









KONINKLIJK MUSEUM VOOR MIDDEN-AFRIKA — TERVUREN, BELGIË
ANNALEN — REEKS IN-8° — ZOOLOGISCHE WETENSCHAPPEN — n° 145, 1966



IXODID TICKS
(ACARINA, IXODIDAE)
OF
CENTRAL AFRICA

VOLUME I

by

Alena ELBL

and

George ANASTOS

MUSEE ROYAL DE L'AFRIQUE CENTRALE — TERVUREN, BELGIQUE
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VOLUME I

*To Henry and Heda ELBL,
Katharine KOSMAK and
Gustave MATHYS.*



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CENTRAL AFRICA

VOLUME I

GENERAL INTRODUCTION

GENUS *AMBLYOMMA* KOCH, 1844

by

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Sorti de presse en mars 1966.

D/1966/0254/2

ABSTRACT

The present study consists of three parallel investigations: (1) survey and critical review of the world-wide literature dealing with the ixodid ticks of Central Africa in general and of the Congo, Rwanda and Burundi in particular, (2) examination and identification of available ixodid tick materials previously collected in Central Africa (Congo, Rwanda and Burundi), comprising some 70,000 specimens located primarily in the collections of the Musée Royal de l'Afrique Centrale, Tervuren, Belgium, and the Institut des Parcs Nationaux du Congo et du Rwanda, Bruxelles, Belgium; and (3) collection and identification of new materials coupled with field and laboratory observations on the biology and ecology of some of the tick species occurring in the Kivu Province of the Congo and in the Republic of Rwanda.

*Up to the present time, 78 species of ixodid ticks belonging to nine genera (Amblyomma — 12 species, Aponomma — three species, Boophilus — two species, Dermacentor — two species, Haemaphysalis — five species, Hyalomma — five species, Ixodes — 23 species, Rhipicentor — one species, Rhipicephalus — 25 species), have been reported from Central Africa (Congo, Rwanda and Burundi). Of this, the presence of 75 species in this area is validated by available materials and new collections. The geographical distribution, as well as the list of affected hosts vary with each species. The species *Amblyomma cohaerens*, *A. splendidum*, *A. variegatum*, *Boophilus decoloratus*, *Haemaphysalis l. leachii*, *Ixodes muniensis*, *I. pseudorasus*, *Rhipicephalus appendiculatus*, *Rh. compositus*, *Rh. longus*, *Rh. s. sanguineus*, and *Rh. s. simus* are quantitatively outstanding. Most of these species occur on a variety of domestic and wild animals and are capable of causing severe economic losses to the livestock industry as well as transmitting agents of human diseases.*

*Field collections and ectoparasite surveys of small mammals show that while numerous insectivores and rodents serve as hosts to the immature stages of the genera *Amblyomma*, *Ixodes* and *Rhipicephalus*, the insectivores are generally more heavily infested. This is true in the savannah as well as in the forest habitats.*

The periods of activity vary with each species, however, it is apparent that the favorable, equatorial climate allows a quick succession of generations.

The results of these studies are presented in such a way that each genus is treated as a discrete unit in which each species is dealt with from the viewpoint of taxonomy, distribution and hosts, biology, relationship to disease, diagnosis, description and illustration. The distribution of each of the species in the Congo, Rwanda and Burundi is plotted individually on maps, and keys to the identification of the adults of each species are presented in the treatment of each genus. Immature stages are listed but not treated at this time.

P R E F A C E

The literature data and available materials pertaining to the ixodid ticks of Central Africa in general, and to the Congo, Rwanda and Burundi in particular, are relatively voluminous. Moreover, new records and materials were added in the course of the present study. Because of this, the work is divided into four independent volumes. Volume I comprises the introductory passages (historical review, materials and methods, phytogeographical and bioclimatic characterization of the locality) pertaining to the entire study as well as a detailed discussion of the genus Amblyomma KOCH, 1844. Volume II comprises the genus Ixodes LATREILLE, 1795 and volume III the genus Rhipicephalus KOCH, 1844. The genera Aponomma, Boophilus, Dermacentor, Haemaphysalis, Hyalomma and Rhipicentor form volume IV along with the host and distribution lists and bibliography pertaining to all the nine genera discussed.

It is with distinct pleasure that we express our sincere gratitude to our friends, colleagues and mentors Dr. Harry HOOGSTRAAL (U.S. NAMRU N. 3, Cairo, United Arab Republic), Dr. Gertrud THEILER (Onderstepoort Veterinary Laboratories, Onderstepoort, South Africa), and Miss Jane WALKER (E.A.V.R.O. Kikuyu, Kenya) for their help in securing of specimens, provision of facilities, willingness to engage in scientific discussion and constant encouragement.

The field studies comprised in this work could not have been carried out without the generous help of Dr. Urs H. RAHM, Director General, Mr. Antoine CHRISTIAENSEN, botanist, BONIFASI, MUPENDA, ROMANO, BURASHENGWA, KIBOKO and FRANÇOIS, technicians, trappers and taxodermists, all of I.R.S.A.C., Lwiro, Kivu, Congo, and the gracious cooperation of the gouvernement of the Republic of the Congo and the United Nations Command, Bukavu, Kivu, Congo.

Various pilots of the O.N.U.C. command were responsible for the transportation of specimens from Bukavu to Léopoldville and Col. Averell HOLMAN, U.S.A.F. for the transportation of specimens from the Congo to the United States.

Special thanks are given to Dr. Pierre L.G. BENOIT, Chief of the Invertebrate Section of the Musée Royal de l'Afrique Centrale, Tervuren, Belgium, for his whole-hearted cooperation and the many kindnesses extended to us during our collection studies at Tervuren, and for his generous help in the final editing of the manuscript. Mr. and Mrs. VANDERLINDEN and Mr. Tony DUJARDIN were also most helpful in providing technical assistance at the Museum.

Dr. G. Owen EVANS of the British Museum (Natural History) rendered a great service by making the various type specimens deposited at the Museum available for study.

Our sincere thanks are given to Mrs. Allie Mae BROWN, Mrs. Ann HAIKALIS and Mrs. Anita SCHINDLER and to Messrs. Marty MEUSCHKE and Richard THACKER for technical assistance in the preparation of the manuscript.

We are indebted to the Musée Royal de l'Afrique Centrale for the final printing in book form of this work.

The investigation was supported by the U.S. Army Medical Research and Development Command, Department of the Army, under research contract No. DA-49-007-MD-981.

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INTRODUCTION

“ O Jordens upphöjda anlete, må ett rop för dig bli hört, du som sist natt vara lovsånger ! ”

St. JOHN PERSE / DAG HAMMARSKJÖLD
“ Chronique ”

T.S. ELIOT has spoken of our era as one wherein we have forsaken wisdom for knowledge and knowledge for information. All the fields of science are open to this charge. And yet, the very essence of science is the organization of available information in order to acquire insight and knowledge, and the correlation of knowledge to provide a basis for wisdom. Conversely, new information is acquired through judicial and wise application of established knowledge. Thus, knowledge is limited by the quality and quantity of available data and the wisdom and lucidity with which this data is evaluated and utilized. Thus, all three — information, knowledge and wisdom — share equally in man's progressive mastery of history and the world. For to survive, man must indeed master his world, but to do it, he must know it.

In the field of acarology our efforts to know the world are often tempered with pragmatic considerations. This is primarily applicable in the case of the ticks (*Acarina. Ixodoidea*) which are the worst of the known pests of domestic and wild animals, and, next to the mosquitoes, the worst of the known pests of man. Many tick species serve as vectors and natural reservoirs of the agents of bacterial, spirochaetal, viral, rickettsial and protozoan diseases. Frequently, they transmit these disease agents from animal to animal, and given the opportunity, from animal to man. Occasionally, tick bites evoke an often fatal toxic reaction known as tick paralysis. Whenever a mass infestation occurs, ticks cause serious losses among animals due to loss of blood and the infliction of large wounds that are difficult to heal and are, therefore, open to secondary infection. Because of their great importance, ticks have been the subject of many studies throughout the world for many years. More recently, this is especially true of the economically important tick species in the underdeveloped areas of the world where control measures are difficult to apply and diseases of “ unknown ” etiology appear to be abundant. The continent of Africa represents one of such areas. Thus, it is not surprising that in any serious study of African ticks one en-

counters a vast amount of available data. Unfortunately, these data, even when organized in an orderly fashion, fail to yield precise and definite working knowledge of many of the important species. Significant gaps exist not only in our knowledge of the life cycles, ecology, genetics and relationship to disease, but also in our knowledge of the distribution and host ranges and the taxonomy of the African tick species. Only two comprehensive studies of the African *Ixodoidea* have been published up to the present time. These are : *African Ixodoidea*, Volume I, *Ticks of the Sudan* by HOOGSTRAAL (1956) and *Arthropod Parasites of Vertebrates in Africa South of the Sahara*, Volume II, *Ixodoidea* by THEILER (1962). The first work, though an invaluable source of well organized and valid information, deals only with the tick species occurring in the Sudan. The second work, while dealing with all the tick species reported up to the present time from Africa, limits itself to a critical listing of the known synonymy and of the previously reported distribution and host ranges of each species, and to a few occasional remarks on the ecology and biology of some of the species. Various other works of lesser depth and scope contribute substantially but not significantly to the total picture of the African *Ixodoidea*. This is especially true in regard to the tick species occurring in Central Africa, particularly in the Congolese and Rwandaise Republics and in the Kingdom of Burundi.

The purpose of this study is, therefore, an attempt to alleviate somewhat this situation by :

1. the organization and objective, critical evaluation of available information and materials concerning the ixodid ticks of Central Africa in general and of the Congo, Rwanda and Burundi in particular;
2. the expansion and supplementation of the available data through additional collections and field and laboratory observations carried out in the Congo and Rwanda;
3. the resulting formation of a basis for future studies dealing primarily with the biology, relationship to disease and modern systematical treatment of the tick species occurring in these areas.

In scope, this study consists of three parallel investigations :

1. survey and critical review of the world-wide literature dealing with the ticks of Central Africa (Congo, Rwanda and Burundi) in particular and the ticks of Africa in general;
2. survey, examination and identification of available ixodid tick materials previously collected in Central Africa (Congo, Rwanda and Burundi) comprising some 70,000 specimens;
3. collection and identification of new materials coupled with field and laboratory observations on the biology and ecology of some of the tick species occurring in the Kivu Province of the Congo and in the Republic of Rwanda.

The results of these investigations are presented in such a manner that each genus of ticks represents a definite unit in which each species is dealt with from the

viewpoint of taxonomy, distribution and hosts, biology (including ecology), relationship to disease, diagnosis, description and illustration. Altogether 78 species of ixodid ticks belonging to nine genera have been reported from Central Africa (Congo, Rwanda and Burundi) to date. Of this, the presence of 75 species in these areas is validated by available materials. The distribution of each of the species in the Congo, Rwanda and Burundi is plotted individually on a special distribution map. Keys to the identification of adults of each species are presented in the treatment of each genus. Immature stages are listed but not treated at this time and will be the subject of a future study. Host lists and distribution lists for Congo, Rwanda and Burundi are included as well as a comprehensive bibliography.

