

ROVEDA, R. J. (1940) Primera contribución al estudio de la bionomia del Argas persicus. Publ. Inst. Parasit. Esc. Vet. B. Aires, 1(6):1-22.

________ (1950) Segunda contribución al estudio de la bionomia del Argas persicus. Rev. Fac. Agron. B. Aires, 12(2-3): 201-209 (1949).

RUSER, M. (1933) Beiträge zur Kenntnis des Chitins und der Muskulatur der Zecken (Ixodidae). Z. Morph. Ökol. Tiere, 27(2):199-261.

RUTTLEDGE, W. (1930) Notes on Argas brumpti (Acarina). Bull. ent. Res., 21(3):273.

S

SAID, M. S. (1948) Experiments on the effect of "gammexane" (666) dust on ecto-parasites infesting Egyptian animals. J. Egypt. vet. med. Soc., 3(3):24-35.

SALMON, D. E. & STILES, C. W. (1902) Cattle ticks (Ixodoidea) of the United States. 17th Rep. Bur. Anim. Ind., USDA, pp. 380-491 (Reprint).

SAMPAIO, A. & FAIA, M. (1952A) Estudo comparativo de algumas reacções sorológicas no diagnóstico da febre escaro-nodular. (English summary). Bol. Inst. Sup. Hig. Doutor Ricardo Jorge, 7:106-107.

__________ (1952B) Contribuicao para o estudo da biologia da Rickettsia conori em Portugal. Ibid, 7: 118-124.

SAMPAIO, A., DA CRUZ, A. A. & FAIA, M. M. (1952) Outro artropodo infectado com a Rickettsia dermacentroxenus conori em Portugal. Bol. Inst. Supr. Hig. Doutor Ricardo Jorge, 7:125-130.

__________ (1953) Idem. An. Inst. Med. trop., 10(3):637.

SAMSON, K. (1908) Die Eiablage und die Larve der Zecke Rhipicephalus sanguineus Latr. Vorläufige Mitteilung. S. B. Ges. naturf. Fr. Berl., 3:46-50.

__________ (1909) Zur Spermiohistiogenese der Zecken. Ibid, 8: 486-499.

__________ (1910) Zecken als Krankheitsuberträger. Naturw. Wschr., 25, n.s. 9, (46):721-725.

SANBORN, C. C. & HOOGSTRAAL, H. (1953) Some mammals of Yemen and their ectoparasites. Fieldiana, Zool., 34(23):229-252.

__________ (1955) The identification of Egyptian bats. J. Egypt. publ. Hlth Ass., 30(4):103-121.

SANT'ANNA, J. F. (1911) On a disease in man following tick-bites and occurring in Lourenço Marques. Parasitology, 4(2): 87-88.

SANT'ANNA BARRETO, J. V. (1929) Principais insectos hematófagos da Guiné Portuguesa. Bol. Ag. ger. Colon., 44:195-207.

*SANTOS DIAS, J. A. T. (1947A) Mais dois Ixodídeos do género Amblyomma para a fauna de Moçambique, A. theileri n. sp. e A. tholloni Neumann, 1899. Soc. Estud. Colon. Moçambique, 15 pp.

________________ (1947B) Anomalias nos Ixodídeos. Subsídios para o seu estudo. Docum. Moçambique, (51):5-30.

________________ (1947C) Sobre alguns casos teratológicos observados no "Amblyomma hebraeum" Koch, 1844, ♂. An. Serv. vet. Moçambique, 1:77-93.

________________ (1947D) Nótula acerca de dois ixodídeos do género "Aponomma" existentes em Moçambique: "Ap. exornatum" (Koch, 1844) e "Ap. latum" (Koch, 1844). Ibid, 1:95-112.

________________ (1948A) Quelques cas curieux d'anomalies, observés chez des Ixodidés des genres Rhipicephalus et Aponomma. Ann. Parasit. hum. comp., 23(1-2):27-30.

________________ (1948B) Contribução para o conhecimento da fauna Ixodológica de Moçambique. Rhipicephalus maculatus Neumann, 1901. A carraça do elefante. Docum. Moçambique, (53):81-110.

________________ (1948C) Estudo sobre a biologia do "Amblyomma tholloni" Neumann, 1899. Ibid, (54):127-139.

---

*It has been impossible to determine accurately the actual year of issue of a number of these journals.

SANTOS DIAS, J. A. T. (1949A) Mais um Ixodídeo do grupo *Aponomma* para a fauna de Moçambique: *Ap. transversale* (Lucas, 1844) a carraça do piton. An. Inst. Med. trop., Lisboa, 6:127-138.

________ (1949B) Contribução para o estudo da teratologia dos Ixodídeos: Dois monstros obtidos espontâneamente numa criação de *Amblyomma nuttalli* Dönitz, 1909. *Ibid*, 6:229-237.

________ (1949C) Un caso de deformidade num "*Amblyomma tholloni*" Neumann, 1899. Docum. Moçambique, (55):41-44 (1948).

________ (1949D) Estudo sobre e "*Amblyomma tholloni*" Neumann 1899. Morfologia do ovo, da larva e da ninfa. *Ibid*, (55):45-51 (1948).

________ (1949E) Três casos de malformação observados na espécie *Amblyomma variegatum* (Fabricius, 1794). *Ibid*, (56):47-55 (1948).

________ (1949F) Não é o "*Rhipicephalus ayeri*" Lewis, 1933, uma espécie distinta do "*Rhipicephalus capensis capensis*" Koch, 1844? An. Serv. vet. Moçambique, 1948-49: 169-182.

________ (1950A) Mais um ixodídeo do género *Amblyomma* para a fauna de Moçambique. Docum. Moçambique, (59): 51-75 (1949).

________ (1950B) Contribuição para o conhecimento da fauna ixodológica de Moçambique. *Ibid*, (61):113-170.

________ (1950C) A propósito de alguns lotes de carraças provenientes da colónia de Angola. An. Inst. Med. trop., Lisboa, 7:155-197.

________ (1950D) Mais dois Ixodídeos do género *Rhipicephalus* (s. str.) Koch, 1844 para a fauna de Moçambique. *R. tricuspis* Dönitz, 1906 e *R. lunulatus* Neumann, 1907. *Ibid*, 7:199-216.

SANTOS DIAS, J. A. T. (1950E) Uma nova espécie do género *Rhipicephalus* (s. str.) Koch, para a fauna de Moçambique. *Rhipicephalus tendeiroi* n. sp. An. Inst. Med. trop., Lisboa, 7:217-222.

__________ (1950F) *Rhipicephalus piresi* n. sp. parasita do *Paraxerus cepapi auriventris* Roberts, 1926 em Moçambique. Docum. Moçambique, (62):133-141.

__________ (1950G) Mais uma nova espécie de carraça para a fauna de Moçambique. *Ibid*, (63):143-151.

__________ (1951A) Descrição de uma nova espécie de carraça (Acarina-Ixodoidea) de Moçambique: *Amblyomma faiai* n. sp. *Ibid*, (66):87-98.

__________ (1951B) Mais um Ixodídeo do género "*Rhipicephalus*" s. str. Koch, 1844, para a fauna de Moçambique: R. *punctatus* Warburton 1912. An. Inst. Med. trop., Lisboa, 8(3):373-390.

__________ (1951C) Nótula sobre o "*Amblyomma astrion*" Dönitz, 1909. *Ibid*, 8(3):391-395.

__________ (1951D) Sobre a existência em Moçambique do "*Ixodes pilosus*", Koch, 1844 (Acarina-Ixodoidea). Rev. Med. vet., Lisboa, 46(338):230-242.

__________ (1952A) Una nova espécie de carraça (Acarina Ixodoidea) para a fauna de Moçambique. *Ixodes mossambicensis* n. sp. Docum. Moçambique, (69):67-76.

__________ (1952B) Notas sobre alguns ixodideos de Moçambique novos ou insuficientemente conhecidos. Mem. Mus. Zool. Univ. Coimbra, (210):1-16 (reprint).

__________ (1952C) Estudo sobre alguns *Rhipicephalus* do "Grupo Simus". Bol. Soc. Estud. Moçambique, (74): 3-13.

SANTOS DIAS, J. A. T. (1952D) Resultados de um reconhecimento zoológico no alto limpopo efectuado pelos Drs. F. Zumpt e J. A. T. Santos Dias. I. Organização da expedição, prospecção glossínica, fauna ixodológica e lista dos animais hospedeiros. Docum. Moçambique, (70):43-104.

———————— (1952E) Um caso de ginandromorfismo observado no ixodídeo Rhipicephalus neavi Warburton, 1912. An. Inst. Med. trop., Lisboa, 8(4):523-530 (1951).

———————— (1952F) Acerca de existência em Moçambique de uma nova subespécie do género Dermacentor Koch, 1844: D. (Puncticentor) circumguttatus cunha-silvai n. ssp. Ibid, 8(4):531-547 (1951).

———————— (1952G) Estudo sobre o Rhipicephalus simpsoni Nuttall, 1910, um novo ixodídeo para a fauna de Moçambique. Ibid, 8(4):549-561 (1951).

———————— (1952H) Subsídios para o estudo da fauna ixodológica da Província do Niassa. Ibid, 8(4):563-614 (1951).

———————— (1953A) Acerca de alguns lotes de carraças provenientes da circunscrição do Alto Limpopo (Distrito de Gaza, provincia do Sul do Save). An. Serv. vet. Moçambique, 1951, 207-226.

———————— (1953B) List of Mozambique ticks and their known hosts. Ibid, 1951, 227-252.

———————— (1953C) Sobre uma pequena colecção de carraças provenientes do Mossurize (Manica e Sofala - Moçambique). Rev. Fac. Sci. Lisboa, 2nd series C, 2(2):293-304 (1952).

———————— (1953D) Sobre uma nova subespécie de Rhipicephalus do "Grupo Capensis" Zumpt. R. capensis pseudolongus n. ssp. Mem. Mus. Zool. Univ. Coimbra, (214):1-15 (reprint).

SANTOS DIAS, J. A. T. (1953E) Sobre a posição sistemática de algumas espécies africanas do género Amblyomma C. L. Koch (Acarina-Ixodoidea). Docum. Moçambique, (73):119-139.

__________ (1954A) A further case of gynandromorphism, observed on an Amblyomma variegatum govurensis T. Dias, 1950. An. Inst. Med. trop., Lisboa, 10(1):63-68 (1953).

__________ (1954B) Sobre uma nova espécie de carraça do génro Haemaphysalis Koch, 1844 (Acarina, Ixodoidea) para a fauna de Moçambique. Mem. Mus. Zool. Univ. Coimbra, (219):1-7 (reprint) (1953).

__________ (1954C) Sobre uma pequena colecção de carraças (Acarina-Ixodoidea) colhidas pelo Dr. F. Zumpt em Moçambique. Bol. Soc. Estud. Moçambique, (83):1-8 (reprint).

__________ (1954D) Contribuição para o conhecimento da fauna ixodológica do Protectorado de Ruanda-Urundi (África Central). Mem. Mus. Zool. Univ. Coimbra, (224): 1-17 (reprint).

__________ (1954E) Mais uma nova espécie de carraça do género Haemaphysalis C. L. Koch, 1884 (sic), para a fauna de Moçambique. Ibid, (225):1-9 (reprint).

__________ (1954F) Um novo ixodídeo do género Haemaphysalis C. L. Koch para a fauna de Moçambique: H. parmata Neumann, 1905. Bol. Soc. Estud. Moçambique, (86):3-14 (reprint).

__________ (1954G) Acerca de uma espécie muito pouco conhecida do grupo marmoreum (Acarina, Ixodoidea); Amblyomma poematium Schulze, 1932. Docum. Moçambique, (77):121-134.

