TICKS

and

TICK-BORNE DISEASES

in

NYASALAND

by

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THESIS

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PART I

A SYSTEMATIC STUDY

of the

IXODOID SPECIES in the Northern and Central

Provinces of NYASALAND

with

NOTES on their BIOLOGY and CONTROL.
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INTRODUCTION

Ticks in whatever country they occur, present a constant menace to the health and well-being of both humans and domestic animals. Many species such as *Rhipicephalus sanguineus* and *Boophilus* species are distributed over wide areas while others such as *Rhipicephalus duttoni* appear at present to be restricted to definite small localities. Usually, however, in any one area, a confusing number of species and varieties occur together. For instance, Lewis (1939) records 74 species from East Africa, Bedford (1932) at least 57 species from South Africa, and Jack (1936) about 20 different species from Southern Rhodesia.

Despite their importance, and despite constant and continuing investigations there are still many gaps in our knowledge concerning the life-histories of the various species and especially of their environmental requirements. The exact geographical distribution and the variety of hosts has been determined for only a few species, and much may still remain to be discovered regarding their importance as disease vectors. For these reasons additional knowledge regarding tick morphology and ecology is desirable in any African Colony. This is especially so in Nyasaland as here relatively large-scale tick-control measures have been practised over the last fifteen years. The problems, therefore, which confronted the author were not obscure nor merely of
academic interest but were fundamentally important to future administration in the Territory.

**SOME OF THE PROBLEMS**

The first and most obvious problem was purely systematic in that it was necessary to determine the species of ticks occurring in the area. In some instances this was a relatively simple task. Accurate descriptions of such species as *Ixodes pilosus*, *Rhipicephalus appendiculatus* and *Amblyomma variegatum* could readily be consulted and identified specimens for comparison with Nyasaland material could be obtained from Onderstepoort Veterinary Laboratories, S. Africa, or from the Veterinary Research Station, Kabeta, Kenya. In other cases, especially with the more rare species belonging to the *R. appendiculatus* group, only the original descriptions and records were available, and as will be seen later, in *R. neavei var. punctatus*, *R. sculptus* and *R. supertritus*, these descriptions were inadequate and it was necessary to compare the Nyasaland specimens with type-specimens preserved in the collections of the British Museum. Further, as there are no accurate check-lists of the species of the neighbouring territories of Tanganyika and Northern Rhodesia, and only the more common species had been described from Portuguese East Africa (Theiler 1943), it was impossible to forecast the number of species likely to be encountered in the present Nyasaland
survey. Lastly, some of the genera have recently been revised, namely, *Hyalomma* by Schulze (1927, 1930), *Boophilus* by Minning (1934), and *Rhipicephalus* by Zumpt (1939-43). It was, therefore, necessary to reconsider the Nyasaland genera and species in the light of this recent work.

The second problem considered had reference to the biology of each species collected. Many of the species had been described by systematists from material in Museum collections, and no biological data was available, yet some of the sub-species or even species differ so immaterially from the "Nominatiform" or closely allied species that biological features must be considered to confirm the validity of the classification. Biology, as considered in this work concerns the study of life-histories of ticks under field conditions and not merely to their development in the laboratory under controlled conditions. Climate and weather affect the speed of development, the fertility and length of life of individual ticks and the summation of these effects determines the incidence or even the survival of any tick species. Temperature, humidity, pressure, light and wind are some of the factors which go to make weather, so an economic entomologist must correlate biological events with meteorology. But as ticks have the power of movement, and change of position of only a few feet may be accompanied by a distinct alteration of the microclimate, a knowledge of the ground flora is essential. The result of some of these observations have already
been published (Wilson 1946), but it is to be noted that most of these observations have to do with qualitative rather than quantitative aspects, and it is as yet not possible to give an exact measurement of the density of any tick population. Fortunately, in Nyasaland, we are dealing with three well defined types of climate; from December to March the climate is hot and wet, from April to September it is dry and relatively cold, while during October and November it is hot and dry. As a result there is a distinct variability in the seasonal incidence of species which was recognised for the first time in Central and East Africa. It is not suggested that laboratory technique is unnecessary, but field investigations serve to limit laboratory work to the study of particular aspects of a tick problem. The present study emphasises the need for a closer examination of the humidity requirements of female *R. appendiculatus* during the engorging and ovipositing period.

Conversely, the failure of *R. capensis* and *R. tricuspid* to breed successfully under ordinary atmospheric conditions in the laboratory almost compel a further field study of the micro-climates suitable for the larvae and nymphs of these species.

A third problem which cannot be neglected in any study of tick populations is the exact determination of species which are known or potential disease vectors. In Nyasaland, the vectors of East Coast Fever are especially important, and the danger of applying to Nyasaland results acquired in other territories is
very clearly shown in the present survey (Part II of this thesis).

Lastly, the efficacy of tick control methods has been reconsidered in the light of the present findings.

Although work on the various problems raised by this tick-survey can not be completed for many years, it was considered important at this juncture to record the actual facts established. In this way the questions which require further investigation are emphasised, and knowledge gained is made available to other workers.

A SHORT REVIEW OF PREVIOUS WORK ON THE IXODOIDEA

The first comprehensive account and classification of the IXODOIDEA was published by Koch in 1844. He placed ticks in the order Ricini as distinct from the Acari. Within the Ricini he erected three families, i.e. Argasides or soft ticks, the Ixodides containing the genera Ixodes, Amblyomma and Hyalomma with long mouth parts, and the Rhipistomides or species with short mouth parts. At the same time Koch also described many new species.

Neumann in his "Revision de la Famille des Ixodides", begun in 1896 used more satisfactory morphological features in his descriptions of each species, and his classification was more adequate than that given by Koch. He placed the ticks in the family IXODIDES with two sub-families, the Argasinae, and the Ixodinae. The Ixodinae are divided into three tribes. The tribe Ixodae contained only the genus Ixodes which was recognised as being distinct
from all other ticks. The tribe Rhipicephalae contained the genera with short mouth parts, while the genera with long mouth parts were placed in the tribe Ambylommeae.

Donitz (1910) also suggested a classification, but the one generally used to-day is that of Warburton (1907). In the latter, Ixodes species are again kept separate, being placed in the group PROSTRIATA with the anal groove encircling the anus in front. All the other genera of hard ticks are grouped as METAESTRIATA, with the anal groove, when visible, behind the anus. This group is further sub-divided into BREVIROSTRATA or ticks with short mouth-parts and LONGIROSTRATA with long mouth-parts. This classification can only be regarded as one of convenience, and the grouping does not necessarily indicate the true relationships of the various species. More detailed knowledge of the internal structure and biology of ticks is necessary before a natural classification can be established.

In the early part of the present century the literature on IXODOIDEA is dominated by the writings of Donitz, Neumann, Nuttall and Warburton. Of special interest to African collectors was the work of Nuttall who, in 1910, described Rhipicephalus simpsoni n. sp. and later in 1913, 1915, 1919, recorded his observations on the biology of ticks, and, in 1916, published a valuable survey of the ticks of the Belgian Congo. Warburton in 1912 described
R. neavei n. sp., R. neavei var. punctatus n. sp. and R. sculptus n. sp. Robinson and Davidson (1913) published a careful detailed study of the anatomy of *Argas persicus*. Some of this work was later summarised in a monograph "The Ixodoidea" (1908-1926) published in four parts.

The early work begun by Lounsbury (1903, 1905) and Howard (1908) on South African ticks was amplified by Bedford (1932, 1934, 1936) and by Theiler (1941, 1943, 1945). The ticks of Portuguese East Africa and Southern Rhodesia were dealt with by Theiler (1943) and Jack (1936) respectively, and Lewis (1931, 1932, 1939) has made most valuable contributions to our knowledge of the East African species. Knowledge of the tick fauna of Tanganyika and Northern Rhodesia is still very inadequate.

In more recent years the systematics of two genera in particular have been subjected to detailed study. The genus *Boophilus* has been revised by Minning (1934) and the genus *Hyalomma* by Schulze (1930). Zumpt (1939-43) has attempted a similar study for the genus *Rhipicephalus*. The American species of the genus *Amblyomma* have been studied by Cooley and Kohls (1944), but has slight application in East Africa, since few members of the genus occur there. Of more direct interest is the work of these same authors on the *Argasidae* (1944).
METHOD OF COLLECTING AND PRESERVING TICKS

The practical details of collecting ticks on cattle require no description. Native cattle are wild and unaccustomed to handling, and collecting is, therefore, a slow and tedious task. Ticks picked from a beast are immediately placed in a fluid lethal agent, the most successful being that recently recommended by Boardman (1944). This consists of a mixture of 97 parts of 20 per cent alcohol and 3 parts of ether. Ticks killed in this solution die with their legs extended and so allow of easy examination of the anal plates, coxal armature and other ventral characters. The dead ticks are then transferred as soon as possible into a final preserving fluid. For this purpose, a solution of 75 per cent alcohol containing a few drops of glycerine may be used. In the tropics, the formalin-chloroform solution recommended by Monning was found most useful and most easily obtained.

Collections on cattle were carried out systematically all the year round, but collections on game animals, wild carnivores and rodents were more fortuitous. Attempts were made to collect specimens from bush-grazing areas by dragging a blanket over the vegetation. This method, however, had no success owing to the rough nature of the open bush country.
RECORDED DATA

The present tick survey was started in 1937 in Mzimba area, but in 1942 collecting became more systematic and organised, and the area of the survey was extended to include the whole of the Southern and Central Provinces. It was necessary to pay particular attention to the Ixodoidea of cattle, and over 900 collections were made during the survey. Thus ample material was obtained to determine the incidence of each species during any particular month or season. The brief record for each collection gave the name of host, date of collection and locality. Additional notes were also made at the time of collection regarding other important facts. Thus it was of interest to know if the collection had been a comprehensive one or only a partial one for one or a few hosts. In many instances an attempt was made to collect all the adult ticks from 8 to 12 animals in order to determine an approximate index of the degree of tick infestation of the host at that particular time. Often, however, only partial collections were made with the sole aim of determining the variety of species present.

It was also found necessary to record the comparative prevalence of each stage of the tick collected. For instance, it was important to discover at the time of collecting whether only males and females were represented to the exclusion of nymphs and larvae, or vice-versa. Attention was also paid during field collecting to the state of engorgement of female ticks.
and it was found that engorged female *R. appendiculatus* did not occur in the drier months of the year. In this way an insight was gained as to the environmental requirements of each species, and interest in collecting was thereby maintained.

The site of attachment of the various species on their host was also recorded. Each species had its favoured "haunt" and seldom engorged elsewhere. The chief sites of attachment for the tick species found on cattle are given in Table I.

**TABLE I**

<table>
<thead>
<tr>
<th>Tick Species</th>
<th>Site of attachment of each stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adult</td>
</tr>
<tr>
<td><em>R. appendiculatus</em></td>
<td>Ears</td>
</tr>
<tr>
<td><em>R. neavei</em></td>
<td>Udder region</td>
</tr>
<tr>
<td><em>R. neavei var. punctatus</em></td>
<td>Ears</td>
</tr>
<tr>
<td><em>R. simus</em></td>
<td>Tails</td>
</tr>
<tr>
<td><em>R. tricuspis</em></td>
<td>Tails</td>
</tr>
<tr>
<td><em>R. capensis</em></td>
<td>Udder and flanks</td>
</tr>
<tr>
<td><em>R. sanguineus</em></td>
<td>Ears</td>
</tr>
<tr>
<td><em>Boophilus appl</em></td>
<td>Neck, dewlap, belly and sides</td>
</tr>
<tr>
<td><em>A. variegetum</em></td>
<td>Udders and belly.</td>
</tr>
<tr>
<td><em>H. imp. transiens</em></td>
<td>Tails, perianal region.</td>
</tr>
</tbody>
</table>
Time and facilities did not permit of any very systematic or complete collection being made from game or other wild animals, and the complete absence of records of tick species infesting wild birds is especially unfortunate. The facts of Table I together with field experience suggest that many of the species infesting cattle as adults, engorge during their larval and nymphal instars almost entirely on avian hosts.

LABORATORY PROCEDURE

The greater part of the time in the laboratory was occupied in examining dead tick material previously collected in the field and in examining spleen smears for Koch's bodies as outlined in Part II of the thesis. Tick material was examined as soon after collection as possible so that records could be completed when events were still vivid, and details observed at collection not forgotten. Attempts were made, however, to rear every species collected under ordinary atmospheric conditions as no apparatus to control temperature or humidity was available. Engorged females were placed in a test tube half full of dry fine sawdust and on occasions moisture was added by placing a few drops of water on a filter paper projecting into the tube. *R. appendiculatus*, *R. sanguineus*, *A. variegatum* and *Boophilus Spp.* were easily bred under these conditions, but, as noted later, less success was achieved with other species. This procedure was really designed to augment field observations, but it also assisted in identifications.
For instance, engorged living nymphs of uncertain identification were collected from a cane-rat and after moulting were more readily identified as R. simpsoni. Larvae of many species were similarly treated with equal success.

CLIMATE AND VEGETATION

The variety of ticks present in any area will depend largely on the prevailing climate and vegetation. This aspect has, however, been previously discussed (Wilson, 1946) and temperature, humidity and rainfall charts are given on page 58, Part II of this thesis.
Dorsal surface of a hard tick

(a) Hypostome  (k) body protruding beyond scutum.
(b) Palps showing Articles I, II and III.
(c) Basis Capituli.
(d) Lateral angle of basis capituli.
(e) Coxa I.
(f) Scapula of scutum.
(g) Median and lateral cervical grooves.
(h) Eyes
(i) Lateral groove.
(j) Festoons.
(l) Caudal process of body.
(m) Postero-lateral dorsal grooves.
(n) Median dorsal groove.
(o) Porose areas of
(p) Cornua of basis capituli.
(q) Cornual ridge.
The chief characters on the ventral surface used for classification are the adanal, or anal plates and the accessory plates found in the males of *Rhipicephalus*, *Boophilus* and *Hyalomma*. In the males of *Ixodes* there are several flat chitinous plates present. In *Ixodidae* there is usually an anal groove present, which curves round the anus in front or behind. In all the species the character of the immovable coxa, or first leg joint is also important.

**KEY TO THE NYASALAND GENERA**

The super-family *IXODOIDEA* is divided into two families, the *Ixodidae* or hard ticks and the *Argasidae* or soft ticks.

**Family - Ixodidae**

This family is distinguished chiefly by the presence of a scutum which may be only a small round or oval plate behind the head in the females, nymphs and larvae, but covers the entire dorsal surface in the male; and by the capitulum situated on anterior margin, and always plainly visible dorsally. Eyes, when present are only two in number and situated on the lateral margin of the scutum. This family is represented in Nyasaland by six genera which may be differentiated as follows:

1. Anal groove surrounding anus in front ...... 2
   Anal groove surrounding anus behind
or obsolete .......................... 3

2. Inornate, eyes and festoons absent; male
   with six ventral plates ............... *Ixodes* (page 176)
3. Hypostome and palps short .............................. 4
   Hypostome and palps long ............................ 9

4. Eyes absent, Article II of palps project laterally beyond the basis capituli. Dorsal spur on 1st trochanter ...... Haemaphysalis (page 178)
   Eyes present ........................................... 5

5. Festoons present ........................................ 6
   Festoons absent ........................................ 7

6. Inornate (no ornate species occur in Nyasaland), basis capituli hexagonal dorsally, coxae I to IV approximately equal. A pair of adanal shields present and usually a pair of accessory plates ............ Rhipicephalus (page 17)


8. Eyes present ............................................. 9
   Eyes absent or rudimentary ............................ 10

9. Usually ornate. Male without adanal shields
   Amblyomma (page 167)
   Inornate, legs banded with light markings.
   Male with adanal plates, with or without accessory plates and with two posterior abdominal protrusions........ Hyalomma (page 171)

10. Species found almost exclusively on Reptilia.
    Aponomma (page 175)

Family - ARGASIDAE

The three genera of this family are described on page 182.

PLAN OF DESCRIPTIONS

The following sequence has been adapted in describing the ticks discussed in this paper.

(a) Name of species and synonyms.
(b) Distinguishing microscopic features, site of attachment.
(c) Salient features of male.

(i) Basis capituli.

(ii) Palps.

(iii) Scutum including Coxae I, cervical and lateral grooves, dorsal furrows, and punctations.

(iv) Adanal plates and accessory plates, and any other distinguishing ventral feature.

(d) Salient features of female.

(i) Basis capituli.

(ii) Palps.

(iii) Scutum and body.

(e) Description of nymphs and larvae (if collected).

(f) Biology.

(g) Geographical distribution.

(h) Choice of hosts.

(i) Comments.

(j) Illustrations and drawings.
Genus I - *Rhizophalus*

This genus contains some of the most important disease-carrying ticks found in Africa and as their recognition is so essential to veterinarians, they are given prior consideration. No ornate species occur in Nyasaland, and the scutum of all the species dealt with varies from reddish-brown to very dark brown or even black in colour. The hexagonal basis capituli, the short palps, bifid first coxae, and shape of the anal plates characterise the genus. The specific characters are, however, more difficult to define, owing to the range of variation within the species of any one character. Identification of the species recorded in the present survey is facilitated by arranging them into four groups.

**Group I:** the "appendiculatus" group.

The group contains at least eight species which are found in East or Central Africa i.e.

*R. appendiculatus*, *R. neavei*, *R. neavei var. punctatus*, *R. supertritus*, *R. sculptus*, *R. kochi*, *R. duttoni* and *R. masseyi*. *R. ziemanni*, although a West African species is also included and the affinities of *R. pravus* and *R. oculatus* are discussed.

All these species appear related to each other, some more closely than others, either by a similarity of their scutal punctuation or in the structure of their basis capituli, palps or anal plates. The scutum is generally well punctated, medium sized punctations predominating though fine punctations can also be
distinguished especially in the anterior portions of the scutum. In *R. sculptus*, and to a less extent in *R. supertritus*, the scutum is ridged or sculptured, a feature which may be faintly seen on some specimens of *R. appendiculatus*. The structure of the basis capituli varies, but generally it is broader than long with the lateral angles anterior and obtuse, the striking exception being *R. neavei*. The projection on Coxae I is usually distinctly visible dorsally while the median and postero-lateral dorsal grooves on the scutum are well developed. The adanal plates show considerable variation and assist in differentiating the various species.

Zumpt (1942 b), in considering *R. neavei*, recalls the range of variations shown to occur within *R. appendiculatus* species by Nuttall (1913), and with *R. sanguineus* by Cunliffe (1914) and with *R. bursa* by Zumpt (1942 a). After examining two pairs of paratypes of *R. neavei* from the Luangwa valley in N.E. Rhodesia, Zumpt concludes that they fall within this range of variations of *R. appendiculatus* and the species is not valid. He was unable to examine the types and paratypes of *R. neavei var. punctatus* but from the descriptions suggests this species might also be considered identical with *R. appendiculatus*. (Zumpt examined 3 females from Ufipa determined by Nuttall and Warburton as *R. neavei var. punctatus* but he considered they did not agree with the published description). The recent material from Nyasaland does
not support Zumpt's conclusions and the species are retained and re-described, together with the larval forms from R. neavei.

Numerous specimens of R. supertritus were collected and the species has also been re-described. R. sculptus was only collected on one occasion but an examination of this material, together with that found in the British Museum, showed features not recorded in the original description. R. oculatus is retained as a valid South African species, the completely orbited eye being the chief distinguishing feature. The position of R. pravus is fully considered and discarded as an invalid species, and specimens so named are regarded either as R. neavei, or as R. neavei var. punctatus.

R. kochi, an East African species, is only briefly considered and closely resembles R. neavei. The type specimens of R. duttoni were re-examined and the shape of the adanal plates was so strikingly different from that seen in R. appendiculatus that the species must be retained until further more abundant material can be collected and examined. Only a few specimens of R. masseyi were collected and R. ziemanni is described from specimens found in the British Museum. The following key, adapted from Zumpt (1943 b) may assist in distinguishing between these two latter species as well as between the closely related species R. aurantiacus Neumann and R. jeanelli Neumann.
MALE

1. Coxae I without, or with weakly developed dorsal process. Basis Capituli about twice as broad as long ........................................ 2

2. Median and postero-lateral dorsal grooves not well marked; only one festoon protrusible 3-4.5 mm. East Africa.  
   R. jeannelli
   Median and postero-lateral grooves always present but sometimes only faintly developed. Three festoons protrusible ............... 3

3. Lateral grooves absent and not even marked by serial punctations .............................. 4
   Lateral grooves marked by densely arranged serial punctations and deeper in the posterior portions. Postero-lateral dorsal furrows rounded. Basis Capituli and adanal plates as in R. aurantiacus 3-4 mm. Cameroons and Belgian Congo.  
   R. ziemanni

4. Postero-lateral dorsal grooves very long and narrow. Basis with acute lateral angles and larger cornuae. Posterior portion of adanal plates smaller and median border without projection 3-5 mm. West and Central Africa.  
   R. aurantiacus
   Postero-lateral dorsal grooves round as a rule. Lateral angles of basis obtuse. Posterior portion of anal plates broader and median border with more or less a retangular projection angle 3.45 mm. East Africa.  
   R. masseyi

FEMALE

1. Scutum as long as broad or slightly broader ...... 2

2. Lateral angles of basis caputuIi 90°... R. aurantiacus  
   Lateral angles of basis caputuIi more or less 90°........................................... 3

3. Eyes large ........................................ R. masseyi
   Eyes smaller ........................................ R. jeannelli
It is clear therefore that few characters distinguish the females of these four species. Zumpt's description of the new species *R. muhlensi*, Zumpt (1943) is given on page 89.
Rhipicephalus appendiculatus Neumann 1901

This is the commonest species of tick found in Nyasaland. The site of attachment of all instars is usually on the ear but they may be found on the head and neck region generally and nymphs are quite common on the tail switch. The male is a small reddish brown tick and is reasonably easily distinguished by the characters given below, more especially by the shape of the basis capituli, the numerous fine and medium sized scutal punctations and the pointed anal plates. The detailed characters are as follows:-

**MALE**: (Figs. 2 (a)(b)).

**Basis Capituli**: Generally broader than long, with strong cornua and the lateral angles obtuse and near the anterior third of the basis, i.e. the postero-lateral border of the basis is longer than the antero-lateral. The antero-lateral borders are only slightly convergent from behind forwards. A row of coarse hairs runs nearly parallel to the posterior and postero-lateral borders.

**Palps**: Short, broader than long, and angular in outline with the external contour convex and irregular. Article I visible dorsally.

**Scutum**: Coxae I projects dorsally beyond the pointed shoulder. The cervical grooves on the conscutum are limited to two small depressions but lateral grooves well marked. Punctations are numerous, fine and
evenly dispersed with a tendency for a clear space to be left medially on both sides. In the anterior portion there are a limited number of larger deep punctations.