The present report is intended for the use of the student, the practical worker and the professional alike. Above all, it should serve as a basis for future investigations dealing with the basic problems of tick biology, within the rapidly changing ecological conditions of Central Africa, investigations, which — it is hoped — will lead to a better understanding of the role of ticks in disease transmission and to the development of effective tick control or eradication measures facily applicable under difficult conditions. The importance of these measures to the general development of agriculture and the improvement of the public health picture in Central Africa needs no emphasis and it is therefore desirable that strong efforts be made to achieve this end.



HISTORICAL REVIEW OF THE LITERATURE

The study of ticks (*Acarina, Ixodoidea*) in Central Africa (Congo, Rwanda and Burundi) is a historically recent undertaking and belongs almost fully to the twentieth century. Relatively few references, dealing with ticks in connection with the locality designation "Congo", have been published before the year 1900. Generally, these references consist of, or are included in, general treatises on ticks and in the various published records of early explorers. Thus, LIVINGSTONE (1875), mentions the finding, in 1871, of the argasid tick, *Ornithodoros moubata* at Nyangwe in the present day Kivu Province of the Congo, while NEUMANN (1897) describes a new species of ixodid ticks, *Dermacentor circumguttatus*, on the basis of specimens collected in the Congo (Haut-Ubangi), as a part of his comprehensive "Révision de la Famille Ixodidés". Another type of early work is MARTIN's (1895) "Sur une Nouvelle Espèce d'Ixodidae du Congo, *Amblyomma quantini*", a description of a single species. Each one of these three types of early references serves, in a way, as a starting point of a separate but parallel group of investigations. These chronologically parallel groups of studies will be described as separate sections on the basis of the following classification :

- a) descriptions or redescriptions of single tick species, or of stages of a single species, including studies of the distribution, ecology or biology of a single species;
- b) studies effected in connection with arthropod-borne diseases of man and domestic animals;
- c) lists and check-lists of species occurring or collected in the various areas of the Congo, Rwanda and Burundi in particular and in Central Africa in general including, occasionally, some taxonomic evaluation, keys for the determination of genera and species, as well as bionomic and physiological observations.

Studies Concerning Individual Species

The group of studies treating individual species, although numerically smaller than either one of the other two categories, forms nevertheless an important unit in the knowledge of Central African ticks and serves as a source of basic information utilized in the more pragmatic works in medical acarology and the more comprehensive faunistic surveys and checklists.

The works comprising this group range from the description of *Amblyomma quantini* of MARTIN (1895) cited above to the description of a new species of *Ixodes* from bats found in the Parc National de la Garamba in the northeastern part of the Congo published by KOHLS and CLIFFORD (1961). Most of the earlier works deal with *Ornithodoros moubata*, discussing its geographical distribution (MERRIMAN, 1911; BEQUAERT, 1919; GHESQUIÈRE, 1922; RODHAIN, 1922c; VAN SACEGHEM, 1923; SCHWETZ, 1924; VAN DEN BRANDEN, 1924; FLAMAND, 1928; SCHOUTEDEN, 1928), and its biology (NEWSTEAD, 1906; PEARSON, 1917; RODHAIN, 1919 b; 1920; 1922 a). Several later papers deal also with the laboratory rearing and field control of this species in the Congo (HIMPE and PIERQUIN, 1951; PIERQUIN and NIEMEGERES, 1953). These studies are closely related to the investigations of relapsing fever (*Borrelia duttoni*) carried out during the same period (1900-1930) in the Congo and in Central, East and South Africa.

From the late twenties and early thirties until the present time the emphasis has been gradually transferred, in this group, to the study of ixodid ticks, partially because of their involvement in the maintenance and transmission of various diseases of man and of domestic animals, and partially because of a generally increased emphasis on basic research. Significant contributions in this category are the works of SCHOUTEDEN (1927, 1950), SANTOS DIAS (1951 b, d), THEILER and ROBINSON (1953 a, b), WILSON (1954), ARTHUR (1956 a, b; 1957 a, b, c, d; 1958 c; 1961 b), THEILER, WALKER and WILEY (1956), WALKER (1956), ARTHUR and BURROW (1957) all of which, save two, are not directly concerned with the study of ticks from the Congo, but all of which describe and discuss species whose distribution range reaches into or includes Congo, Rwanda and Burundi. Only the works of SCHOUTEDEN (1927, 1950) and ARTHUR (1956 a, 1961 b) deal with species occurring in the Congo directly.

Studies in Medical Acarology

The suspected or established medical importance of any group of arthropods, including the acarines, has been the leading stimulus behind the extensive investigations to which these organisms have been subjected in the last seventy years throughout the world. It is not surprising, therefore, that in the study of ticks from the Congo, Rwanda and Burundi, works dealing with species of medical importance, their distribution, hosts, biology and actual involvement in the transmission or maintenance in nature of disease, constitute the major part of all the tick studies in these three areas.

The majority of the earlier works, again, concerns the study of relapsing fever (*Borrelia duttoni*) and of its vector *Ornithodoros moubata*. The first and virtually the most important work of this series is that of DUTTON and TODD (1905 a, b) reporting the results of their observations on relapsing fever in the Congo which show that the disease is caused by a spirochaete occurring in the blood and is transmitted by the bite of the tick *O. moubata* which serves as an intermediate host of the spirochaete

and can transmit it to its progeny as well. Following this pioneering study, several works have appeared, dealing also, with the etiology of relapsing fever and its treatment (RODHAIN, PONS, VAN DEN BRANDEN and BEQUAERT, 1913; DE RUDDERE, 1917; VAN HOOF, 1917; RODHAIN, 1919). The three latter works are the direct results of observations made among the Belgian Colonial Armies during their march through the northern parts of German East Africa (now Rwanda and Burundi). The soldiers were apparently very susceptible while the local natives exhibited a high degree of immunity. Many other studies on relapsing fever have appeared since the end of the First World War. These include studies on its vector *O. moubata* (TODD, 1919; RODHAIN, 1922), general etiological observations (VAN DEN BRANDEN and VAN HOOF, 1922; OLIVIER, 1923), control and prevention of the disease (VAN HOOF, 1928), the natural infection of wild animals with spirochaetes (SCHWETZ and COLLART, 1929), isolation of various strains of *S. duttoni* (DUBOIS, 1931; 1949) and the discovery of hidden sources of *S. duttoni* in the Congo (SCHWETZ, 1942; 1943).

The increasing development of agriculture including cattle production in the Congo immediately following World War I, as well as the beginning of the development of a network of veterinary services in the 1930's, has resulted in the publication of various studies dealing with ixodid ticks, their role as pests of domestic animals and vectors of disease affecting domestic animals and their control. The first of this series is the work of VAN SACEGHEM (1914) a military veterinarian in service of the Colony, who reviewed the general role of ticks in disease transmission, the biology of the species involved and control measures against them. Although this pilot work was designed for use in the Belgian Congo its information is based mostly on observations made in South Africa. In later works VAN SACEGHEM (1918) reported the occurrence of heartwater fever (*Rickettsia ruminantium*) in the Bas-Congo District (Léopoldville Province) but felt that ticks were not the vectors. The first report of East Coast Fever (*Theileria parva*) from the Congo area is that of DE GREEF (1919) who observed it in Burundi (Kitega) among tick infested animals concentrated along the trade routes. The tick species most frequent on the cattle at that time belonged to the genera *Rhipicephalus*, *Hyalomma*, *Amblyomma*, *Boophilus* and *Haemaphysalis*. Many other similar works dealing with various piroplasmoses and spirochetoses and their epizooties appeared in the following years (VAN SACEGHEM, 1925; SERAGLIA, 1932; SCHWETZ, 1933 b, 1934; GILLAIN, 1935; RODHAIN, 1936). In 1936, VAN SLYPE and BOUVIER reported for the first time the occurrence of Boutonneuse fever (*Rickettsia conori*) in the regions of Luputa (Kabinda District, Kasai Province) and Port-Francqui (Kasai District, Kasai Province) in connection with its vector, *Rhipicephalus sanguineus*.

In more recent times tick-borne Q fever has been discovered in Rwanda and Burundi among domestic and wild animals (GIROUD and JADIN, 1950; JADIN and GIROUD, 1950; JADIN and GIROUD, 1951). Later, new records of bovine theileriosis as well as of Boutonneuse-like rickettsiosis were reported from Rwanda and Burundi (SCHOENAERS, 1951 a; JADIN and PANIER, 1953), and a new type of virus affecting

man — the Bashi virus — was isolated from man and from the ticks *Ornithodoros moubata* and *Haemaphysalis leachii leachii* in the Kivu Province of the Congo (GIROUD and JADIN, 1954; 1955). Most recently, the tick *Amblyomma variegatum* has been reported as the suspected vector of contagious dermatosis of ruminants in the Congo (MAEMERICKX, 1961).

Lists of Species, Regional Surveys and Comprehensive Studies

The survey studies of ticks in the Congo compiled since 1900 follow a faunistic pattern and consist primarily of species either collected by the author(s) or found in various musea or reported in literature. Frequently, these lists are generalized and do not give distribution or host data or both. Occasionally, however, these works give not only the host and distribution but also record some ecological and biological observations on the species listed. The generalized lists range from MASSEY's "Some ticks of Central Africa" (1908) to MOREL and FINELLE's "Les Tiques des Animaux domestiques du Centrafrique" (1961) and include many works of some interest but little value (e. g. GAMBLE, 1914, MARCQ, 1924, SEYDEL, 1925) as well as many important and valuable contributions e. g. the lists of Congo tick materials available at the Royal Museum of Natural History in Brussels and at the Royal Museum for Central Africa in Tervuren, compiled by SCHWETZ (1927 a, b) which represent the first attempt to give a complete list of the ticks of the Congo.

Other types of checklists of species are the reports of the works of various expeditions, or concern collections made during a particular voyage (SCHOUTEDEN, 1929; BEQUAERT, 1930 a, b; SCHOENAERS, 1951 b) as well as species checklists made in the course of regional faunistic studies (GHESQUIÈRE, 1919 — Katanga; 1921 b — Lower Congo; SCHWETZ, 1927 c, d — Katanga; 1932 — Orientale Province; 1933 — Parc National Albert, Kivu Province; WANSON, RICHARD and TOUBAC, 1947 — Léopoldville; COOREMAN, 1948 — Parc National Albert, Kivu Province; FAIN, 1949 — Léopoldville Province; SANTOS DIAS, 1954 b — Rwanda, Burundi; VAN VAERENBERGH, 1954 — Rwanda, Burundi; CLIFFORD and ANASTOS, 1962 — Parc National Upemba, Katanga Province; 1965 — Parc National Garamba, Orientale Province).

Several studies comprise checklists of tick species found on particular hosts (ROUBAUD, 1916 — Suidae; ROUBAUD and VAN SACEGHEM, 1916 — cattle; GHESQUIÈRE, 1919; 1921 a, b — birds).