__________ (1954H) Acerca de alguns lotes de carraças em colecção no museu Dr. Álvaro de Castro. Mem. Mus. de Castro, 2:27-41 (reprint) (1953).

SANTOS DIAS, J. A. T. (1954J) Contribuição para o conhecimento da fauna ixodológica da India Portuguesa. An. Inst. Med. trop., Lisboa, 11(2):361-439.

__________ (1954K) Noticia sobre alguns hospedeiros vicariantes do Ornithodoros moubata (Murray) em Moçambique. Ibid, 11(3-4):635-639.

__________ (1955A) Nova contribuição para o estudo da tetratologia dos Ixodídeos. An. Inst. Med. trop., Lisboa, 10(3):2249-2275 (1953).

__________ (1955B) Alguns dados biológicos sobre o "Amblyomma nuttalli" Dönitz, 1909. Ibid, 10(3)3: 2277-2286 (1953).

__________ (1955C) Nota acerca de dois Ixodídeos africanos do género Aponomma Neumann, 1899 muito pouco conhecidos. Mem. Mus. Zool. Univ. Coimbra, (228):1-18 (reprint).

__________ (1955D) Contribuição para o conhecimento da fauna ixodológica do Sudoeste Africano. An. Inst. Med. trop., Lisboa, 12(1-2):75-100. (Not seen or quoted).

__________ (1955E) Key to the adult Ixodidae of the genus Haemaphysalis C. L. Koch, 1844 of Ethiopian Africa. Ibid, 12(3):463-475. (Not seen or quoted).

SAPRE, S. N. (1940) The life-history of Boophilus australis (Fuller). Indian J. vet. Sci., 10(4):346-353.

__________ (1943) Some methods of feeding ticks. Ibid, 13(2): 175-177.

__________ (1944) Some observations on the life-history of the dog tick Rhipicephalus sanguineus (Latreille) at Muk-teswar. Ibid, 14(2):111-112.

SAUNDERS, P. T. (1914A) Spraying for control of ticks in Antigua. W. Ind. Bull., 14(2):122-125.

SAUNDERS, P. T. (1914B) Notes on some parasites of live stock in the West Indies. W. Ind. Bull., 14(2):132-138.

_____________ (1915) Skin disease of cattle in Antigua. Ibid, 15(1):36-46.

_____________ (1919) Douchage pour la destruction des tiques à Antigues. Bull. Sta. agron. Guadeloupe, (1):31-35.

SAUTET, J. (1936) Invasion domiciliaire de Rhipicephalus sanguineus et de Teutana triangulosa. Role ixodiphage des araignées. Ann. Parasit. hum. comp., 14(2):126-129.

SAVIGNY, H. (1826) Description de l'Egypte. Planches de zoologie. 51 Plates. Paris.

SCAFFIDI, V. (1937) Caratteri della febbre ricorrente dell'alto-piano nord-etiopico. Arch. Sci. med., 64(4):333-394.

SCHMIDT, K. P. & MARX, H. (1956) Results of the NAMRU-3 South-eastern Egypt expedition, 1954. Reptiles and amphibians. Proc. zool. Soc. Egypt. [In press].

SCHMITZ, H. & BEQUAERT, M. (1914) Contribution à l'étude de la faune cavernicole de la Belgique. Ann. Soc. zool. malac. Belg., 48:67-84.

SCHOENAERS, F. (1950) Présence au Katanga d'Ornithodorus megnini (Dugès, 1833). Ann. Soc. belg. Med. trop., 30(6): 1541-1543.

_____________ (1951A) Liste des tiques récoltées au cours d'un voyage d'études au Congo Belge. Bull. agric. Congo belge, 42(1):117-122.

_____________ (1951B) Essai sur la répartition de la theilériose bovine et des tiques vectrices, au Ruanda Urundi, en fonction de l'altitude. Ann. Soc. belge Med. trop., 31(3):371-375.

SCHOUTEDEN, H. (1927) (Ixodes rasus et Rhipicephalus sanguineus trouvés sur l'okapi). Rev. zool. afr., 15(2):14.

_____________ (1928) A propos des kimputus. Ibid, 16(4):68.

_____________ (1929) Voyage au Congo de S.A.R. le Prince Léopold de Belgique (1925): Arachnides. 2. Acariens, Ibid, 17(1):19-20.

SCHREUDER, P. J. v.d.H. & WRIGHT, F. B. (1948) The horse on the farm. X. Common diseases of horses in South Africa. Fmg in S. Afr. (264), 23:184.

SCHULZ, K. (1939) A rickettsiosis new to South Africa. Onderstepoort J. vet. Sci., 13(2):287-289.

SCHULZE, P. (1918) Ein Beitrag zur Zeckenfauna Mazedoniens. S.B. Ges. naturf. Fr. Berl., (1-2):61-66 (Published 1919).

_____________ (1919) Bestimmungstabelle für das Zeckengenus Hyalomma, Koch. Ibid, (5-6):189-196.

_____________ (1921) Über das Vorkommen von Zecken unter der Haut von Säugtieren. Berl. tierärztl. Wschr., 37(32):378-379.

_____________ (1923A) Die algerischen Zecken der gattung Hyalomma, Koch. Z. Schädlbekämpf., 1(2):99-100.

_____________ (1923B) Ixodina. Zecken. Biol. Tiere Dtschl., 2(21):2-28.

_____________ (1927) Beitrage zur Kentniss der Zecken Europas. S.B. Ges. naturf. Fr. Berl. (1925-1927) (1-10):109-126.

_____________ (1929) Die heutige Verbreitung einzelner Tierarten im Lichte der Erdgeschichtlichen Vergangenheit (besonders der Zecken Dermacentor reticulatus Auct. und Hyalomma marginatum Koch). Z. Morph. Ökol. Tiere, 15(4):735-754.

SCHULZE, P. (1930) Die Zeckengattung Hyalomma I. (H. aegyptium L., detritum P. Sch., H. volgense P. Sch. u Schlottke, H. scupense P. Sch. und H. uralense P. Sch. u Schlottke). Z. Parasitenk., 3(1):22-48.

__________ (1932A) Neue und wenig bekannte Arten der Zeckengattungen Amblyomma und Aponomma. Ibid, 4(3):459-476.

__________ (1932B) Die Zecken als Vogelparasiten. J. Orn. Lpz., 80(3):318-329.

__________ (1932C) Über das Zustandekommen des Zeichnungsmusters und der Schmelzfärbung in der Zeckengattung Amblyomma Koch nebst Bemerkungen über die Gleiderung des Ixodidenkörpers. Z. Morph. Okol. Tiere, 25(2-3):508-533.

__________ (1932D) Über die Körpergliederung der Zecken, die Zusammensetzung des Gnathosoma und die Beziehungen der Ixodoidea zu den fossilen Anthracomarti. S.B. naturf. Ges. Rostock, 3(3):104-126.

__________ (1933A) Neue Ixodiden aus den Gattungen Amblyomma und Aponomma. Zool. Anz., 104(11-12):317-323.

__________ (1933B) Uber Zeckengynander. Z. Morph. Okol. Tiere, 26(3):427-436.

__________ (1933C) Die Arten der Zeckengattung Dermacentor s.l. aus Europa, Asien, und Neu-Guinea. Z. Parasitenk., 6(3):416-431.

__________ (1935) Zur Kenntnis der Zeckengattung Aponomma Neum. Zool. Anz., 112(11-12):327-331.

__________ (1935X) Acarina: Ixodoidea. Wiss. Ergebn. niederl. Exped. Karakorum, 1:178-186. (Leipzig).

__________ (1936A) Zur Vergleichenden Anatomie der Zecken. (Das Sternale, die Mundwerkzeuge, Analfurchen, und Analbeschilderung, ihre Bedeutung, Ursprünglichkeit, und Luxurieren). Z. Morph. Okol. Tiere, 30(1):1-40.

SCHULZE, P. (1936B) Das Schmelzmuster des Scutums von Amblyomma, ein kleiner Nachtrag zu der Arbeit von G. Frick: Ueber das Zeichnungsmuster der Ixodiden. Z. Morph. Okol. Tiere, 31(3):431-432.

__________ (1936C) Zwei neue Rhipicephalus und eine neue Haemaphysalis nebst Bemerkungen über Zeckenarten aus verschiedenen Gattungen. Z. Parasitenk., 8(5):521-527.

__________ (1936D) Zwei neue Arten der Gattung Hyalomma und die morphologische Bedeutung der Analbeschilderung der Ixodiden. Zool. Anz., 114(7-8):187-192.

__________ (1936E) Neue und wenig bekannte Amblyommen und Aponommen aus Afrika, Südamerika, Indien, Borneo und Australien. (Ixodidae). Z. Parasitenk., 8(6):619-637.

__________ (1936F) Die Untergattung Hyalommina und die erste Art aus dem tropischen Afrika (Ixod.). Zool. Anz., 116(9-10):258-264.

__________ (1937A) Trilobita, Xiphosaura, Acarina. Eine morphologische Untersuchung über Plangleichheit zwischen Trilobiten und Spinnentieren. Z. Morph. Okol. Tiere, 32(2):181-226.

__________ (1937B) Eine afrikanische Zecke (Haemaphysalis leachi Aud.) auf einem mecklenburgischen Storch. Arch. Ver. Naturg. Mecklenb. n.s., 11:73.

__________ (1937C) Die kleinhöhlenbewohnenden Zecken der artengruppe um Ixodes autumnalis Leach 1815. Z. Parasitenk., 9(3):351-372.

__________ (1938A) Durch Raummangel bedingte Hemmungserscheinungen an einzelnen Körperteilen in der Ruhenymphe der Ixodiden und das Auftreten entsprechender Bildungen als Art-und Gattungsmerkmal. Z. Morph. Okol. Tiere, 33(4):445-495 (1937).

SCHULZE, P. (1938B) Über rein glabellare Karapaxbildungen bei Milben und über die Umgestaltung des Vorderkörpers der Ixodoidea als Folge der Gnathosomaentstehung. Z. Morph. Okol. Tiere, 34(1):135-149.

__________ (1941) Das Geruchsorgan der Zecken. Untersuchungen uber die Abwandlungen eines Sinnesorgans und seine Stammesgeschichtliche Bedeutung. Ibid, 37(3):491-564.

__________ (1941X) Ein neues Amblyomma und ein neues Aponomma mit Augenrudimenten aus Haiti. Zool. Anz., 133(9-10): 225-229.

__________ (1942) Uber der Hautsinnesorgane der Zecken, besonders uber eine bisher unbekannte Art von Arthropoden Sinne-sorganen, die Krobylophoren. Z. Morph. Okol. Tiere, 38(2):379-419.

__________ (1943A) Ueber zwei bemerkenswerte afrikanische Schwest-erarten von Ixodes: I. rasus Neum. und vanidicus n. sp. Zool. Anz. 142(5-6):121-141.

__________ (1943B) Die Gestaltung des Mittledarmes bie den Zecken und die Einrichtungen für die Körperdehnung bei der Blutaufnahme (nebst Beiträgen zur Lebensgeschichte der Ixodoidea). Z. Morph. Okol. Tiere, 39(2):320-368.

__________ (1944A) Ueber eigentümliche Beziehungen zwischen dem Pigmentgehalt des Chitins und bestimmten Körper-bildungen bei der Nashornzecke Amblyocentor rhinocerinus (Denny). Ibid, 40(3):406-417.

__________ (1944B) Ixodides und Linguatulida. In: Brohmer, Fauna von Deutschland.

__________ (1950A) Amblyomma diemeniae, eine neue schlangenzecke aus Australien nebst Bermerkungen über Abweichende Clavabildungen in der Gattung Amblyomma. Z. Parasitenk., 14(5):432-441.