The three posterior dorsal grooves are well defined, all three being narrow and elongated, the median being the longer.

**Anal Plates:** The external posterior angle is smooth and rounded while the internal posterior angle tends to form a point.

**FEMALE:**

**Basis Capituli:** Wider than long with prominent angles placed medially. Cornua short and cornual ridge well defined with the porous areas defined and wide apart.

**Palps:** Short as in the male with Article II attached at some distance from the basis, i.e. Article I visible dorsally.

**Scutum:** The characteristic features of this species are found on the scutum where, in a typical specimen the lateral and cervical grooves are not well defined. The lateral border area of the scutum, therefore, while slightly raised is less distinctly defined than in most other species. Punctations are small, evenly distributed with a few larger ones scattered unevenly throughout. The whole general appearance of the scutum is smooth, slightly longer than broad with rounded posterior margin and angles.
NYMPHS:

Common on cattle in Nyasaland attached to ears and head regions from April to November.

Basis Capituli: Wider than long, with sharp lateral angles mid-way and a straight posterior margin carrying no cornua.

Palps: Short, about as broad as long with the distal end of Article III broadly rounded.

Scutum: Wider than long, sub-circular in outline with deep cervical grooves reaching almost to the posterior margin of the scutum. Lateral grooves also defined marking off a raised lateral border. A few punctations are present especially in the central field.

LARVAE:

Larvae appear on cattle in Nyasaland only for a very short period, i.e. immediately after the rainy months in March, April and May, they are rare in June and July and then disappear. They are characterised by the wide short Basis capituli bearing acute lateral angles.

Palps: Are markedly constricted at base and the distal extremity of Article III bluntly rounded off.

Scutum: Very wide with short straight cervical grooves.

BIOLOGY:

The three most important facts revealed by the present survey was the failure of adult
R. appendiculatus females to engorge during the dry months of the year, the short survival time of the unfed larvae and the limited number of hosts on which this tick fed. Within these limitations, the tick thrives well in the field under the prevailing climate of Nyasaland and breeds easily in the laboratory at room conditions of temperature and relative atmospheric humidity. The following are two typical life-histories under laboratory conditions.

(a)  
Pre-oviposition period 6 days  
Laying commenced 8/2/44  
Larvae emerge 29/3/44  
i.e. Incubation period 50 days  
Larvae engorge ........ 5 "  
Larvae drop 10/4/44  
Nymphs emerge 1/5/44  
i.e. Larvae moult...... 21 days  
Nymphs engorge ........ 5 "  
Nymphs drop 8/5/44  
Adults emerge 10/6/44  
i.e. Nymphs moult..... 33 days  
Adults unfed and all died by 1/7/44.

(b)  
Pre-oviposition period 7 days  
Laying commenced 26/2/44.  
Larvae emerge 10/4/44  
i.e. Incubation period 44 days  
Larvae engorge ........ 5 "  
Larvae drop 22/4/44  
Nymphs emerge 8/5/44  
i.e. Larvae moult...... 16 days  
Nymphs engorge ........ 6 "  
Nymphs drop 23/5/44  
Adults emerge 1/7/44 to 14/7/44  
i.e. Nymphs moult.. 38-51 days  
When fed, ♀ died unattached while ♂ remained active.

The time taken from when the engorged female detached until the adults of F4 generation emerged varied from 110 days in (a) to 116-129 days in (b).

Typical partial developmental periods were as follows:

(c) Engorged nymphs collected from cattle 30/5/44  
Adults emerging 8-15/7/44  
i.e. Nymphs moult  
69-76 days

(d) Engorged nymphs collected 15/6/44  
Adults emerge 5/8/44  
i.e. Nymphs moult  
51 days

(e) Engorged nymphs collected 28/6/44  
Adults emerge 26/8/44  
i.e. Nymphs moult  
59 days
(f) Engorged nymphs collected from cattle 24/6/44  
Adults emerge 17/8/44  
i.e. Nymphs moult  
54 days

(g) Engorged nymphs collected 20/7/44  
Adults emerge 30/8/44  
i.e. Nymphs moult  
40 days

(h) Engorged nymphs collected 16/8/44  
Adults emerge 19/9/44  
i.e. Nymphs moult  
34 days

(i) Engorged nymphs collected 21/8/44  
Adults emerge 25-28/9/44  
i.e. Nymphs moult  
35-38 days

(j) Engorged nymphs collected 29/8/44  
Adults emerge 26-28/9/44  
i.e. Nymphs moult  
28-30 days

(k) Engorged nymphs collected 5/10/44  
Adults emerge 24/10/44  
i.e. Nymphs moult  
21 days

(l) Engorged nymphs collected 5/10/44  
Adults emerge 21-22/10/44  
i.e. Nymphs moult  
16-17 days

The rate of development is obviously influenced by the temperature, the shortest time of development occurring during October when the mean maximum temperature was 84°F.

The longest periods of development occurred from May to July when the mean maximum temperatures varied from 75°F to 79°F.

Under natural conditions the nymphal stage of *R. appendiculatus* would appear to be more resistant to adverse conditions than the larvae. Larvae were only really common in April and May though they are found in March, June and July. They do not appear consistently in collections from cattle at any time i.e. in numerous collections no larvae were found on
on any of the cattle herds examined. They would thus appear to feed largely on some other alternate host or hosts (cf. R. capensis, R. tricuspis, R. neavei and R. neavei var. punctatus).

Nymphs are consistently found on cattle during all the dry months of the year from mid-March to November, and are always found in much larger numbers than larvae. They are, however, especially prevalent during August, September and October when they may be collected in hundreds off a single animal. They are rarer in November and disappear completely during the rainy months of December to February.

The wet hot months of December to March are especially characterised by massive infestations of adult R. appendiculatus ticks on the ears of bovines. It is only during these months that females will engorge and oviposit.

There are two limiting factors therefore in the life-cycle of this tick. Larvae, if not engorged by June or July appear to perish. The adult females will only oviposit and start a new life-cycle when humidity is high during the months of January to March. Under Nyasaland conditions, therefore, R. appendiculatus can have at most, in the field, one life-cycle during each year. And as noted elsewhere (page 190), this should influence control measures.
GEOGRAPHICAL DISTRIBUTION:
This tick is common throughout Nyasaland wherever domestic animals are found. It has also been reported from S. Africa, S. and N. Rhodesia, Belgian Congo, Portuguese East Africa, Tanganyika, Kenya and Uganda.

CHOICE OF HOST:
The list of hosts on which *R. appendiculatus* has been found is very limited.

<table>
<thead>
<tr>
<th>Host</th>
<th>Developmental Stage Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Larvae, nymphs, adults</td>
</tr>
<tr>
<td>Sheep</td>
<td>&quot;</td>
</tr>
<tr>
<td>Goats</td>
<td>&quot;</td>
</tr>
<tr>
<td>Dog</td>
<td>Nymphs, Adults (both rare)</td>
</tr>
<tr>
<td>Donkey</td>
<td>Adults</td>
</tr>
<tr>
<td>Cane Rat</td>
<td>Nymphs</td>
</tr>
</tbody>
</table>

The adult stages of this tick feed, therefore, almost entirely on cattle, sheep and goats, being absent from game animals, the largest carnivora and poultry.
Rhipicephalus appendiculatus male showing diagnostic features of (a) basis capituli and palps and (b) adanal plates.
**RHIPICEPHALUS neavei** Warburton 1912.

This is a small tick with scutum varying from brown to blackish brown, and brownish-red legs. It shows a range of size variations similar to *R. appendiculatus*.

The salient microscopic features are as follows:

**MALE**: (Figs. 3(a)(b)(c) and 6).

**Basis Capituli**:- Much broader than long with straight posterior border and strong cornua. The antero-lateral border is slightly convex and meets the concave postero-lateral border medially at an acute angle. This angle is recurved backwards, especially ventrally, and is characteristic of the species. The median field is punctate, especially posteriorly, where a row of large punctations may occur. Cornual grooves faintly outlined.

**Palps**:- Article I visible dorsally, Article II usually larger than Article III and both are slightly concave dorsally.

**Scutum**:- Coxae I prominent dorsally. Small medium sized punctations are found all over the scutum except on region immediately in front of the eyes. These punctations are better defined than in *R. appendiculatus*. Cervical grooves are deep oval pits continued posteriorly as divergent shallow linear depressions. The lateral grooves are well defined, contain punctations, and include no festoons. The three posterior dorsal furrows are well marked, the median posterior being long and
pointed, and the postero-laterals are long oval depressions with punctations on all their surfaces. Eyes are large, yellowish, and flat with either a definite groove or with one or two large punctations on their dorsal border. The body may extend beyond the scutum posteriorly and bear plaques.

**Anal Plates:** Broader than in *R. appendiculatus* with the external posterior angle about 90°. The internal border is longer than the external and may bear an inwardly projecting tip posterior to the median concavity and near the postero-median angle. None of these features are however constant. The accessory plates are indicated by chitinous points.

**FEMALE:** (Figs. 4, 7)

**Basis Capituli:** Antero-lateral margin is more convex than in the male, meeting the concave postero-lateral in an acute recurved point. The porose areas are small and wide apart.

**Palps:** Large with Article II greater than Article III and Article I visible dorsally.

**Scutum:** Eyes large and situated posteriorly at junction of the lateral and posterior scutal margins. A definite groove is usually found along their dorsal border. Cervical grooves are well defined, as in male, by anterior elongated depressed areas. No definite lateral groove occurs but the marginal area is raised, convex and glossy. Punctations as in male with area in front of eyes and convex margins almost devoid of punctations. The central field is closely punctated with medium sized
punctations with few on the scapulae, also finer faint punctations occur on the median anterior cervical field and on the smooth lateral ridges.

**LARVAE.** (Figs. 5 and 8)

**Basis Capituli:** As in *R. appendiculatus* the chitinized portion does not completely cover the whole dorsal surface so that the basis appears oblong in outline, and longer than broad. The antero-lateral border is equal to the postero-lateral border and they meet in a blunt angle which does not project as far as the shoulder.

**Palps:** Slightly constricted at base with Article III ending bluntly.

**Scutum:** Definitely broader than long with no trace of dorsal grooves. Coxae I prominent dorsally and bears a stout hair. (Also seen in *R. appendiculatus* larvae but better developed in *R. neavei*.) Ventrally, Coxae I bears a short blunt external spur, Coxae II and III are unarmed. Cervical grooves faintly delineated. Eyes large and at junction of lateral and posterior borders. (The specimens were examined after cleaning in Euperal and in glycerine).

**BIOLOGY:**

The life history of *R. neavei* is unknown as only adults have been collected to date. In Lilongwe, one female from batch No. 284 oviposited and the following details of the life history were determined at room temperature and at ordinary atmospheric humidity.
Pre-oviposition period - 6 days.
Egg hatched ........... - 33 to 39 days.

There was a good hatch of larvae, the first lot appearing on the 16th April, 1945. They were fed on the ear of a bovine suffering from East Coast Fever but failed to engorge and no further trials were possible.

GEOGRAPHICAL DISTRIBUTION:

This tick was first described by Warburton (1912) from material received from N.E. Rhodesia, Nyasaland, and British East Africa. In Nyasaland it was recorded from the Roan antelope, bushbuck, warthog, Lepus species, cattle, and from the Grass, but no localities are given. Lewis (1939) also records it from Kenya.

RECORDS FROM NYASALAND:

The distribution of this species in Nyasaland is shown on Map I. Although occurring at widely scattered points on a variety of hosts it never appeared in large numbers on any host, being usually found as occasional specimens associated with R. appendiculatus infestations. The only possible exceptions were specimens No. 224 (q♂, 2♀) and 248A (n♂, q♀) from the wild hare (Lepus whytei) and specimens Nos. 284 (♂♂♂, ♀♀♀) and 296 (♂♂♂, ♀♀♀) from cattle in Dowa district. But in each case the numbers of males and females collected are small compared with similar collections of R. appendiculatus, R. capensis and R. tricuspis.
During the present survey, this species was collected on 21 occasions from the following hosts - cattle, sheep, gwape, duiker, bushbuck, eland, kudu, buffalo, and the hare (Lepus whytei).

With one exception - specimen No. 185, from Kota-Kota - all the records are from areas above 4000 feet sea level. Thus in Mzimba at an altitude of 4500 feet the hare (Lepus whytei) carried *R. neavei* while at Lilongwe, 3500 feet above sea level, only *R. sanguines* adults were common on this host. Cattle in Dowa, again at 4500 feet above sea level, carried *R. neavei* while this species was consistently absent from cattle at Lilongwe. Antelope generally carry few ticks of any species, and *R. neavei* was only collected on these animals as rare specimens, few in numbers.

In addition to being present in small numbers, the adults, at least, seem to be rarer in the dry season than in the rains. But in the female the desire to engorge fully seems to persist longer than in *R. appendiculatus*. Thus engorged females were collected from September to March. The site of attachment on the host also varies from that of *R. appendiculatus*, *R. neavei* being most often found attached to the udder and flank regions.
Rhipicephalus neavel male showing capitulum and grooves and punctations on scutum.

Fig. 3(a)
Fig. 3 (b) and (c)
Adanal plates of *Rhipicephalus neavei*.

Fig. 4.
*Rhipicephalus neavei* female showing shape, grooves, and punctations of scutum.
Fig. 5.
Larva of *Rhipicephalus neavei* - dorsal view.

Palps concave dorsally
Recurved angle of basis
Coxa I visible dorsally

Fig. 6.
*Rhipicephalus neavei* male - dorsal view.
Fig. 7.
Rhipicephalus neavei female - dorsal view.

Fig. 8.
Larva of Rhipicephalus neavei - dorsal and ventral view.
RHIPICEPHALUS neavei var. punctatus

Warburton 1912.

This species does not differ either in shape, size or colouration from R. neavei and R. appendiculatus, but it can be distinguished by the following characters:

MALE: (Figs. 9, 10, 11, 12, 13, 14, 15 and 18).

Basis Capituli: - As in R. neavei but the angles of the basis are less acute and certainly not so recurved as those of R. neavei but in many specimens are more acute than as shown in the drawing by Warburton (1912). Cornuae short and blunt. Dorsal surface punctated especially near posterior border and may carry a row of hairs as in R. appendiculatus (Fig. 15).

Palps: Stout, broader than long, Article II equal to Article III. External contour convex and slightly broken at junction of Article II and III. Article III with bluntly rounded anterior margin and dorsal surface appears deeply concave.

Article I visible dorsally.

Scutum: - The punctations on the scutum are more numerous and deeper than in R. neavei or R. appendiculatus and extend even on to the region in front of the eyes. Thus, while R. neavei has punctations resembling R. appendiculatus, the punctations of R. neavei var. punctatus more nearly approach those of R. capensis. While the coarse punctations occur all over the scutum, a few fainter small punctations occur on the anterior central area and shoulder region. The cervical grooves resemble those of R. neavei but the
deep anterior portion may not appear so distinct owing to the presence of the more numerous and deeper cervical punctations, while the continuing diverging posteriorly directed depressions are more pronounced and are bordered laterally by a scattered row of larger punctations. The three posterior dorsal grooves are well developed. The lateral groove is also distinct and includes no festoons. In engorged specimens, the yellowish body protrudes laterally beyond the scutum at a level a little posterior to the eyes. Eyes are distinct and placed relatively far back and limited dorsally by punctations.

**Anal plates:** (As in Figs. 10 and 11). The angle formed by the external and posterior borders is obtuse and rounded, and situated more posteriorly than in *R. neavei*. An internal protuberance on the median border posterior to the concavity is also common and similar to that found in *R. neavei*. The accessory anal plates are strongly developed in specimens No. 254 (A), Fig. 13, (C.f. Warburton 1912).

**FEMALE:** (Figs. 16, 17 and 19).

**Basis Capituli:** Is twice as broad as long with the lateral borders approximately equal, the posterolateral border being strongly convex while the antero-lateral is straight or slightly concave. The lateral angles are medial and acute. The posterior border is straight with the cornua blunt and not well developed and cornual ridge only faintly
represented. The porose areas are well marked, oval, wide apart and directed slightly inwards.

Palps:—Are short, well developed and with Article II and III equal. The whole appearance is very similar to that of *R. appendiculatus*. The hypostome is usually longer than the palps.

Scutum:—Is longer than broad with cervical and lateral grooves well defined. The cervical grooves have anterior deep converging areas with more faintly delineated posterior diverging furrows. The lateral groove is well marked for its whole length, deeply punctated and reaches the posterior border, and defines raised lateral areas from the central depressed scutal area. The lateral border of the scutum is slightly convex while the posterior border is undulating, being first concave and then convex. The whole scutum is punctated, those in the central area being coarse and deep, but fine punctations occur on the shoulders and the anterior central area. In some specimens these fine punctations continue along the raised border giving a coarse central punctated area and lateral more finely punctated areas.

Eyes are salient and placed far back on the lateral border and are limited dorsally, as in the male, by an adjacent row of punctations or by a definite dorsal groove.

Body:—Shows lateral grooves, festoons and three linear equal posterior dorsal furrows.

In Nyasaland collections, it is most important
to distinguish the female *R. neavei* var. *punctatus* from the female *R. sanguineus*. Not only are they often found together in collections especially from the hare (*Lepus whytei*), but the scuta... have a superficial resemblance. Thus the scutum of *R. neavei* var. *punctatus* is oval, longer than broad, with an undulating posterior border as in *R. sanguineus*. But in *R. sanguineus*, the lateral grooves are deeper and better defined while the punctations are more sparse and markedly unequal.

**BIOLOGY:**

The life history of this species is unknown.

**CHOICE OF HOST:**

This species was originally described by Warburton from Kudu, Impala and reed buck from Nyasaland. In the present survey it was recorded on twelve occasions from the following hosts:— Cattle, hartebeest, gwape, buffalo, and hare (*Lepus whytei*). The best collections were taken from *Lepus whytei* and from the hartebeest while on cattle it was only occasionally taken in small numbers in collections from Mzimba and N. Nyasa districts.

**GEOGRAPHICAL DISTRIBUTION:** See map (1)

This species has, as yet, only been recorded from Nyasaland and Belgian Congo. Theiler (1943) does not include in the collections from Portugese East Africa nor does Lewis (1939) record it from Kenya. In Nyasaland it is rare, in Central Province and with
two exceptions, all the present specimens came from Mzimba and North Nyasa. No doubt it extends into Southern Tanganyika and N.E. Rhodesia.

**COMMENTS:**

Bequaeret (1930) referring to *R. capensis* var. *compositus* states as follows:— "I am inclined to think that this form of *R. capensis* was described anew by Warburton as *R. neavei* var. *punctatus*." Actually this species superficially resembles *R. capensis* in the nature of its punctations and in the shape of the anal plates but is a much smaller species. It seems too distinct a species to be placed as a sub-species, and when the biology has been fully worked out it will, no doubt, be given specific rank.
| TABLE II  
<table>
<thead>
<tr>
<th>Differentiation of <em>R. neavii</em> and *R. neavii var. mutatus</th>
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</thead>
<tbody>
<tr>
<td><strong>MALE CHARACTERS</strong></td>
</tr>
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</table>
| Resin Camollatus | Pales | Description | Anal Plates | Dental markings  
<table>
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<tr>
<td><strong>FEMALE CHARACTERS</strong></td>
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| Resin Camollatus | Pales | Description | Anal Plates | Dental markings  
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<tbody>
<tr>
<td>Ant. lat. border shorter than post. Lat. angles in ant. 3° acute but never recurved. Cervical ridges well developed with depressed central area and well defined porous areas.</td>
<td>More strongly developed, than in <em>R. neavii</em>. Article II and III broader than long and equal. Article II attached some distance from basis and Article I visible dorsally. Article III arising bluntly.</td>
<td>Small, fine, evenly distributed. Few large punctations scattered irregularly over surface.</td>
<td>Triangular depressed areas in lat. ant. portion of scutum represent grooves but lat. grooves may be present. Post, angles and post, border of scutum rounded and circular.</td>
</tr>
<tr>
<td>Ant. border convex with lat. angles acute or rounded. Cervical ridges defined marking off central, depressed area. Porous areas small and wide apart.</td>
<td>Compact, well developed. Article II attached some distance from basis and Article I visible. Article II projecting post, lat. angle. Article III arising bluntly.</td>
<td>Central field with uniform, small well defined punctations. Lat. field especially in front of eyes glossy and almost devoid of punctations.</td>
<td>Cervical grooves with deep ant. converging portion and divergent post. linear depressions. Lat. groove absent. Post, border and angles rounded.</td>
</tr>
<tr>
<td>Ant. border convex with lateral angles median or acute. Cervical ridges not well developed. Porous areas large and close together.</td>
<td>Compact, regular with Article I visible. General appearance as in <em>R. camollatus</em>.</td>
<td>Deep uniform punctations over entire scutum, with tendency for smaller punctations on ant. central field and lateral border.</td>
<td></td>
</tr>
</tbody>
</table>

**R. neavii var. mutatus**
Showing cephalic and dorsal surface of cibarium

Phthiraptera neesi var. punctatus - enrobed male

Fig. 9
Rhipicephalus neavei var. punctatus - adanal plates of male from Belgian Congo in British Museum.

Fig. 10.

Rhipicephalus neavei var. punctatus - adanal plates of male collected from Kudu, C. Angoniland 1910. British Museum specimen.
Fig. 12.
*Rhipicephalus neavei* var. *punctatus* male – capitulum and anterior portion of scutum.

Fig. 13.
*Rhipicephalus neavei* var. *punctatus* male, showing anal and accessory plates.
Fig. 14.
*Rhipicephalus neavei* var. *punctatus* male - dorsal view.

Note dense punctations
Posterior dorsal grooves distinct

Fig. 15.
*Rhipicephalus neavei* var. *punctatus* male - dorsal view showing projection of Coxa I and row of hairs on basis capituli.
Rhipicephalus neavei var. punctatus female showing capitulum and scutum.

Note: No area clear of punctations in front of eye. (cf. Fig. 7)
Fig. 18.
*Rhipicephalus neavei* var. *punctatus*—engorged male dorsal view.

Fig. 19.
*Rhipicephalus neavei* var. *punctatus*—engorged female showing grooves and punctations on scutum.
**Rhipicephalus supertritus.** Neumann 1907

**Rhipicephalus coriaceus.** Nuttall and Warburton 1907

**Distinguishing Features.**

This is a large black tick with reddish brown legs, the scutum being larger and more coarsely punctated than in *R. appendiculatus* and with reticulations rather than punctations on the surfaces of the cervical and dorsal depressions.

**MALE:** (Figs. 20, 21, 22, and 23)

**Basis Capitulum:** Large, almost twice as long as broad with the concave postero-lateral borders long and meeting the shorter antero-lateral borders in an obtuse angle in the anterior half of basis as in *R. appendiculatus*. A transverse row of long hairs runs parallel to the posterior border of the basis and continues on to the antero-lateral margins. The posterior border is concave with well developed cornua.