The most important part of this group of works, however, consists of the few available comprehensive but not all inclusive studies on ticks of the Congo, Rwanda and Burundi. Chronologically first in this series is the report of NEWSTEAD, DUTTON and TODD (1907) on their expedition to the Congo Free State 1903-1905. In this report all localities are listed along with dates of visits and a general résumé of the climatic conditions and occasional observation on the biology are included. Fourteen

species of ticks have been collected and are listed in this paper along with their hosts, place of collection, month of collection and the collector's name. Chronologically second, but of greater importance, is the work of NUTALL and WARBURTON (1916 a, b) consisting of a general account of the ticks of the Congo and the diseases they convey. This study includes a general discussion of the classification of ticks and their biology as well as the special biology of Congo ticks and their relation to disease, methods of collection, rearing and study of ticks, illustrations of the 29 species occurring in the Congo and their hosts. Also included is a brief review of their host preferences, the life cycles of ten species and the involvement of ten species in disease transmission. One of the best works of its kind, this study, however, fails to indicate the distribution ranges of the species discussed. A third study "Synopsis des tiques du Congo Belge", published by BEQUAERT in 1931, lists 45 species and five varieties of ticks belonging to 12 genera (two argasid and ten ixodid), gives keys for the determination of males and females of every species known in the Congo at that time, lists distribution, hosts and collecting data for each species, reviews critically the taxonomy of the species whenever necessary and includes a bibliography of previous works dealing with the ticks of the Congo. The lack of illustrations and the absence of biological data as well as a certain confusion in the determination of localities, however, reduce somewhat the value of this work. Chronologically fourth, and the first of the modern studies, is the tick survey checklist of ticks recorded from the Congo, Rwanda and Burundi, Angola and Northern Rhodesia, compiled by THEILER and ROBINSON (1954). This excellent work is based on the records of SCHWETZ (1927 a, b, c, d), BEQUAERT (1930 a, b; 1931), and tick specimens sent to the Onderstepoort Laboratory by H.R.F. COLBACK and Dr. WANSON. Older records are included but do not have much practical value in regard to localities. Records of FIASSON (1943), ROUSSELOT (1951) from French Africa, SOUSA DIAS (1950) from Angola and the tick survey for Northern Rhodesia are included to show the distribution of each species and to estimate the factors influencing this distribution. The list is set up to give the species, locality and author. A selected bibliography is included as well as a brief critical discussion of the distribution of the more common species of ticks. The list includes the distribution records of 70 species of ixodids and seven species of argasids reported from the Congo. However, the localities are not listed according to districts or provinces and no information is given concerning the hosts. The most recent in this group of works are the studies of PIERQUIN and NIEMEGERES (1957, 1958) and the supplementary work of PIERQUIN (1960). The first of the three is a list of geographical distribution of ticks in the Congo, Rwanda and Burundi, consisting of a non-critical compilation of all available published information concerning the locality and hosts of all the species of ticks reported from the three states. For the first time all the reported localities have been associated with the hosts and an effort was made to determine the location of each locality within a province. The work lists 61 species and follows the opinions of HOOGSTRAAL and THEILER in matters of taxonomy and identification. The second work, PIERQUIN and NIEMEGERES (1958), is a sequel to the distribution and host list and consists of keys for the determination

of the males and the females of the 61 species of ticks listed in the preceding work. A short diagnostic description of both sexes of each species is included along with a glossary of the terminology employed. Illustrations of the distinguishing characters of the various tick species are included, but they are generally poor in quality. The third and supplementary work, PIERQUIN (1960), examines literature pertaining to Congo, Rwanda and Burundi ticks published since the compilation of the original distribution and host list (1958) and presents a revised checklist, and also new distribution and host records based on the determination of specimens collected in various parts of the Congo, Rwanda and Burundi by H.R.F. COLBACK. New literature data for each genus is discussed briefly. The new list includes two genera and four species of the Argasidae and nine genera and 63 species of the Ixodidae. Of these, 62 species are listed as occurring in the Congo and 29 as occurring in Rwanda and Burundi. Twenty-four species are common to all three areas. All three works are an important source of reference for this and any future study of ticks in Central Africa.

MATERIALS AND METHODS

Literature Survey

SELECTION OF REFERENCES. The original selection of references was based on the extensive and almost complete bibliography of African *Ixodoidea* presented in HOOGSTRAAL's *Ticks of the Sudan*, 1956 : 912-1101. The pertinent references selected were then checked against the bibliography of the ticks of the Congo included in the checklist compiled by PIERQUIN and NIEMEGEERS, 1958 : 43-48. Finally, the bibliography was completed by addition of references listed by THEILER, in the *Arthropod Parasites of Vertebrates in Africa South of the Sahara*, 1962 : 248-255 and of the latest available works of various authors pertaining to the subject. The final list comprises some 500 references.

The selection of references had a dual purpose. In the first place, it was directed toward the compilation of the most complete list possible of references dealing specifically with the ixodid ticks of the Congo, Rwanda and Burundi. In the second place, it was directed toward the compilation of a working list of references dealing broadly and comprehensively with ixodid ticks of Africa in general and with ticks of Central Africa other than the Congo in particular. A special care was given to the selection of references dealing with the pathogenic and economic importance of ticks in Africa.

PRESENTATION OF REFERENCES IN TEXT, TABLES AND MAPS. Direct and paraphrased reference quotations in the text are accompanied by the author's name and the date of publication, except in the literature section on "Distribution and Hosts, Congo, Rwanda and Burundi", where this information is given in the accompanying tables (Appendix A). In the literature section on "Distribution and Host, Africa" only the distribution data is supported by the accompanying tables (Appendix C). The host data in this section, unless otherwise stated, is taken from THEILER, 1962.

In the tables, literature data is cited by the author or authors, the date of publication and the pages involved. There is a separate table for each species which lists the name of the species, the distribution, the host, the author(s), the date of publication and the pertinent pages, as well as the number of specimens and the date of collection whenever these are given. Materials cited in literature under one species and subsequently identified as another species are cited under the species to which they actually belong.

Literature data on the distribution of each species in the Congo, Rwanda and Burundi is entered on the distribution map of each species whenever this data is considered valid and whenever the geographical coordinates of the localities listed could be ascertained.

Phytogeographic and bioclimatic information, unless stated otherwise in the text is based on the *Atlas General du Congo Belge*, Institut Royal Colonial, Bruxelles, 1954, the *Life — Pictorial Atlas of the World*, Time Inc., 1961 and DE SAEGER, 1956, *Exploration du Parc National de la Garamba*. Mission H. DE SAEGER (1949-1952), Fasc. 5, Entomologie-Renseignements éco-biologiques.

Examination of Collection Materials

LIST OF COLLECTIONS. The materials reviewed in the course of this study consist approximately of 70,000 specimens belonging primarily to the collections of the Musée Royal de l'Afrique Centrale, Tervuren, Belgium, the Institut des Parcs Nationaux du Congo et du Rwanda, Brussels, Belgium, and the collection A. ELBL made in the Congo and Rwanda in 1962. Supplementary materials, as well as type materials were examined at the Onderstepoort Veterinary Research Laboratory, Onderstepoort, South Africa (Theiler Collection); the East African Veterinary Research Organization, Kikuyu, Kenya (Walker Collection); the United States Naval Medical Research Unit No. 3, Cairo, Egypt (Hoogstraal Collection) and the British Museum (Natural History), London, England. Some materials were obtained on loan from the Paris Museum, Paris, France; the Museum of Comparative Zoology, Cambridge, Massachusetts, U.S.A. and the Rocky Mountain Laboratory, Hamilton, Montana, U.S.A. A limited number of specimens was available in the collection of the Department of Zoology, University of Maryland, College Park, Maryland, U.S.A.

EXAMINATION AND RECORDING OF MATERIALS. All of the specimens were examined with the aid of a Leitz binocular microscope with a twinlight illumination. Whenever necessary, comparisons were made with type materials. Information pertaining to each unit of material, usually a vial with specimens representing a single collection, was then recorded on a special form giving the collecting locality (province, district, place name), the host, the abbreviated code for the museum or institution, the accession number, the date of collection, the number, sex or developmental stage of the specimens (♂, ♀, N, L), and the name of the collector.

The abbreviated code of the names of musea and institutions used in the tables is as follows :

T = Musée Royal de l'Afrique Centrale, Tervuren, Belgium.

INCR = Institut des Parcs Nationaux du Congo et du Rwanda, Bruxelles, Belgium.

O = Onderstepoort Veterinary Research Laboratory, Onderstepoort, South Africa.

EAVRO = East African Veterinary Research Organization, Kikuyu, Kenya.

NAMRU 3 = U.S. Naval Medical Research Unit No. 3, Cairo, Egypt, U.A.R.

BM(NH) = British Museum (Natural History), London, England.

PM = Paris Museum, Paris, France.

MCZ = Museum of Comparative Zoology, Cambridge, Massachusetts, U.S.A.

RML = Rocky Mountain Laboratory, Hamilton, Montana, U.S.A.

UMd = University of Maryland, Department of Zoology, College Park, Maryland, U.S.A.

All provinces, districts and localities are listed alphabetically in each table and multiple records for a single locality are arranged chronologically. Records giving only Congo or Rwanda or Burundi or the ex-protectorate of Ruanda-Urundi as locality, as well as records giving only locality names, of which the exact geographical location within Congo, Rwanda or Burundi could not be determined, are listed in alphabetical order before the first province listing in each table. The spelling of locality names follows that given in the *Liste des localités du Congo Belge qui figurent à la carte à l'échelle du 1/3,000,000^e*, Bruxelles, 1959. The exact geographic coordinates of each locality whenever determined are entered into the table under the name of the locality. The internal, territorial divisions (provinces and districts) listed are those presented on the 1/3,000,000 scale map (1959) and do not necessarily correspond to the present day administrative units which are currently being reapportioned and reassigned. No internal divisions (provinces, territories, districts) are given for Rwanda and Burundi. Whenever a locality name used in the collection could not be found in the above list, an attempt was made to trace it through literature data or through the collector, since the areas in which various collectors operated are frequently known. In this way, although it was impossible to determine the exact geographical coordinates of these exclusive localities, it was possible, at least, to ascertain the province or district in which they exist or existed. The personal files of Dr. P.L.G. BENOIT, Director of the Section of the Invertebrates at the Tervuren Museum were frequently consulted in this work.

In this listing of hosts, all scientific names, whenever given, were checked against the following references :

Mammals : ALLEN, G.M., 1954, *Checklist of African Mammals*, Bull. Mus. Comp Zool., Harvard, 83, 2nd ed.

SCHOUTEDEN, H., 1948, *Faune du Congo Belge et du Ruanda-Urundi*, I. Mammifères, Ann. Mus. Congo Belge, sér. 8^o, Zool., I, 331 pp.

Birds : CHAPIN, J.P., *The Birds of the Belgian Congo*, vols. I-IV, Am. Mus. Nat. Hist., New York, 1932-1954.