SCHULZE, P. (1950B) Über Missbildungen der Schildzecken in Allgemeinen sowie über Missbildungen von _Hyalomma steineri enigkianum_ n. ssp. im besonderen. Z. Parasitenk., _14_(6): 545-573.

________ (1955) Über Ausscheidungsvorgänge und Ablagerung von Stoffwechselprodukten bei den Zecken. _Ibid_, _17_(3): 217-236.

SCHULZE, P. & GOSSEL (= Schulze 1936D).

SCHULZE, P. & SCHLOTTKE, E. (1929) Kleinhöhlenbewohnende deutsche Zecken mit Beschreibung dreier neuer Baumhöhlenbrüter und einer Bestimmungstabelle der deutschen _Ixodes_. Erste Mitteilung. S. B. Ges. naturf. Rostock, ser. 3, _2_:95-110 (1927-1929). [Reprint published 1929, journal published 1930].

________ (1930) Bestimmungstabellen fur das Zeckengenus _Hyalomma_ Koch s. str. _Ibid_, ser. 3, _2_: 32-46 (1927-1929).

SCHWETZ, J. (1927A) Note sur les Ixodidae (tiques) du Katanga. Rev. zool. afr., _15_(1):65-72.

________ (1927B) Contribution à l'étude des Ixodidae (tiques) du Congo Belge (d'après les collections du Musée Royal d'Histoire naturelle de Bruxelles). (Deuxième note). _Ibid_, _15_(1):73-80.

________ (1927C) Contribution des Ixodidae (tiques) du Congo belge (d'après la collection du Musée du Congo belge de Tervueren-Bruxelles). (Troisième note). _Ibid_, _15_ (1):81-92.

________ [1927A,B,C, Idem of three references above. Pp. 109-138 in: Schwetz, J., (1927) Etudes et notes d'entomologie médicale sur le Katanga (élevage, tsé-tsé, tiques, et moustiques). Comité special du Katanga, Bruxelles.]

SCHWETZ, J. (1932) Notes géographiques d'entomologie médicale sur la province Orientale (Congo Belge). (Tiques, tabanides et "maringoins"). Ann. Soc. belge Med. trop., 12(4): 549-555.

__________ (1933A) Notes parasitologiques sur la plaine du Lac Édouard (Parc National Albert, Congo Belge). Rev. Zool. Bot. afr., 23(3-4):259-266.

__________ (1933B) Sur quelques spirochétoses de plusieurs espèces de mammifères, trouvées à Stanleyville (Congo Belge). Bull. Soc. Path. exot., 26(8):1032-1036.

__________ (1934) Sur une epizootie de theileriose mortelle (East Coast Fever) à Stanleyville (Congo Belge). Ann. Parasit. hum. comp., 12(3):228-247.

__________ (1942) Sur plusieurs foyers de spirochétose du Congo Oriental. Acta biol. belg., 2(3):326-329.

__________ (1943) Sur quelque foyers cryptiques de Spirochaeta duttoni du Congo oriental. Ann. Soc. belge Med. trop., 23(3-4):219-236.

SCHWETZ, J. & COLLART, A. (1929) Notes protozoologiques. Spirochètes sanguicoles chez Cobus vardoni et Gonderia mutans chez Cobus ellipsiprymnus et chez Ourebia hastata. Bull. Soc. Path. exot., 22(8):651-656.

SELWYN-CLARKE, P. S., LE FANU, G. H. & INGRAM, A. (1923) Relapsing fever in the Gold Coast. Ann. trop. Med. Parasit., 17(3):389-426.

SEN, S. K. (1934) The sucking apparatus in ticks. Nature, Lond., (3391), 134:664.

__________ (1935) The mechanism of feeding in ticks. Parasitology, 27(3):355-368.

SEN, P. (1938) A check- and host-list of Ixodoidea (ticks) occurging in India. Indian J. vet. Sci., 8(2):133-147.

SENEVET, G. (1920A) Contribution à l'étude des Ixodes. Adaptation biologique des ambulacres de la première paire de pattes. Bull. Soc. Path. exot., 13(2):147-155.

_______ (1920B) Note sur quelques Ixodes parasites des animaux domestiques recueillis à Mytilène de février à juin, 1916. Ibid, 13(4):260-261.

_______ (1921) A propos de la reproduction chez *Hyalomma aegyptium* L. Bull. Soc. Hist. nat. Afr. N., 12(5):104-105.

_______ (1922A) Monstruosités chez deux tiques. Ibid, 13(4):95.

_______ (1922B) Les espèces algériennes du genre *Hyalomma*. Arch. Insts. Pasteur Afr. N., 2(3):393-418.

_______ (1922C) Contribution à l'étude des Ixodides (IXo note). Espèces trouvées en Algerie sur les bovins, pendant les mois d'été. Ibid, 2(4):519-528.

_______ (1924A) Description de la nymphe de *Hyalomma mauritanicum* Senevet 1922. Arch. Inst. Pasteur Algér., 2(2): 233-234.

_______ (1924B) [Une curieuse variété du *Hyalomma aegyptium* (L.) en Algérie.] Bull. Soc. Hist. nat. Afr. N., 15 (9):379.

_______ (1925) Description des nymphes de *Rhipicephalus bursa* et de *Hyalomma lusitanicum* avec un tableau pour la détermination des nymphes des ixodides algériens. Arch. Inst. Pasteur Algér., 3(1):59-63.

_______ (1928A) *Hyalomma mauritanicum* et *Hyalomma lusitanicum*. Arch. Inst. Pasteur Algér., 6(1):35-41.

_______ (1928B) Clé pour la détermination des larves d'Ixodidés trouvées sur les bovins en Algérie. Ibid, 6(1): 42-46.

_______ (1937) Ixodoides. Faune Fr. (32): 101 pp.

SENEVET, G. (1938) Quelques ixodidés de la Guadeloupe. Arch. Inst. Pasteur Algér., 16(2):226.

SENEVET, G. & ROSSI, P. (1924) Contribution à l'étude des Ixodidés (XIIe Note). Etude saisonnière des Ixodidés de la région de Bouira (Algérie). Arch. Inst. Pasteur Algér., 2(2):223-231.

________________ (1925) Note sur deux Ixodides, parasites accidentels de l'homme. Ibid, 3(3):298.

________________ (1926) Ixodes ricinus, tique des régions froides ou tempérées. Bull. Soc. Path. exot., 19(7): 558-560.

SENEVET, G., COLAS-BELCOUR, J. & GIL COLLADO, J. (1933) De la présence, en différents points de l'Afrique du Nord de Dermacentor niveus Neumann. Bull. Soc. Path. exot., 26(1):29-31.

SERAGLIA, P. (1932) Contributo allo studio sulle condizioni sanitarie dei Baluba del Lomami. Arch. ital. Sc. med. colon., 13(5):283-295.

SERDYUKOVA, G. V. (1941) On the role played by ticks of the family Ixodidae in the transmission of the relapsing fever spirochaetes. (In Russian, English summary). Trav. Acad. milit. Med., 25:135-144.

________________ (1946A) On the cycle of development of the tick Hyalomma anatolicum anatolicum, Koch. (In Russian, English summary). Bull. Acad. Sci. U.R.S.S., Ser. biol., 1946 (2-3):199-202.

________________ (1946B) Instances of the local mass increase of the ticks Hyalomma anatolicum anatolicum Koch in Tadzhikistan and their causes. (In Russian). Izv. tadzhiks. Fil. Akad. Nauk SSSR, (6):60-63.

________________ (1956) In regard to the differential characteristics of larval and nymphal ixodid ticks. (In Russian). Zool. Zh., 34:1037-1051.

SERGENT, A. (1930) Nymphe de tique parasitant une autre nymphe de la même espèce, Hyalomma mauritanicum. Bull. Soc. Hist. nat. Afr. N., 21(9):195-196.

__________ (1933) Un nouvel agent de transmission naturelle de la récurrente hispano-africaine: la tique du chien (Rhipicephalus sanguineus). C. R. Acad. Sci., Paris, 197(14): 717-718.

__________ (1936) Epreuve de la prémunition croisée appliquée à quelque souche algérienne de spirochétose hispano-africaine. Bull. Soc. Path. exot., 29(3):245-251.

__________ (1938A) Fièvre récurrente à Spirochaeta hispanicum en Algérie. Transmission par le rhipicéphale du chien. Prémunition. Sérum de convalescents. Ann. Inst. Pasteur, 61(3):217-254.

__________ (1938B) Fièvre récurrente hispano-nord-africaine en Algérie. Arch. Inst. Pasteur Algér., 16(4):403-450.

SERGENT, A. & LEVY, H. (1935) Spirochétose hispano-africaine chez un homme piqué par une tique du chien (Rhipicephalus sanguineus). Bull. Soc. Path. exot., 28(9):789-790.

SERGENT, Edm. (1936) Habitat des tiques pendant leur vie libre. Livre Jub. Bouvier, pp. 97-98.

__________ (1948) Insecticides D.D.T. et tiques du boeuf (deuxième note). Arch. Inst. Pasteur Algér., 26(1): 15-20.

__________ (1953) L'oeuvre de l'institut Pasteur en Algerie. Documents Algériens. Série: Sociale, No. 44, 18 pp.

SERGENT, Edm. & FOLEY, H. (1910) Recherches sur la fièvre récurrente et son mode de transmission dans une épidémie algérienne. Ann. Inst. Pasteur, 24(5): 337-373.

____________________ (1922) L'épidémiologie de la fièvre récurrente dans l'Afrique du Nord. Trans. R. Soc. trop. Med. Hyg., 16(3):170-187.

SERGENT, Edm. & FOLEY, H. (1939) Exposé des recherches faites à l'Institut Pasteur d'Algérie sur la fièvre récurrente. Demonstration épidémiologique et expérimentale du rôle du pou dans la transmission, 1907-1908. Etiologie: *Spirochaeta berbera* n. sp., 1910. Traitement par l'arsénobenzol, 1911. Immunité et sérodiagnostic, 1914. Pamphlet, 8 pp. ("Typo-Litho, impr., Alger, 1939").

SERGENT, Edm. & SERGENT, Et. (1904) Sur une hemogrégarine parasite de *Testudo mauritanica*. C.R. Soc. Biol., Paris, *56*(4): 130-131.

SERGENT, E., DONATIEN, A. & PARROT, L. (1945) Expériences de protection des animaux domestiques contre la piqure des tiques par la poudre insecticide D.D.T. Arch. Inst. Pasteur Algér., *23*(4):249-259.

SERGENT, E., DONATIEN, A., PARROT, L. & LESTOQUARD, F. (1928A) Transmission de la piroplasmose bovine à *Theileria dispar* de l'Afrique de Nord par la tique *Hyalomma mauritanicum*. C.R. Acad. Sci., Paris, *187*(4):259-260.

____________ (1928B) Sur la lutte biologique contre la piroplasma bovine due à *Theileria dispar*. *Ibid*, *187*(8):433-434.

____________ (1928C) Tiques et piroplasmoses bovines d'Algérie, première note. Bull. Soc. Path. exot., *21*(10):846-849.

____________ (1931A) Du mode de transmission de la theilériose bovine nord-africaine par la tique *Hyalomma mauritanicum*. C.R. Acad. Sci., Paris, *192*(5):253-255.

____________ (1931B) Considerations étiologiques sur la theilériose bovine nord-africaine. *Ibid*, *192*(7):393-395.

____________ (1931C) 5e, 6e, et 7e campagnes de prémunition contre les piroplasmoses bovines dans l'Afrique du Nord (1928-1930). Arch. Inst. Pasteur Algér., *9*(2):193-237.