**Palps:** Well developed with Article II and III concave dorsally and article II greater than III. The lateral margin is broken by Article III projecting slightly beyond Article II.

**Scutum:** Coxae I prominent dorsally. Cervical grooves definite and converging behind, marking off on each side small cervical depressed fields with surface covered by fine reticulations. Lateral grooves are definite and not picked out with punctations, usually ending in first festoon. Punctations on posterior part of scutum are rugosities rather than punctations but medium sized punctations occur on the anterior half of scutum, the shoulders, lateral fold and on festoons.
The surfaces of the posterior depressions show similar fine reticulations as on the cervical depression. There is a tendency on some specimens for further slight reticulated depressions external to postero-lateral depressions.

Festoons well marked, longer than broad with ventral plaques on protruding abdomen which also carries three finger-like body protrusions. (Fig. 22) Anal plates:-- as in *R. appendiculatus*, with a tendency for the median posterior angle to be pointed. The internal margin is only slightly concave while the lateral margin is markedly convex and meets the convex posterior border in an obtuse postero-lateral angle.

Body:-- The whitish hairs on the shoulder, in the cervical grooves, the lateral field and posterior part of scutum in the male described by Nuttall and Warburton (1907) are present but not conspicuous on the Nyasaland material.

FEMALE: (Fig. 24).

Basis Capituli:-- As in male, with the postero-lateral borders longer than the antero-laterals and meet in an obtuse lateral angle in the anterior half of the basis (Cf. *R. appendiculatus*) Cornu definite but not pronounced. Porose areas well marked, circular and wide apart.

Palps:-- Not unlike *R. appendiculatus* with Article I visible dorsally and Article III rectangular. Dorsal surfaces of Article II and III are not concave as in the male.
Scutum:— Almost circular, about as broad as long. Lateral grooves are pronounced reaching the posterior margin. Cervical grooves are deep and converging for their anterior third, but become fainter towards the posterior of the scutum and diverge. The cervical triangular depression is pronounced and has a reticulate surface as in male. These reticulations extend backwards as a definite band medial to the lateral groove. Punctations are definite on areas not reticulated but, as in the male, may be confluent in the central posterior region and give a rugose appearance. Again, as in the male, the hairs on the scutum and between the dorsal furrows of the abdomen are not distinctive on the Nyasaland specimens.

COMMENTS:—

Only a brief description of this species is given as it has recently been re-described by Theiler (in press) from material loaned to her from Nyasaland. This species shows some similarity to R. appendiculatus. In the males the basis capituli and anal plates are very similar but the larger size and the reticulations and rugosities on the scutum of the male R. supertritus distinguish this species. In the females the similarity may be more striking as in some specimens of R. appendiculatus the cervical depressions on the scutum may be as prominent as in R. supertritus and coarse type of punctations occur. But the reticulations and coarser punctations and defined lateral groove again
differentiate the *R. supertritus* female. Some specimens are seen where these characteristics are not prominent and the two species tend to merge towards each other.

**GEOGRAPHICAL DISTRIBUTION:**

This species has been previously recorded from Nyasaland, 2 males and 6 females being collected by Dr. Old in North Nyasaland in 1907 but no host stated. 1 male has also been collected by Dr. F.C. Wellman from Benguella in 1907. In the present survey it has been identified on three occasions. On the first occasion - Specimen No. 193 - 3 males were taken in the Lilongwe laboratory on 30/8/1944 from the hide of a Sable antelope shot 30 hours previously at Fort Manning, 90 miles distant. This affords ample proof of how ticks can be carried from one area to another if no preventive precautions are taken. Specimens No.280 were from a collection of ticks sent to me by Mr. S.W. Saffikin from a Buffalo shot at Chinunka, Songwe River, North Nyasa, on the 21/12/1944, and consisted of five females and twelve males. Some of the females were fully engorged. The third record - Specimen No.319 - consisted of 1 male and 1 female from a Hartebeest shot on the 15/5/1944, also sent by Mr. Saffikin from Chinunka.

Specimens No. 193 and part of No.280 were deposited at the Onderstepoort Veterinary Research Laboratories, South Africa, and it is from these
specimens that Dr. Theiler's revised description is based.

The remaining specimens in Tube No. 280 and specimen No. 319 have been deposited in the Zoology Department, Edinburgh.

Fig. 20.

*R. supertritus* male - capitulum
Fig. 21

*Rhipicephalus supertritus* male - ventral view showing adanal shields and the three posterior protrusions.

---

Fig. 22

*Rhipicephalus supertritus* engorged male - dorsal view of extreme posterior showing festoons and plaques.
Fig. 22.
*Rhipicephalus supertritius* engorged male - dorsal view of extreme posterior showing festoons and plaques.
Fig. 23.
*Rhipicephalus supertritus* male - dorsal view

Fig. 24.
*Rhipicephalus supertritus* female - dorsal view.
RHIPICEPHALUS sculptus Warburton 1912.

This tick is usually large but varies in size. The scutum is dark brown in colour and has yellowish legs.

The present description is based on specimens collected from a zebra in Kasungu district of Nyasaland, and on the type specimens examined in the British Museum.

MALE:

Basis Capituli:— Closely resembles R. supertritus, being almost twice as broad as long with the lateral angles anterior and obtuse and cornua well developed. There are no cornual ridges but the dorsal surface is punctated and carries a row of hairs as in R. supertritus and R. appendiculatus.

Palps:— Broader than long. Article I visible dorsally, Article II roughly rectangular and Article III ending bluntly. The median dorsal surfaces of Articles II and III are concave.

Scutum:— Coxae I visible dorsally with the projection curving markedly outwards. The scutum is narrow anteriorly, becomes slightly impressed at the level of the eyes and attains its greatest breadth slightly posterior to the median line. The lateral cervical grooves are well marked and define the raised lateral borders; they curve inwards posteriorly on meeting the raised glossy ridge which runs transversely across the scutum to define the pseudo scutum. The median cervical grooves begin as elongated converging pits and are continued posteriorly for a short
distance as faint divergent furrows. The depressed areas found between these cervical grooves have their anterior portion, together with the surface of the grooves, reticulated. Punctations, however, encroach into the posterior and median portions of the depressions, and the reticulated areas therefore are not so extensive as in *R. supertritus*. The lateral grooves are well developed, commencing behind the eyes and include one festoon. The three posterior narrow dorsal furrows have their depressed surfaces reticulated; the median groove being the longest and straightest, while the shorter postero-laterals curve outwards. These three grooves are bounded laterally and anteriorly by narrow glossy ridges. A second pair of reticulated depressions is found in most specimens external to the postero-laterals making a total of five posterior depressions. These most lateral depressions curve inwards and a punctated horse-shoe shaped shallow furrow can usually be traced joining their anterior extremities and encircling the median and postero-lateral grooves. Outside this posterior semi-circular depressed area, the suctum is marked with raised punctated areas separated by small irregular depressed reticulated areas. A raised glossy unpunctated ridge runs from the posterior border of the pseudo suctum backwards, parallel and internal to the lateral groove. The punctations are medium sized and deep in the central field but a group of very large punctations occur
on the shoulders while very fine punctations occur on the anterior median cervical area and on the raised border areas. Eyes are medium sized, flat, yellow, with a row of deep punctations along the dorsal border.

Adanal Plates:— Roughly triangular with broadish base. The lateral border is slightly convex, the inner border is longer and concave medially. The posterior border is convex but shows some variation. Thus in the great majority of the specimens examined a slight posteriorly directed spur is formed at the junction of the posterior and lateral borders while a similar inwardly directed spur is found median to the posterior angle. One one of the 2 types in the British Museum these spurs are however absent (Fig. 28). Accessory anal plates are missing.

FEMALE:

Basis Capituli:— Twice as broad as long, with the postero-lateral border concave, the antero-lateral convex and the lateral angle median and slightly obtuse. The posterior border is straight with cornuae short and blunt. Porose areas are large, circular, wide apart and contiguous laterally with the dorsal ridge.

Palps:— Articles II and III longer than broad with dorsal surface concave. Article I visible dorsally. Numerous strong hairs project along the margin of each article.
**Scutum:** Almost circular with the posterior margin showing slight undulations. Cervical grooves deep and converging anteriorly but are continued posteriorly as shallow divergent furrows. The lateral groove is well developed, reaching the posterior scutal margin and defines the broad raised lateral border from the depressed circular central area. The surface of the anterior depressed triangular area limited by the lateral and cervical grooves is reticulated and a band of reticulations also occur along both grooves posteriorly. Punctations in the central field are medium sized, discreet and uniformly distributed. A group of large punctations occur on the lateral border as in the male while faint small punctations occur on the lateral border and on the anterior median cervical field. Eyes are small, to medium sized and bordered dorsally by a groove which would appear to represent one to two coalesced punctations.

**Body:** is fringed dorsally by a row of stout white hairs, while a further row of hairs is found along the marginal groove. The dorsum is strongly punctated and grooved.

**BIOLOGY:** Unknown.

**GEOGRAPHICAL DISTRIBUTION:**

Nyasaland. Specimens labelled *R. sculptus* from Kenya seen at the British Museum differed from the type species.
CHOICE OF HOST: - Roan antelope, zebra.

COMMENTS: -

The above description is more complete and differs in many respects from that given by Warburton (1912). For instance, Warburton omitted mention of the variations in shape shown by the adanal plates, but merely refers to them as being similar to those of R. supertritus. With regard to the relationship of this species Warburton (1912) comments as follows: - "R. appendiculatus and R. sculptus are three forms closely allied and in certain structural points practically identical, but presenting quite different facies, on account of their progressively complicated scutal sculpture on both sexes."
Fig. 25.

*Rhipicephalus sculptus* male - capitulum and anterior portion of scutum.
Fig. 26

*Rhipicephalus sculptus* female - capitulum and scutum
**Fig. 27**

*Rhipicephalus sculptus* male - posterior portion of scutum showing dorsal grooves and festoons.

**Fig. 28.**

*Rhipicephalus sculptus* - adanal plates of male from type specimen British Museum resembling *Rhipicephalus supertritids.*
Fig. 29.

*Rhipicephalus sculptus* - adanal plates of type specimen from British Museum showing small notches on the postero-lateral and postero-median angles.
Fig. 31.
R. sculptus male - dorsal view.

Fig. 32.
R. sculptus female - dorsal view.
**RHIPICEPHALUS oculatus** Neumann 1901

This species has not been collected in Nyasaland but the following brief description is given from material examined in the British Museum.

**MALE:** (Fig. 33 (a)(b)).

**Basis Capituli:** About twice as broad as long. The postero-lateral border is concave, the antero-lateral border convex, with the lateral angles mesial and acute. The posterior border is slightly concave, and cornua well developed. The dorsal surface bears grooves and punctations.

**Palps:** Well developed, Article I visible dorsally, Article II angular and equal to Article III which ends bluntly. The external contour is irregular.

**Scutum:** Covers all the dorsum and is uniformly brown in colour. Coxae I visible dorsally. The cervical grooves are deep and convergent in the anterior portions and are continued posteriorly by shallow divergent furrows. The lateral grooves are well developed, beginning immediately behind the eyes and include no festoons. The eyes are characteristic, being small, shiny and deeply orbited. Medium sized punctations are numerous, uniformly distributed and three well-developed dorsal grooves are present. There is usually no caudal appendage.

**Adanal plates:** Triangular, almost twice as long as broad, with the posterior border convex, the internal angle acute, and the internal border concave. A medial projection on the internal border posterior to the median concavity is occasionally seen. The
accessory plates are absent or only slightly chitinised.

**FEMALE:**

**Basis Capituli:** Twice as broad as long with borders and angles very similar to the male. The porose areas are oval, parallel in position and the distance apart equals the diameter of each area.

**Palps:** As in the male.

**Scutum:** Oval, as long as broad with distinct lateral grooves extending almost to the posterior border. Cervical grooves deep and converging for a short distance anteriorly, but soon diverge and become shallow, but can be traced posteriorly to join the lateral groove and thus enclose an elongated, slightly depressed, lateral area. Punctations uniform and numerous. Eyes small orbited and placed far back near the junction of the lateral and posterior borders of the scutum.

**GEOGRAPHICAL DISTRIBUTION:**

This species has been recorded from Ethiopia, Kenya, Tanganyika and South Africa, but probably the East African records refer chiefly to *R. neavei* and "*R. pravus".*

**CHOICE OF HOST:** - Rabbit, cattle, giraffe, gazelle.

**COMMENTS:**

Specimens collected by R.A. Cooley from *Lepus zuluensis* at Pretoria market have punctations and basis capituli very similar to *R. neavei var. punctatus.* The cervical grooves, Coxae I, the three well developed dorsal grooves and the presence
of a caudal appendage increase this resemblance but the small round orbited eyes offer a very marked contrast to the large yellow flat ovoid eyes of *R. neavei var. punctatus*. 
Fig. 33 (a)
*Rhipicephalus oculatus*
male showing capitulum and orbited eyes.

Fig. 33 (b).
*Rhipicephalus oculatus*
adanal plate showing resemblance to that of 
*Rhipicephalus neavei.*
RHIPICEPHALUS pravus

Donitz 1910.

There seems to be considerable doubt as to the validity of Rhipicephalus pravus. Donitz (1910, p. 479) first suggested this species in the following terms: "R. oculatus was described by Neumann from 2 males and 2 females from South Africa and 1 female from German East Africa. The East African form, of which I have received a number of specimens in several consignments, shows a striking divergence from the South African type. In part, the eyes are larger, not shining but white, and not regularly hemispherical, but it is "nach unten und vorn" flattened and elongated and passes over more evenly into the dorsal surface of the edge of the scutum. Only dorsally is it bounded by a groove; elsewhere it forms the edge direct while in oculatus proper, it lies inward from the edge and is encircled by a deep furrow. The male is often strikingly narrow towards the anterior end as manifest in the rate of "width between eyes" - "scutal length": - but is not a decisive character; there are too many intermediate forms. The small point on the inner edge of the adanal plate behind the notch, is absent. The difference in the form of the eyes is so striking that I consider it specific. I name this species pravus i.e. deformed".

Warburton (1912) refers to this species as follows: - "Some ticks which Donitz has alluded to as R. pravus but has never described, and of which he had kindly sent us specimens, seem to belong to this variety (R. neavei var. punctatus) though their eyes
are exceptionally prominent." Zumpt (1942b) considers *R. pravus* a valid species. He comments that Neumann, unaware of the description of *R. pravus*, described *R. oculatus*. Nuttall and Warburton although aware of the description place *R. pravus* specimens with *R. neavei*. He (Zumpt) differentiates *R. pravus* from *R. appendiculatus* as follows:

**MALE SPECIES.**

1. Anal plates with rounded external angles. Accessory plates generally present ............2

2. Eyes quite flat, basis capituli generally narrow about one and a half times as long as broad, with the antero-lateral border in front of the obtuse lateral angles only slightly converging. (In some specimens however the basis capituli is similar to that of the subsequent species). South and East Africa.

   *R. appendiculatus.*

   Eyes smaller and slightly enucleated. Basis capituli more than twice as broad as long and the antero-lateral borders in front of acute lateral angle strongly convergent. East Africa.

   *R. pravus.*

In the **FEMALE** the distinction is as follows:

1. Scutum as long as broad or slightly broader. Eyes flat and large and placed medially on the lateral scutal margin. *R. appendiculatus.*

2. Scutum distinctly longer than broad. Eyes slightly orbited, smaller and placed posteriorly on the lateral margin. *R. pravus.*

In his description of *R. pravus*, Zumpt describes a male with scutum more elongated than *R. appendiculatus* and uniformly punctated with coarser and finer punctations, cervical grooves well developed but the lateral cervical furrows faint or missing. The characters of the female apart from the slightly
orbited eyes, are even more indefinite and the lateral grooves are referred to as "die Lateral-furchen fehlen jedoch häufig oder sind nur angedeutet, seltener voll ausgepragt." The over emphasis of one character has caused the inclusion of varying types in the one species. Examination of the present Nyasaland collection of R. neavei and R. neavei var. punctatus and of the type species in the British Museum shows that in both the above species the eyes are frequently either "orbited" dorsally by a definite furrow or by a row of contiguous punctations. Specimens labelled in the British Museum as R. oculatus var. pravus from Kampala Uganda, correspond to R. neavei var. punctatus while specimens similarly labelled from Pinnars River, S. Africa taken off Lepus zuluensis proved to be R. neavei. The type species sent to the Museum by Donitz (Fig. 34, 37) was, apart from a few minor differences, similar to R. neavei. For these reasons R. pravus is here considered an invalid species.
"Rhipicephalus pravus" capitulum of male showing resemblance to that of *Rhipicephalus neavei* var. punctatus.

"Rhipicephalus pravus" female. Capitulum and anterior portion of scutum resembling *Rhipicephalus neavei*.
Fig. 36.
"Rhipicephalus pravus"
type specimen of
Donitz in British
Museum – adanal plates
resembled those of
Rhipicephalus neavei.
Fig. 37.

*Rhipicephalus pravus* Donitz male showing groove along dorsal border of eye and area clear of punctations in front of eye as in *Rhipicephalus neavei.*
The species resembles *R. appendiculatus* dorsally but differs in the distinctive shape of the adanal plates. Only the males of the species have been described and co-types of Neumann's specimens from Zambu, Kenya, from cattle are in the British Museum collection.

**MALES:**

**Basis Capituli:** As in *R. appendiculatus*, with row of dorsal hairs present.

**Palps:** As in *R. appendiculatus*.

**Scutum:** Coxae I has the anterior summit much elongated and conspicuous dorsally as an auricle. The cervical grooves are very broad and form a shallow elongated depressed area, not punctated but reticulated as in *R. supertritus*. Median and para-median grooves short and deep with shagreened surfaces. The lateral grooves are broad and shallow with few fine punctations, commence immediately behind the eyes and include one or two festoons. Punctations irregular with punctations coarsest in front and fine and superficial over remainder of scutum.

**Adanal Plates:** Long, triangular. There is usually a small projecting knob on the posterior border near the postero-lateral angle though this may be absent as in *R. sculptus*. The internal-posterior angle is prolonged as a blunt point. No chitinised
accessory plates but prominent no-chitinised folds are present.

The biology of this species is unknown and the only records are from cattle in the Congo Free State. Bequaeret (1931) quotes Schwetz as having collected this species from Banana and Hoanda in the Lower Belgian Congo.

COMMENT:

The adanal plates are very distinct and the accessory plates constantly absent so until more material can be collected and the constancy of these features studied, the species must be retained as distinct.
Fig. 38.
Rhipicephalus duttoni male - Belgian Congo showing
(Rhipicephalus attenuatus, Neumann 1908).

Rhipicephalus masseyi is a medium sized tick corresponding approximately in size to R. tricuspid but the scutum is reddish-brown to yellowish brown in colour, the legs and the soft body parts being more lightly coloured. It was only collected on one occasion from a dog, but type specimens and other material were examined at the British Museum.

MALE:

Basis Capituli:— Broader than long. The lateral angles are in the anterior one third and obtuse, and a row of hairs runs across the punctated dorsal surface as in R. appendiculatus. Cornua blunt.

Palps:— Article I visible dorsally. Article II and III are equal, broader than long and concave dorsally. A row of hairs projects from the convex lateral border.

Scutum: One and a half times as long as broad being widest posteriorly. Cervical grooves are small deep crescentic pits, continued posteriorly by very shallow divergent depressions which may, however, be very indistinct, and the lateral cervical groove is never present. The lateral groove is only indicated anteriorly by shallow punctations which become deeper posteriorly and a definite groove is formed. Zumpt (1943 b) described this lateral groove as missing. The Nyasaland material, and also that seen at the
British Museum, show only the median and one pair of postero-lateral grooves. This agrees with Theiler (1946) and Zumpt (1943 b). In the Nyasaland material the postero-lateral grooves are oval but Zumpt states that in some specimens they are long and linear and approach those which he describes for *R. aurantiacus*. Two pairs of foveolae are also seen placed diagonally anterior to the postero-lateral grooves, the median pair being anterior. Punctations are numerous and relatively fine; some specimens showed punctations as fine as those seen in *R. simus*. Occasional large punctations occur but are not very obvious. Eyes large and flat.

**Adanal Plates:** Not dissimilar to those of *R. neavei var. punctatus*, being broad behind, with rounded external and internal angles with an inner projection on the median border anterior to the internal angle. Accessory plates are small bluntly triangular tips. **Ventral surface** very hairy.

**FEMALE:**

**Basis Capituli:** Is shorter and broader than in the male with the lateral angles anterior and not very acute. The dorsal surface is slightly punctated, porose areas are rounded and have an anterior gutter and dorsal ridges are slight. **Cornua** are short and bluntly rounded.

**Palps:** Well developed with article I visible dorsally and Article II and III together as long as broad.
Scutum:— Circular in some specimens but more elongated in others. Cervical grooves as in the male; lateral grooves are absent but the lateral borders are raised. Punctations medium sized and more numerous on the central field and sparse on the raised lateral borders. Eyes flat and large.

GEOGRAPHICAL DISTRIBUTION:—

This species has been recorded from N. Rhodesia, Tanganyika, Nyasaland and S. Africa and material in the British Museum was examined from Portugese East Africa.

HOST:— Bushbuck, Nyala, Buffalo and Dog.

COMMENTS:—

Zumpt (1943 b) describes this species from the paratypes from Kansanshi N.W. Rhodesia and others from the same locality and from Tanganyika with smaller eyes. He also includes a pair of specimens from Songea, identified by Nuttall and Warburton as R. neavei.
Fig. 39.

*Rhipicephalus masseyi* — capitulum of female and male

Fig. 40.

*Rhipicephalus masseyi* — adanal and accessory plates
Fig. 41.
*R. masseyi* male - dorsal view.

Fig. 42.
*R. masseyi* female - dorsal view.
A medium reddish brown tick with weakly-developed legs. This species has not been collected in Nyasaland but owing to its resemblance to *R. neavei*, material from Kenya and Tanganyika was examined in the British Museum.

**MALE:**

*Basis Capituli:* Twice as broad as long with the lateral angles anterior and obtuse, approximately 90°. In none of the specimens was the basis so "hunched" as shown by Donitz (1910) and resembled *R. appendiculatus* more closely than *R. neavei*.

**Palps:** Article III ending bluntly and Article I scarcely visible dorsally.

**Scutum:** Coxae I prominent dorsally in some specimens, but scarcely visible in others. Cervical grooves short and deep but lateral grooves and dorsal furrows are absent. Punctations are numerous, equal and evenly distributed. Eyes flat and placed relatively far back.

**Adanal Plates:** Triangular, the internal border slightly concave and may form a small knob-like projection at the point where it meets the convex posterior border.