Reptiles : WITTE, G.F. (DE), 1953, *Exploration du Parc National de l'Upemba*. Mission G.F. DE WITTE (1946-1949), Fasc. 6, Reptiles, INCR, Bruxelles.

The host list compiled by THEILER (1962) was also consulted.

DESCRIPTION OF THE SPECIES. All the ixodid species occurring in the Congo, Rwanda and Burundi were redescribed on the basis of specimens collected in these

areas. Whenever entire series of specimens were available for a species, measurements were made to determine the variations in the scutal length and width, the body length and width and the hypostomal length. Simultaneous observations were made of the variations in the scutal ornamentation, if any, and in the density and pattern of scutal punctation. Special care was taken to determine the morphological variation, if any, in cases of species with a broad geographical range.

A brief diagnosis was placed at the beginning of the description of both the male and the female of each species.

The terminology used in both diagnoses and descriptions is that of NUTTALL *et al.*, 1911-1926; COOLEY, 1938; 1946; COOLEY and KOHLS, 1945, and consists of the following terms :

Accessory shields : Small, sclerotized projections or shields exterior to the adanal shields in males of *Hyalomma* and *Rhipicephalus*.

Adanal plates : Paired ventral plates bordering the anal plate in males of *Ixodes*.

Adanal shields : Paired ventral shields surrounding the anus in males of *Hyalomma* and *Rhipicephalus*.

Anal groove : A groove that encloses fully or partially the anus (anteriorly or fully in *Ixodes*, posteriorly in *Dermacentor*).

Anal plate : A single, median plate surrounding the anus in males of *Ixodes*.

Anteroaccessory stripe : A dark, longitudinal stripe on the mesial side of the lateral spots; variable (ornamentation, *Amblyomma*).

Anus : The posterior opening of the alimentary tract, situated caudally and ventrally on the median line. Has two movable valves surrounded by a chitinized ring.

Article : A definite and distinct division of a jointed appendage.

Auriculae : Paired ventral projections at the sides of the basis capituli in some species of *Ixodes*.

Basis capituli : The basal portion of the capitulum to which the mouth parts are attached.

Capitulum : The anterior portion of the tick including the basis capituli, palpi, hypostome and chelicerae.

Cervical grooves : Paired anterior depressions in the scuta of all stages and both sexes. Vary in length, shape and depth.

Cervical spot : A dark spot surrounding the cervical groove and often extending to the scapulae (ornamentation, *Amblyomma*).

Cervical stripe : A dark narrow band extending posteriorly from the cervical spot (ornamentation, *Amblyomma*).

Chelicerae : Paired mouthparts located dorsally on the hypostome, each terminating in an internal and an external, serrated digit.

Cornua : Caudal projections extending from the latero-posterodorsal angles of the basis capituli.

- Corona* : The apical portion of the hypostome, usually armed with many small denticles.
- Coxae* : The paired ventral plates to which the legs are movably attached. Beginning anteriorly, they are designated as I, II, III, and IV.
- Crenulations* : The transverse or diagonal rows of mild denticles found on some male hypostomes.
- Denticles* : The individual, recurved "teeth" on the ventral side of the hypostome, usually arranged in parallel longitudinal rows or files.
- Dentition* : The arrangement or number of files of denticles on either side of the median line of the hypostome.
- Dorsal ridge* : The posterior, transverse ridge between the cornua.
- Emargination* : The excavation between the scapulae in which the basis capituli is seated.
- Epimeral plates* : The paired, ventral plates in males of genus *Ixodes* situated at the sides posterior to the spiracular plates.
- Falciform stripe* : The dark, crescentic transverse stripe about halfway down the male scutum of some species of *Amblyomma*. May be reduced or modified.
- Festoons* : Uniform, more or less rectangular areas separated by grooves, along the posterior submarginal area of the dorsum of both sexes of all the genera but *Boophilus* and *Ixodes*.
- Frontal spot* : The small, dark spot located in the anterior portion of the lateral field of the scutum between the cervical stripe and the ocular spot (ornamentation, *Amblyomma*).
- Genital aperture* : The sexual opening of adult ticks situated medially between the coxae.
- Genital apron* : The small sclerotized plate covering the genital aperture in some of the species.
- Genital grooves* : Long, ventral grooves diverging from each side of the genital aperture and extending close to the posterior margin of the body.
- Goblets* : The numerous pores surrounding the macula in the spiracular plate.
- Hypostome* : The median ventral member of the piercing mouthparts bearing rows or files of denticles.
- Lateral carinae* : The faint or strong ridges along the sides of the scutum and continuous with the lateral grooves of *Ixodes* species.
- Lateral grooves* : The dorsal grooves at the sides of the scutum in male ixodid ticks.
- Lateral spots* : The three dark spots in the lateral field of the male scutum in *Amblyomma*; may be fused or reduced to a varying degree.
- Limiting spot* : The dark spot located below or on the sides of the falciform stripe in the male and on the posterolateral margin of the scutum of the female (ornamentation, *Amblyomma*).

- Macula* : The heavily sclerotized central portion of the spiracular plate.
- Marginal body folds* : The folds outside the marginal (female) or lateral (male) grooves.
- Marginal grooves* : The dorsal grooves posterior to the scutum at the sides of the body in the female.
- Marginal spots* : The four or more enameled spots on the posterior portion of the male marginal body folds in *Amblyomma*; may be variously modified or fused.
- Median plate* : The median ventral plate of males of *Ixodes* situated between the genital and anal apertures.
- Ornamentation* : The pattern of enameling or the pattern produced by the enameling in *Amblyomma*, *Aponomma*, *Dermacentor* and *Rhipicephalus*.
- Palps* : The movable, paired appendages, parallel on each side of the hypostome. Each consists of four articles numbered from the base. The first article may be reduced or absent.
- Porose areas* : The paired, roundish, usually depressed areas with pitted or irregular bases located on the dorsoposterior portion of the female basis capituli.
- Posteroaccessory stripe* : The dark symmetrical stripe passing anteriorly from the level of the third festoon either vertically or inclined toward the median line of the male scutum (ornamentation, *Amblyomma*).
- Posteromedian stripe* : The dark stripe extending anteriorly from the median, unpaired festoon of the male scutum (ornamentation, *Amblyomma*).
- Pregenital plate* : The ventral plate present occasionally in males and situated anteriorly to the genital aperture.
- Punctations* : Pits in the surface of the scutum and others parts of the exoskeleton; vary in size, depth, density and pattern of distribution.
- Scapulae* : The anterior angles of the scutum in both sexes.
- Scutum* : The sclerotized plate covering all or most of the dorsum in males and the anterior portion of the dorsum in females, nymphs and larvae.
- Spiracular plates* : The paired, respiratory pores, usually situated behind and lateral, to coxa IV.
- Subanal shields* : The small, paired shields posterior to the adanal shields in the males of the genus *Hyalomma*.
- Tarsal hump* : The terminal dorsal hump, present on the tarsi of certain species of *Ixodes*.
- Tarsus* : The terminal article of the leg.
- Trochanter* : The second article of the leg between the coxa and the tibia.
- Ventral plates* : The ventral plates of males of *Ixodes*.

ILLUSTRATIONS. All the species described were illustrated on the basis of specimens collected in the Congo, Rwanda and Burundi. The scutum, dorsal and ventral views of the capitulum, the spiracular plate, tarsus I, coxae I to IV and, occasionally

the anal groove were illustrated for both sexes of each of the species. All drawings were made directly from the specimens with the aid of a reticule in the ocular of the microscope.

In species with a large degree of variation both extremes of the variation were illustrated.

PRESENTATION OF THE MATERIALS IN THE TEXT, TABLES AND ON THE MAPS. All the data pertaining to the materials examined was treated in the text as observations and the source of the material (Museum or Institute) was not specified unless this was necessary for the sake of discussion or clarity. All the records of the specimens examined were arranged in the tabular form specified above and support the sections on "Distribution and Hosts, Congo, Rwanda and Burundi and Africa" under each species (Appendices B and D). The distribution records of the specimens examined were entered on the species distribution maps whenever the geographical coordinates could be ascertained.

Collection of Materials, Field Observations

PURPOSE AND SCOPE. The purpose of the field study was to complement the already available tick materials from the Congo, Rwanda and Burundi and to make the collection more broadly representative of the actual situation in the field. The study was directed primarily toward the systematic survey of the tick and other ectoparasites of small mammals in the Mountain Forest area of Rwanda and in the Equatorial Rain Forest and the Eastern Savannah areas of the Kivu Province.

The field study was carried out between May 1 and August 22, 1962 and consisted of ten separate collecting expeditions carried out from the laboratories of the Institut pour la Recherche Scientifique en Afrique Centrale in Lwiro about 30 kilometers north-east of Bukavu, the capital city of the Kivu Province, Congo. One separate expedition was made into Rwanda where the I.R.S.A.C. field station, Uinka, served as the base of operations. In the Rwanda study, 16 ecologically and climatically different trapping localities were investigated and ectoparasites were collected from 220 small mammals, seven large wild mammals and 65 domestic animals. In the Congo study, 21 ecologically and climatically different localities were investigated and ectoparasites were collected from 587 small mammals, 17 large wild mammals and 260 domestic animals.

SELECTION OF TRAPPING LOCALITIES. In the selection of the trapping localities, emphasis was placed on the exploration of the greatest possible variety of available biotopes. Special attention was given to transitional areas where secondary growth or currently cultivated lands met with the primeval forest. Previous records of acarines and small mammals collected in the Kivu and Rwanda areas were used as guides. Each locality was carefully reconnoitered before the final selection was made

in consultation with Dr. Urs H. RAHM, chief of the mammalogy section and director general of I.R.S.A.C.

TRAPPING, COLLECTING AND PREPARATION TECHNIQUES. A total of 200 "Museum special" snap traps (rat-size) and of 100 Oxford, Longworth and Traub live traps was utilized throughout the study. These traps were set alternately either in parallel lines, two or three meters distant, or in the checkerboard formation with one meter square units, depending on the terrain. Maps of the exact trap location were sketched on the spot and each trap was given a location number. Live traps were camouflaged with available vegetation. Whenever possible, traps were placed at openings to rodent nests or burrows. Both the live traps and the snap traps were baited alternately with peanuts and meat, the latter to attract insectivores. Traps were maintained in each trapping area for a minimum of three days and were examined and rebaited twice a day — in the evening, just before sunset (18 : 00 hours) and at dawn (06 : 00 hours). In this manner it was possible to trap both diurnal and nocturnal rodents.

Each of the animals caught was transferred directly from the trap to a polyethylene bag containing a small wad of cotton with chloroform and the number of the trap from which the animal was removed. The bag was then closed with a rubber band. The daily catch was then transported to the base camp, hut, house or laboratory depending on the situation, for further processing.