SERGENT, E., DONATIEN, A., PARROT, L. & LESTOQUARD, F. (1931D)
La transmission naturelle de la theilériose bovine dans l'Afrique du Nord. Arch. Inst. Pasteur Alger., 9(4):527-595.

_______________ (1931E)
La prémunition contre les piroplasmoses bovines dans l'Afrique du Nord. Cinquième, sixième, et septième campagnes (1927-1930). Ann. Inst. Pasteur, 47(1): 63-72.

_______________ (1931F)
Recherches sur la mode de propagation et sur le réservoir de virus de la theilériose nord-africaine (*Theileria dispar*). Ibid, 47(6):579-600.

_______________ (1931G)
Transmission hereditaire de *Piroplasma bigeminum* chez *Rhipicephalus bursa*. Persistance du parasite chez les tiques nourries sur des chevaux. Bull. Soc. Path. exot., 24(3):195-198.

_______________ (1931H)
Le traitement de la babésiellose bovine à *Babesiella berbera* par l'ichthargan. Ibid, 24(10):939-948.

_______________ (1932A)
Suppression expérimentale de la reproduction sexuée chez un hématozoaire *Theileria dispar*. C. R. Acad. Sci., Paris, 195(23):1054-1056.

_______________ (1932B)
Trois cas d'éruption cutanée due à la theilériose chez le boeuf. Arch. Inst. Pasteur Algér., 10(2): 294-295.

_______________ (1933A)
L'anaplasmose bovine à *Anaplasma centrale*. Ibid, 11(4):526-569.

MARINE BIOLOGICAL LABORATORY LIBRARY WOODS HOLE, MASS.

SERGENT, E., DONATIEN, A., PARROT, L. & LESTOQUARD, F. (1933B) Etude expérimentale de Anaplasma centrale Theiler du boeuf. Bull. Soc. Path. exot., 26(7):922-924.

__________ (1935A) Au sujet de la classification des piroplasmes du boeuf. Le genre Piroplasma et son sous-genre Babesiella. J. Comp. Path., 48(4):261-266.

__________ (1935B) Theilérioses bovines de l'Afrique du Nord et du Proche-Orient. Arch. Inst. Pasteur Algér., 13(4):472-488.

__________ (1936A) Etude morphologique du cycle évolutif de Theileria dispar chez le boeuf et chez la tique. Ann. Inst. Pasteur, 57(1):30-55.

__________ (1936B) Cycle évolutif de Theileria dispar du boeuf chez la tique Hyalomma mauritanicum. Arch. Inst. Pasteur Algér., 14(3):259-294.

__________ (1936C) Cycle évolutif du sporozoaire Theileria dispar, agent de la theilériose bovine des pays méditerranéens chez le boeuf et chez une tique. C. R. Acad. Sci., Paris, 202(10):809-811.

__________ (1945) Etudes sur les piroplasmoses bovines. Alger, 816 pp.

SERGENT, E., DONATIEN, A., PARROT, L., LESTOQUARD, F. & PLANTUREUX, E. (1926) Sur la virulence du sang dans la theilériose sud-africaine, à Theileria parva. C. R. Acad. Sci., Paris, 183(26):1362-1364.

__________ (1927A) Les theilérioses bovines. Etude comparative de Theileria parva de l'Afrique du Sud et de Theileria dispar de l'Afrique du Nord. Arch. Inst. Pasteur Algér., 5(2):161-187.

SERGENT, E., DONATIEN, A., PARROT, L., LESTOQUARD, F. & PLANTUREUX, E. (1927B) Les piroplasmoses bovines d'Algerie. Deuxième mémoire: méthodes de prémunition. Arch. Inst. Pasteur Algér., 5(3):245-468.

________ (1927C) Les piroplasmoses bovines. La "fièvre de la côte orientale" et la theilériose nord-africaine (étude expérimentale comparative). Ann. Inst. Pasteur, 41(5): 489-506.

________ (1927D) Etudes expérimentales sur les piroplasmoses bovines d'Algérie (deuxième mémoire [I]). Ibid, 41(7): 721-784.

________ (1927E) Etudes expérimentales sur les piroplasmoses bovines d'Algérie (deuxième mémoire [2]). Ibid, 41(11):1175-1188.

SERGENT, Edm., SERGENT, Et., & PARROT, L. (1935) Insectes et maladies en Afrique du Nord. In: Parasites, transmetteurs, anim. venimeux. Rec. Trav. 25e Anniv. sci. Pavlovsky 1909-34, pp. 68-70. Moscow.

SERGENT, Edm. & PONCET, A. (1937) Tableau de la répartition saisonnière des tiques les plus répandues en Algérie. Arch. Inst. Pasteur Algér., 15(2):220-224.

________ (1940) Idem. 6th Int. Congr. Ent. (Madrid, 1935), 2:899-902.

________ (1941A) Observations morphologiques sur la descendance d'une tique monstrueuse. Arch. Inst. Pasteur Algér., 19(4):432.

________ (1941B) Etude d'une souche de tiques se reproduisant uniquement par union entre consanguins. Ibid, 19(4):433-434.

SERGENT, Edm. & PONCET, A. (1943) Etude expérimentale de la régénération des appendices chez les tiques (ordre des Acariens, sous-famille des Ixodinae). Arch. Inst. Pasteur Algér., 21(4):215-232.

_______________ (1952) Longues infections latentes, accompagnées de prémunition dans la fièvre récurrente Hispano-Nord-Africaine expérimentale du Cobaye (4e note). Ibid, 30(1):11-30.

SETZER, H. W. (1956) Mammals of the Anglo-Egyptian Sudan. Proc. U.S. nat. Mus. [In press]

SEYDEL, C. (1925) Les tiques. Bull. méd. Katanga, 2:161-164.

SFORZA, M. (1947) Dermotifo in Eritrea. (Identificazione dei virus storico, murino e da zecche). Boll. Soc. ital. Med., Sez. Eritrea, 7(5-6):430-463.

SHARIF, M. (1924) The external morphology and bionomics of the commonest Indian tick (*Hyalomma aegyptium*). Bull. 152, Agric. Res. Inst. Pusa, 35 pp.

_______ (1928) A revision of the Indian Ixodidae, with special reference to the collection in the Indian Museum. Rec. Indian Mus., 30(3):217-344.

_______ (1930) A note on monstrosities observed in ixodid ticks. Ibid, 32(2):107-112.

_______ (1934) Historical review and relationship of the genera of the family Ixodidae. Parasitology, 26(1):49-56.

_______ (1938) Diseases transmitted by the Indian species of ticks and the possibility of their prevention through biological control. Ind. J. vet. Sci., 8(4):353-366 (Reprinted 1939).

SHARMA, G. P. (1943) Spermatogenesis of the dog-tick, *Rhipicephalus sanguineus* (Latreille). Proc. Indian Sci. Congr., 30(3): 66 (Abstract).

SHARMA, G. P. (1944) Spermatogenesis of the fowl-tick, Argas persicus (Oken). Proc. Indian Sci. Congr., 31(3): 82-83.

SHARP, N. A. D. (1925) Epidemic disease in West Africa (Relapsing Fever and Ornithodorus). Trans. R. Soc. Trop. med. Hyg., 19(4):256-264.

SHATAS, I. F. (1952) Ecological and faunistic description of ticks in Stalingrad and northern districts of Astrakhan Regions in connection with new projects. (In Russian). Zool. Zh., 31(6):802-818.

SHATAS, I. F. & BUSTROVA, N. A. (1954) Role of ixodid ticks in sustaining the natural foci of tularemia. (In Russian). J. Mikrobiol., Moscow, 6:55-61.

SHELLEY, H. M. (1943) Tick typhus. E. Afr. med. J., 20(9):300-301.

SIGALAS, R. & LAMONTELLERIE, M. (1954) Problèmes posés par l'épidémiologie de la fièvre boutonneuse. J. Méd. Bordeaux, 131(10):963-986.

SIGWART, H. (1915) Beitrag zur Zeckenkenntnis von Deutsch-Südwestafrika, unter besonderer Berücksichtigung der Funde in den Bezirken Outjo und Waterberg. Z. Infektkr. Haustiere, 16(6):434-444.

SIMMONS, J. S., WHAYNE, T. F., ANDERSON, G. W. & HORACK, H. M. (1944) Global epidemiology. A geography of disease and sanitation. I. Part one: India and the Far East. Part 2: The Pacific area. 504 pp., Philadelphia, London, Montreal.

———— (1951) Idem. II. Africa and the adjacent islands. 652 pp.

———— (1954) Idem. III. The Near and Middle East. 357 pp.

SIMPSON, J. J. (1911) Entomological research in British West Africa. I. Gambia. Bull. ent. Res., 2(2):187-239.

SIMPSON, J. J. (1912A) Entomological research in British West Africa. II. Northern Nigeria. Bull. ent. Res., 2(4):301-356.

__________ (1912B) Idem. III. Southern Nigeria. Ibid, 3(2): 137-193.

__________ (1913) Idem. IV. Sierra Leone. Ibid, 4(3):151-190.

__________ (1914) Idem. V. Gold Coast. Ibid, 5(1):1-36.

__________ (1918) Bionomics of tsetse and other parasitological notes in the Gold Coast. Ibid, 8(3-4):193-214.

SINCLAIR, J. M. (1916) Veterinary report. Rhod. agric. J., 13(2): 265-268.

__________ (1928) Report of the chief veterinary surgeon, Southern Rhodesia, 1927, Fol., 9 pp.

SMITH, A. (1955) The transmission of bancroftial filariasis on Ukara Island, Tanganyika. I. A geographical and ecological description of the islands with an annotated list of mosquitoes and other arthropods of medical importance. Bull. ent. Res., 46(2):419-436.

SMITH, C. N. & COLE, M. M. (1943) Studies of parasites of the American dog tick. J. econ. Ent., 36(4):569-572.

SMITH, J. M. (1933) [Piroplasmosis and anaplasmosis in cattle, sheep, and goats. Rep. Palestine Dept. Agric. for 1927-1930, from Rev. Appl. Ent. 1936, p. 136.] [Not seen. Quoted by Brumpt (1936B)].

SMITH, T. & KILBORNE, F. L. (1893) Investigations into the nature, causation, and prevention of Texas or southern cattle fever. 8th and 9th Reps., Bur. Anim. Ind., USDA, pp. 177-304 (Reprint).

SNODGRASS, R. E. (1948) The feeding organs of Arachnida, including mites and ticks. Smithson. misc. Coll., 110(10):1-93.

SOUSA DIAS, V. (1950) Subsídios paro o estudo dos ixodídeos de Angola. Pecuaria, 2:127-280 (1947-1948) (reprint pp. 1-154).

SOUSA DIAS, V. A. (1953) Subsidio paro o estudo do Ixodídeos de Angola. (Resumo). An. Inst. Med. trop., Lisboa, 10(3):2287.

SPEISER, P. G. E. (1909) Milben (Acarina). Dtsch. SüdpolExped., v.10, Zool., 2(5):597-603.

STEFKO, W. (1917) Piroplasmose et anaplasmose en Turquie. Bull. Soc. Path. exot., 10(8):723-724.

STEINHAUS, E. A. (1947) Insect microbiology. An account of the microbes associated with insects and ticks with special reference to the biologic relationships involved. 763 pp. Ithaca, New York.

STELLA, E. (1938A) Gli Ixodidi dell'Africa orientale italiana. Riv. Biol. colon., 1(2):135-153.

_________ (1938B) Ovogenesi e spermatogenesi di Rhipicephalus sanguineus. Arch. Zool. (ital.) Torino, 27(1):11-30.

_________ (1938C) Ixodoidea della Libia. Aggiunte al "Prodromo della fauna della Libia", di Edoardo Zavattari. Boll. Soc. ent. ital., 70(6-7):123-124.