**FEMALE:**

*Basis Capituli:* Twice as broad as long, lateral angles median and porose areas wide apart.

**Palps:** Well developed, Article I visible dorsally and Article II greater than Article III.
Scutum: Sub-circular, longer than broad, with cervical grooves as in R. neavei and lateral grooves absent. Punctations medium sized, uniformly distributed with smaller punctations in the lateral field.

BIOLOGY: Unknown.

GEOGRAPHICAL DISTRIBUTION:

Specimens were examined from Ma*o-Narobi, and Masai Reseme Kenya, and Kilindi, Tanganyika. It has also been reported from Zanzibar.

CHOICE OF HOST:

Cattle, dog, bushbuck, buffalo and leopard.

COMMENTS:

This species closely resembles R. neavei in many respects, but the lateral angles of the basis are never recurved and the punctations are evenly distributed with no clear space in front of the eyes and the lateral grooves are absent. In specimens sent to the British Museum by Dr. Lewis from Kenya, the basis capituli is more approximately like that of R. appendiculatus, while lateral grooves are present, in the ♀ though faint in some female specimens. The scutum of the ♀ is also more circular than in typical R. kochi, with numerous sub-equal punctations uniformly distributed. Zumpt (1943) considers this species as closely allied to R. jeanneli and would, in fact, consider the latter species as a synonym of R. kochi if R. jeanneli had been collected at
Sadani in Tanganyika where type species of *R. kochi* was collected. No species of *R. jeanelli* were found in the British Museum so no comparison was possible. *R. kochi* is, therefore, retained as a distinct species pending more knowledge on the biology and until a study of the range of variations as shown by the F1 or F2 generations is possible.
RHIPICEPHALUS mublenzi, Zumpt 1943.

This new species has recently been described by Zumpt from a relatively small number of specimens received from Tanganyika. The following account is merely an abstract from Zumpt's original paper (Zumpt 1943). The males are described from 17 males collected at Kondo-Irangi, while female descriptions are based on 3 females collected at Malwe Lake, Tanganyika.

MALE.

The male resembles R. appendiculatus in various characters, especially in having a strongly developed apical process of Coxa I but differs in having the lateral furrow missing or only faintly indicated and punctations are dense and rather uniform.

Palps and Basis capituli. very similar to R. appendiculatus.

Scutum: about 1½ times as long as broad. Cervical grooves broad and deep anteriorly and are continued posteriorly as shallow furrows. Median and postero-lateral grooves are well differentiated, the median being long and shallow while the laterals are short and oval. Punctations are medium sized, flat, and densely arranged with more delicate punctations on the margins of the scutum. The lateral furrow is missing or only slightly indicated posteriorly. The surface of all the grooves and furrows are shagreened. Median festoon together with the two neighbouring ones protrude, eyes are flat.
Anal and accessory plates: as in R. appendiculatus. Colour reddish-brown. Size 2.3 to 4.5 mm long; 1.3 to 2.5 mm broad.

**Female.**

Palps and Basis capituli: as in R. appendiculatus.

Scutum - somewhat longer than broad. Cervical grooves deep and slightly converging, with furrows weakly impressed, divergent, bow-shaped and shallow and do not reach the posterior border. Lateral grooves are missing. Eyes flat.

**Geographical Distribution.**

This species has only been recorded from three localities in Tanganyika, i.e. Kondoa-Irangi (17 males) Mikindani (3 males and 1 female) and from Maliwe Lake (3 males, 7 females). Seven additional males from Tanganyika had no locality recorded.

**Choice of Host.**

No host was recorded for the Kondoa-Irangi collection. The Maliwe Lake collection was from a bush-buck. Other hosts were giraffe and Hippotragus equinus.

**Comment.**

The males of this species closely resemble R. appendiculatus while the females correspond very closely to R. neavei. Zumpt (1942(b)) has discarded the latter species as a variant of R. appendiculatus without, however, adequate prior examination of the type species. A more careful re-examination of the present species is, therefore, required to show its relationship to already described species, before it can be considered as valid.
RHIPICERHALUS ziemanni Neumann 1903.

(R. cuneatus - Neumann 1908)

R. ziemanni is a medium-sized tick 4.25 mm. x 2.3 mm. the scutum being elongated, narrow, and glossy, chestnut brown in colour with the festoons a lighter colour. The following descriptions is based on specimens examined in the British Museum collection.

MALE:

Basis Capituli: - is about twice as broad as long with the lateral angles median and acute and slightly recurved.

Palps: - short, about as broad as long with Article I visible dorsally and Article III ending obtusely.

Scutum: - cervical grooves are short deep pits. Lateral grooves are missing or only faintly marked by a row of punctations. Posterior dorsal grooves are well marked, the median groove being elongated, the para-median grooves oval. Punctations are medium-sized, and uniformly distributed on the median field but less dense on the lateral portions of the scutum. Eyes are medium-sized, flat and yellowish. Neumann described the scapulae as being prolonged into a curved protuberance pointing outwards but this is not a constant or marked feature in the specimens at the British Museum. Also, Coxa I is definitely visible dorsally.

Adanal plates: - triangular, with external and posterior margins convex and the internal margin slightly concave. Accessory plates present.
In specimens labelled *R. cuneatus* (Belgian Congo) seen in the British Museum collection, the median and immediately adjacent segments were enlarged to form three posterior protrusions. Two lateral body segments were also enlarged and separated from these posterior protrusions by one normal segment.

**FEMALE:**

*Basis Capituli:* very broad with lateral angles median and acute and with oval porose areas about their diameter apart.

*Palps:* well developed with Article I visible dorsally.

*Scutum:* about as broad as long with short deep converging cervical grooves, continued backwards almost to the posterior margin by small distinct furrows. Lateral grooves missing. The numerous medium-sized punctations in the central field are partially replaced on the lateral fields by finer punctations. Eyes are flat, yellowish, large and placed at the junction of the lateral and posterior scutal borders.

**BIOLOGY:** Unknown.

**CHOICE OF HOST:** Cattle, antelope.

**GEOGRAPHICAL DISTRIBUTION:** Cameroons, French and Belgian Congo, Sierra Leone.

**COMMENTS:** The specimens examined in the British Museum were from an antelope from Sierra Leone and superficially, the males closely resembled *R. neavei*. There is, however, no area clear of punctations in front of the eyes, the lateral grooves are indistinct and the scapulae are more prolonged while the lateral angles of the basis capituli are not so definitely
recurved as in *R. neavei*. The absence of the lateral groove in the female increases this resemblance but in *R. ziemanni* the scutum is more oval. Zumpt (1943) finds this species closely resembling *R. aurantiacus*. Bequaert (1930) hesitates to regard *R. cuneatus* as a synonym of *R. ziemanni* but from the examination of material in the British Museum collection, especially *R. cuneatus* specimens collected from a buffalo in the Belgian Congo, it was found impossible to distinguish between the two species.
Genus - **Rhipicephalus** cont'd.

Group II - The "SIMUS" Group

The "simus" group is represented in Nyasaland by four distinct species: - *Rhipicephalus simus*, *Rhipicephalus tricuspis*, *Rhipicephalus simpsoni*, and *Rhipicephalus falcatus*. Two distinct types of scutal punctations are found on all the species. The coarse punctations are always present and strongly marked but are relatively few and sparse and tend to be arranged in four irregular rows on the scutum. The fine punctations may be very small or "pin-prick" like in size; they are usually numerous and uniformly scattered over the scutum but may be few or absent in the males. The median and postero-dorsal grooves are not so well developed as in the "appendiculatus" group. The shape of the adanal plates greatly assist the differentiation of the males of the four species. The nature of the punctations, the shape of the scutum and the intensity of the lateral grooves all assist in differentiating the females. A preliminary determination is possible on the following main characters:

**MALES**

*R. simus*:
Coarse punctation in four irregular rows, fine punctations are always "pin-prick" like in size, may be numerous or may scarcely be visible. Anal plates triangular with convex posterior margin and rounded postero-lateral and postero-
median angles and median border markedly concave. Lateral angle of basis is anterior and blunt. 3-4 m.m. long.

**R. tricuspid**:
Coarse punctations arranged more irregularly and fine punctations more numerous and obvious than in **R. Simus** but are still very small in size. Adanal plates with the postero-lateral angle prolonged as a sharp point and the posterior border concave. Lateral angle of basis as in **R. Simus**. 2 - 4 m.m. long.

**R. simpsoni**:
Coarse punctations more sparse than in above species. Fine punctations as in **R. tricuspid**. Adanal plates broadly sickle-shaped. Lateral angle of basis is median, acute or recurved. 2.3 - 3.6 m.m. long.

**R. falcatus**:
Coarse punctations fewer and small punctations predominate over entire scutum. Adanal plates sickle-shaped. Lateral angle of basis as in **R. Simus**.

**FEMALES**

**R. simus**:
Large punctations scattered, well defined; fine punctations more obvious than in the ♂ but vary in size. Posterior border of scutum circular.
Lateral borders may be glossy with few punctations.

**R. tricuspis:**
Large punctations scattered, irregular, seen especially on anterior of scutum and along the lateral grooves. Finer punctations always medium sized and obvious with raised lateral border punctated. Posterior border of scutum sinuous. Course of lateral grooves more irregular than in *R. simus* and broken by large punctations.

**R. simpsoni:**
Punctations more confined to the central field and raised glossy lateral borders may be unpunctated. The large punctations are irregular and few; smaller punctations obvious but not so intense as in *R. tricuspis*. Posterior border of scutum rounded with median protrusion. Lateral grooves not so distinct as in either of the above species.

**R. falcatus:**
Large punctations few while smaller punctations have increased in size, are numerous and give the scutum a definite punctate appearance. Posterior border of scutum circular. Lateral grooves are more distinct than in *R. simpsoni* but not so deep or punctated as in *R. simus* or *R. tricuspis*. 
Bedford (1929) described *Rhipicephalus distinctus* Bedford 1935 (synonymous *R. punctatus* Bedford 1929) which differed from *R. simus* in that the male is smaller, with larger scutal punctations, finer punctations missing, basis with indistinct cornua, and wide internal spur on Coxae I. In the females the cervical grooves are short, the lateral grooves are missing and large punctations sparse. No specimens were collected from Nyasaland.

*Rhipicephalus longicoxatus* Neumann 1904 would appear to belong to this group but few specimens have been recorded from any locality, since the species was originally described. Lewis (1939) merely records it from Kenya.

Type specimens of *Rhipicephalus complanatus* were examined in the British Museum but none were collected in Nyasaland during the present survey.

This group has recently been dealt with by Zumpt (1943 a) with key and descriptions of seven African species including one new species and one new sub-species. *R. simus* is split into two sub-species because of the difference noted between the shape of the anal plates of East and West African forms, i.e.:

Anal plates more or less triangular, external and internal angles rounded. The median border with a blunt angle or with a flat S-shaped outline. Only the median festoon protrusible. Spiracle with short broad point. 2.5-5 mm. Found in South and East Africa. *R. simus simus*. 
Anal plates sickle-shaped, bent inwardly. Frequently the three median festoons protrude. 2.5-5 mm. Found in West and Central Africa. \textit{R. simus longoides.}

The females are indistinguishable. Zumpt, however, admits that populations possibly exist where, owing to the variability of the shape of the anal plates, it would be impossible to determine \textit{R. simus longoides} from the "nominatiform". Certainly no distinction is possible with the Nyasaland material.

Similarly, from examination of the type species and the abundant material of \textit{Rhipicephalus planus} available to him from Kenya and Tanganyika, Zumpt creates two sub-species as follows:-

- Anal plates more or less triangular, postero-median and postero-lateral angles rounded. Median border with blunt angle or rounded S-shaped outline. E. Africa. \textit{R. planus planus.}
- Anal plates with postero-lateral angles projecting so that the posterior margin is slightly concave. West and Central Africa. \textit{R. planus complanatus.}

Again the ♀♀ are indistinguishable and again the sub-species may merge into each other.

\textit{Rhipicephalus reichenowi} Zumpt 1943, is described from 13 ♀♂ from Mikesse, Tanganyika found in a glass tube labelled "R. simus" by Nuttal and Warburton. Zumpt attributes the ease with which he recognised such aberrant forms as being due to his method of preserving specimens mounted dry, and not in preserving solutions.
RHIPICEPHALUS simus Koch 1844.

This tick has a glossy scutum black or dark brown in colour with legs reddish brown and size very variable. It is found on cattle attached to region of the tail switch but is a common ecto-parasite of wild carnivores, less so of dogs.

The detailed features are briefly as follows:

**MALE:** (Figs. 43, 44, 45)

*Basis Capituli:*—Resembles in some respects the basis of *R. appendiculatus*. Slightly broader than long, the antero-lateral borders short, slightly convex, bearing bristles and meets the longer concave postero-lateral border at an obtuse angle in the anterior half of the basis. Posterior border straight carrying definite pointed cornua at either end. Dorsal ridges not very prominent and central area slightly depressed and marked by two or three large punctations which may represent the ♀ porose areas.

**Palps:** Palps well developed, short, broader than long, Article II equal to article III and tend to be concave dorsally. Article I inconspicuous dorsally.

**Scutum:**—Coxae I slightly visible dorsally. Median cervical grooves short deep pits, lateral cervical grooves represented by a linear row of large punctations which curve slightly inwards posterior to the eye. The linear arrangement is not however always definite. The lateral groove well
defined, starting posterior to the eye and lateral to the lateral cervical punctations, and posteriorly include one festoon. Posterior dorsal grooves not well defined.

Large punctations sparse over scutum and tend to be arranged in four more or less regular longitudinal rows. Very fine punctations all over scutum, but in some specimens they are indistinct or missing. Festoons well defined, longer than broad and posterior protrusion of body beyond scutum may bear a median posterior plaque.

**Anal plates:** Well developed with the convex posterior margin meeting the lateral and internal borders without forming any abrupt angle. Median border concave medially and surface deeply punctated. Accessory plates small chitinised tips.

**FEMALE:** (Figs. 46, 47, 48).

**Basis Capitulii:** About twice as broad as long. Straight antero-lateral and concave postero-lateral borders about equal and meet medially in moderately acute angle. Dorsal grooves definite and marked off central depressed area from raised lateral marginal areas. Pores large and contiguous laterally with the dorsal grooves, and showing gutters. Posterior border of basis concave and cornuae slight.

**Palps:** Long and well developed, article II greater than article III. Article I conspicuous dorsally.

**Scutum:** Circular (In *R. tricuspus* the scutum is concave behind the eyes). Both median and lateral grooves have common origin in a deep pit anteriorly.
The anterior one third of the median cervical groove is deep and slightly S-shaped. Posteriorly, the grooves are widely divergent and can only be faintly traced to meet lateral groove at the posterior scutal margin.

Lateral cervical grooves well marked with deep punctations and extend almost to posterior border. These grooves define the raised marginal glossy borders from the depressed central scutal area. Large punctations are well defined, occurring as small groups on the anterior of the scutum between the cervical grooves, along the lateral grooves, a few on the scapulae and a few scattered irregularly on the posterior portion of the scutum. The fine punctations are always numerous but vary in intensity; in some specimens they are fine "pin-pricks" with a few medium sized punctations associated with the larger punctations; in other specimens medium sized punctations predominate with scutum very punctated in appearance resembling that of *R. falcatus*. The raised convex glossy borders are fairly free of punctations except for the large punctations on the scapulae.

**BIOLOGY:**

From the hundreds of tick collections made during the three years of this survey, *R. simus* was only collected on a total of 24 occasions and found on only 10 occasions on cattle. It is not therefore a common Nyasaland tick and certainly not a common cattle tick. Specimens were found
throughout the year but insufficient material is available for any very accurate observations on the field biology of this species. Its occurrence is however distinct from that of R. triouspis and while females do engorge during the rainy months of December and January, they also engorge later in the year, at least until the dry month of May.

No laboratory data was collected on the life history.

Choice of Host:

Adult ticks were found on cattle, buffalo, leopard, jackal, cheetah, lion, dog, ant-bear, and wart-hog. Nymphs were found only on an unidentified species of field-rat. Larvae were not collected. As nymphs and larvae do not feed on cattle this species is not an important disease vector.

COMMENT:

The number and arrangement of the large punctations are fairly regular in both sexes. The fine punctations, however, vary considerably. Males are found when these fine "pin-prick" punctations are numerous and uniformly distributed over the scutum, in others they are only present on the anterior and posterior thirds of the scutum while in others they are rare or indistinguishable. In all other respects the specimens are structurally similar to each other. In the female, the fine punctations are never absent but two varieties are noted; i.e. variety (a) with fine punctations of normal size and variety (b)
when the fine punctations are replaced by more medium sized punctations. Variety (a) is usually found associated with males showing few fine punctations and so may represent a biological race rather than a sub-species. At any rate, no attempt is made to divide *R. simus* into sub-species until more field data has been collected on the biology, seasonal incidence and geographical distribution of the above varieties.
Fig. 43. Rhombocephalus simus male - scutum and anal plates.
Fig. 44. 
*Rhipicephalus simus* male - dorsal view.

Fig. 45. 
*Rhipicephalus simus* male - ventral view.
Fig. 46 (a) (b)

*Rhipicephalus simus* - scutum of female showing (a) type with fine punctations and (b) type with coarse punctations.

Fig. 47.
*Rhipicephalus simus* female - dorsal view showing numerous coarse punctations.
Fig. 48.

*Rhipicephalus simus* engorged female - dorsal view showing well defined lateral grooves on scutum.
**RHIPICEPHALUS simus longoides** Zumpt 1943.

This sub-species has been created by Zumpt to contain West African specimens with sickle-shaped anal plates, and with the strong punctations on the scutum of the males more numerous than in *R. simus*. A further difference noted is that in *R. simus longoides* the caudal appendage may consist of the median and two adjacent festoons while in *R. simus* proper, only the median festoon protrudes. Otherwise the sub-species is indistinguishable from the "Nominatform" and the females are completely similar. In addition small specimens of *R. simus longoides* may be found with anal plates similar to *R. simus*.

**GEOGRAPHICAL DISTRIBUTION:** The types and para-types are from Bismark, Cameroons. It has also been recorded from Sierra Leone, Ivory Coast, Gold Coast, Togoland, and French and Belgian Congo.

**HOSTS:** Horse, cattle, *Potamochoerus porcus*.

**COMMENT:** This sub-species only differs slightly from *R. simus* and, as noted above the punctations of *R. simus* show a certain range of variation within the species and the structure of the anal plates also show some variation. More biological data are therefore required before *R. simus longoides* can be accepted as a valid sub-species.
RHIFICEPHALUS tricuspis. Donitz 1906

R. lunulatus. Neumann 1907
R. glyphis. Donitz 1910
R. simus var. lunulatus. Warburton.

This is a small, glossy, dark brown tick, showing a smaller range of size variations than R. simus, the average size of R. tricuspis being 3 to 4 mm. Adult ticks are common on cattle from mid-November to mid-February, being found like R. simus, on the region of the tail switch, but have also a wide range of alternate hosts.

The detailed features are as follows:

MALE: (Figs. 49, 50, 51).

Basis capituli:— Very similar to that of R. simus with dorsal grooves indistinct and cornua not prominent.

Palps:— as in R. simus. Small and broad, the dorsal surface of article II and III being concave and article I conspicuous dorsally.

Scutum:— Coxa I prominent dorsally in the Nyasaland material. Median cervical grooves are deep crescentic pits. Lateral cervical grooves marked by a linear row of deep punctations which may become continuous with the lateral groove in the region of the eye. The lateral grooves well defined and deep posteriorly and include one festoon. The posterior dorsal grooves are not so well defined as in R. simus. In no specimens were they found so prominent as figured by Donitz. (1906). The large deep punctations are mainly restricted to the
posterior part of the scutum, especially to the 
region between dorsal grooves, and to the anterior 
portions of the scutum, and there is little tendency 
for these punctations to be linear in arrangement. 
Finer punctations present as in *R. simus* but more 
obvious. Festoons present but not so definite as in 
*R. simus*. Eyes well developed with a few small 
punctations adjacent to their dorsal border. 

**Anal Plates:-** (Fig. 50). The shape of the anal 
plates characterise this species in that the 
posterior border is deeply indented forming a blunt 
internal lobe and a more slender elongated external 
point. The adanal plates have also well chitinised 
tips and so with the anal plates form three points. 

**FEMALE:** (Figs. 52, 53). 

**Basis Capituli:-** Twice as long as broad. Posterior 
border straight and cornua poorly developed. Postero-
lateral border concave and meeting the convex antero-
lateral border medially in an acute angle. Porose 
areas large, less than 1 diameter apart with a small 
gutter leading to the anterior border. The central 
area of the basis is depressed. 

**Palps:-** Well developed. Article II equal to 
article III and as long as broad. Article I 
visible dorsally, representing the contracted portion 
of the palpal outline. 

**Scutum:-** Varies in size being usually somewhat longer 
than broad but may be broader than long as figured 
by Donitz and also in Fig. 53. The salient 
features are the well developed punctated lateral
grooves, the relatively large eyes and the sinuous postero-lateral margin. The cervical grooves are deep and converging anteriorly and continued posteriorly as shallow divergent furrows for about two-thirds the length of the scutum. The well developed lateral grooves have a common origin with the cervical grooves, extend almost to the posterior scutal margin and are well indicated throughout by large punctations. Eyes are salient, yellowish, situated at the junction of the lateral and postero-lateral borders with several medium-sized punctations along their mesial border somewhat similar to those seen in *R. neavei*. The scutum is broadest at eye level, the lateral borders strongly convex in front of the eyes, the postero-lateral border concave and the posterior border convex and may show a slight median protrusion as in *R. simpsoni*. Large punctations occur along the lateral grooves on the scapulae and irregularly over the median field. Numerous smaller medium-sized punctations are scattered over the entire scutum. In no specimens were these punctations as small as those seen in some specimens of *R. simus* (Fig. 46 (a)).

**BIOLOGY:**

This tick has recently been reared in the laboratory through all its stages by Theiler (personal communication) but no details are available. In Nyasaland, after being entirely absent from collections throughout the dry season,
adults suddenly became common later in November. They remain common until early in February and then disappear. Little success was encountered in breeding these ticks under uncontrolled laboratory conditions. In the season 1943-1944 several females oviposited but only a few larvae hatched after an incubation period of 56 days. In 1944-1945 hatching was more successful with an average incubation period of 47 days but the larvae soon died. It is obvious that special conditions, to be found in the microclimate of some vegetation communities, are necessary for the full development of this tick species.

Larvae and nymphs do not feed on cattle, nor have they been collected from any other host.

**CHOICE OF HOST:**

*R. tricuspis* adults are common on cattle during the wet hot months mentioned above. They have also been collected from the following wide variety of hosts - sheep, goat, dog, buffalo, lion, duiker, gwape, steinbuck, reedbuck, warthog, serval and hare.