At the camp the ectoparasites were collected from each of the animals by brushing them out from the animal's hair onto a white enameled pan, by picking them off the animal with watchmaker's forceps (Dumond no. 3, Switzerland) and by picking up all those that may have fallen into the polyethylene bag or the wad of cotton. Usually, all three methods had to be used to get a complete collection. All the ectoparasites thus collected were placed in a small (procaine) vial containing 70 % ethanol and a small ticket listing the accession number of the host, the scientific or common name of the host, the collection locality, the elevation in meters, the date of collection and the name of the collector. The same information was recorded in a collecting notebook along with data on the exact habitat of the host, the average temperature in °C, and the ticks, mites, lice or fleas, if any, collected. The accession number, scientific or common name of the animal, the collection locality, date of collection and the collector's name were then entered on another ticket that was attached to the animal's leg.

The animal was then weighed (in grams) and measured (in mm) for the length of the body, length of the tail vertebrae, length of the hind foot and length of the ear. This information was entered along with the collection data on a special form provided by the I.R.S.A.C. Mammalogy section. Following this the animal was skinned. One male and one female of every one of the host species collected in each of the trapping localities were stuffed. Other specimens of the same species, if collected in the same locality, were prepared as flat skins and mounted on a strip of cardboard

according to the Tervuren method. The skull of each of the animals was tagged with a duplicate tag and placed in a jar with water prior to cleaning.

Larger wild mammals were collected either with the aid of large native traps, were hunted down by local hunters, or were shot. Both ectoparasites and hosts were processed as above except that the skins were stretched out flat, salted down and dried for several days in the sun.

Domestic animals were searched for ectoparasites, particularly ticks, and these, when found, were collected alive and placed into shell vials containing a strip of moistened blotting paper along with a tag giving the pertinent collecting data. The vials were stoppered with a tight wad of absorbent cotton. Engorged females or nymphs were placed, in their vials, into jars with a wad of moistened cotton at the bottom. These jars served as provisory incubators and were kept near a fire so that the temperature was maintained at ± 20 °C. On return to the main base at Lwiro, these materials were transferred to an electric, controlled incubator for purposes of further biological study.

Males and non-fed females were placed into alcohol and entered into the collection records as specified above. A small fee was usually paid to the owners of the livestock for allowing and assisting in the collection of the ectoparasites.

SHIPPING TECHNIQUES. Living specimens were shipped directly from the Congo to the Walter Reed Army Medical Center for bacteriological examination. Shipping vials were prepared by using 5 cm \times 1 cm shell vials and stuffing them one third with moistened absorbent cotton and by placing a wide strip of moistened blotting paper along one side. The ticks were then placed in the vials along with the collection data slip, and the vials were tightly stoppered with absorbent cotton. The vials were placed horizontally in metal containers and insulated with cotton against shock. The container was pierced several times to allow for passage of air and packed into an ordinary cardboard carton and shipped by air (O.N.U.C. from Bukavu to Léopoldville and U.S.A.F. from Léopoldville to Washington, D.C.). In each instance the trip took four to five days and all specimens were alive on arrival.

Ectoparasites in alcohol were shipped in the usual manner, and care was taken that the vials be properly insulated against shock with wads of cotton.

Stuffed animals, skins and skulls, treated with arsenic against the possible invasion of dermestid beetles and other pests, were shipped in crates and metal foot lockers. All skulls were wrapped individually in tissue paper and placed into hard cardboard pharmacist's boxes to prevent crushing.

DEPOSITIONS OF MATERIALS. Most of the stuffed animals, skins, skulls and all of the host collection data of the Rwanda collection were deposited in the Division of Mammals, U.S. National Museum, the Smithsonian Institution, Washington, D.C. The skins, stuffed animals and skulls of the Congo collection are currently at the Department of Zoology, University of Maryland, awaiting transfer to the U.S. National Museum. These specimens were determined by Dr. Urs H. RAHM of I.R.S.A.C. Lwiro.

The ectoparasite collection other than ticks is being identified by the following :

Mites : Dr. Gustave MATHYS, Stations fédérales d'essais agricoles, Changins/Nyon, Switzerland in collaboration with A. ELBL.

Lice : Dr. P.L.G. BENOIT, Musée Royal de l'Afrique Centrale Tervuren, Belgium.

Fleas : Dr. Robert TRAUB, University of Maryland, School of Medicine, Baltimore, Maryland, U.S.A.

IDENTIFICATION OF TICK MATERIALS COLLECTED. All adult specimens in the Rwanda and Congo collections have been identified and entered into the materials tables as specified above. The immature stages shall be the subject of a future study.

PHYTOGEOGRAPHIC AND BIOCLIMATIC CHARACTERIZATION OF THE CONGO, RWANDA AND BURUNDI

Classification

The territories of the Congo, Rwanda and Burundi lie entirely within the Inter-tropical African Zone, a part of the Paleotropical kingdom, and are characterized by the occurrence of numerous varieties of floristic elements and intertropical vegetal groupings caused by geomorphologic and bioclimatic diversity. The entire area can be divided into eleven phytogeographic districts (Map II), the limits of which, however, are still only approximate. These districts are in turn placed within the large phytogeographic subdivisions of the African Region established by A. ENGLER (1910), as follows :

GUINEAN PROVINCE. Contains Guinean floristic elements, hygrophiles and xerophiles, Equatorial Rain Forest and Guinean Savannah with forest galleries.

Congolese Sector.

- I. Coastal District.
- II. Mayumbe District.
- III. Bas-Congo District.
- IV. Kasai District.
- V. Bas-Katanga District.
- VI. Central Forest District.
- VII. Ubangi-Uelé District.

EASTERN PROVINCE. Contains Eastern floristic elements mostly xerophiles Eastern Savannahs with forest galleries and diverse mountain formations.

Centro-African Sector.

- VIII. Lac Albert District.
- IX. Lac Edouard and Lac Kivu District.
- X. Rwanda-Burundi District.

ZAMBEZIAN PROVINCE. Contains Zambeziian floristic elements mostly xerophiles Forrested Savannahs and Southern Savannahs with forest galleries.

Bangwelo-Katanga Sector.

- XI. Haut-Katanga District.

Description of Districts

I. COASTAL DISTRICT. Stretches from the coast to the Lukunga valley in the east and along the estuary of the Congo river to Boma. The bioclimate is characterized by low annual precipitation (800 to 900 mm) and a long dry season of about six months (May to October).

Two subdistricts are recognized. The first, the maritime subdistrict covers the beaches and the estuary of the river and bears halophile vegetation. The second, the littoral subdistrict, consists of the plateaulike hinterland of the beaches, with open savannah with xerophile, herbaceous vegetation and occasional forest galleries.

II. MAYUMBE DISTRICT. Limited by the basin of the Chiloango and Luki in the east and in the south, this district extends north toward French Equatorial Africa. Consists of many steep hills up to 500 to 600 m high separated by deep valleys. The bioclimate is characterized by its subequatorial type with average annual precipitation of 1,200 mm to 1,400 mm and an average dry season of five months attenuated by frequent and dense fogs.

The vegetation consists of Subequatorial Rain Forests containing a mixture of evergreens and tropophiles. Many of the forests are actually secondary and the vegetation is quite heterogeneous.

III. BAS-CONGO DISTRICT. Covers the region of the Cristal Mountains from Boma in the west to the division between the Lufimi and Kwango basins in the east. A hilly country, intersected with numerous valleys this district has many waterfalls. The bioclimate is characterized by an annual rainfall which fluctuates between 1,000 mm and 1,400 mm, and by a four month dry season (May to September).

The characteristic vegetation consists of savannah grass with *Adansonia digitata* L. (Baobab trees), interspersed with small woods and forest galleries containing many climbers and lianas.

IV. KASAI DISTRICT. Situated east of the Bas-Congo District and south of the Central Forest District, this district comprises the major part of the Kasai basin up to and including the basin of the Lulua in the east and extends to Angola in the south. Consists of sandy or grassy plateaus the altitude of which increases southward and which are divided by numerous valleys of variable depth directed perpendicularly to the equator. The bioclimate is similar to that of the Bas-Congo District but the annual precipitation is higher and reaches 1,600 mm in the south.

The plateaus are covered by herbaceous savannah formations and by brush formations in the north. These are crisscrossed by forest formations which pass gradually into the Equatorial Forest in the north and which turn into forest galleries of diminishing importance toward the south.

V. BAS-KATANGA DISTRICT. The District of Bas-Katanga is enclosed between the Equatorial Rain Forest in the north, the Tanganyika graben in the east, the Haut-

Katanga District in the south and the Kasai District in the west, and includes highly diverse floristic regions. It consists mostly of sandy and grassy plateaus separated by shallow but large valleys. The bioclimate resembles that of the Kasai District but the amount of annual precipitation exceeds hardly 1,400 mm, and the dry season lasts from four to five months in the south.

The plateaus are covered with herbaceous savannah with occasional scrub-bush formations which assume parklike aspects resembling forested areas especially in the north. Forest galleries are well developed in the north but are reduced southward where a prairielike formation can be seen.

VI. CENTRAL FOREST DISTRICT. This district covers approximately an area of 1,000,000 square kilometers and occupies the Central Congo basin. It is limited north and south of the Equator by the fourth parallel. In the east it is stopped by the western ridge of the Central African graben except in the Semliki Valley where it passes north of the Ruwenzori massif into Uganda. In the west it continues into French Equatorial Africa. The bioclimate is equatorial and the annual precipitation exceeds 1,600 mm. There is no dry season but two maximum rainfall peaks are reached on the equinoxes. Atmospheric humidity is quite high and the saturation deficit is relatively weak.

The climax vegetation is that of the Equatorial Rain Forest, a strong vegetal formation with an underbrush consisting mostly of climbers and lianas with great vitality. The forest is mostly hygrophile and evergreen except in the outer limits where tropophile formations are observed.

VII. UBANGI-UELÉ DISTRICT. This district which covers the entire northern district of the Congo except the extreme northeast, is a region of plateaus with sub-equatorial climate and a dry season of three months (December to February).

The vegetation consists of savannahs and parklike savannah formations interspersed with forest galleries and forested strips, containing tropophilic plants, which gradually pass into the Equatorial Rain Forest in the south.

VIII. LAC ALBERT DISTRICT. This district comprises the extreme northeast of the Ituri with the basin of Lac Albert up to approximately east of the Tapa-Aba line. It is a mountainous region with altitudes from 1,000 to 2,500 meters and many deep valleys. The bioclimate is characterized by annual precipitation of 1,400 mm in the west and of 1,000 mm in the east in the plain surrounding the lake, where the dry season lasts about three months (December to February).

The western part of the district is covered by a dry savannah which becomes slightly forested and is occasionally traversed by a forest gallery. The alluvial plain around the lake is covered with a dry savannah consisting of succulents and occasional bush and *Acacia* formation.

IX. LAC EDOUARD AND LAC KIVU DISTRICT. This district includes the Ruwenzori and the entire central graben with ridges up to an area just north of Albertville.

Because of its varied relief this district has extremely variable bioclimatic conditions. In the alluvial plains, the annual rainfall amounts to 1,000 mm and the climatic regime is subequatorial. The dry season lasts here from two to four months depending on the latitude. In the mountain regions the udometric and thermic variations produce local bioclimates. Several subdistricts can be recognized :

A. *The alluvial plains.* Comprises the plains of Semliki, Rutshuru and the Ruzizi covered with dry, herbaceous savannahs.