_________ (1938D) Contributo alla conoscenza degli issodini della Campagna Roma. Boll. Zool., 9(1-2):1-7.

_________ (1939A) Gli Ixodidi fino ad ora conosciuti per l'Africa Orientale. G. ital. Clin. trop., 3(5-6):1-7 (Reprint).

_________ (1939B) Acarina, in: Missione Biologica nel paese dei Borana. Raccolte zoologiche, pp. 387-395; Reale Accademia d'Italia, Rome.

_________ (1940) Nuovi dati sugli Ixodidi dell'Africa Orientale Italiana. Riv. Biol. colon., 3(6):431-435.

STELLA, E. (1942) Anatomia e istologia di *Rhipicephalus sanguineus*. Arch. Zool. (ital.) Torino, 30:155-180.

STEWART, J. L. (1933) (Report of the) Veterinary laboratory. Rep. Dep. Anim. Hlth Gold Cst., 1932-1933, pp. 11-18.

__________ (1934) *Idem*. 1933-1934. *Ibid*, pp. 11-19.

__________ (1935) *Idem*. 1934-1935. *Ibid*, pp. 12-22.

__________ (1936) *Idem*. 1935-1936. *Ibid*, pp. 9-17.

STEYN, J. J. (1955) A second locality record in Uganda for the tick parasite *Hunterellus hookeri* and a few discussions on other tick parasites. E. Afr. med. J., 32(9):357-360.

STORDY, R. J. (1914) East Coast fever in British E. Africa. Rep. Dep. Agric. B.E.A., 1912-1913, pp. 24-28.

__________ (1920) The spinose ear-tick. Practical suggestions for suppression. J. Dep. Agric. S. Afr., 1(7):647-654.

STRICKLAND, C. & ROY, D. N. (1939) Ticks found on man. Indian J. med. Res., 27(1):251-252.

SULDEY, E. W. (1916) La fièvre récurrente malgache. Bull. Soc. Path., exot., 9(9):688-693.

SURBOVA, S. T. (1955) Distribution, biology and ecology of Ixodidae in the Balchish region with special considerations on epizootologic and epidemiologic significances. (In Bulgarian). Svremen. med., Sofia, 6(2):13-27.

TARANTINO, G. B. (1939) La heart-water e la lotta contro le zecche nel governatorato dei Galla e Sidama. Riv. Biol. colon., 2(5):335-344.

TARASEVICH, I. V. (1955) In regard to a study of Q fever vectors in focus C. (In Russian). J. Microbiol., Moscow, 6:31-35.

TARTAGLIA, P. (1939) Eksantemationa krpeljna groznica. Fievre boutonneuse. (French summary). Glasn. hig. Zav., 22:306-313.

TASCHENBERG, E. L. (1873) Die einheimische Saumzecke. Z. Ges. Naturw. Berlin, n.s., 7:381-383.

_______________ (1874) The Canterbury tick (Argas reflexus). Sci. Gossip (116), 10:171-172.

TATE, H. D. (1941) The biology of the tropical cattle tick and other species of ticks in Puerto Rico, with notes on the effects on ticks of arsenical dips. J. Agric. Univ. P.R., 25(1):1-24.

TAYLOR, F. H. (1913) Report of the entomologist. Rep. Aust. Inst. trop. Med., 1911, pp. 49-74.

TAYLOR, F. H. (& MURRAY, R. E.) (1946) Spiders, ticks, and mites including the species harmful to man in Australia and New Guinea. Serv. Publ. Dep. Hlth Aust. trop. Div. no. 6, 275 pp.

TAYLOR, J. I. (1954) East Coast fever in Uganda. Bull. Off. int. Epiz., Africa, 2:391-392.

TAYLOR, J. I. & McANULTY, E. G. (1951) Benzene hexachloride and chlorinated camphene for spraying cattle. E. Afr. agric. J., 17(1):12-15.

TAYLOR, R. M. & HURLBUT, H. S. (1953) Isolation of West Nile virus from Culex mosquitoes. J. Egypt. med. Ass., 36(3):199-208.

TAYLOR, R. M., MOUNT, R. A., HOOGSTRAAL, H. & DRESSLER, H. R. (1952) The presence of Coxiella burnetii (Q fever) in Egypt. J. Egypt. publ. Hlth Ass., 27(4):123-128.

TAYLOR, R. M., WORK, T. H., HURLBUT, H. S. & RIZK, F. (1956) A study of the ecology of West Nile virus in Egypt. Amer. J. Trop. Med. Hyg. [In press].

TAYLOR, R. M., HURLBUT, H. S., WORK, T. H., KINGSTON, J. R. & FROTHINGHAM, T. E. (1955) Sindbis virus: a newly recognized arthropod-transmitted virus. Amer. J. trop. Med. Hyg., 4(5):844-862.

TEESDALE, C. (1952) The control of Ornithodorus moubata (Murray) with 0.5 percent gammexane insect powder (D.034) at Golini, Kwale. E. Afr. med. J., 29(4):138-141.

TEICHLER, G. H. J. (1952) Beobachtungen beim afrikanischen Rückfallfieber. Zschr. Tropenmed. u. Parasit., 4(1):121-124.

TENDEIRO, J. (1946A) Ixodídeos da Guiné Portuguesa: Rhipicephalus simus Koch, 1844 e Rhipicephalus sanguineus (Latreille, 1806). Bol. cult. Guiné portug., 1(3):397-423.

__________ (1946B) O Anaplasma marginale Theiler 1910 na Guiné portuguesa. Rev. Med. vet., Lisboa, 41(317):1-38 (Reprint).

__________ (1947) Ixodídeos da Guiné Portuguesa: sub-família Amblyomminae Neveu-Lemaire 1938. Bol. cult. Guiné portug., 2(7):617-709.

__________ (1948) Subsídios para o conhecimento da fauna parasitológica da Guiné. Ibid, 3(11):639-738.

__________ (1949A) Ixodídeos da Guiné Portuguesa. Hyalomma savignyi Gervais 1844. Ibid, 4(14):319-334 (reprint).

TENDEIRO, J. (1949B) Algumas anomalias de ornamentação do Amblyomma variegatum (Fabricius, 1794). Rev. Med. vet., Lisboa, 44:248.

__________ (1950) Ixodídeos da Guiné Portuguesa. Aponomma halli n. sp. parasita dos varanídeos. An. Inst. Med. trop., Lisboa, 7:135-154.

__________ (1951A) Alguns ixodídeos recolhidos pela missão zoológica da Guiné. An. Jta. Miss. geogr., Lisboa, 6, 4(1):39-52.

__________ (1951B) Nótula sobre dois casos teratológicos em carraças de Moçambique. Ibid, 6,4(2):153-158.

__________ (1951C) Actualidade veterinária da Guiné Portugesa. Mem. Cent. Estud. Guine portug., 15:213 pp., Bissau.

__________ (1951D) Ixodídeos da Guiné Portugesa. Novos dados acerca da subfamília Amblyomminae. Bol. cult. Guine portug., 6(23):682-690.

__________ (1951E) Idem. Nota sobre duas carracas do género Rhipicephalus. Ibid, 6(24):909-928.

__________ (1951F) Idem. Notas teratológicas. Ibid, 6(22): 339-363.

__________ (1952A) Nota prévia sobre febre Q. Gaz. med. portug., 5(4):645-648.

__________ (1952B) Transmissão da Coxiella burneti pelo Rhipicephalus simus senegalensis Koch, 1844. Estudo da estirpe em cultura e nalguns animais de experiência. Med. contemp., 70(6):327-332. [Idem. Bol. cult. Guiné portug., 7(26):291-297].

__________ (1952C) Ixodídeos da Guiné portugesa. Chaves para a identificação das carraças guineenses. Listas de hospedeiros e de espécies. An. Inst. Med. trop., Lisboa, 9(1):195-263.

TENDEIRO, J. (1952D) Febre Q. Mem. Cent. Estud. Guiné portug., 16:340 pp., Bissau.

__________ (1952E) Infestação natural do porco da Guiné pela Babesia trautmanni (Knut e Du Toit 1921) (sic). Bol. cult. Guiné portug., 7(26):359-364.

__________ (1952F) Subsídios para o conhecimento da entomofauna parasitária de Moçambique. Ann. Jta. Miss. geogr., Lisboa, 6,4(2):121-152 (1951).

__________ (1953) Alguns dados sobre as estirpes de Coxiella burneti isoladas na Guiné Portugesa. Bol. cult. Guiné portug., 8(29):69-87 (reprint no. 29).

__________ (1953X) Alguns ectoparasitas recolhidos nos Bijagós. Garcia de Orta (Rev. Jta. Miss. geogr., Lisboa), 1(2):263-267.

__________ (1954X) Nota sobre uma pupipara e um ixodídeo de Cabo Verde. Hippobosca maculata Leach 1817 e Amblyomma variegatum (Fabricius 1794). Ibid, 2(2):199-203.

__________ (1954) Posição actual do problema da febre Q. Rev. Cienc. Vet., 49(350):30 pp.

__________ (1955) An ixodological survey of Moxambique. Garcia de Orta (Rev. Jta. Miss. geogr., Lisboa), 3(2):231-236.

THEILER, A. (1903) The Rhodesian tick fever. Transv. agric. J., 1(4):93-110.

__________ (1905A) Redwater. Ibid, 3(11):476-496.

__________ (1905B) Further experiments to note how long an area remains infected with East Coast fever. Ibid, 3(12):700-706.

__________ (1905C) Transmission and inoculability of Spirillum theileri (Laveran). Proc. roy. Soc., ser. B (512), 76:504-506.

THEILER, A. (1906) Transmission of equine piroplasmosis by ticks in South Africa. J. comp. Path., 19(4):283-292.

_________ (1909A) Investigations into East Coast fever. Vet. J. (407), 65:260-261.

_________ (1909B) Diseases, ticks, and their eradication. Transv. agric. J., 7(28):685-699.

_________ (1909C) Transmission des spirilles et des piroplasmes par differentes especes de tiques. Bull. Soc. Path. exot., 2(6):293-294.

_________ (1910A) Notes on stock diseases of German and British East Africa and Uganda, and the resolutions of the International Veterinary Congress at the Hague, Holland, 1909. Transv. agric. J., 8(30):183-197.

_________ (1910B) Anaplasma marginale (genus nov. et species nov.). Un nouveau protozoaire du betail. Bull. Soc. Path. exot., 3(3):135-137.

_________ (1910C) Anaplasma marginale. A new genus and species of the protozoa. Trans. roy. Soc. S. Afr., 2(1):69-72.

_________ (1910D) 1. A contribution to our knowledge of gall-sickness. (Anaplasmosis of cattle). Transv. agric. J., 8(31):423-435. (Idem. Fmrs' Bull. Transv. Dep. Agric., no. 111, 14 pp.).

_________ (1910E) Anaplasma marginale (Gen. and spec. nova): A protozoan of cattle; a cause of the so-called gall-sickness. Transv. med. J., 5(6):110-111.

_________ (1911A) Transmission of amekebe by means of Rhipicephalus appendiculatus, the brown tick. Proc. roy. Soc. ser. B (569), 84:112-115. [Idem. J. Trop. Med. (Hyg.), 14(18): 275-276],

_________ (1911B) Diseases, ticks, and their eradication. Agric. J. Un. S. Afr., 1(4):491-508.

THEILER, A. (1912A) The transmission of gall-sickness by ticks. Agric. J. Un. S. Afr., 3(2):173-181.

__________ (1912B) Some observations concerning the transmission of East Coast fever by ticks. Trans. roy. Soc. S. Afr., 2(3):319-338.