**GEOGRAPHICAL DISTRIBUTION:**

Owing to the confused identification of this tick, the exact geographical distribution is difficult to define. Nuttall (1916) records it from a rabbit in the Belgian Congo, Donitz (1910) (as *R. glyphus*) from cattle in Tanganyika, and Bedford (1932) from S. Africa. Theiler (in press) gives fuller details of its distribution in S. Africa and notes its absence from the drier areas of the Karroo and open grassveld.
and high veld Provinces. Lewis (1939) lists it as an East African species.

**COMMENTS:**

*R. tricuspis* was first described by Donitz (1906) and later re-described by Neumann (1907) as *R. lunulatus*. Neumann (1911) admitted that *R. tricuspis* was the valid specific name. Warburton (1912) seems to ignore this work and regards *R. glyphus* Donitz (1910) as a synonym of *R. lunulatus* and places *R. lunulatus* as a smaller sized variety of *R. simus*, since he found that the adanal plates of *R. tricuspis* may be so modified to show a gradual range of variations merging into plates indistinguishable from *R. simus*. Nuttall (1916), without comment, retains both *R. lunulatus* and *R. tricuspis* as distinct species. Bedford (1932) retains all three species as distinct, differentiating the males as follows:

1. Scutum shiny, with few punctations ............... 2
2. Adanal shields with posterior margins convex, not strongly pointed posteriorly. Large punctations on the scutum equal, arranged in longitudinal lines with a number of fine indistinct punctations also present... *R. simus*
   Adanal shields with posterior margins bifid, the postero-external angles longer than the postero-internal angles. .................. 3
3. Scutum with few scattered large punctations and numerous fine ones ............. *R. tricuspis*
   Scutum with large punctations arranged more or less in longitudinal lines, fine punctations hardly visible .................. *R. lunulatus*

In the Nyasaland material, as well as in that examined in the British Museum no differentiation
could be made between \textit{R. tricuspis} and \textit{R. lunulatus} and the latter specific name was regarded as synonymous with \textit{R. tricuspis}. Further, the adanal plates of \textit{R. tricuspis} were of constant shape and never resembled those of \textit{R. simus} though instances were seen when the external points may be so lightly chitinised as to render their presence less obvious. \textit{R. tricuspis} is also a small tick with the lateral cervical grooves deep irregular and punctated especially in the \textit{♀}, the finer punctations more obvious than in \textit{R. simus}, and with the eyes "orbited" massively by punctations. The most important distinction between these two species is probably in their biology. (page 111)

Zumpt (1943) retains the name \textit{R. lunulatus} for the following reasons. Females of the types of \textit{R. tricuspis} were in the Berlin Museum but he could not find the males. From Donitz's description he considers the males of \textit{R. lunulatus} and \textit{R. tricuspis} are closely related if not even identical. But the females of \textit{R. tricuspis} (found in the museum) have a scutum with rather dense and uniform medium sized punctations and "obviously are not \textit{lunulatus}". However, if \textit{R. tricuspis} should later prove identical with \textit{R. lunulatus}, then Zumpt would agree that it would have priority.
Fig. 49.
*Rhipicephalus tricuspid* male - capitulum and anterior portion of scutum.

Fig. 50.
*Rhipicephalus tricuspid* male - adanal plates
Rhipicephalus tricuspis male - dorsal view.
Punctations not so linear in arrangement as in Rhipicephalus simus.

Rhipicephalus tricuspis female - dorsal view.
Lateral grooves tend to be irregular and deeply punctated and posterior border undulating (c.f. Fig. 47, 48.)
Fig. 53.
*Rhipicephalus tricuspid* female - capitulum and scutum.

One figure, in original copy, not included here.
**RHIPICEPHALUS simpsoni** Nuttall 1910.

**Distinguishing features.**

A reddish brown tick with body and legs of similar colouration; body extending beyond scutum in engorged specimens and forming a rounded caudal protrusion.

**MALE.** (Figs. 54, 55, 57, 58)

**Basis Capituli:** Broader than long, Postero-lateral borders concave, and meeting the straight or slightly concave antero-lateral borders at an acute angle in the median part of basis. Antero-lateral and postero-lateral borders of equal length. In some specimens lateral angle may be slightly recurved as in *R. neavi var punctatus*. There are two depressions representing the porose areas of the female but apart from these the basis is practically free of punctations. There are no cornual grooves but small and pointed cornua are present. The posterior border is slightly concave.

**Palps:** Short with article II and III much broader than long, the outline of the palps being broken by the posterior border of Article III extending slightly beyond the lateral border of Article II. Article I slightly visible dorsally.

**Scutum:** Coxae I visible dorsally. Cervical grooves consist only of two short deep depressions directed inward and backward. Lateral cervical groove well marked out by linear run of punctations ending posterior to the eyes and marking off clear lateral
ridges and rounded scapulae. The scutum is deeply emarginated. The lateral groove proper, begins outwardly to the above cervical linear punctations, posterior to the eyes, and continues as well defined groove to include one or two festoons. Punctations consist of a few scattered medium size punctations, and also very fine punctations evenly distributed over scutum except on festoons and lateral borders. Posterior median depression elongated and shallow, postero-lateral depressions oval and ill-defined. Festoons well defined.

**Anal Plates:** Broadly sickle shaped but more closely resembling the adanal plates of *R. simus* than those of *R. falcatus*. Accessory plates only chitinised at their tips.

**FEMALE.** (Fig. 59, 60).

**Basis Capituli:** Differs little from the male.

Porose areas well defined, oval and directed obliquely forward or inward with slight indications of a gutter. Antero-lateral and postero-lateral borders about equal and meet mid-way in an acute angle.

**Palps:** Longer than in the male with article I visible dorsally and article II longer than III.

**Scutum:** Slightly longer than broad; antero-lateral border is slightly convex, the posterior margin is almost circular with slight median protrusion. The cervical and lateral grooves start together
from a deeply depressed pit; the lateral groove follows a course parallel to the antero-lateral border of the scutum, is distinct throughout and defined by large punctations and ends near the posterior border. The cervicals converge and then diverge and are only distinct for a short distance. Eyes are large and distinct. Few large punctations on scutum, more coarse along the lateral grooves, and fine punctations uniformly distributed as in the male but the raised lateral borders tend to be free of punctations. Scutum shows lateral grooves and three distinct sub-equal dorsal furrows.

NYMPHS. (Fig. 56)

Basis Capituli: Twice as broad as long with a smooth dorsal surface. The posterior margin is straight with very slight cornua. The postero-lateral margin is slightly concave and bears a distinct spur ventrally near its junction with the posterior border. The antero-lateral borders are concave, especially their posterior portions which curve sharply outwards to meet the posterior lateral borders at an actual projecting angle.

Palps:— Are relatively long and slender, longer than broad with article II about twice as long as article III. Article III has a blunt distal end.
Scutum:- The scutum at the level of the eyes is slightly broader than long, reddish brown in colour, with straight lateral margins and convex posterior margin. The eyes are far back on the lateral border near the junction of this border and the posterior border. The cervical grooves start as deep oval depressions directed inwards and are continued as shallow divergent depressions which can be traced almost to the posterior border to meet the lateral groove. The lateral grooves are shallow for their complete length, they run parallel to the lateral margin and define a smooth lateral border. The whole surface of the central area of the scutum is covered by a network of fine reticulations, best seen in the depression bounded by the lateral and cervical grooves. A few large punctations are found on the median field.

BIOLOGY:-

The life history of this species is unknown. During the present survey, two nymphs collected off a cane rat, *Aulocodus* species, on the 12/10/44 moulted on the 25-26/10/44 as two females, i.e. the nymphal moult took place in 12 to 13 days during the warmer months.

GEOGRAPHICAL DISTRIBUTION:-

This species was described by Nuttall (1910) from 5 males and 11 females collected off a large rodent in S. Nigeria on 18/2/1910 by J.J. Simpson. One nymph was also found in this collection in the British Museum. The Onderstepoort collection contains...
specimen taken from the edible rat *Thyroriomys swinderianus* from Uganda and from the same host from the Transvaal.

During the present survey in Nyasaland, five collections were taken all from the same host, the large cane rat, *Aulocodus* species. Specimen No. 223 collected on 12/10/1944 at Kalumbu consisted of 6 nymphs, two of which hatched as mentioned above. Specimen No. 205 consisted of 1 engorged ♀ and 2 nymphs collected on the 25/9/1944 from Lilongwe. Specimen No. 243 contained ♀♀ and ♂♂ from Namaguya collected on the 23/11/1944. Several of the females were fully engorged. Specimen No. 222 from Kalumbu collected on the 11/10/1944 consisted of 7 ♀♂ and 4 ♀♀, two of the latter being engorged. Specimen No. 231 collected at Lobe, Daza on the 31/10/1944 consisted of 3 ♀♀ associated with four *Rhipicephalus appendiculatus* nymphs.

Nuttall (1910), when describing this species, states "We at first referred the specimens to *R. falcatus* 1908, but on examining the types in the British Museum, and after consulting Prof. Neumann, we decided to accord them specific rank. In *R. falcatus* the colour is blackish, the punctations numerous, the body and anal shields narrower. In the ♀ the scutum is as long as broad, 2 m.m.; the punctations numerous. Zumpt (1943(a)) has been unable to examine any specimens of this species but suggests it may be closely related to *R. simus longoides* Zumpt 1943."
Rhipicephalus simpsoni male - capitulum and scutum.
Fig. 55 (a) (b)  
*Rhipicephalus simpsoni* - (a) capitulum and (b) anal plates.

Fig. 56.  
*Rhipicephalus simpsoni nymph* - capitulum and scutum.
**Fig. 57.**
Rhipicephalus simpsoni male - dorsal view.

**Fig. 58.**
Rhipicephalus simpsoni male - ventral view showing anal plates.

- Recurved angle of basis
- Large punctations not so obvious (cf. R. simus, R. tricuspis)
- Anal plates bean-shaped
Fig. 59.
*Rhipicephalus simpsoni* female - capitulum and scutum.

Fig. 60.
*Rhipicephalus simpsoni* female - dorsal view.
Rhipicephalus falcatus

This tick resembles R. simus in shape but the scutum is more reddish brown in colour and not so black or glossy and the legs are only slightly lighter colour than the scutum. Only a few specimens from game animals were recorded, collected during the rainy months from January to April.

MALE. (Figs. 61, 62, 63, 65)

Basis Capituli:— More than twice as broad as long with median angles in the anterior one third and obtuse. The antero-lateral border is short and slightly convex while the postero-lateral border is long and concave. The posterior border is straight and cornua, short and triangular. Two large punctations occur in position corresponding to porose areas of ♀, in addition to a few large and smaller punctations.

Palps:— Article I only slightly visible dorsally, article II broader than long, article III with lateral border heavily chitinised giving a slight concavity to the dorsal surface.

Scutum:— Coxae I only slightly visible dorsally. Cervical grooves are short crescentic pits followed by poorly defined divergent shallow depressions. Lateral cervical groove only indicated by a short row of large punctations. Lateral groove is well marked, deep, punctated and includes two festoons. The posterior dorsal furrows are only slightly
indicated, the median being long and linear while the posterior-laterals are oval depressions. Punctations numerous, the finer "pin-prick" variety predominate with large punctations relatively sparse and irregularly scattered over the scutum. Eyes medium sized, flat and yellowish. The body protrudes beyond the scutum and the festoons and carries plagues. The median and two adjacent festoons are especially large, forming three protrusions in engorged specimens. In some of the specimens examined at the School of Tropical Medicine and Hygiene, London, two lateral festoons may be enlarged giving a resemblance to *R. ayrei*.

Adanal plates:— Sickle shaped, the lateral border being convex and merges imperceptibly into the strongly convex posterior border. The anterior one third of the mesial border is straight, posteriorly it becomes concave and where it meets the posterior border a blunt projection may be formed. The accessory plates are well developed, but not heavily chitinised.

**FEMALE.** (Figs. 64, 66).

**Basis Capituli:** — Twice as broad as long with lateral angles median and acute. The porose areas are large and close together. The cornua are weakly developed.

**Palps:**— Somewhat resemble *R. tricuspis* in being well developed, articles II and III each longer than broad and article I clearly visible dorsally.
Scutum: Oval or circular, about as broad as long. Cervical grooves are deep, converging and defined only in the anterior one third of the scutum. The lateral grooves are well marked but not so deep as in R. simus and R. tricuspis, reach the posterior border and define raised lateral borders. Punctations are numerous, the smaller punctations being larger and more numerous, while the larger punctations are not so obvious as the corresponding punctations in R. simus and R. tricuspis. Eyes are about half-way and flat. The lateral border of the scutum is convex, being bent ventrally, while the posterior margin is somewhat sinuous.

Biology: Unknown.


Choice of Host: Roan antelope, buffalo, Phacochoerus aethiopicus, horse.

COMMENTS: From the few specimens available it is impossible to say how closely this species is related to R. simus but until more biological data is available, it is preferable to retain it as a distinct species.
Fig. 61.
*Rhipicephalus falcatus* male - capitulum and anterior portion of scutum.

Fig. 62.
*Rhipicephalus falcatus* male - anal plates.
Fig. 63.
*Rhipicephalus falcatus* - anal plates of male.

Fig. 64.
*Rhipicephalus falcatus* female - capitulum and scutum.
Fig. 65
Rhipicephalus falcatus male - dorsal view.

Note:— Shape of capitulum
Coxa I visible
Cervical grooves

Posterior dorsal grooves indistinct

Fig. 66.
Rhipicephalus falcatus female - dorsal view.

Note:— Shape of scutum
Large punctations

See other copy
Neumann (1907) described *R. simus planus*, a sub-species of *R. simus* from specimens collected at Kilimankjaro, Tanganyika. In 1910, he described *R. planus* from the Cameroons but changed the name to *R. complanatus* as the name "planus" was already occupied. Zumpt (1943 (a)), after examining the original type species of *R. simus planus* and abundant additional material from Kenya and Tanganyika accords this species specific rank i.e. *R. planus*, but, as already noted, divides his specimens into two sub-species - *R. planus planus* Neumann occurring in East Africa and *R. planus complanatus* Neumann for West African specimens. These are merely sub-species as a gradual transition of characters could be traced from one to the other. Both sub-species show a close resemblance to *R. simus* except that the scutum is broader and more flat while the East Africa "Nominatform" (*R. planus planus*) has a smooth scutum or at most only very shallow punctations while the West African sub-species (*R. planus complanatus*) has anal plates with concave posterior borders. The females of both sub-species are only distinguishable from female *R. simus* by slight colour variations, i.e. a broad light coloured band found on the anterior portion of the scutum between the cervical grooves in *R. planus* sub-species, while in *R. simus* this light band is
absent, or indistinct with the light colour not so intense. The females of *R. planus* sub-species are indistinguishable from each other.

*Rhipicephalus planus planus* Neumann

The following description is based on material examined at the British Museum and from Zumpt's description (1943).

**Male:**

Basis Capituli and Palps:— as in *R. simus*

Scutum:— Coxae I with apical process absent or only indicated. Conscutum broad and flat with length never more than 1.5 times breadth. (*R. simus* Fig. 44 showssimilar characters). The scutum is flat or slightly concave owing, Zumpt suggests, to weak chitinization. (This feature was not constant in the British Museum material and although the scutum of *R. simus* specimens from Nyasaland is usually convex, specimens do when the scutum is flat or convex anteriorly while the posterior half is depressed or concave. Zumpt also suggests that in his *R. planus planus* specimens the scutum may be convex.) Cervical grooves, lateral grooves, median and postero-lateral grooves as in *R. simus*. The punctations are used by most authors to distinguish this species from *R. simus*, i.e. the large punctations in *R. planus planus* are frequently so flat as to be indistinct, more seldom they are
scattered, striking and easily recognised. The fine punctations are absent or only recognised by the high power.

**FEMALE:**

*Basis Capituli* and *Palps*:— as in *R. simus*.

*Scutum*:— Very similar to *R. simus*. The large punctations are flat and scattered as in the male while the fine punctations are usually well developed. The only constant difference between *R. simus* and *R. planus* ♀♂ is that the latter shows a broader and more intense yellowish or light brown area on the anterior of the scutum between the cervical grooves. (Colouration in ticks always varies with age of specimen and method of preservation. Such a light band would certainly show up much stronger in dry specimens used by Zumpt than in specimens stored in preserving fluid. At any rate this character proved unreliable with the British Museum material and did not show in any of the Nyasaland material, even when fresh).

**GEOGRAPHICAL DISTRIBUTION:**

Zumpt refers this species to East Africa generally. Lewis (1939) does not, however, report it from Kenya.

**COMMENT:**

The validity of this species cannot be considered as certain until fresh material can be examined and the species is shown to differ biologically from *R. simus*. 
As noted above, this species is described by Zumpt (1943) as *R. planus complanatus*. The British Museum material shows this to be a distinct species differing from *R. simus* chiefly in the shape of the anal plates.

**MALE:**

*Basis Capituli and Palps* (Fig. 67): as in *R. simus*.

*Scutum*: Broader than in *R. simus*, flat or slightly concave. The larger punctations are more numerous than in *R. simus* and more irregularly arranged. The lateral groove is shallow and may be only faintly marked in its anterior portion behind the eyes. In most specimens the three posterior dorsal grooves are well marked and more distinct than in *R. simus*.

*Anal plates*: (Fig. 67). The lateral border is slightly convex, while the posterior border is concave so that a triangular projecting tip is found at the postero-lateral angle. The internal border may be slightly convex and is longer than the lateral border so a projecting median tip is found with the concave posterior border at the postero-median angle. Variations differing from the above description were shown amongst the specimens examined. The internal border may show a slight median concavity and the median and external tips at each end of the posterior border, vary in length, but the posterior border was always concave and thus differed from *R. simus*. 
FEMALES:

As in *R. simus* but large punctations more numerous especially in the posterior third of the scutum.

GEOGRAPHICAL DISTRIBUTION:

West Africa. The co-type examined was of a wild pig labelled "Malundu, Haberer, W. Africa". Specimens were also seen from the Cameroons and Liberia.

*Rhipicephalus reichenowi* Zumpt 1943.

This new species has been described by Zumpt from 13 males from Mikesse in Tanganyika, the females being unknown. The character distinguishing it from *R. simus* depend on the "scattered, shallow, but at the same time large punctations found on the scutum". From Zumpt's description and drawings it must be regarded merely as a slight variant of *R. simus*. 
Fig. 67
*Rhipicephalus complanatus* male - capitulum and adanal shield from collection in British Museum.
Genus RHIPICEPHALUS ctd.

Group III: The "Capensis" group.

Only two Nyasaland species belong to this group - *R. capensis* and the closely related *R. ayrei*. Zumpt (1942), in a paper which I have been unable to obtain places *R. capensis*, *R. supertritus*, *R. sculptus*, *R. sulcatus*, *R. bursa*, and *R. pusillus* in this group. *R. supertritus* and *R. sculptus* appear more closely related to *R. appendiculatus* and so are placed in that group in this survey. *R. sulcatus* Neumann 1908 and *R. capensis* are now regarded as synonymous; specimens of *R. bursa* were only examined at the British Museum but not being an East African species are not included, while I have been unable to trace *R. pusillus*. Zumpt also retains the sub-species *R. capensis longus* Neumann 1907 as a West African variety of the East and S. African species *R. capensis* (c.f. *R. simus longoides* Zumpt). The outstanding characteristics of the "capensis" group are to be found in the description of *R. capensis*, especially in the more dense, deep, punctations of the scutum. In this, as well as in other characters it approaches *R. neavei var. punctatus* of "appendiculatus" group.

Considerable difficulty was experienced in differentiating *R. capensis* from *R. ayrei*. The latter species, however, is rare in Nyasaland and insufficient material was obtained to determine structural gradations between the two species and also *R. ayrei* adults occurred during the rainy season when *R. capensis* adults were absent. For these reasons *R. ayrei* is retained as a distinct species.
Rhipicephalus capensis Koch 1844.

This is a large tick with the scutum a deep reddish brown to dark brown in colour and with reddish legs, and the numerous punctations and rugosities on the dorsal surface may give this tick a dull appearance. Size varies up to 6 mm, and it is thus one of the largest Rhipicephalus species found on cattle. Adults are found attached in the region of the udder and flanks of cattle from August to November.

The microscope characters are as follows:—

**MALE:** (Fig. 68, 69.)

**Basis capituli:** well developed, about twice as long as broad. The posterior margin is straight with postero-lateral margin convex and long, meeting the shorter straight or slightly convex antero-lateral margin at an obtuse angle in the anterior third of the basis. Dorsal ridge prominent running into pronounced cornues.

**Palps:** Articles of palps are about as broad as long, article II and III being equal and article I slightly visible dorsally. The antero-lateral edge of article III is strongly chitinised and gives the article a hollow appearance dorsally and this concavity may extend on to the anterior portion of article II.

**Scutum:** Coxa I slightly visible dorsally. Median cervical grooves comma-shaped, short deep, anterior pits being followed by indefinite posterior converging depressions. The lateral cervical groove is indicated by a row of large punctations.
which converge inwards at the beginning of the lateral grooves. Lateral grooves pronounced. The posterior dorsal grooves are feebly developed. The caudal projection in engorged specimens is broad and flat and only involves the median festoon (of R. ayrei).

The punctations are characteristic of this species being medium-sized, densely packed, deep and well distributed over scutum. In some specimens the punctations in the anterior half are finer than those on the posterior half and a pseudo-scutum may be well defined, but this feature is not well shown in the Nyasaland material.

Anal plates: are well developed. The posterior border is rounded and prominently convex and the external-lateral angle obtuse. The posterior half of median border is deeply concave. In some of the Nyasaland material a narrow pointed anal plate resembling R. appendiculatus is found. The ventral body surface may be very hairy and hairs may extend on to the anal plates. No adanal plates were seen.

FEMALE: (Fig. 70, 71.)

Basis Capituli. More than twice as broad as long, posterior border straight or slightly concave ending in short blunt cornua. The postero-lateral border concave and meets the shorter straight or slightly convex antero-lateral border at an acute angle in the anterior half of the basis. Dorsal ridges distinct, marking off the depressed central area from the raised glossy areas. These ridges extended the whole length of the basis from the
cornuae to the anterior border. Porose areas large with lateral borders contiguous with dorsal ridge and with a wide gap between them which may carry a few punctations. A short gutter leads from the porose areas to the anterior border of the basis.

Palps. Broad and strongly developed. Article I visible dorsally and article II greater than III and broader than long. Dorsal surface not concave. The anterior margin of article III is widely rounded and the lateral contour of the palps scarcely broken by the overlapping of the post-lateral angle of article III. Palps carry a few projecting hairs.