B. *The lava plains.* Comprises the lava field in the north of Lake Kivu as well as the islands in this lake and several surrounding arid areas.

C. *The mountain forest.* Comprises the Ruwenzori, the Virunga volcanoes and the eastern and western ridges of the graben. The mountain vegetation is characterized by a succession of vegetation forms which follow virtually the same pattern on all the massifs. These zones are as follows :

1. *Mountain forest zone.* A rain forest formation located at altitudes from 1,750 and 2,200 to 2,400 meters in an area of annual precipitation fluctuating from 1,600 to 2,250 mm.

2. *Bamboo zone.* A monophytic forest association consisting of dense growth of *Arundinarietum alpinae* reaching up to 20 or 22 meters in height, located within the altitude zone reaching from 2,200 to 2,400 or 2,600 meters.

3. *Zone of arborescent Ericacea.* Ericetum which generally extends through the subalpine region from 2,600 meters to the altitude of 3,700 or 3,800 meters, forms here bush or arborescent formations reaching from four to ten meters in height, covered with hanging mosses.

4. *Alpine zone.* Above the tree line at an altitude of 3,700 meters there appear associations of *Dendrosenecio* and giant *Lobelia*. The soil is covered entirely by mosses. From 4,300 meters up the vegetation is gradually reduced giving way to fields of lichens which extend in the Ruwenzori up to the glaciers.

X. RWANDA-BURUNDI DISTRICT. Located on the eastern part of the ridge, this district is a plateau with numerous ravines and an average altitude of 1,400 to 1,800 meters. The bioclimate is subequatorial with a three to four month dry season (June to September) and a high saturation deficit.

The vegetation consists of brush savannah interspersed with forest screens mostly xerophiles.

XI. HAUT-KATANGA DISTRICT. The northern limit of this district is approximately the Dilolo-Sankisia-Kiambi-Niamba-Albertville line. A variable region with average altitude of 1,400 to 1,700 meters, this district includes the high plateaus of Bianco, Kundelungu, Kibara and Malungu. In many places the soil is heavily mineralized. The bioclimate is tropical with annual precipitation less than 1,200 mm and a single dry season of five to seven months (April to October) depending on the latitude.

Outside the high plateaus the climax formation consists of forested savannah or dry forest of variable character.

The undulating high plateaus with sandy soil are covered with a herbaceous savannah from an altitude of 1,600 meters up.

The administrative units of the Congo, Rwanda and Burundi (Map I) can be thus characterized by the phytogeographic and bioclimatic districts as follows :

Equateur Province

Equateur District — VI. Central Forest District.

Mongala District — VI. Central Forest District, VII. Ubangi-Uelé District.

Tshuapa District — VI. Central Forest District.

Ubangi District — VI. Central Forest District, VII. Ubangi-Uelé District.

Kasai Province

Kabinda District — V. Bas-Katanga District.

Kasai District — IV. Kasai District, VI. Central Forests District.

Lulua District — IV. Kasai District, V. Bas-Katanga District.

Sankuru District — IV. Kasai District, V. Bas-Katanga District, VI. Central Rain Forest District.

Katanga Province

Haut-Katanga District — XI. Haut-Katanga District.

Haut-Lomami District — V. Bas-Katanga District, XI. Haut-Katanga District.

Lualaba District — XI. Haut-Katanga District.

Tanganika District — V. Bas-Katanga District, XI. Haut-Katanga District.

Kivu Province

Maniema District — V. Bas-Katanga District, VI. Central Forest District.

Nord-Kivu District — VI. Central Forest District, IX. Lac Edouard and Lac Kivu District.

Sud-Kivu District — VI. Central Forest District, IX. Lac Edouard and Lac Kivu District.

Léopoldville Province

Bas-Congo District — I. Coastal District, II. Mayumbe District, III. Bas-Congo District.

Cataractes District — III. Bas-Congo District, IV. Kasai District.

Kwango District — III. Bas-Congo District, IV. Kasai District.

Kwilu District — IV. Kasai District.

Lac Léopold II District — III. Bas-Congo District, IV. Kasai District, VI. Central Forest District.

Orientale Province

Bas-Uelé District — VI. Central Forest District, VII. Ubangi-Uelé District.

Haut-Uelé District — VI. Central Forest District, VII. Ubangi-Uelé District, VIII. Lac Albert District.

Ituri District — VI. Central Forest District, VIII. Lac Albert District.

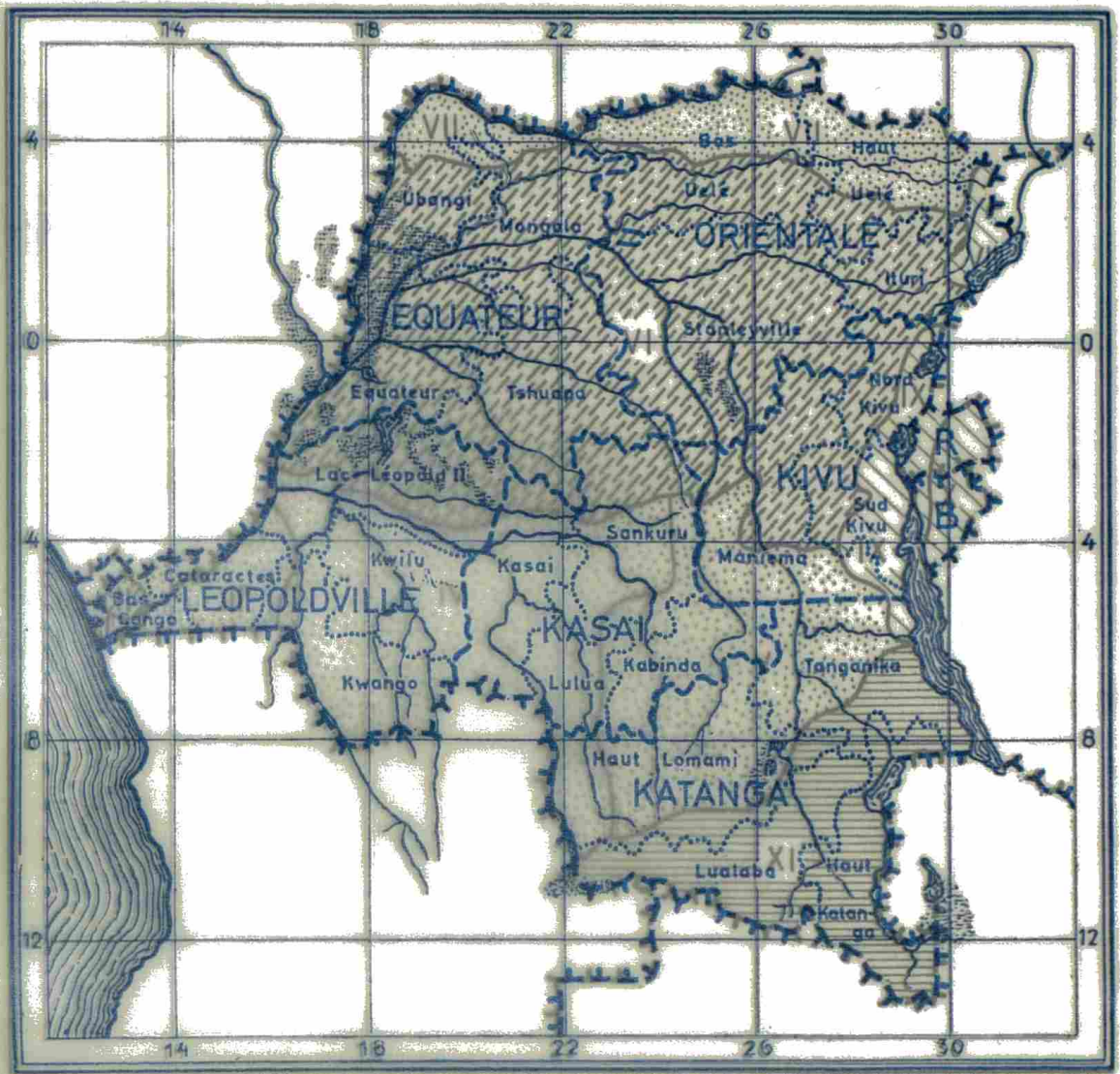
Stanleyville District — VI. Central Forest District.

Rwanda

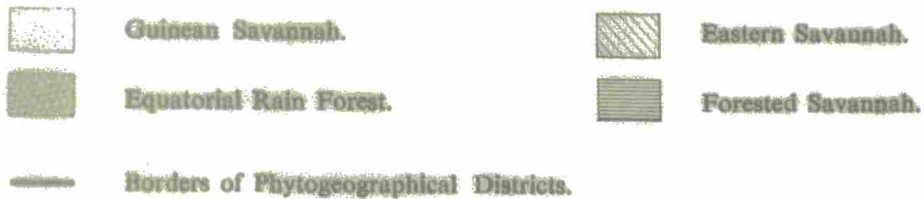
Entirely within the Rwanda-Burundi phytogeographical and bioclimatic district (X).

Burundi

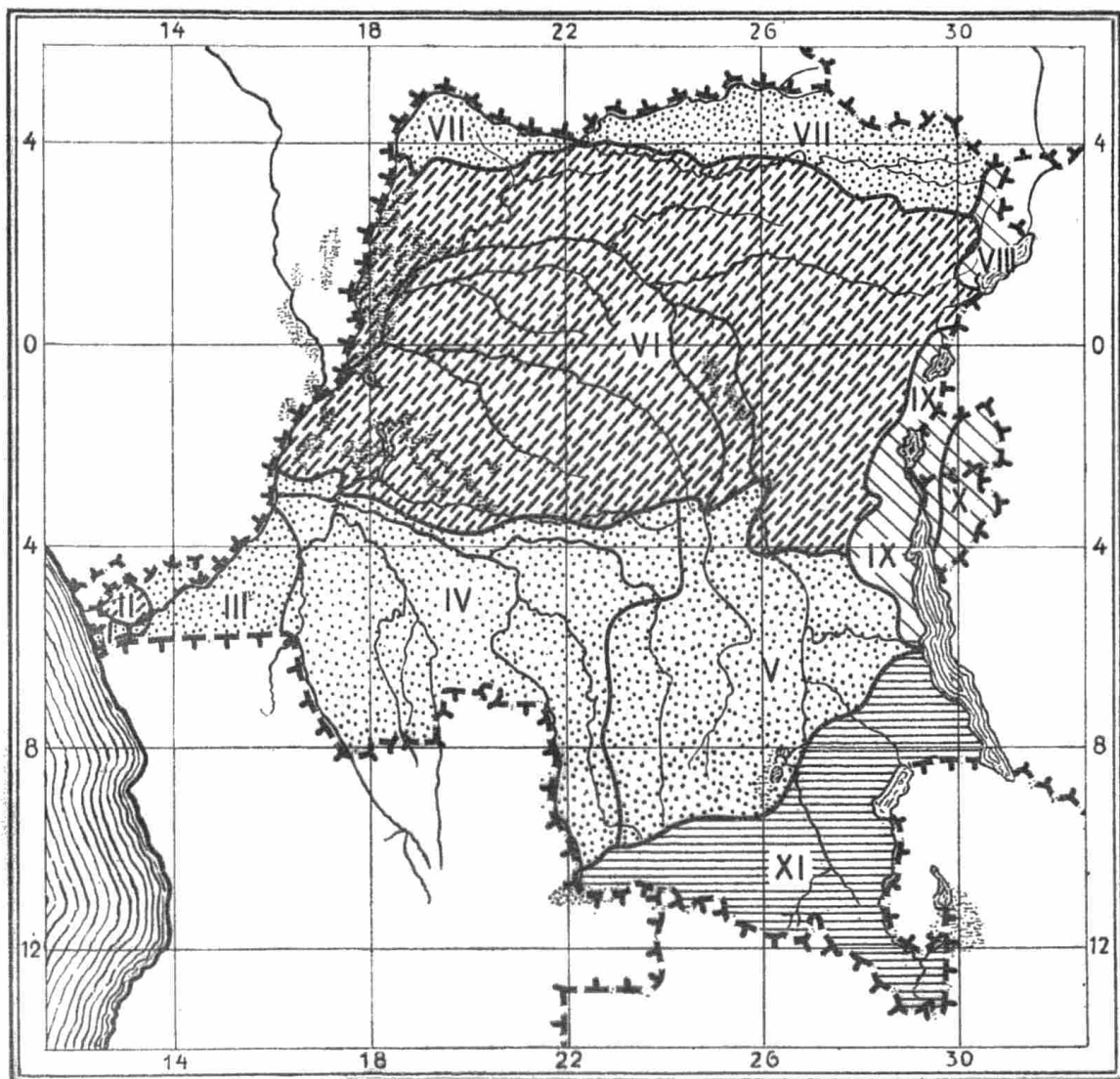
Entirely within the Rwanda-Burundi phytogeographical and bioclimatic district (X).