__________ (1921) Idem of 1911B. J. Dep. Agric. S. Afr., 2(2): 141-159. [Reprint no. 6, 1921, 20 pp.].

THEILER, A. & CHRISTY, J. M. (1910) The prevention and eradication of East Coast fever. Transv. agric. J., 9(33):1-13. [Idem. Fmrs' Bull. Transv. Dep. Agric., no. 129, pp. 3-15].

THEILER, A. & STOCKMAN, S. (1904) Some observations and experiments in connection with tropical bovine piroplasmosis (East Coast fever or Rhodesian redwater). J. comp. Path., 17(3):193-203. [Idem. Transv. agric. J., 3(9):49-60].

____________________ (1905) Further experiments to determine how long an area remains infected with East Coast fever. J. comp. Path., 18(2):163-171.

THEILER, G. (1941) Ticks in the South African zoological survey collection. Part I. Ixodes alluaudi Neumann 1913, a primitive tick parasitc [sic] on shrews. Onderstepoort J. vet. Sci., 17(1-2):51-60.

__________ (1943A) Idem. Part II. Ibid, 18(1-2):85-89.

__________ (1943B) Notes on the ticks off domestic stock from Portuguese East Africa. Estac. Anti-Malarica, Lourenco Marques, 55 pp.

__________ (1945A) Ticks in the South African zoological survey collection. Part III. The ornate aponommas. Onderstepoort J. vet. Sci., 20(2):165-178.

__________ (1945B) Idem. Part IV. The inornate aponommas. Ibid, 20(2):179-190.

THEILER, G. (1945) Ticks in the South African zoological survey collection. Part V. Three African haemaphysalids parasitic on domestic stock. Onderstepoort J. vet. Sci., 20(2):191-207.

________ (1947) Idem. Part VI. Little known African rhipicephalids. Ibid, 21(2):253-300.

________ (1948) Zoological survey of the Union of South Africa. Tick survey. Part I. Ibid, 23(1-2):217-231.

________ (1949A) Idem. Part II. Distribution of Boophilus (Palpoboophilus) decoloratus, the blue tick. Ibid, 22(2):255-268.

________ (1949B) Idem. Part III. Distribution of Rhipicephalus appendiculatus, the brown tick. Ibid, 22(2): 269-284.

________ (1949C) Ticks (Presidential address). Pamphl. S. Afr. biol. Soc., No. 14, 37 pp.

________ (1950A) Zoological survey of the Union of South Africa. Tick survey. Part IV. Distribution of Rhipicephalus capensis, the Cape brown tick. Onderstepoort J. vet. Sci., 24(1-2):7-22.

________ (1950B) Idem. Part V. Distribution of Rhipicephalus evertsi, the red tick. Ibid, 24(1-2):33-36.

________ (1950C) Idem. Part VI. Distribution of the ixodes: Ixodes pilosus and Ixodes rubicundus. Ibid, 24(1-2): 37-51.

________ (1952A) Standardised tick names for South Africa. J. S. Afr. Vet. med. Ass., 23:43-45.

________ (1952B) List of standardised tick names for South Africa. Fmg. in S. Afr., 27:370-373. [Reprint No. 49, 3 pp.]

THEILER, G. (1956) Zoological survey of the Union of South Africa. Tick Survey. Part IX. The distribution of the three South African hyalommas or bontpoots. Onderstepoort J. vet. Res. [In press].

THEILER, G. & HOOGSTRAAL, H. (1955) The identity of *Ornithodoros savignyi* (Audouin, 1827) and *O. pavimentosus* Neumann, 1901 (Ixodoidea, Argasidae). J. Parasit., 41(3):245-247.

THEILER, G. & ROBINSON, B. N. (1953A) Zoological survey of the Union of South Africa. Tick survey. Part VII. Distribution of *Haemaphysalis leachi*, the yellow dog tick. Onderstepoort J. vet. Res., 26(1):83-92.

____________________ (1953B) Ticks in the South African Zoological Survey Collection. Part VII. Six lesser known African rhipicephalids. *Ibid*, 26(1):93-136.

____________________ (1954) Tick survey (Part) VIII. Checklists of ticks recorded from the Belgian Congo and Ruanda Urundi, from Angola, and from Northern Rhodesia. *Ibid*, 26(3):447-461.

THEILER, G. & SALISBURY, L. E. (1956) Zoological survey of the Union of South Africa. Tick survey: Part VIII. Distribution of *Margaropus winthemi*, the winter horse tick. Onderstepoort J. vet. Res. [In press].

THEILER, G., WALKER, J. B. & WILEY, A. J. (1956) Zoological survey of the Union of South Africa. Tick Survey. Two East African ticks. Onderstepoort J. vet. Res. [In press].

THEODOR, O. (1932) Ueber *Ornithodorus coniceps* Canestrini in Palestina. Z. Parasitenk., 5(1):69-79.

THORBURN, J. A. (1947) The control of ectoparasitic infestations of farm stock with gammexane, with special reference to the arsenic-resistant blue tick. Emp. J. exp. Agric., 15(57):42-50.

THORBURN, J. A. (1952) The control of ecto-parasites of domestic stock with "toxaphene". J. S. Afr. vet. med. Ass., 23 (3):171-178.

THORP, J. M., DE MEILLON, B. & HARDY, F. (1948) The effect of 2:3-dimercaptopropanol (British anti-lewisite) on the toxicity of neoarsphenamine for Ornithodorus moubata. S. Afr. J. med. Sci., 13(4):151-158.

TICKS IN THE WEST INDIES (1914) Agric. News, W. Ind., 13(310):90.

TODD, J. L. (1913) A note on the transmission of spirochaetes. Proc. Soc. exp. Biol. N.Y., 10(4):134-135.

__________ (1919) Tiques et spirochétose dans le bassin du Congo. (Correspondence). Bull. Soc. Path. exot., 12(6):290.

TOMPKINS, V. (1953) Ticks and rabies. An anecdote. N.Y. St. Dep. Hlth Bull., 6(22):99.

[TONELLI-] RONDELLI, M. (1926A) Alcuni ixodidi della Somalia Italiana. Res. biol., 1(3):33-43.

__________ (1926B) Missione zoologica del Dr. E. Festa in Cirenaica, Ixodoidea. Ibid, 1(4):45-48.

TONELLI-RONDELLI, M. (1930A) Ixodoidea del Museo di Milano. Atti. Soc. ital. Sci. nat., 69(2):112-124.

__________ (1930B) Ornithodoros franchinii, n. sp., un nuovo Argasidae della Tripolitania. Boll. Zool., 1(3):113-115.

__________ (1932A) Missione Scientifica del Prof. E. Zavattari nel Fezzan (1931). Boll. Soc. ent. ital., 64(6):106-108.

__________ (1932B) Presenza di Ornithodoros savignyi (Audouin) in Tripolitania. Arch. ital. Sci. med. colon., 13(2):117.

TONELLI-RONDELLI, M. (1932C) Hyalomma nuovi della colonie italiane. Atti. Soc. ital. Sci. nat., 71(2):119-125.

________________ (1932D) Spedizione scientifica all'oasi di Cufra (Marzo-Luglio 1931). Ixodoidea. Ann. Mus. Stor. nat. Genova, 55:369-373.

________________ (1932E) Ixodoidea del Museo di Torino. Boll. Mus. Zool. Anat. comp. Torino, 41 Ser. 3, (6):1-10.

________________ (1935) Ixodoidea del Fezzan e della Somalia italiana raccolti dal Prof. E. Zavattari e dal Prof. C. Tedeschi. Atti. Soc. ital. Sci. nat., 74(3):239-252.

________________ (1938) Per una migliore conoscenza della zecche italiane. Riv. Parassit., 2(3):233-241.

TOUMANOFF, C. (1944) Les tiques (Ixodoidea) de l'Indochine. Recherches faunistiques avec indications sur les Ixodides des pays voisins. Notions generales sur la biologie et les moyens de combattre ces Acariens. Instituts Pasteur d'Indo-Chine, 220 pp. Saigon.

TRAGER, W. (1939A) Acquired immunity to ticks. J. Parasit., 25 (1):57-81.

________ (1939B) Further observations on acquired immunity to the tick Dermacentor variabilis Say. Ibid, 25(2):137-139.

________ (1940) A note on the problem of acquired immunity to Argasid ticks. Ibid, 26(1):71-74.

TROLLI, G. (1931) Colonie de Congo Belge. Rapport sur l'hygiene publique pendant l'année 1929. 164 pp. Brussels.

TROMMSDORFF (1913) Beitrag zur Zeckenkarte Deutsch-Südwestafrikas. Landw. Beil. Amtsbl. Schutzgeb. Deutsch-Sudwestafrika, 3(12):1-11 (reprint).

_________ (1914) Beitrag zur Kentniss der in Deutsch-Sudwest-afrika verkommenden Zeckenartem. Arch. Schiffs-u. Tropenhyg. 18:731-747.

TROUP, J. M. & PIJPER, A. (1931) Tick-bite fever in southern Africa. Lancet (5648), 221, 2(22):1183-1186.

TRUE, G. H. (1932) Studies of the anatomy of the pajaroello tick, *Ornithodorus coriaceus* Koch. I. The alimentary canal. Univ. Calif. Publ. Ent., 6(3):21-48.

TSELISHCHEVA, L. M. (1953) Ticks of the superfamily Ixodoidea in Chu district and their harmful significance. (In Russian). Trud. zool. Inst. Kazakst. Fil. Akad. Nauk SSSR, 1, 25-29.

U

UNSWORTH, K. (1949) Sub-division of parasitology. Rep. Vet. Dep. Nigeria, 1948, pp. 71-72.

__________ (1952) The ixodid parasites of cattle in Nigeria, with particular reference to the Northern territories. Ann. trop. Med. Parasit., 46(4):331-336.

VAN DEN BRANDEN, F. (1924) Contribution à l'étude de la répartition de l'Ornithodorus moubata dans le Moyen-Congo. Ann. Soc. belge Méd. trop., 3(3):303.

VAN DEN BRANDEN, F. & VAN HOOF, L. (1922) Recherches sur la fièvre récurrente africaine. Bull. Soc. Path. exot., 15(4): 220-229.

VAN EYNDHOVEN, G. L. (1939) [Not seen].

__________ (1950) Some acarological results of the Netherlands chiropterological research (Chir. notes 26). Proc. 8th Int. Congr. Ent. (Stockholm, 1948), pp. 1008-1011.

VAN HOOF, L. (1917) Note préliminaire sur la fièvre récurrente parmi les troupes belges dans l'Est Africain Allemand. Bull. Soc. Path. exot., 10(9):786-791.

__________ (1924) Conservation du pouvoir infectieux de l'Ornithodorus moubata nourri sur reptiles et sauriens. Ibid, 17(5):376-378.

VAN HOOF, L. & DUKE, H. L. (1928) Epidemiology of sleeping-sickness in the G. palpalis and T. gambiense areas and various observations on treatment. Final Rep. L. o. N. Int. Comm. Human Trypanosomiasis, pp. 325-388. Geneva.

VAN SACEGHEM, R. (1914) Les tiques. Les maladies qu'elles transmettent; les moyens de les détruire. Bull. agric. Congo belge, 5(1):73-87.

__________ (1918) La peste du cheval ou horse sickness au Congo Belge. Bull. Soc. Path. exot., 11(5):423-432.

__________ (1923) Remarque sur la dispersion geographique de l'Ornithodorus moubata. Bull. agric. Congo belge, 14(4):612-613.

VAN SACEGHEM, R. (1925) Contribution à l'étude du 309 Forneau dans les trypanosomiases animales. Bull. agric. Congo belge, 16(3-4):574-592.

_______________ (1930) Action de la température sur la propagation de l'East Coast fever par les tiques. Ibid, 21(2): 511-512.