Scutum. Almost circular. Medium cervical grooves deep crescentic pit extending to the level of the eyes. In some specimens this groove may be faintly traced backwards and outwards to join the lateral groove at the posterior scutal margin. The lateral grooves have a common origin with the median grooves anteriorly and extend backward to the posterior border of the scutum. These lateral grooves therefore define a subcircular depressed deeply punctated area from raised glossy marginal borders. The punctations in the depressed central area are medium sized, relatively deep, and on the whole, evenly distributed. There is, however, a tendency especially in the posterior part of the scutum, for the punctations to become confluent and form rugose lines running across the scutum. On the lateral raised borders punctations are present except on the region adjacent to the eyes. A few scattered large punctations are present on the humeral region.
Body. In typical specimens body shows three posterior grooves, equal in length, the raised ridges between carrying a few large punctations (see Fig. 70). The lateral grooves are well marked; does not include any of the festoons, and carries a few whitish hairs or is hairless.

BIOLOGY.

The most important features in the biology of R. capensis revealed by the present survey was the marked seasonal appearance of the adults, the failure to find either larvae or nymphs engorging on cattle and the difficulties found in rearing this tick under ordinary laboratory conditions. As previously reported (Wilson 1946) adult ticks appear towards the end of August and disappear again towards the end of November. During these months the mean maximum temperatures vary from 82°F to 86°F approximately, while the average relative atmospheric humidity may range below 50 per cent. Adults disappear in November or early in December when the atmospheric humidity rises due to the onset of the rains. It is most significant that larvae and nymphs do not engorge on cattle and, therefore, this tick, in Nyasaland, cannot be an important disease vector.

In the laboratory, engorged females frequently oviposit but the eggs seldom hatch. In October, 1944, three broods of larvae were obtained. The pre-oviposition period was 12, 13 and 10 days, and the larvae hatched in 35, 40 and 42 days respectively. In many cases, emergence from the egg, as observed under the microscope was incomplete and in all
cases the larvae soon died. A further detailed study of the biology of this tick under Nyasaland conditions is essential.

**CHOICE OF HOST.**

Adult *R. capensis* are especially abundant on cattle but have also been collected from goats, pig, wart-hog, reed buck and civet.

**GEOGRAPHICAL DISTRIBUTION.**

Theiler (1943) records this tick from the drier parts of South Africa and from Quelimane in Portuguese East Africa. Jack (1936) records it from Southern Rhodesia and Lewis (1939) records it from East Africa. It has also been reported from the Belgian Congo.
Fig. 68
*Rhipicephalus capensis* male - dorsal view.

Fig. 69.
*Rhipicephalus capensis* male - various types of adanal plates.
Fig. 70.
*Rhipicephalus capensis* female - dorsal view.

Fig. 71.
*Rhipicephalus capensis* female showing lateral grooves and punctations.
This is a large blackish-brown tick with reddish legs, characterised in well-fed specimens by a conspicuous protuberance of the body contour opposite the two lateral exterior festoons and the median festoon also protrudes as a dome-shaped caudal appendage of lighter colouration than the remaining festoons. In unfed specimens all these protuberances are relatively inconspicuous. The chief microscopic features are as follows:

**MALE:** (Figs. 72, 73, 74).

**Basis Capituli.** As in *R. capensis* except that the dorsal groove defining the raised glossy margins from the depressed median field is less definite in *R. ayrei* than in *R. capensis*. Also the lateral angle may be more acute and the cornua shorter in *R. ayrei* than in *R. capensis*.

**Palps.** As in *R. capensis* except that article III is shorter than article II. Article I is slightly visible dorsally. Palps are concave dorsally.

**Scutum.** The cervical grooves resemble *R. capensis*. There is no trace of a pseudo-scutum as in *R. capensis* and the punctations are numerous and discrete all over the scutum proper but are sparse on the scapulæ, lateral folds and festoons.

Lateral grooves well defined and include two festoons. Dorsal grooves better defined than in *R. capensis*, the median being straight and elongated, the laterals being shallow, short, comma-shaped depressions.
Adanal plates:— There is little to distinguish the adanal plates from *R. capensis*, but there is a tendency for the posterior portions to be broader, approaching those of *R. simus* but again, as in *R. capensis* there is a considerable variation depending on the size of the specimen examined. Accessory plates as in *R. capensis*. In no specimens was the ventral surface hairy and no hairs appear on the adanal plates.

Body. Extended beyond scutum carrying external festoons, lateral protuberance and caudal plaque as noted above.

**FEMALE** (Fig. 75);

Basis Capituli. As in *R. capensis*, i.e. basis broader than long with acute lateral angle in anterior half. Median portion of basis depressed and bearing porous areas with short anterior gutter while external borders are raised and separated from the central depressed area by definite ridge.

Palps. As in *R. capensis*.

Scutum. Subcircular, usually broader than long but one specimen measured 2.2 x 2.0 mm. The posterior border is slightly more convex than in *R. capensis*. The median cervical grooves as in *R. capensis* but the lateral groove may be deeper and defines the broad raised, deeply emarginated lateral areas from the depressed deeply punctated central area. The raised lateral areas carry fewer punctations than in *R. capensis* but again a few larger punctations appear on the humeral region. The body is deeply punctated, rugose, and dorsal grooves inconspicuous.
COMMENT:

Very few characters distinguish *R. ayrei* from *R. capensis*. In the male *R. capensis* the distinguishing lateral and posterior body protuberances of *R. ayrei* are absent but the other differential characters are only of minor importance. The adanal plates show such variation that they cannot be used for differentiating the species. In the female, differentiation is even more difficult and I can find no important distinguishing character. The lateral grooves may be more definite in *R. ayrei* than in *R. capensis* but this is variable. Lewis (1933) compares this species with *R. sculptus* but not with *R. capensis*. The validity of the species may, therefore, be open to question and it may be referred to as a variety of *R. capensis*. In Nyasaland, the most definite collection was obtained from the udder region of a buffalo in Kasingu district in December, 1943. Three females were also found in a collection from a buffalo at Chunumka on 21st December, 1944. Two males and 4 females were found on a lion in January, 1944.

On a cheetah shot at Mutundu, Lilongwe, in January, 1944, 2 males and 3 females have also been identified as *R. ayrei*. It is evident, therefore, that in Nyasaland *R. ayrei* adults occur during the rainy season, when adult *R. capensis* have completely disappeared from tick collections taken from cattle. Also *R. ayrei* adults are never abundant and feed chiefly on wild animals. For these reasons *R. ayrei* is retained as a distinct species, until more details are known regarding its complete life history.
Fig. 72.
*Rhipicephalus syrei* male - dorsal view.

Fig. 73.
*Rhipicephalus syrei* male - adanal plates.

- Punctations as in *R. capensis*
- Lateral protuberances
- Posterior protuberance

(a) Lightly coloured tips
Fig. 74.
*Rhipicephalus ayrei* male - adanal plates.

Similar to *R. capensis*

Fig. 75.
*Rhipicephalus ayrei* female - dorsal view.
GENUS - RHIPICEPHALUS  (cont'd)

Group IV. - The "RHIPICEPHALUS sanguineus" group

R. sanguineus is a very distinct tick distributed widely in Africa, Asia and America and does not appear to be related to any other Rhipicephalus species so I have placed it in a separate group.

RHIPICEPHALUS sanguineus - Latreille 1806.

R. sanguineus is a common tick on dogs and wild carnivora in Nyasaland. It requires little description, having been illustrated and described by Nuttall (1916) and more recently by Theiler (1943) and Zumpt (1943).

MALE:

Basis Capituli:-- Broader than long, with prominent angles in the anterior half of the basis. The postero-lateral border is, therefore, longer than the antero-lateral. The dorsal surface shows no ridges. Posterior border straight and cornua short and blunt.

Paups:-- Broader than long, Article III longer than Article II with dorsal surface showing slight concavity.

Scutum:-- Definite lateral groove on conscutum. Punctations numerous and unequal, distributed uniformly over the scutum, the larger punctations being present more especially in the anterior half.

Anal plates:-- The anal plates are characterised by a convex external margin which is continuous with the curved convex posterior margin. The internal border is slightly concave medially and where it joins the external border there is a tendency to form a pointed angle as in R. appendiculatus.
**Basis Capituli:** broad, with sharp lateral angles medially, definite porose areas and no cornua.

**Palps:** The palps are short and compact, the external contour being a straight line, with Article III larger than Article II.

**Scutum:** The female *R. sanguineus* is chiefly distinguished by the oval scutum, longer than broad, and marked by long well developed lateral grooves. These grooves extend to the posterior border and define very definite lateral borders. Punctations are markedly unequal and irregular. The posterior border is undulating and forms a point medially. Eyes prominent.

**BIOLOGY:**

*R. sanguineus* is not an important cattle tick in Nyasaland, so little biological data was collected. Only one life-history was carried through in the laboratory.

- **Pre-oviposition period** 6 days
- Laying commenced 13/3/1944.
- Larvae emerged 27/4/44.
  - **incubation period** 45 days
  - Larvae engorged 6 days
  - Larvae dropped 9/5/44
  - Nymphs emerged 10/6/44
    - *larvae moulted in* 32 days
    - Nymphs engorged 6 days
    - *dropped 21/6/44.*
- Adults emerged 28/7/44
  - i.e. Nymphs moulted in 37 days

Engorged females are most commonly found on the dog during the wet hot months of January to March but are also found during the dry months of April and May. From June to December engorged females are rare. The period suitable for
engorgement therefore is longer than with *R. appendiculatus* female ticks.

**CHOICE OF HOST:**

In Nyasaland, *R. sanguineus* adults have been collected from the following wild hosts: - leopard, wild hare (*Lepus whytei*), lion, antbear, *gwape*, kudu, jackal, cheetah and hedgehog. The dog is the most favoured domestic animal and ear and head infestations of all types of dogs may be heavy from January to May. During March, April and May adult *R. sanguineus* ticks are frequently found, always in small numbers, on cattle, sheep and goats.

**GEOGRAPHICAL DISTRIBUTION:**

*R. sanguineus* has a wide range of distribution in tropical and sub-tropical parts of Africa, Asia and the American continents.
The genus Boophilus has recently been revised by Minning (1934) and three sub genera are now recognised.

I. Sub-genus Boophilus

No caudal appendages and no festoons in the male. In the female there is no deep cleft on Coxae I between the internal and external spurs. The posterior edge of Coxae II and III are smooth, without scale, spur or indentation.

This sub-genus does not occur in Nyasaland.

II. Sub-genus Palpo-boophilus

No caudal appendage and no festoons in male. In the female, there is a deep cleft on Coxae I between the two spurs and the posterior edge of Coxae II and III carries a scale-like spur or has an indentation. In both male and female, Article I of palps carries on its inner ventral margin a knob-like projection bearing one or two bristles.

This sub-genus is represented in Nyasaland by Palpo-boophilus decoloratus. (Boophilus decoloratus Koch 1844).

III. Sub-genus Uroboophilus

Male with caudal appendage. In the female the cleft between the spurs on Coxae I and the spurs on the posterior margins of Coxae II and III are as in Palpo-boophilus. Article I of palps carries no knob-like projection, neither in the male or female.

This sub-genus is represented in Nyasaland by Uroboophilus fallax. (Boophilus microphus Canestrum; Boophilus australis Fuller 1899; Boophilus annulatus Soy 1821).

Ticks of the Boophilus species, (Palpo-boophilus decoloratus and Uroboophilus fallax), are easily distinguished macroscopically by the great disparity in size of the sexes. The small male is yellow to brown in colour while the much larger female is distinguished by the small pale yellow legs and the relatively small size of the scutum and rostrum.
compared with the rest of the yellow-blueish body. Adults and nymphs are found on cattle attached mainly to the udder and belly region but in heavy infestations they may be found all over the body but rarely in the ear, eye and tail regions. Larvae are found usually attached to the ears.

*Pulico-Borophillus decoloratus* Minning 1934.

**MALE:**

**Basis Capituli:** Hexagonal dorsally with very obtuse lateral angles, and the posterior border bears well-developed cornua.

**Palps:** Are compressed and ridged dorsally and laterally. Article I visible dorsally while its ventral internal margin is marked by the knob-like prominence bearing one or two bristles which characterise the members of this sub-genus. In addition, there is a blunt spur or ridge on the mid-ventral surface. Article II is short and dorsally the posterior margin projects externally as a point over article I while ventrally it projects internally as a sharp point. Dorsally, Article III is triangular, pointed anteriorly and the ridging of the palp gives it a concave appearance. Article IV is small and situated far forward on Article III.

**Scutum:** Longer than broad and lightly chitinized so that caeca show through as dark lines. The surface is shiny and covered with strong hairs which rise from deep surface pits. Eyes are large, yellow and circular and are placed near the edge of the
scutum. The cervical grooves and two median dorsal circular depressions are well defined but the posterior dorsal furrows, especially the median furrow, are indefinite.

**Ventral Surface:** The Coxae are strong and well developed. The pointed spurs on Coxae I are both strong, the internal being the larger. Coxae II has two flattened spurs, the internal again being the larger. Coxae III as in Coxae II but spurs less developed. Coxae IV has usually a small external spur. The margins of all these spurs except on Coxae IV are distinguished from the rest of the coxal surface by their deeper brownish chitinous covering.

**Anal Plates:** are long and narrow, the internal margin being longer than the external. The diagonal posterior margin is concave and forms a point with both internal and external lateral borders, the internal point being invariably the longer, and may be visible dorsally as a posterior projection. The posterior border of the accessory plates may show two points, and, as in the case of the anal plates, the internal point is the longer or the plate may be narrow and elongated, both lateral borders meeting in one sharp point.

Caudal appendage fairly large and placed under scutum.

**FEMALE:**

**Basis Capituli:** Broader than long, porose areas large, lying diagonally and one diameter apart. No cornua.
Palps:— Viewed dorsally, Article I visible and Article II projects markedly inwards. Article III large with convex anterior border. Both article II and III are broader than long. Ventrally, Article I carries an inwardly projecting knob with bristles as in the male.

Scutum:— Slightly broader than long, yellow brownish colour and hairy especially in the anterior portions. Cervical grooves pronounced, reaching the posterior extremity dividing the more reddish lateral areas from the pale-yellowish central area. Eyes large and oval situated at edge of scutum.

Coxal Armature:— Coxae I has two spurs, the internal one being more elongated. Coxae II has a definite external spur while the internal spur is represented only by brownish chitinization of the coxal edge. Coxae III as in II but has external spur further reduced. In Coxae IV, the chitinized edge of the coxae is unarmed.

Nymphs:
The nymphs and larvae are not described as insufficient authentic material is available. From the scanty material available the nymphs of _P. decoloratus_ may be differentiated from those of _U. fallax_ by the following characters:— the palps are longer, and equal in length to the hypostome, the scutum shows a pale yellowish middle area as in the female and the legs are slender and bead-like in appearance with the coxal armature poorly developed. The body tapers posteriorly with no definite construction as in _U. fallax_.


Fig. 76.
*Palpb-boophilus decoloratus* male - ventral view showing coxae and anal plates.

Fig. 77.
*Palpb-boophilus decoloratus* female - dorsal view.
MALE:

The male of *U. fallax* cannot be distinguished macroscopically from the male of *P. decoratus* but is slightly longer, the scutum is a deep brown and the dorsal posterior furrow deeper and more pronounced. As in *P. decoratus*, the scutum is lightly chitinised and caeca show through as dark lines. Hairs occur over most of the dorsal surface of the scutum.

Palps:— Article I scarcely visible dorsally, Article II larger, forming the major portion of the palp and does not project over Article I externally as in *P. decoratus*. Article III flat and not triangular dorsally. Ventrally, the scale on Article I is broadly rounded. Hypostome longer than palps.

Scutum:— Is one and a half to two times as long as broad and covered with white hairs except on the various grooves. The posterior grooves are three longitudinal furrows, the median being the longer. The paramedian grooves do not show a deep anterior or posterior portion as described by Theiler (1943). Eyes oval at edge of scutum and not conspicuous.

Coxal Armature:— Coxae I bears two spurs, the internal being broader and the pointed tips tend to be rounded off while the external is triangular and pointed. On Coxae II, the internal spur is broad, rounded and scale-like with the external spur more triangular. Coxae III as on Coxae II but relatively less well developed. Coxae IV unarmed, or with a short external spur.
Anal Plates:—Differ little from *P. decoloratus*, but external and internal lateral margins are more nearly equal and the points formed with the concave posterior border are more blunt than that in *P. decoloratus*. The internal point especially is less elongated than in *P. decoloratus* and is never visible dorsally.

**FEMALE:**

Basis Capituli:—Twice as long as broad with areae porosae large and wide apart. Cornuae indefinite.

Palps:—Article I visible dorsally, all the articles broader than long with Article III triangular with pointed anterior apex.

Scutum:—Broader than long. The cervical grooves well developed and reach the posterior border, dividing the scutum into three. Eyes oval at edge of scutum. Scutum deeper brown than in *P. decoloratus* with no higher coloured anterior area.

Coxal Armature:—As in male but spurs less developed especially on Coxae I. Legs stouter than in *P. decoloratus*.

**NYMPH:**

Easily distinguished by pale blueish body, reddish scutum a construction of body posterior to fourth leg.

Basis Capituli:—Hexagonal—longer than broad.

Palps:—Article II about as broad as long. Article III longer than broad with slight anterior tip bearing bristles. Hypostome longer than palps.

Scutum:—Well pigmented, as broad as long, lateral borders straight and directed slightly outwards.
Postero-lateral border also straight meeting at a bluntly rounded apex and forming a sharp angle with the lateral borders. The small eye is at junction of lateral and posterior borders. Cervical grooves well developed reaching the posterior border and as in female, divide the scutum into three.

**Coxal Armature:** All four coxae bear a small external triangular spur, best developed on coxae I and III.

**LARVAE:**

This stage has been described by Thoiler (1943). In the Nyasaland material the cervical grooves on the scutum do not reach the posterior margin and correspond therefore to the description given by Bedford (1934).

The foregoing descriptions are brief but the following list of differential characters may assist in distinguishing *Palpo-boophilus decoloratus* from *Uroboophilus fallax*.

**Male characters assisting differentiation:**

<table>
<thead>
<tr>
<th></th>
<th><em>U. fallax</em></th>
<th><em>P. decoloratus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Colour of scutum.</td>
<td>Brownish colour with yellow legs.</td>
<td>Usually yellowish colour and less heavily chitinized than <em>U. fallax</em>.</td>
</tr>
<tr>
<td>2. Post. dorsal grooves</td>
<td>Well marked.</td>
<td>Not so obvious and confused by caecal markings showing through the scutum.</td>
</tr>
</tbody>
</table>
3. Anal plates
Anal plates are a deep brown colour and points, especially the internal one, weakly developed. Anal plates yellowish, poorly chitinized with elongated internal point which may project beyond body and be visible dorsally.

4. Palps.
Article III dorsally much longer than broad. Article I ventrally no vent. protuberance.

5. Coxal armature.
Little difference but less well developed in U. fallax where ext. spur on Coxae II and III is triangular.

6. Caudal appendage.
No definite differences.

7. Ventral hairs.
Hairs restricted to genital groove margins and coxae. Very hairy general appearance.

8. Shape of Scutum.
Elongated in appearance with body extending beyond scutum about mid. lat. margin. Body widest posterior to attachment of fourth leg.

Female Characters.

1. Hypostone.
Usually 4/4 and about twice as long as palps. 3/3 and about same size as palps.

2. Palps.
Art. III dorsally twice as broad as long with slight ant. point bearing bristles. Art. III about as broad as long.

3. Scutum.
Scutum usually reddish yellow with slightly more yellowish central area. Scutum with yellowish central area and reddish lateral areas.

4. Legs
Stouter in P. decoloratus.
BIOLOGY:

Few observations were unfortunately made on the biology of these ticks. Engorged females were found all the year round, but oviposition seldom occurred in the laboratory during the hot months of the dry season. The most interesting observation made was that while nymphs and adults are invariably found together on the body of the same beast, larvae are usually absent, and when they occur they are found attached to the ears of cattle. It would, therefore, appear that these ticks are two-host ticks in Nyasaland. This observation was not confirmed experimentally.

GEOGRAPHICAL DISTRIBUTION:

Minning (1934) gives the distribution of *P. decoloratus* as Rhodesia, Tanganyika, W. Africa, S.W. Africa, Abyssinia and Northern Syria. Theiler (1943) records it from Portuguese E. Africa, but has been collected from areas all over Northern and Central Provinces.

*U. fallax* is the common species of Nyasaland and occurs generally all over the Territory. It also occurs in East Africa, Portuguese East Africa and South Africa. Minning (1934) suggests that the species was introduced into Africa from India or Madagascar by cattle importations, the "Stamm form" probably originating on the coastal strip of the Indian peninsula.

CHOICE OF HOST:

Cattle are the principal hosts of these ticks, but they also feed to a lesser extent on sheep and goats.
The only other host found infested was the sable, from which a good collection of *P. decoloratus* were taken.

**Fig. 78.**
*Uroboophilus fallax* male - dorsal view.

**Fig. 79.**
*Uroboophilus fallax* female - dorsal view.
Fig. 80 (a) and (b).
*Uroboophilus fallax* nymphs (a) dorsal view and (b) capitulum and scutum.

Fig. 81.
*Uroboophilus fallax* male - ventral view of Coxae and genital shield.
Ticks of the genus *Amblyomma* are easily recognised by their long mouth parts and ornate pattern of the scutum, and the male is without anal shields. Robinson (1926) in his Monograph has described all the valid species then known and Cooley and Kohls (1944) have described the genera found in U.S.A. At least four species occur in Nyasaland i.e. *A. variegatum*, *A. tholloni*, *A. petersi* and *A. marmoreum*.

1. *A. variegatum* - Fabricus 1794.

As this is a well-known East Africa species and the adult stages are easily identified no detailed description is given. Nymphs only are described.

**Nymphs:**
- **Basis Capituli:** roughly triangular in shape with very rounded lateral angles.
- **Palps:** elongated with Article II twice as long as Article III. Article I small and constricted. Palps are slightly longer than the hypostome. Hypostome strong and teeth arranged 2/2.
- **Scutum:** is very characteristic being heart-shaped with short convex antero-lateral margins meeting to form a rounded convex medial portion of the scutum.

The cervical grooves are deep and reach the posterior border, converging at first and then diverging, and so divide the scutum into three areas. The lateral areas are dark red in colour with paler shoulders and are marked by a group of deep large punctations. The central area is yellowish red and has fewer smaller punctations. The whole scutum is
covered by fine reticulations. Eyes are prominent, round and bead like, placed at the lateral corners of the scutum. Coxae as shown in Fig. 52 carry spurs on their posterior border, Coxae I having two sharp spurs while Coxae II to IV have only an external spur.