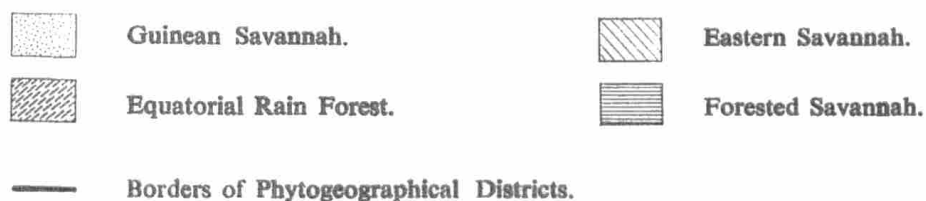
Map I. Administrative units in Congo, Rwanda, Burundi.



Phytogeographical Districts: I. Shore; II. Mayumbe; III. Bas-Congo; IV. Kasai; V. Bas-Katanga; VI. Central Forest; VII. Ubangi-Uelè; VIII. Lac Albert; IX. Lac Edouard and Lac Kivu; X. Rwanda-Burundi; XI. Haut-Katanga.



Map II. — Phytogeographical zones — Congo, Rwanda, Burundi.



Phytogeographical Districts : I. Shore ; II. Mayumbe ; III. Bas-Congo ; IV. Kasai ; V. Bas-Katanga ; VI. Central Forest ; VII. Ubangi-Uelé ; VIII. Lac Albert ; IX. Lac Edouard and Lac Kivu ; X. Rwanda-Burundi ; XI. Haut-Katanga.

Distribution : Africa (continued).

Province	District	Locality	Author and date of publication	Host	Date	Specimens	Collector
West Africa	—	SIERRA LEONE	Neumann, 1899 : 268-271	—	—	—	—
"	—	GAMBIA	Simpson, 1911 : 187-239	—	—	—	—
"	—	GHANA	Simpson, 1914 : 1-36	—	—	—	—
"	—	DAHOMY	Rousselot, 1951 : 307-309	—	—	—	—
"	—	IVORY COAST	Neumann, 1899 : 268-271	—	—	—	—
"	—	PORTUGUESE GUINEA	Howard, 1908 : 1-96	—	—	—	—
Outlying Islands	—	BIJAGOS ISLANDS	Tendeiro, 1953 : 263-267	—	—	—	—
"	—	ZANZIBAR	Neumann, 1899 : 268-271	—	—	—	—
"	—	MAURITIUS	"	—	—	—	—
"	—	MA-DAGASCAR	"	—	—	—	—
"	—	REUNION	"	—	—	—	—
"	—	COMORES GROUP	Millot, 1948 : 137-155	—	—	—	—

APPENDIX D

MATERIAL EXAMINED AND IDENTIFIED

Distribution :

Africa



TABLE 1

Material examined and identified as *Amblyomma astrion* DÖNITZ, 1909.
Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
Southern Africa	—	ANGOLA (Ngembe, 40 km south of Boma)	Buffalo	T 12355	—	1♂, 3 N	Mesmaeckers

TABLE 2
 Material examined and identified as *Amblyomma cohaerens* DÖNITZ, 1909.
 Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
North Africa	—	ABYSSINIA (Dore Dalona)	—	UMd A coh-1	26.VI.1920	1♂	—
"	—	—	Buffalo	UMd A coh-3	—	2♀	—
East Africa	—	UGANDA	—	HH 1	1956	1♂, 1♀	—
"	—	" (Bunyoro)	Buffalo	T 93835/93844	—	5♂, 5♀	Yunker

TABLE 3

Material examined and identified as *Amblyomma cuneatum* NEUMANN, 1899.
Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
West Africa	—	LIBERIA	<i>Manis longicaudata</i>	UMd AC-1	1926	3♂, 2♀, 4L	Bequaert
East Africa	—	UGANDA	<i>Manis</i> sp.	HH ex BM (NH)	1933	1♂, 1♀	Pitman
"	—	" (Mubango)	"	T 93909	"	1♂	"

TABLE 4
 Material examined and identified as *Amblyomma eburneum* GERSTAECKER, 1873.
 Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
Africa	—	—	Giraffe skin	UMd AGe-2	—	1♂, 1♀	Lang
East Africa	—	KENYA (Mindikuri) ca ± 4,300 feet	—	HH 3	6.VIII.1956	1♂, 1♀	Kaiser
"	—	FRENCH SOMALI- LAND	Cattle	UMd AGe-1	12.VII.1950	2♂	Hoogstraal

TABLE 5
 Material examined and identified as *Amblyomma nuttalli* DÖNITZ, 1909.
 Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
Central Africa	—	SUDAN	Tortoise	Hoogstraal	3.III.1950	1♂	Hoogstraal
East Africa	—	TAN- GANYIKA	<i>Kinixys belliana</i>	UMd	23.I.1928	3♂, 1♀	Loveridge
"	—	" (Kilosa)	"	UMd ANu-1	"	3♂, 1♀	"
West Africa	—	NIGERIA	On ground	Hoogstraal	21.V.1957	1♀	McDonald
South Africa	—	MOZAM- BIQUE	<i>Kinixys belliana</i>	T 76272/76279	10.X.1950	6♂, 3♀	Santos Dias

TABLE 6

Material examined and identified as *Amblyomma paulopunctatum* NEUMANN, 1899.
Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
Central Africa	—	CAMEROONS (Yaoundé)	Pig	T 77147	4.VI.1951	1♀	Adam

TABLE 7

Material examined and identified as *Amblyomma pomposum* DÖNITZ, 1909.
Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
East Africa	—	TAN- GANYIKA	<i>Alcelaphus lichtensteini</i>	T 111284	3.XII.1953	1♀	Bomans

TABLE 8
 Material examined and identified as *Amblyomma rhinocerotis* (DE GEER, 1778).
 Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
East Africa	—	BRITISH EAST AFRICA (Rhino Camp)	—	T 37665/37674	VI.1913	2♂	Bayer
"	—	"	—	T 123405	"	2♀	"
"	—	UGANDA (River M'sisi)	—	T 5600	—	1♀	"

TABLE 9

Material examined and identified as *Amblyomma sparsum* NEUMANN, 1899.
Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
Africa	—	—	—	UMd AMar-1	—	1♂	Loveridge
"	—	—	<i>Testudo</i> sp.	UMd AMar-2	—	3♂	—
East Africa	—	BRITISH EAST AFRICA	—	T 123406	VI.1913	1♂	Bayer
"	—	KENYA COLONY (near foot of Mt. Kenya, upper Tana River)	—	UMd AMar-3	—	1♀	—
"	—	SUDAN	—	HH-7	—	1♂, 1♀	Hoogstraal

TABLE 10

Material examined and identified as *Amblyomma splendidum* GIEBEL, 1877.
Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
Central Africa	—	CAMEROONS (Yaoundé)	<i>Bos indicus</i>	T 77148/77149	10.VI.1948	1♂, 1♀	Adam
Southern Africa	—	ANGOLA (N'gembé)	Buffalo	T 70729/70788	—	70♂, 2♀	Mesmaeckers
"	—	"	"	T 70654/70703	—	61♂	"
"	—	"	"	T 70704/70728	—	1♂, 23♀	"
"	—	"	"	T 70783/70868	—	1♂, 32♀	"
"	—	" (Région de Taire)	"	T 73338/73387	10.XI.1952	59♂	"
"	—	"	"	T 73388/73403	"	2♂, 12♀, 1N	"

TABLE 11.
 Material examined and identified as *Amblyomma tholloni* NEUMANN, 1899.
 Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
East Africa	—	UGANDA	Elephant	T 73052/73062	1952	4♂	Ver Eyken
North Africa	—	SUDAN	"	T 93832/93834	IV.1950	2♂, 1♀	Hoogstraal