VAN SLYPE, W. & BOUVIER, G. (1936) Sur l'existence de la fièvre boutonneuse dans les régions de Luputa et de Port-Franqui. Ann. Soc. belge Med. trop., 16:143-148.

VAN SOMEREN, V. D. (1951) The red-billed oxpecker and its relation to stock in Kenya. E. Afr. agric. J., 17(1): 1-11.

VAN VAERENBERGH, R. (1954) Notes relatives à quelques déterminations de tiques du Ruanda-Urundi et du Congo Belge. Bull. (Ann.) Soc. ent. Belg., 90(7-8):222-226.

VELU, H. (1919) Existence au Maroc d'une nouvelle espèce d'*Ornithodorus*. Bull. Soc. Path. exot., 12(2):99-104.

________ (1921) La piroplasmose bovine au Maroc et ses rapports avec les piroplasmoses circumméditerranéenes. Ibid, 14(2):116-124.

VENERONI, C. (1928) Le paralisi da zecche in Somalia. Arch. ital. Sci. med. colon., 9(7):405-406.

VIAZKOVA, S. F. & BERNADSKAIA, Z. M. (1954) Chlorten, new acaricidal preparation. (In Russian). J. agric. Sci., Moscow, Ser. g (Vet.), 31(6):54-57.

VILLIERS, A. (1955) Note sur quelques Ixodidae et Gammasidae parasites des vertébrés rencontrés en Afrique Occidentale Française. Bull. Inst. franc. Afr. noire, 17A(2):444-454.

VIREY, J. J. (1822) Mémoire sur les insectes parasites de l'homme et de divers animaux ou les extozoaires. J. Compl. Dict. Sci. méd,, 14:193-201.

VOGEL, R. (1927) Einige Beobachtungen über Zecken Kleinasiens. Zbl. Bakt., Abt. 1, Orig. 103(1-3):119-123.

________ (1932) Zur Verbreitung von *Argas persicus* Oken und *Argas reflexus* Latr. Ibid, 125(1-2):142-143.

VOLLMER, O. (1931) Kleidermotten als Fresser lebender Zecken. Z. angew. Ent., 18(1):161-174.

VON KÜNSSBERG, K. (1911) Eine Anticoagulindrüse bei Zecken. Zool. Anz., 38(9-10):263-268.

WAGNER, O. (1941) Experimentelle Untersuchungen über Ostküstenfieber an einheimischen Rindern. Dtsch. tropenmed. Z., 45(4):97-102.

WALKER, J. (1927) Technical research. Rep. Dep. Agric. Kenya, 1926, pp. 70-117.

__________ (1928) Idem. Ibid, 1927, pp. 103-202.

__________ (1929) Heartwater (R. ruminantium). Bull. Div. vet. Res. Kenya, 25:10 pp.

__________ (1931) Research. East Coast fever. Rep. Dep. Agric. Kenya, 1930, pp. 100-108.

__________ (1932) Annual report of the chief veterinary officer. Ibid, 1931, pp. 288-314.

WALKER, J. B. (1956) Rhipicephalus pravus Dönitz 1910. Parasitology. [In press].

WALLACE, A. F. (1913) An attempt to transmit Trypanosoma rhodesiense by means of Ornithodoros moubata. Appendix B, pp. 301-302, in: Kinghorn, A., Yorke, W. and Lloyd, L. (1913), Final Report of the Luangwa Sleeping Sickness Commission of the British South Africa Company 1911-1912. Ann. trop. Med. Parasit., 7(2):183-302.

WALSH, N. (1945) An epidemic of tick typhus in East Africa. E. Afr. med. J., 22(1):11-14.

WALTON, G. A. (1950A) Relapsing fever in the Meru District of Kenya. E. Afr. med. J., 27(2):94-98.

____________ (1950B) Argas brumpti Neumann 1907 (Argasidae, Ixodoidea) in Kenya Colony. Ibid, 27(5):207.

____________ (1951) Ornithodorus savignyi (Audouin) 1826, Argasidae, in the Embu District of Kenya Colony. Ibid, 28(4):189.

WALTON, G. A. (1953) Ornithodorus moubata in warthog and porcupine burrows in Tanganyika Territory. Trans. R. Soc. trop. Med. Hyg., 47(3):410-411.

__________ (1955) Relapsing fever in the Digo District of Kenya Colony. E. Afr. med. J., 32(10):377-393.

WANSON, M., RICHARD, P. & TOUBAC, M. (1947) Les rongeurs et insectivores de Leopoldville et leurs ectoparasites. Rec. Sci. med. Congo Belge, (6):3-38.

WARBURTON, C. (1907) The ticks infesting domesticated animals in India. Bull. Imp. Dep. Agric. India, no. 6, 13 pp.

__________ (1910) On two collections of Indian ticks. Parasitology, 3(4):395-407.

__________ (1912) Notes on the genus Rhipicephalus, with the description of new species, and the consideration of some species hitherto described. Ibid, 5(1):1-20.

__________ (1913) On four new species and two new varieties of the ixodid genus Haemaphysalis. Ibid, 6(2):121-130.

__________ (1921) Acarina I: Ixodidae. In: Michaelsen, W., Beiträge Zur Kenntnis der Land-und Süsswasserfauna Deutsch-Sudwestafrikas. Ergebn. Hamburg. deutsch-sudw. Afrk. Studienreise 1911, 2:91-93.

__________ (1926) Fauna simalurensis. Ixodidae. Treubia, 8(3-4):279.

__________ (1927) Acarina II. Ixodidae. In: Gruvel, A., Faune Colon. Franc. 1(6): Contrib. a l'etude de la faune du Cameroun. Ie partie, par. Th. Monod, pp. 633-634. Paris.

__________ (1933) On five new species of ticks. (Arachnida Ixodoidea) Ixodes petauristae, I. ampullaceus, Dermacentor imitans, Amblyomma laticaudae and Aponomma draconis, with notes on three previously described species, Ornithodorus franchinii Tonelli-Rondelli, Haemaphysalis cooleyi Bedford, and Rhipicephalus maculatus Neumann. Parasitology, 24(4):558-568.

WARBURTON, C. & NUTTALL, G. H. F. (1909) On new species of Ixodidae, with a note on abnormalities observed in ticks. Parasitology, 2(1-2):57-76.

WARREN, E. (1931) The spermatogenesis of ticks. Nature, Lond. (3228), 128:454-455.

WASSIF, K. (1954) On a collection of mammals from northern Sinai. Bull. Inst. Desert Egypt, 3(1):107-118 (1953).

WEBER, N. A. (1943) Ants of the Imatong Mountains, Anglo-Egyptian Sudan. Bull. Mus. comp. Zool. Harv., 93:288 [Page of tick reference, remainder not seen].

__________ (1948) Observations on the incidence of ticks on Kenya mammals. Ent. News, 49(9):235-242.

WEISS, A. (1911A) Sur les ectoparasites du hérisson de Djerba. Arch. Inst. Pasteur Tunis, (3):208-213.

__________ (1911B) Catalogue et distribution des arthropodes piqueurs de l'Ile de Djerba. Ibid, (4):268-274.

__________ (1912) Addition au catalogue des anthropodes (sic) piqueurs de Djerba. Ibid, (4):227.

WEITZ, B. & BUXTON, P. A. (1953) The rate of digestion of blood meals of various haematophagous arthropods as determined by the precipitin test. Bull. ent. Res., 44(3):445-450.

WELLMAN, F. C. (1905A) Case of relapsing fever, with remarks on its occurrence in the tropics and its relation to "tick fever". J. Trop. Med. (Hyg.), 8(7):97-99.

__________ (1905B) Relapsing fever: its occurrence in the tropics and its relation to "tick fever" in Africa. Am. Med., 10(4):151-155. (Reprint, 13 pp.).

__________ (1905C) Notes on the tropical diseases of the Angola highlands. N.Y. med. J., reprint, 49 pp. New York.

WELLMAN, F. C. (1906A) Human trypanosomiasis and spirochaetosis in Portuguese South-West Africa, with suggestions for preventing their spread in the colony. J. Hyg. Camb., 6(3):237-245.

———— (1906B) On a hemipterous insect which preys upon blood-sucking arthropods and which occasionally attacks mammals (man). J. Trop. Med. (Hyg.), 9(7):97-98.

———— (1906C) A note on the habits of *Ornithodoros moubata*. (Observations of two gravid females). *Ibid*, 9(14):215.

———— (1906D) On *Ornithodoros moubata* Murray, a disease-bearing African tick. Medicine, Detroit, 12(7):493-498.

———— (1907A) *Idem*. of 1906D. Am. Soc. Trop. Med., 2, reprint, 16 pp.

———— (1907B) Preliminary note on some bodies found in ticks - *Ornithodoros moubata* (Murray) fed on blood containing embryos of *Filaria perstans* (Manson). Brit. med. J. (2429), 2:142-143.

WENYON, C. M. (1926) Protozoology; a manual for medical men, veterinarians, and zoologists. 2 vols., 1563 pp., London.

WERNER, F. (1924) Wissenschaftliche ergebnisse der mit unterstützung der Akademie der Wissenschaften in Wien aus der Erbschaft treitl von F. Werner unterkommenen zoologischen expedition nach dem Anglo-Aegyptischen Sudan (Kordofan) 1914. XVIII. Schildkroten. Denkschr. Akad. Wiss. Wien, 99:263-273.

WERNER, H. (1906) Zur Epidemiologie des afrikanischen Recurrens. Arch. Schiffs-u. Tropenhyg., 10(24):776-781.

WEYER, F. (1955) Über eine Laboratoriumsinfektion mit Zeckenbissfieber. Z. Tropenmed. u. Parasit., 6(2):226-230.

WHITE, A. (1846) List of Annulosa (principally insects) found on the journey of Henry H. Methuen, Esq., pp. 307-318. In appendix of: H. H. Methuen, Life in the wilderness, or wanderings in South Africa. London.

WHITE, E. G. (1949) East African Veterinary Research Organization, annual report, 1948, 12 pp. [mimeographed].

WHITNALL, A. B. M. (1947) Gammexane. "Progress", suppl. to "Libertas", July, 4 pp. (reprint).

WHITNALL, A. B. M. & BRADFORD, B. (1945) Is there an arsenic-resistant tick? Survey of experimental work. Fmrs' Wkly. Bloemfontein, 69:1200-1201.

__________ (1947A) An arsenic-resistant tick and its control with "gammexane" dips. S. Afr. J. Sci., 43:325-326.

__________ (1947B) Idem. Bull. ent. Res., 38(2):353-372.

__________ (1949) Idem. Part II. Ibid, 40(2):207-226.

WHITNALL, A. B. M. & FENWICK, E. M. (1945A) Die bosluis wat arsenik weerstan. I. (In Afrikaans). Veld, 10:2 pp. (reprint).

__________ (1945B) Idem. II. (In Afrikaans). Ibid, 10(24):2pp. (reprint).

WHITNALL, A. B. M., BRADFORD, B., McHARDY, W., WHITEHEAD, G. B. & MEERHOLZ, F. (1948) Some observations on biological and chemical tests to determine the effectiveness of benzene hexachloride dip washes. S. Afr. Sci., 2(5): 112-113.

__________ (1949A) A benzene hexachloride-resistant tick. S. Afr. J. Sci., 45:113-114.

WHITNALL, A. B. M., BRADFORD, B., McHARDY, W., WHITEHEAD, G. B. & MEERHOLZ, F. (1949B) Some preliminary observations on the control of the bont tick Amblyomma hebraeum Koch. S. Afr. J. Sci., 45:115-116.

WHITNALL, A. B. M., McHARDY, W. M., WHITEHEAD, G. B. & MEERHOLZ, F. (1951) Some observations on the control of the bont tick, Amblyomma hebraeum Koch. Bull. ent. Res., 41(3): 577-591.