**BIOLOGY:**

Several important points in the biology of this tick were revealed by the present survey. The seasonal prevalence of the various stages are dealt with elsewhere (Wilson 1946). Nuttall (1915) failed to rear this tick in the laboratory through all its stages, and Lewis (1932) only succeeded after many attempts. No difficulty was found in Nyasaland in getting females to oviposit in the laboratory and the larvae fed freely on cattle. The life-history under Lilongwe conditions was as follows:

- **Incubation period of egg**: 83-97 days.
- **Larvae engorge**: 3-6 days.
- **Larvae moult**: 25-44 days.
- **Nymphs engorge**: 6-7 days.
- **Nymphs moult and adults emerge**: 54-78 days during May to July.
- **28-35 days during August to November.**

In Nyasaland *A. variegatum* can have only one life cycle per annum. The females engorge and oviposit during the hot wet months of December to March. Larvae have adapted themselves to a variety of hosts so the majority are engorged before August and nymphs prevail throughout most of the dry season.
CHOICE OF HOSTS:

All the instars of *A. variegatum* engorge on a wide range of hosts. The adult ticks favour cattle and are found attached chiefly on the udders and flanks. They have also been collected from sheep, goats, reedbuck, sable, duiker, gwape, buffalo, and more rarely on dog. Nymphs are also most common on cattle but have also been collected from poultry, humans, *Lepus whytei*, dog, gwape, duiker, hedgehog, cane-rat and cheetah. Larvae have been found on cattle, sheep, goats, cheetah, humans, and on grass.

GEOGRAPHICAL DISTRIBUTION:

*A. variegatum* is a Tropical African tick ranging from Abyssinia to Portuguese East Africa and Belgian Congo. Jack (1936) does not record it from Southern Rhodesia, but Bedford (1932) records it from the Transvaal and from Mazabuka North Rhodesia.


This tick was collected on two occasions, 6 males from an elephant in July from Kota district and 3 males and 3 fully engorged females during December from an elephant in Kasungu district.

Robinson (1926) records this species from the East Africa Territories, Belgian Congo, Sudan and Sierra Leone. It is mainly a parasite of elephants.


Four males and ten females of this species were collected from a rhinoceros in Kasungu in December 1943. Bedford records this species from the East Africa Territories, Liberia and Zululand. It is mainly a parasite of rhinoceros.
4. *AMBLYOMMA PAMOREUM* - Koch 1844. (Sp. No. 246)

Adults, nymphs and larvae are common parasites of the Tortoise in Nyasaland. It has also been recorded from South Africa, East Africa, Belgian Congo and Sudan either from Tortoise or rhinoceros.

*Fig. 82 (a)(b)(c)*

*Amblyomma variegatum* nymphs (a) capitulum and scutum, (b) ventral view of coxae and (c) dorsal view of nymph complete.
GENUS IV - HYALOMMA Koch.

Ticks of this genus have long mouth parts and banded legs but can easily be distinguished from Amblyomma species by the reddish-brown to black colour of the scutum, the eyes are more prominent and may be orbited and the male has anal shields.

Schulze (1927, 1930) reclassified this genus and in his key the following species are given for East and South Africa: - H. impressum rufipes, H. impressum transiens, H. impressum albipartatum, H. planum and H. zambesianum.

In the present Nyasaland collection, H. impressum transiens is the only species definitely recorded. Some specimens showed a tendency toward H. planum but, as the length of the tarsi vary within the species and even on a single specimen, none could definitely be identified as H. planum.

HYALOMMA impressum transiens - Schulze 1927.
(H. aegyptium aegyptium Linnaeus 1911).

A detailed description of the adult stages is not given owing to the very distinctive appearance of this tick and to the fact that it has been recently described by Schulze (1927) and Theiler (1943).

NYMPHES:

Engorged specimens measured 5.4 x 5 mm. while smallest unengorged specimens measured 2.4 x 2.1 mm. Basis capituli: - hexagonal, broader than long with sharply pointed lateral angles not extending beyond the shoulders of the scutum. Uniform brownish red
colour, with few irregularities on dorsal surface. Palps:- elongated, Article II twice as long as Article III, the latter ending bluntly with a few projecting hairs. Hypostome slightly longer than palps with strong teeth, arranged 2/2.

Scutum:- longer than broad with pronounced cervical grooves which reach the posterior margin and divide the scutum into two lateral convex areas and a larger depressed central area. The lateral areas in fresh specimens are dark reddish brown in colour while the central area, especially the posterior portion, is light yellowish in colour.

The lateral margins are convex while the posterior lateral margins are first concave and then convex, meeting bluntly posteriorly. Eyes large and yellow in younger specimens, dark in engorged specimens, orbited and situated at the angle formed by the lateral and posterior lateral scutal margins. Punctations are absent but the whole scutal surface is covered by a network of fine reticulations.

Legs:- stout, pale yellowish red in colour. Coxae I short with two sharp spurs. Coxae II to IV rectangular, each with two spurs on their posterior border.

BIOLOGY:

This is a two-host tick but in the present survey no larvae were collected. Adult males and females were common on cattle during March until May when females were engorging. Occasional
specimens were collected during the remaining months of the dry season but they were rare or absent during November to February. The most common site of attachment was on the tail or perianal region. On the sheep the tick may be found between the hoof segments and cause lameness. Nymphs were found on the hare, *Lepus whytei*, especially during October.

Under laboratory conditions engorged females collected in March oviposited and larvae emerged in 59 days. An engorged female found in October did not oviposit. Adults emerged from nymphs collected from a hare on 8/10/1944, after 25 to 28 days.

**CHOICE OF HOST:**

Adults were found on cattle, sheep, eland, buffalo, lion and ant-bear. Nymphs were only found on *Lepus whytei*.

**GEOGRAPHICAL DISTRIBUTION:**

The precise geographical distribution of this species is unknown. Theiler (1943) records it from certain parts of S. Africa and Portuguese East Africa, while Lewis (1939) lists this species as occurring in East Africa.
Fig. 83.

H. impressum transiens nymph - (a) dorsal view of capitulum and (b) ventral view of coxae, (c) dorsal view of complete nymph.
Species of this genera have long palps and hypostome but differ from the genera Amblyomma and Hyalomma in that the eyes are rudimentary or absent. They occur almost exclusively on Reptilia. Only two species have yet been recorded from Nyasaland.

1. **APONOMMA falsa-laeve** - Schulze.
   (Aponomma laeve capensis Neumann 1901).

   Adult males and females were collected by Mr. Mitchell from unidentified snakes from Salima area Down in January 1942.

   The scutum is uniformly reddish-brown, anal groove present, and scutum of male and body of female not broader than long.


   A good collection of male and female adults and nymphs of this species were taken from an iguana at Lilongwe on December 1944. Nine metallic green spots occur on the scutum of the male, and three on the scutum of the female.
GENUS VI - IXODES

This genus is distinguished from all other IXODIDEA in having the anal groove encircling the anus anteriorly. Eyes and festoons are absent and the mouth-parts are long. The ventral plates in the male may be up to seven in number. The only species here recorded is *Ixodes pilosus* though Nuttall (1916) records *I. brunneus* Koch 1844 on a dove from Mlange mt. Nyasaland.

*IXODES pilosus* Koch 1844.

**MALE:**
A small tick, with long oval outline.

*Basis capituli:*- trapezoid dorsally, broadest anteriorly and produced, ventrally to a median retrograde point.

*Scutum:*- Surrounded by a prominent marginal body-field. Cervical grooves shallow, no lateral grooves, punctations numerous and unequal.

Coxae I has a short trenchant internal spur.
Coxae II and III with trenchant posterior border and Coxae IV has a slight indication of an external spur.

**FEMALE:** - body reddish brown with numerous long white hairs.

*Basis capituli:*- Sub-triangular, broader than long.
Porose areas pear-shaped and wide apart.

*Scutum:*- Longer than broad, lateral grooves straight and reach the posterior border, cervical grooves fairly distinct. Punctations numerous, deep and discrete.
Coxae as in male.
BIOLOGY:

May be a 2 or 3 host tick. While *I. pilosus* in South Africa is a winter tick, in Nyasaland adults are only collected during January to April, i.e. during the hot wet season. At no time are they numerous, and females were always more numerous than the smaller males. Comparison with the South African species shows no anatomical differences. Rearing in the laboratory under atmospheric conditions proved difficult, only a few lots hatching with an average incubation period of 51 days and the larvae failed to engorge.

CHOICE OF HOST:

This tick was collected on twenty-one occasions from cattle, steinbuck, gwape, duiker, reedbuck, lion, squirrel, dog and serval.

GEOGRAPHICAL DISTRIBUTION:

This species occurs, probably in localised areas in East and Central Africa and also in South Africa. Lewis (1939) records from Kenya as occurring in hills, mountain and forest areas rather than in lowlands.
GENUS VII - *HARMAPHYSALIS*

All the species within this genus are inornate, without eyes and the male has no anal or accessory plates. The palps are short and conical and Article II projects laterally beyond the basis capitulum. There is a dorsal spur on the first trochanter and spurs may also be found on the Articles II and III of the palps and on some or all coxa. Nuttall and Warburton (1915) list 45 species and varieties but only two species, are recorded from Nyasaland.

1. *HARMAPHYSALIS leachi* - Audouin 1827.

*Haemaphysalis leachi* is a common ecto-parasite of dogs in Nyasaland and rivals *Rhipicephalus sanguineus* as a canine pest.

**MALE:** - The male is distinguished by its elongated shape and light reddish-brown colour. The size is variable but the Nyasaland species average 3 x 1.2 mm.

**Basis Capituli:** - The lateral borders converge posteriorly so that the basis is broadest in front.

**Cornua:** are well developed.

**Palps:** - meet at an obtuse angle. Article II is very broad, extending laterally well over the shoulders, and carries a dorsal and ventral triangular retrograde spur from each lateral salient. Article III is small and bears a strong ventral retrograde spur.

**Scutum:** - long and narrow, punctations numerous and lateral grooves distinct, including one or two festoons.
Legs: - Coxae I bluntly pointed posteriorly, Coxae II-IV with small internal spur. Tarsus tapering.

FEMALE:

Basis Capituli: - is broader than in the male with porose areas wide apart.

Palps: - As in the male but relatively longer and all spurs on palps and coxae less pronounced.

Scutum: - punctuated as in male with cervical grooves long and close together.

NYMPH: - not unlike female with characters less pronounced.

LARVA: - Basis capituli and palps as in nymphs but scutum is more rounded and coxae are unarmed.

VARIETIES OF H. leachi.

Nuttall and Warburton (1915) considered H. leachi as a very variable species and degraded at least two varieties as synonyms of H. leachi.

More recently, Theiler (1943) records two varieties of this tick from African collections, i.e.

(a) H. leachi var. indica, a small form with oval outlines with compact mouth-parts in the male and palpal spurs in the female much reduced. The external contour of the palps in both sexes shows a concavity. This is regarded as the typical parasite of small carnivores of South and East Africa.

(b) H. leachi var. humerosoides, a very long, elongated form with all spurs exaggerated and sharper and all coxae longer than broad. Ventral surface has numerous long white hairs. This variety has been recorded from the dog from Portuguese East Africa and from Euxerus sp. from Uganda. The only evidence of a
small variety found in the Nyasaland collections was in Specimen No. 282 of a hedge-hog where 3 males were collected all consistently measuring 1.8 x 0.9 mm. On the other hand male specimens of the dog, and cheetah varied little from 3.3 mm. long by 1.4 mm. broad. The average for all the male specimens was 3 x 1.2 mm. with variants from 2.7 to 3.7 mm. long, slightly larger measurements than those usually accepted for this species. The females vary enormously in size. On all the specimens examined, however, the spurs appeared of normal length and the coxae were broader than long. The Nyasaland material is identified, therefore, as *H. leachi*.

**BIOLOGY:**

It was not possible to do much work on the biology of this tick in Nyasaland.

Fully engorged females were collected from October to May but they were rare or absent during the cold drier months of June to July and August. They bred easily in the laboratory, larvae hatching after an incubation period of 35 days.

**CHOICE OF HOST:**

*H. leachi* is a common tick on the dog in Nyasaland but infestations are seldom so heavy as with *R. sanguineus*. Other favoured hosts were the leopard, civet cat, cheetah, jackal , mongoose and hedge-hog. Smaller collections were taken from the lion, squirrel, the small porcupine while nymphs were collected from several species of rats.
GEOGRAPHICAL DISTRIBUTION:

Widely distributed throughout Africa and also recorded from India, Malaya, Burma and the Dutch East Indies.

2. HATMAPHYSALIS hoodi - Warburton and Nuttall (1915).

Recorded by the above authors of the ears of partridges in Nyasaland.
FAMILY - ARGASIDAE

The characters of the Argasidae are definite and there is little difficulty in recognising most species. They are soft or non-scutate IXODIDEA, the integument of the adults and nymphs being leathery, wrinkled, granulated, mamillated or with tubercles. The capitulum in the adults is usually in a depression on the ventral surface at a varying distance from the anterior margin. Porose areas are absent, eyes if present are on the supra-coxal folds and the spiracles of adults and nymphs are usually anterior to Coxae IV. The life-history also differs from the Ixodidae in that the nymphal stages are plural and vary in number and the adult may not engorge.

This family has been described by Nuttall, Warburton, et alia (1908) and later the South African species were fully dealt with by Bedford (1934), who only recognised the one genus Argas. More recently Cooley and Kohls (1944) describing the Argasidae of North America re-established the genera Ornithodoros and Otobius in addition to the genus Argas, and this classification is followed as it most clearly demonstrates the difference in the species of Nyasaland. The three species occurring in Nyasaland, therefore, are Argas persicus, Otobius magnini and Ornithodoros moubata.

1. **ARGAS persicus** - Oken 1818.
   (Numerous synonyms).

In all species of the genus Argas, the sexes are similar and the nymphs and adults are similar.
The body is flattened with the margin distinctly flattened even in engorged specimens. A sutural line is present. The integument is leathery and minutely wrinkled in folds of many shapes. Discs are present on both the dorsal and ventral surfaces and placed more or less radially. The position of the capitulum from the anterior margin varies and eyes are absent.

*Argas persicus* is the widely distributed common fowl tick. Owing to the nocturnal habits of the nymphs and adults, this species has only been recorded on one occasion - type specimen No. 272 being taken from poultry in Lilongwe. The hens were unthrifty and anaemic but no specific disease was present.

2. **OTOBUS megnini** - Duges 1884.

*Argus megnini* - Bedford 1934).

In the genus *Otobius*, the sexes are similar but adults and nymphs are dissimilar. The integument of the adults is granulated, in the nymphs it is striated or with spines. There is no flattened marginal sutural area as in *Argas* and the capitulum is some distance from the anterior margin in adults but near the margin in nymphs. Eyes are absent and the hypostome though well developed in nymphs is vestigial in adults.

Adults of *Otobius megnini*, the spinose ear tick, do not feed, but the one larval and two nymphal molts take place on the same host. Only one collection was made, these being taken from the ears of a horse imported from Southern Rhodesia about twelve months previously.
In the genus *Ornithodoros* the body is flat when unengorged but very convex on the dorsal surface when distended. It is never marginated and no sutural line separates the dorsal and ventral surfaces but the integumental structures are continuous over the sides from dorsal to ventral surfaces. The dorsal humps are more prominent on adults than on the nymphs or larvae. The hypostome is well developed and similar in the sexes and in adults and nymphs. Eyes may be present or absent. The anterior end is pointed or hood-like.

*Ornithodoros moubata*, the Tampan tick, is a common tick in the huts of African natives and carries human Tropical Relapsing Fever caused by the spirochaete *Treponema duttoni*. Eyes are absent, the skin has hemispherical granulations and the legs have a series of characteristic humps. Feeding takes place usually at night every 7-10 days, the ticks being attached for about half-an-hour. Eggs are laid in the sand in batches at intervals of 1-2 weeks, usually after a meal.
METHODS OF CONTROL

Measures have only been designed to control those ticks which feed on cattle and by reference to Table I (page 10) the most important species, therefore, are *R. appendiculatus*, *Boophilus* species and *A. variegatum*. All stages of these ticks engorge on cattle, whereas, only the adult stages of the remaining species engorge. This was probably one of the most important findings of the survey and influenced the work dealt with in Part II of this thesis. *Boophilus* species although probably two-host ticks in Nyasaland, remain longest on their host and are most easily controlled. The fact, however, that infestations of all three species may still be heavy after 15 years continual cattle dipping prompted the present study.

Some of the reasons for the apparent failure of control are obvious. All areas have not been supplied with tanks, and undipped areas are contiguous with dipped areas and cattle can move practically unrestricted from one area to another. Thus, apart from actual cattle movements, dipped and undipped cattle mixed on communal grazing grounds, at markets, or when bulls wander to other herds. The relation of dipped to undipped areas is shown in Map II (Appendix I).

In the past there has also been a certain amount of overcrowding at certain times, and when 6,000 head of cattle are forced to use one tank it is almost impossible to maintain the dipping solution at proper strength with present primitive labour methods.
An important factor which negatived the effects of dipping was the absence of any fencing of pastures and grazing was, therefore, unrestricted and communal. Also there was no dipping of sheep and goats.

A real difficulty in tropical countries is to find the correct site for a tank. Map III shows the site of the Likuni dipping tank placed at the junction of the Likuni and Lilongwe rivers. The tank has, therefore, a convenient and constant water supply, but unfortunately during the rains, when ticks are abundant, these rivers become swollen and cattle herds to the south of the tank cannot cross for dipping. At other times when they do swim across the river most of the arsenical solution is washed off on their return journey before it can have much effect on engorging ticks.

Map III
Sketch map showing site of Likuni Dipping Tank
In 1940 the numbers of dipping tanks were increased, new legislation drafted, staff was reorganised and improved stock returns introduced. Statistics for the dipping efficiency in any tank area could then be reckoned accurately. A table showing the efficiency of dipping in four tank areas is given below.

DIPPING EFFICIENCY TABLE showing percentage of cattle dipped each quarter - 1943-1944.

<table>
<thead>
<tr>
<th>Tank</th>
<th>Percentage dipped 1st Quarter</th>
<th>Percentage dipped 2nd Quarter</th>
<th>Percentage dipped 3rd Quarter</th>
<th>Percentage dipped 4th Quarter</th>
<th>Annual Efficiency Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIKUNI</td>
<td>(1943) 54</td>
<td>(1944) 53</td>
<td>(1943) 73</td>
<td>(1944) 73</td>
<td>(1943) 65</td>
</tr>
<tr>
<td>MBABZI</td>
<td>(1943) 36</td>
<td>(1944) 70</td>
<td>(1943) 69</td>
<td>(1944) 67.4</td>
<td>(1943) 60</td>
</tr>
<tr>
<td>LOMBADZI</td>
<td>(1943) 53</td>
<td>(1944) 52</td>
<td>(1943) 64</td>
<td>(1944) 77</td>
<td>(1943) 48</td>
</tr>
<tr>
<td>MASULA</td>
<td>(1943) 53</td>
<td>(1944) 73</td>
<td>(1943) 65</td>
<td>(1944) 93</td>
<td>(1943) 72</td>
</tr>
</tbody>
</table>

There is a general tendency for dipping to be low during the first quarter of the year owing either to heavy rains falling during the dipping days or to the swollen rivers which cattle cannot cross in order to reach the tank. Only 50 per cent approximately of the cattle are dipped during this quarter. During the second quarter dipping may improve in most areas but it is seldom that more than 70 per cent of the total cattle are dipped. During the third and fourth quarters of the year, dipping efficiency may again
decrease owing to the fact that crops have been harvested and as strict herding is no longer necessary cattle wander freely over the country-side; they are difficult to collect at nights and herds may either fail to appear at the dipping tank or else appear in greatly reduced numbers. Other facts such as closure of the tank for cleaning and repairs, or the temporary cessation of dipping during Black-quarter inoculations or during a Trypanosomiasis outbreak may also affect the dipping ratio.

It can, therefore, be concluded that with the present native system of animal husbandry, and with the present dipping staff and organisation, we can seldom hope, in Nyasaland, to dip more than 70 per cent of our cattle population. Combined with this fact is the absence of any supplementary measures such as the controlled grazing of the cattle herds, the clipping of the long hairs in the ears and on the bush of the tail, and the lack of brushes for the hand-dressing of cattle. In South Africa where the climatic conditions are less tropical and the grazing areas are better controlled and less suitable for tick propagation than in Nyasaland, it is generally considered that all cattle should be dipped at 5-day intervals if *R. appendiculatus* is to be controlled.

Improved tick control in Nyasaland, however, may not entirely depend on improved dipping facilities and organization. A knowledge of the biology of the tick suggests that control may be assisted by the less expensive method of improved grazing arrangements.
for the native cattle with the aim of preventing certain instars from engorging. The seasonal prevalence of the adult stages of the commoner ticks is shown in Fig. 31.

Diagram representing the seasonal incidence of some of the commoner ticks of domestic animals in N. Province, Nyasaland.
As previously pointed out, the majority of the ticks under Nyasaland conditions have only one life-cycle per annum, and the adult instar is generally restricted to a definite season. In the case of the most important species, *R. appendiculatus*, the female engorges only during the rainy season from December to March. If cattle grazing could be restricted at this time of the year to the drier upland areas of open *Brachystegia* woodland, then the majority of *R. appendiculatus* females would oviposit and the larvae would hatch in a vegetative association which becomes bare and dry early in the dry season and therefore inimical to tick development. Cattle should be removed from the *Brachystegial* grazing in March to the more fertile better grazing areas of *Combretum - Acacia - Bauhinia Thonningii* woodland associations. The early grazing of these areas will, however, depend on an improvement of the present agricultural system with the establishment of more permanent cultivated areas fenced off from the surrounding woodland grazing areas. The early burning of the *Brachystegia* woodland cannot be recommended as strong grass fires late in the dry season are often essential to maintain the open nature of the woodland and the continued growth of grasses suitable for grazing. Unengorged larvae would, however, appear to die relatively quickly in Nyasaland (page 27). Manual deticking of animals during the short wet season when engorged *R. appendiculatus* females are prevalent on the ears and are easy to find and remove would also greatly assist control. Apart from this question of
organized grazing of cattle, the most important problem is to find the alternate hosts, avian or mammal, on which larvae feed. An early assessment of the real importance of the three dominant vegetative associations is also necessary, i.e. what instars find their most suitable environment in the BRACHYSTEGIA - ISOBERLINIA association, the COMBRETUM - ACACIA - BAUHINIA THONNINGI]association or in the seasonally saturated DAMBO grasslands.

Some evidence of the extreme effect that change of the dominant vegetative communities can have on a tick population is seen in the Naheu district. Faulty methods of cultivation have caused serious erosion in this area and grazing is now insufficient for native stock so the erosion continues and much of the vegetation has been destroyed, and river tracks instead of forming dambo land now run in deep eroded gullies. In such hard bare eroded ground few ticks breed and both R. appendiculatus and A. variegatum are rare or absent.