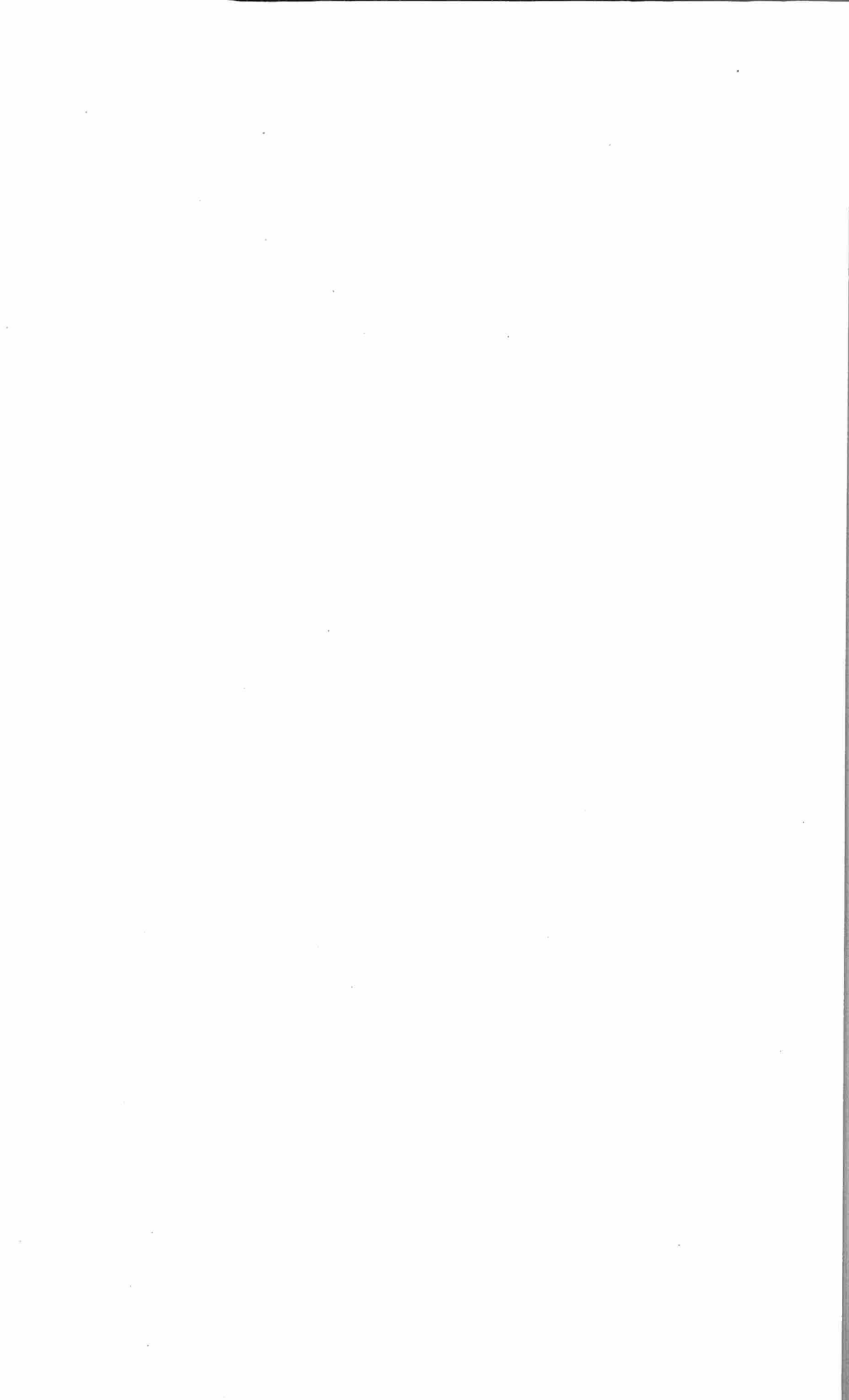
TABLE 12

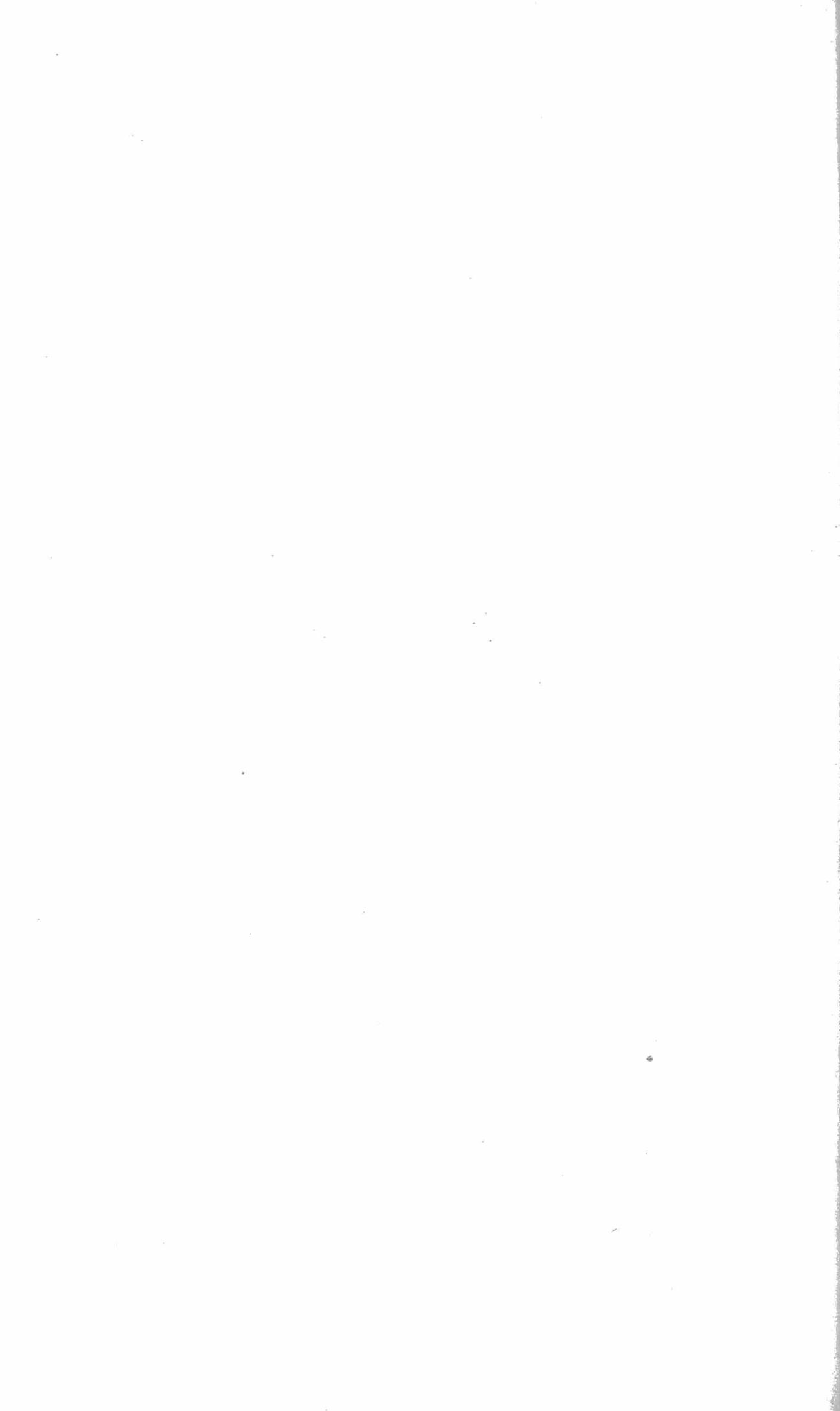
Material examined and identified as *Amblyomma variegatum* (FABRICIUS, 1794).
Distribution : Africa.

Province	District	Locality	Host	Collection	Date	Specimens	Collector
Central Africa	—	CAMEROONS (Yaundé)	<i>Bos indicus</i>	T 77164	18.X.1951	1♂	Adam
North Africa	—	SUDAN	Cattle	UMd AV-1	1948	7♂, 7♀	Alison
"	—	"	Buffalo	PNG E 4073	22.IX.1952	20♂, 5♀	De Saeger
"	—	"	—	T 123066	1962	1♀	Cloudsley- Thompson
Southern Africa	—	MOZAM- BIQUE	<i>Bos taurus</i>	T 76250/76263	1.VII.1953	13♂, 3♀	Santos Dias
West Africa	—	NIGERIA	Cow	T 123602	IV.1953	25♂, 1N	Neusser and Bouquiox

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de		van
l'imprimerie PUVREZ		
59, avenue Fonsny		Fonsnylaan 59
Bruxelles		Brussel

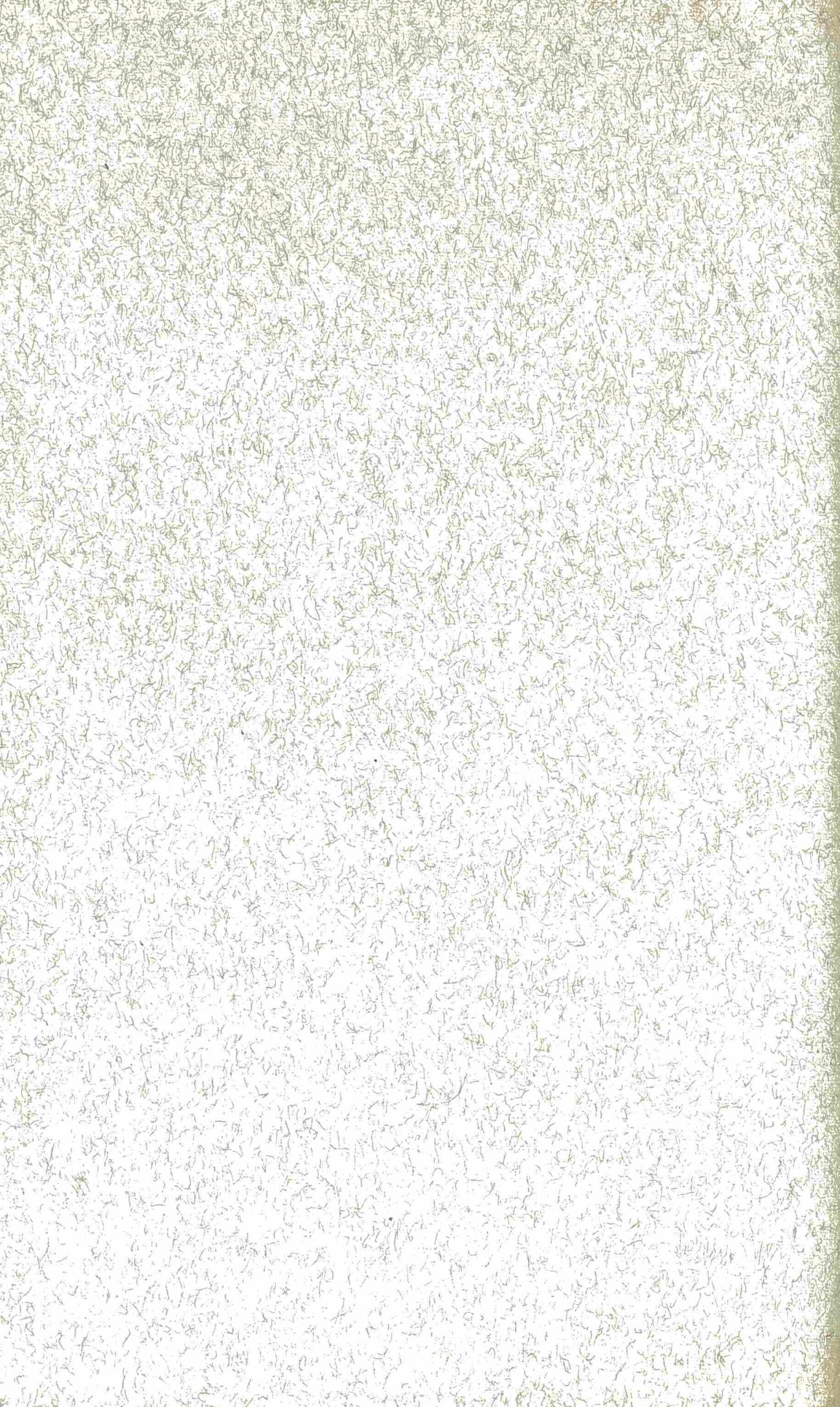














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