WHITNALL, A. B. M., THORBURN, J. A., McHARDY, W. M., WHITEHEAD, G. B. & MEERHOLZ, F. (1952) A BHC-Resistant Tick. Bull. ent. Res., 43(1):51-65.

WHITNALL, A. B. M., THORBURN, J. A., WHITEHEAD, G. B., McHARDY, W. M. & MEERHOLZ, F. (1949) A tick resistant to y-Benzene hexachloride. Nature, Lond. (4179), 164:956-957.

WHITNEY, D. M., ANIGSTEIN, L. & MICKS, D. W. (1950) Antibacterial activity of hydrolyzed red blood cells in vitro. Proc. Soc. exp. Biol. N.Y. (17902), 74:346-350.

WHITTICK, R. J. (1938) On a new tick from British Somaliland. Parasitology, 30(3):333-338.

WIGGELSWORTH, V. B. (1943) The fate of haemoglobin in Rhodnius prolixus (Hemiptera) and other blood-sucking arthropods. Proc. roy. Soc., Series B, 131:313-339.

———————— (1945) Transpiration through the cuticle of insects. J. exp. Biol., 21:97-114.

WILEY, A. J. (1953) Notes on animal diseases. XXV. Common ticks of livestock in Kenya. E. Afr. agric. J., 19(1):1-6.

WILLCOCKS, F. C. (1922) Acarina. In: A survey of more important economic insects and mites of Egypt. Tech. Bull. Sultanic agr. Soc., No. 1, pp. 427-432.

WILLIAMS, C. B. (1923) A short bio-climatic study in the Egyptian desert. Bull. tech. Sci. Serv., Min. Agric. Egypt, No. 29, 30 pp.

WILLIAMS, C. B. (1924A) Bio-climatic observations in the Egyptian desert in March, 1923. Bull. tech. Sci. Serv., Min. Agric. Egypt, No. 37.

______________ (1924B) A third bio-climatic study in the Egyptian desert. Ibid, No. 50, 40 pp.

WILSON, S. G. (1943) Cattle ticks and their control by dipping in Nyasaland. Nyasal. agric. quart. J., 3(4):15-24.

______________ (1944) Theileriasis in cattle in Northern Province, Nyasaland. Vet. Rec., 56(30):255-258.

______________ (1945) Some factors affecting the incidence of East Coast fever in Northern Province, Nyasaland. J. S. Afr. vet. med. Ass., 16(2):47-52.

______________ (1946) Seasonal occurrence of Ixodidae on cattle in Northern Province, Nyasaland. Parasitology, 37(3-4): 118-125.

______________ (1948A) Research. Rep. Vet. Dep. Uganda, 1947. pp. 13-20.

______________ (1948B) A method of assessing the acaricidal properties of DDT and "gammexane" preparations in field trials. Bull. ent. Res., 39(2):269-276.

______________ (1948C) The feeding of "gammexane" and DDT to bovines. Ibid, 39(3):423-434.

______________ (1949) The use of benzene hexachloride as a dispersable powder (gamatox 2) in cattle-dipping tanks. E. Afr. agric. J., 15(1):1-3.

______________ (1950A) Research. Rep. vet. Dep. Uganda, 1948, pp. 17-25.

______________ (1950B) A check-list and host-list of Ixodoidea found in Nyasaland, with descriptions and biological notes on some of the rhipicephalids. Bull. ent. Res., 41(2):415-428.

WILSON, S. G. (1950C) Research. Rep. vet. Dep. Uganda, 1949, pp. 16-29.

__________ (1950D) An experimental study of East Coast fever in Uganda. I. A study of the type of East Coast fever reactions produced when the number of infected ticks is controlled. Parasitology, 40(3-4):195-209.

__________ (1950E) Idem. II. The durability of immunity in East Coast fever. Ibid, 40(3-4):210-214.

__________ (1951A) Idem. III. A study of the East Coast fever reactions produced when infected ticks 31 days old are fed on susceptible calves in limited numbers over a period of 3 weeks. Ibid, 41(1-2):23-35.

__________ (1951B) Idem. IV. A study of the East Coast fever reactions produced when infected ticks 171 days old were fed on susceptible calves in limited numbers over a period of 3 weeks. Ibid, 41(1-2):36-45.

__________ (1953) A survey of the distribution of the tick vectors of East Coast fever in East and Central Africa. Proc. 15th Int. vet. Congr., 1:287-290.

__________ (1954) *Rhipicephalus hurti* n. sp. (Ixodidae) from Kenya game and domestic animals. Parasitology, 44(3-4):277-284.

WOODCOCK, H. M. (1920) Correspondence. Brit. Med. J. (28 Feb.). pp. 310-311.

WORSLEY, R. R. Le G. (1950) Benzene hexachloride as a cattle dip. E. Afr. agric. J., 15(3):127-145 (1949).

YAKIMOV (YAKIMOFF), W. L. (1917) Les tiques des animaux domestiques du Turkestan russe. Bull. Soc. Path. exot., 10(4): 298-301.

__________________ (1922) Contribution à l'étude des ixodidés de Russie. Ibid, 15(1):41-46.

__________________ (1923) A propos des Ixodidés de Russie. Parasitology, 15(3):253-255.

YAKIMOV, L. & KOHL-YAKIMOV, N. (1911) Etude des ixodidés de Russie. Arch. parasit., Paris, 14(3):416-425.

YAKOUB, K. (1945) Relapsing fever in Egypt. J. Egypt. med. Ass., 28(7):327-330.

YALVAC, S. (1939) Histologische Untersuchungen über die Entwicklung des Zeckenadultus in der Nymphe. Z. Morph. Okol. Tiere, 35(4):535-585.

YAMASHITA, J. (1939) Studies of ticks found in Manchoukuo. I. On two species of ticks from cattle at the Yamuyingtzu stock-farm, near Wangyehmiao, Inner Mongolia, Manchoukuo. (In Japanese, English summary). Jap. J. vet. Sci., 1 (6):602-609.

YASAROL, S. (1954) Toxophene in cattle tick control. (In Turkish, French summary). Türk vet. Hekim. dern. Derg., 24:1756-1766.

YORKE, W. & BLACKLOCK, B. (1915) Notes on certain animal parasites of domestic stock in Sierra Leone. (Fourth Report of the Thirty-second Expedition of the Liverpool School of Tropical Medicine 1914-15). Ann. trop. Med. Parasit., 9(3):413-420.

YOUNG, W. A., FARR, A. G. & McKENDRICK, A. J. (1946) Relapsing fever in the Lake Province of Tanganyika, with an account of a case in an eight day old infant. E. Afr. med. J., 23(11):345-347.

ZANON, V. (1919) Invasione di Leptodemus minutus Jak. a Bengasi nel maggio 1919. Agricoltura colon., 16(2):445-450, 17(1):22-30.

ZAPHIRO, D. (1949) Notes on Loelli Game. Sudan Wild Life, 1(2): 6-17.

ZASUKHIN, D. N. (1932) Nuttallia minor n. sp. a new blood parasite of horses. Preliminary report. (In Russian, English summary). Rev. Microbiol., Saratov, 9(3): 181-185.

———— (1935) Ticks and the problems of the control of the piroplasmosis of horses. 2d ed. (In Russian). 159 pp., Saratov, Sarat. Gos. Izd.

ZAVATTARI, E. (1930) Note di parassitologia Cirenaica. Boll. Soc. ital. Med. e Ig. colon., (13), 11 pp. (reprint).

———— (1932) Ornithodoros e febbri ricorrenti nella Libia. G. ital. Mal. esot., 5(12):317-322.

———— (1933) Ancora: Ornithodoros e febbri ricorrenti nella Libia. Ibid, 6(2):38-48.

———— (1934) Sulla asserita presenza dell'Ornithodoros moubata in Libia e sull'asserita conseguente presenza in Libia della febbre ricorrente de Spirochaeta duttoni. Arch. ital. Sci. med. colon., 15(5):347-352.

ZHMAEVA, Z. M., PCHELKINA, A. A., MISHCHENKO, N. K. & KARULIN, B. E. (1955) The epidemiological importance of ectoparasites of birds in a natural focus of Q fever in the south of Central Asia. (In Russian). C. R. Acad. Sci. U.R.S.S., 101(2):387-389.

ZIEMANN, H. (1905) Beitrag zur Verbreitung der blutsaugenden Tiere in West-Afrika. Arch. Schiffs-u. Tropenhyg., 9(3):114-119

ZIEMANN, H. (1912A) Zur Verbreitung der blutsaugenden Tiere in Kamerun. Ibid, 16(2):53-58.

__________ (1912B) Zeckenlarven an Menschen in den Tropen. Ibid, 16(6):196.

ZOLOTAREV, N. A. (1934) Contribution to the knowledge of the species and geographical distribution of ticks in Daghestan. (In Russian). Mag. Parasit., Leningrad, (4):217-227.

ZOTOVA, A. A. & BOLDITZINA, K. S. (1943) An experiment in infecting ticks with brucellosis under laboratory conditions. (In Russian). Izv. kazan. Fil. Akad. Nauk SSSR, ser. a, (2):44-49.

ZUELZER, M. (1920A) Beiträge zur Biologie von Argas persicus Wldh. Arb. ReichsgesundhAmt., 52(1):163-183.

__________ (1920B) Biologische Untersuchungen an Zecken. Z. ImmunForsch., 30(2):183-201.

__________ (1921) Ueber Entwicklung und Verwandtshaftsbeziehungen von Argas persicus. Verh. dtsch. zool. Ges. (26. Jahreversamml., Göttingen), pp. 67-69.

ZUMPT, F. (1940) Zur Kenntnis der Ausserafrikanischen Rhipicephalus-arten. II. Vorstudie zu einer Revision der Gattung Rhipicephalus Koch. Z. Parasitenk., 11(5):669-678.

__________ (1942A) Die Gefleckten Rhipicephalus Arten. III. Idem. Ibid, 12(4):433-443.

__________ (1942B) Zur Kenntnis Afrikanischer Rhipicephalus-arten. V. Idem. Ibid, 12(4):479-500.

__________ (1942C) Rhipicephalus appendiculatus Neum. und verwandte Arten. VI. Idem. Ibid, 12(5):538-551.

__________ (1943A) Rhipicephalus simus Koch und verwandte Arten. VII. Idem. Ibid, 13(1):1-24.

ZUMPT, F. (1943B) Rhipicephalus aurantiacus Neumann und ähnliche Arten. VIII. Idem. Ibid, 13(1):102-117.

——— (1949) Das Hallersche Organ der Zecken und seine systematische Bedeutung. In A. Remane and A. Thienemann, Verh. dtsch. Zool., Kiel 1948, pp. 427-431. Leipzig.

——— (1950A) Preliminary study to a revision of the genus Rhipicephalus Koch. Docum. Mocambique, (60):57-125 (1949).

——— (1950B) Records of some parasitic Acarina from Madagascar, with description of a new Chiropotonyssus (Acarina, Parasitiformes). Mem. Inst. sci. Madagascar, Ser. A, 4(1):165-173.

——— (1950C) Ectoparasites of bats from the Sterkfontein caves, Transvaal. J. Ent. Soc. S. Afr., 13:87-98.

——— (1951) Phylogenie der Zecken und "Natürliches System." Z. Parasitenk., 15:87-101.

——— (1952) The ticks of sea birds. Australian National Antarctic Research Expedition Report, Ser. B, 1:12-30.

ZUMPT, F. & GLAJCHEN, D. (1950) Tick paralysis in man. S. Afr. med. J., 24:1092-1094.

☆ U. S. GOVERNMENT PRINTING OFFICE 1956 O—390800