The future control of ticks in Nyasaland, therefore, is not simply dependant on increasing the number of dipping tanks. Final success must await the construction of a proper system of land utilization.
At the onset of this work, the actual number of species of *Ixodoidea* occurring in Nyasaland was unknown, it was assumed that all the instars of such common ticks as *R. simus* and *R. capensis* engorged on cattle and a seasonal prevalence of any of the species was not suspected. The present systematic study, based on very numerous field collections in addition to some laboratory data, has corrected these fundamental errors and has created a basis for future research.

The most important points clarified in the biology of *R. appendiculatus* was the failure of the female to engorge except when atmospheric humidity was above 75 per cent, and the short survival time of unengorged larvae when humidity was below 65 per cent.

Adult *R. neavei* and *R. neavei var. punctatus* have also been redescribed. *R. oculatus* has been retained as a valid species but *R. pravus* has been discarded.

*R. duttoni, R. masseyi, R. kochi, R. ziemanni* have been redescribed together with a description of *R. muhleni* n. sp.

The classification of the species in the "Simus" group is modified and four species recorded from Nyasaland, i.e. *R. simus, R. tricuspis, R. simpsoni* and *R. falcatus*. The biology of the first two species has been studied, the adult stages showing a seasonal prevalence and the nymphal and larval stages do not feed on cattle. The nymphs of *R. simpsoni* have been described for the first time.
The relationship of *R. capensis* and *R. ayrei* has been reconsidered, the latter being probably a variety of *R. capensis*. *R. sanguineus* is recorded with list of hosts.

The genus *Boophilus* has been re-examined in the light of Minning's recent classification and it seems probable that under Nyasaland conditions they are two-host ticks.

Four species of *Amblyomma* were collected and the seasonal prevalence of the various stages of *A. variegatum* have been recorded for the first time. Nymphs have also been described for the first time.

*Hyalomma impressum transiens* is the only species of that genus occurring in Nyasaland and nymphs are described for the first time. Two species of *Aponomma* were collected.

Only one species of *Ixodes*, *I. pilosus*, was collected, but is never numerous and the adults only occur for a brief season.

*Haemaphysalis leachi* is recorded, with host list, and consideration of varieties.

Three species of *Argasidae* were collected.

Control of the species feeding on cattle by dipping at 7-day intervals in arsenical solutions is not certain. Eradication will only be possible when more consideration is given to the biology of the species concerned and a proper system of land utilisation is practised.
I wish to acknowledge with grateful thanks the assistance and guidance given to me by Professor James Ritchie, D.Sc., and without the facilities he placed at my disposal at the Zoology Department, Edinburgh, this work would not have been completed. Also to Dr. A.E. Cameron, I record thanks for his valuable criticism and help. The drawings are original and have been done by the author but I gratefully acknowledge the valuable assistance of Mr. R. J. Fant without whose expert technical knowledge, the results from the numerous photo-micrographs would not have been so successful. All these photographs and drawings have been done from Nyasaland specimens, collected and identified by the author, with the exception of the few based on British Museum specimens. I also wish to thank Professor Ritchie for arranging my visit to study tick material at the British Museum and at the London School of Tropical Medicine and Hygiene, and to thank the authorities of these institutions for the facilities offered me during my visit. I also record thanks to the many persons who sent me collections of tick material in Nyasaland, and to Dr. Theiler, Onderstepoort, and Dr. Lewis, Kabete, for the valuable help given me on many occasions.
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Map II

Appendix I (ref Page 188)
showing
Dipped and Undipped Areas

Sketch Map
A STUDY OF THE INCIDENCE OF EAST COAST FEVER
IN NYASALAND

AS REVEALED BY THE PRESENCE OF KOCH'S
BODIES IN THE SPLEEN

PART II OF THESIS
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INTRODUCTION

In many of the British African Colonies there are few reliable vital statistics from which the constant changes that occur in the domestic animal populations may be interpreted. There is therefore a lack of data on the incidence and epidemiology of many of the commoner cattle diseases and a corresponding absence of statistics regarding the effectiveness or otherwise of disease control measures. In some areas there is so much diagnostic uncertainty that some diseases have escaped detection for many years. As a consequence, the investigator who wishes to study any particular disease problem may find little reliable data on which to formulate a research programme.

The state of our knowledge regarding the incidence of East Coast Fever in Nyasaland may be taken as a specific example. Theileriiasis due to Theileria parva infections has always been regarded as the principle cattle disease in both the Northern and Central Provinces, and the greatest veterinary effort has been devoted towards the control of its tick vectors. Since 1931, an elaborate cattle-dipping programme has been maintained as a first step towards control. Data, however, have not previously been available regarding the exact incidence of the disease either before or after the commencement of dipping.
The work presented in this paper is therefore planned with a view to providing the data required and also answers to such pertinent questions as: What is the present mortality from East Coast Fever; what age-groups of cattle are chiefly affected; and is the present cattle dipping system economic and effective? The answers to these questions are of vital importance both to the present administration and also to those who must plan future policy. The research envisaged was of such a nature that it could be readily undertaken by a field officer without the aid of elaborate laboratory facilities. And, as the problem was a local one, it could not be conveniently dealt with at a Central Research Institution.

The first essential step was to construct an accurate and continuous cattle census system. Tentative steps were taken to achieve this in 1939 but no real progress was possible until Government Notice No. 86 of 1942 became law. It then became compulsory for all cattle owners to report immediately, and to ensure the accurate recording of all births, deaths and stock movements in their cattle herds. Spleen smears were collected from all dead animals and examined in the Lilongwe laboratory for *Theileria* infections. The necessary field organisation to prosecute the scheme exists, at present, only in dipping areas. These areas are divided into suitable small sub-divisions, each with its own dipping-tank and supervised by a
trained African Veterinary Assistant. It was therefore possible for cattle owners to submit their reports expeditiously to the Veterinary Assistant who was, in turn, able to maintain up-to-date the cattle register of his area. Further, since all cattle herds were assembled and counted at their respective dipping tanks once a week for dipping purposes, it was possible to detect early any falsification of herd records.

The mortality rate for East Coast Fever, therefore, in undipped areas still awaits elucidation. Since the results of the tick survey showed that cattle ticks are not being effectively controlled by dipping in the area now under investigation the necessity for further investigation in the undipped areas is not urgent. A comparison of the disease incidence in two areas with contrasting climatic and vegetative conditions would more likely be productive of useful information. In this respect, the results from the highland area of the present investigation could well be compared with those obtained from an examination of the Karonga lakeshore plain. It is hoped that the present technique and results may form a reliable basis for all similar future investigations.
East Coast Fever as caused by *Theileria parva* was first recognised by Theiler (1904) as a distinct and independent disease. The opportunity for studying the disease as an epizootic arose when in 1901 a consignment of cattle originating from the interior of Tanganyika was shipped from Dar-es-Salasam, landed at Beira, and then transported by rail to Umtali and Salisbury in Southern Rhodesia. A fatal disease had appeared in the herd while en route; on arrival the disease became more serious and not only caused considerable mortality in the imported herd but quickly spread and by 1902 had become a virulent epizootic throughout Rhodesia (Sinclair 1922).

Early investigations were confused by the fact that some years earlier (1897), Koch, while investigating redwater in East Africa had incorrectly regarded the small piroplasms of *Theileria* found in the red blood cells as immature stages of *Piroplasma bigemina*, and the disease caused as an acute type of redwater. This mistaken diagnosis may have been possible when dealing with *Theileria* infections in enzootic areas, where mortality was low, but with the Rhodesian epizootic, Koch, as shown by his interim report dated 23rd March 1903, soon realised that the disease was not redwater. Theiler in 1904
gave the first accurate description of the parasite. He was investigating outbreaks of disease in the Transvaal which had been introduced in the north with cattle smuggled from Rhodesia, and in the south-east from cattle moved from Portuguese East Africa, especially from Delagoa Bay and Lourenço Marques (Henning 1932). Theiler called the parasite *Piroplasma parva* but it was later placed in a new genus, *Theileria*, by the Portuguese investigators Bettencourt, Fransca and Borges (1907). The family *Theileriidae* was created by du Toit in 1918 to include all organisms which, like *T. parva*, multiply only in the cells of the lymphatic system by the formation of "Koch's blue bodies". These bodies produce gametes ("small piroplasms") which invade the red blood cells and are later ingested by the blood-sucking ticks where they undergo further changes (GONDER, 1910; COWDRY and HAM, 1932; REICHENOW, 1938, 1940). The role of ticks as transmitters of the disease was first demonstrated by Lounsbury (1903) by using adult *Rhipicephalus appendiculatus* ticks which had been fed as nymphs on infected cattle. Later these observations were soon extended to include *R. simus*, *R. capensis*, and *R. evertsi*. Later experiments by Frotheringham and Lewis (1936), showed that *Hyalomma impressum* near *plumum* can also transmit *T. parva* both in the nymphal and adult stages.

It is thus evident that Southern Rhodesia
and South Africa first became infected with *T. parva* from East Africa, and especially from the coastal districts of these territories; hence the name "East Coast Fever" or "African Coast Fever" now generally assigned to this disease. The main epidemiological difference was that on the East African coast the disease was enzootic amongst indigenous cattle (*Bos indicus*), while in South Africa it was an epizootic amongst herds which had a substantial admixture of European (*Bos taurus*) blood. Just how long the disease had been endemic in East African territories cannot now be accurately assessed. Koch (1903), in his Rhodesian interim report seems to suggest that prior to 1900 the disease was restricted to the African Coastal region from about Dar-es-Salaam in the north to Delagoa Bay in the south. For instance, he states that "this same disease exists on the East African coast as has now broken out in Rhodesia, and that in German East Africa the disease was carried inland in a similar manner to that in which it may have been brought from Beira to Umtali.

The stock on the coast of German East Africa are apparently quite healthy and in the best condition, but as soon as other cattle are brought there from clean districts, for instance, from the inner parts of the country, and graze on veld on which the cattle from the coast have been grazing, these imported
animals will get sick and almost all die.

In connection with Koch's remarks it may be mentioned that even in enzootic East Coast Fever areas isolated districts do exist in which cattle remain free from the disease but rapidly succumb if moved to infected areas. Thus while the disease is enzootic in the Northern and Central Provinces of Nyasaland, the entire Southern Province remains free, and when the disease does occur in the Southern Province as during the outbreak in 1936, it appears as an epizootic which can be controlled by regular dipping of all infected herds. The consignment of cattle embarked at Dar-es-Salaam for Southern Rhodesia in 1901 may have originated from such a clean area in Tanganyika and become infected at one of the coastal ports.

Again, the effect of the sea and land journey on cattle exposed to *Theileria* infections cannot be ignored. Thus Doyle (1924) records a recrudescence of a *Theileria* infection (*T. mutans*) when Cyprus cattle were moved to Egypt. More recently in experiments with what is presumed to be *T. mutans*, De Kock, Van Heerden, du Toit and Neitz (1937), record their view that the high mortality with 100 per cent production of Koch's bodies which occurred in their 1935 lot of experimental Vryburg exposed cattle was mainly due to the fact that these cattle were transported back to Onderstepoort during the height of the reaction to the infecting *Theileria*. 
Koch's assumption that the "inner parts" of Tanganyika were clean areas does not correspond with the views of present day workers. East Coast Fever has been regarded as enzootic for many years over large areas of this territory and in fact it "could not have attained its enzootic condition over such wide areas of East Africa if it had not been there almost as long as the cattle themselves" (Hornby, H.E. personal communication 1940).

The position in Uganda is clearly defined by Mettam and Carmichael (1936) who state that "the presence of a fatal calf disease characterised by glandular hypertrophy has been recognised in Uganda for countless generations". Mortality, however, may still be high and under adverse conditions 40 per cent of the calves may succumb annually.

In Kenya, Daubney (1938) stated "that the disease in its enzootic form was not dispersed over the whole of Kenya, but that on the contrary certain areas were almost completely free of the infection, and that an infection introduced into such areas tended to die out in a comparatively short time." (cf. Nyasaland, Southern Province, page 7). The natural distribution of the disease in Kenya does, however, correspond fairly closely to that of the chief vector, R. appendiculatus.

With regard to the actual origin of East Coast Fever it would appear to be an African disease.
There is no evidence to show that it was introduced by the Shorthorned Zebu cattle which arrived in Somaliland from Syria and Southern Arabia within historic times (Bisschop, 1937). The subsequent migration of these cattle southwards along the East Coast to the Zambesi was assisted by Indian and Arabian traders and their distribution, therefore, corresponded closely to that of East Coast Fever during the last century. On the other hand, Lewis (1943) has recently shown that buffalo may contract a mild form of East Coast Fever which can be transmitted to cattle and may cause mortality. This question of game acting as reservoirs of *T. parva* has been raised on several previous occasions. Ross (1911) found small piroplasms and Koch's Bodies in a hartebeest. Lichtenheld (1911) found Koch's bodies in a kidney infarct of an eland. Beaumont (1939), also from an eland, found Theileria parasites in the blood and Koch's bodies in the spleen. Beaumont further connects this finding with an outbreak of East Coast Fever four months later on the farm where the eland was found. Neitz (1931, 1933) has greatly extended the list of wild animals in which *Theileria spp.* have been found and these results have been summarised by Thomas and Neitz (1933). Carpano (1937), on circumstantial evidence suggested that a bison imported from Canada to Cairo contracted a *Theileria* infection from infected ticks from a neighbouring
wild ruminant enclosure and therefore suggests that existing *Theileria* spp. are not host specific but variants of *T. parva*.

From existing evidence, therefore, it may be assumed that *T. parva* was originally a game parasite.

The actual date of introduction of East Coast Fever into Nyasaland cannot now be determined. Originally populated by short-horned Zebu cattle brought down by the "third bovine invasion" of Africa (Curson and Thorton 1936), Sanga blood was later introduced by the Angoni in 1850 (Collen Young 1923).

In Mzimba where this admixture of Sanga and short-horned Zebu was most pronounced, Stannus (1910) reported a disease of cattle due to a small blood piroplasm. The disease was especially prevalent during the rains from November to April, and the incidence and mortality varied in different herds kept under similar conditions. Although no statistics were available to show mortality rate he suggested that this was about 10 per cent. Small piroplasms were not numerous in the blood corpuscles, even in acute cases. The disease differed from the "Amakebe" disease of Uganda in that in Mzimba adult cattle were chiefly affected, the typical infarcts of the kidney were absent, and chronic cases occurred. Nuttall in a footnote attributes this disease to *T. parva* as Koch's bodies were present in spleen
Garden (1912) also found East Coast Fever enzootic in this district. Further, from the behaviour of the disease, he concluded it had been enzootic there for many years and that "the line of march of the disease" had been from the southern districts of Tanganyika, into north Nyasaland. Later it spread to Mzimba and the central districts of Dowa, Lilongwe and Dedza. This actually is the only possible line of infection. Lake Nyasa forms a barrier to all cattle movements on the east, while Northern Rhodesia on the west and the southern districts of Nyasaland are both regarded as being free of *T. parva*.

At present therefore *T. parva* is recorded as being enzootic in most of the cattle areas of Northern and Central Provinces and absent in the Southern Province. Natives recognise the disease all over the endemic areas, the Akonde calling it "Matussi" from the prominent parotid swellings which characterise the disease, while the Achewa call it "Chigodola." No reason is advanced in this paper as to why the disease has not spread to the Southern Province, as this problem has not been investigated.

The position would be simple if only one *Theileria* species, i.e. *T. parva*, was involved. The presence of *T. parva* cannot long escape detection. It invariably causes a noticeable mortality though
this may be greatly reduced in areas where it has long been enzootic and no recent introductions of more susceptible cattle have occurred. One attack confers a strong sterile immunity. The diagnosis of the disease is relatively simple as glandular swellings usually occur, small piroplasms are present in the blood, Koch's bodies may be numerous in the lymph glands and especially in the spleen, and post-mortem changes of the kidneys and abomasum are typical.

The presence of a second Theileria species, Theileria mutans must however be considered. Theiler in 1906 described this parasite under the name of Piroplasma mutans, and although the small piroplasms in the blood were indistinguishable from those of T. parva, the two parasites differed in several very important respects. Thus "P. mutans" was a harmless parasite and caused little or no reaction in the host animal and no immunity. Further, since no Koch's bodies could be found it was assumed that multiplication in the blood occurred after the manner of P. bigemina. In 1918, du Toit created a new genus, Gonderia, for all parasites of the type of "P. mutans" and for ten years this species was known under the name of "Gonderia mutans".

However, in 1923, Brumpt suggested that Koch bodies, though very rare, may occur in the life history of Gonderia mutans. This was later proved
by Theiler and Graf (1928) and in pure Gonderia
mu tang infections plasma bodies were found that
resembled in every respect those found in the cycle
of all known Theileria spp. including T. parva. The
species was therefore admitted into the genus
Theileria and has since been known as Theileria
mu tang. Owing to the "perfect adaptation" of this
species to its host, it has been able to spread to
almost every corner of the globe (du Toit 1930).

The similarity of T. mutans to T. parva
was carried a step further by de Kock et alii (1937)
when they showed that under certain adverse con-
ditions T. mutans may cause a heavy mortality in
cattle and "assume the pathological picture of
T. parva from which it cannot be differentiated".

In Nyasaland, therefore, where mortality
in enzootic areas is low, the mere presence of Koch's
bodies in the spleen is not sufficient evidence for
the assumption that T. parva was the cause of death.
In some cases and under certain conditions T. mutans
must also be suspected and the epizootological
picture of Theileria infections may therefore be
confused and complicated.

The two remaining Theileria parasites
which occur in cattle and which are regarded as
distinct species i.e. T. dispers and T. annulata are
not considered in this paper as there is no evidence
to show that either these species occur within the
East, Central, and South African territories.
MEASURES OF CONTROL ADOPTED IN THE CENTRAL PROVINCE OF NYASALAND.

No therapeutic drug has yet been found which exerts any curative effect on *T. parva* infections in cattle; and control measures have therefore been directed towards eradicating the tick vectors. The tick population of an infested area can be reduced by starvation i.e. by removing hosts for a period of 2 years, or by controlled grass burning, or by use of acaricidal sprays on pastures, but these methods have little practical value in native territories. Control measures are therefore usually restricted to the regular dipping of cattle in an arsenical dip to kill the ticks when they are concentrated for feeding on their animal hosts.

During the first quarter of this century, Nyasaland, for economic and other reasons, had no East Coast Fever control policy, but about the year 1930 a grant was received from the Colonial Development Fund and 47 dipping tanks were built and a partial dipping policy started for the Central and Northern Provinces. In framing this policy the Nyasaland Veterinary authorities benefited from the experience gained in South Africa where cattle dipping has been in progress for many years. But there were several important differences between the two territories. South Africa was a more wealthy country and cattle were of considerable economic value, so
the initial expense of erecting dipping tanks was fully justified. The nature of the disease in South Africa was also different in that it was epizootic and all outbreaks were treated as active infections. Moreover, the system of animal management was more advanced than in Nyasaland, and fencing with grazing control and isolation of infected herds were practicable measures. In Nyasaland where the disease was enzootic and pasture in many areas consisted of untamed bush land and grazing was uncontrolled, the success of the dipping campaign could not be assured. It is to the credit of the Government and the Chief Veterinary Officer that the venture was undertaken.

The actual process of dipping requires no description as it has altered little since the time of Cooper and Laws (1915), and the arsenical fluids used by Watkins-Pitchford (1911) have scarcely been modified, though interesting developments in the use of D.D.T., derris and nicotine may be expected soon. The position in the several countries has recently been reviewed by du Toit (1942) for South Africa, Wilson (1943) for Nyasaland and by Adamson (1944) for Southern Rhodesia.

Several modifications in the Nyasaland dipping system were deemed necessary to facilitate the present study. Government Notice No. 86 of 1942 was published making it compulsory for cattle
owners to maintain proper records of their herds in any prescribed area. More especially, owners were compelled to submit spleens to the Veterinary Assistant in their tank area from all animals which had died either from disease or by slaughter, so that proper spleen smears could be made and forwarded to the laboratory for examination. The cattle return forms were completely revised, as the old forms showed only the number of cattle owned at the beginning of each month and the numbers of cattle dipped each month. They could not be checked accurately or quickly, and the information supplied was at times inaccurate. Two new forms were introduced. Each owner was provided with a "Stock Card" on which all changes in his herd were recorded, and the Veterinary Assistant at each tank kept a "Cattle Register" which in addition to showing the numbers of cattle dipped also showed the number of calves born, the deaths each month either from disease or slaughter or seizure by wild animals, the numbers of cattle entering or leaving the area by permit, and the numbers missing. The records for each herd were entered separately, and by amalgamation a complete return showing cattle population changes in each tank area was compiled for each month.

Other minor modifications were that greater control over cattle movements was exercised, the training of the African field staff by Veterinary
Assistants was improved and their numbers increased and a small expert staff of African Dipping Supervisors was created. These supervisors assisted the European Officer in the supervision of dipping areas, i.e. by ensuring that Government Notice 86 of 1942 was correctly administered and by checking the monthly cattle returns from the tanks in their area before submitting them to Veterinary headquarters.

The laboratory organisation was also improved so as to deal accurately with the increased number of spleen smears which were now arriving.

As a result of these changes we are now in possession of accurate statistics of the following facts for each tank area i.e.

(a) The number of cattle owned by each owner at any date and the number of cattle owned in each tank area at the end of each month.

(b) The number of calves born each month with the number of each sex.

(c) All cattle movements either by permit between dipping tank areas or between villages within any one tank area.

(d) The number of cattle slaughtered in villages in each tank area.

(e) The number of cattle caught and killed by wild animals or missing.

(f) The number of animals that die of disease in each area with age and sex of each animal.
(g) The number of spleens submitted from all cattle which die of disease or are slaughtered.

(h) The laboratory records show the number of spleens which are positive to Koch's bodies.

(i) Accurate dipping returns showing the number of cattle dipped and undipped each week at each dipping tank.

Some of the results derived from these returns form the basis of this paper.

In addition to this statistical study as much information as possible was accumulated regarding the vegetation and climate of the area and a survey of the ticks of the district was begun in 1940 and forms Part I of this thesis.

As an example of the statistical information now made available the annual return form for Masula dipping tank for 1944 is given in Table I. This cattle return form may be compared with the dipping return form in use in all dipping areas prior to 1943, a copy of which is attached as Appendix I. The advantages of the present system should be obvious. A conglomeration of unreliable and incomplete data has been replaced by an informative system of vital statistics which can be used to good purpose in a community where the system of cattle husbandry is still largely unorganised.
## MONTHLY RETURNS MASULA TANK

1944

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</tr>
</tbody>
</table>

### SUMMARY

**CATTLE OWNED 1ST. JANUARY 1944:** 3180 head

**INCREASES**
- CATTLE OWNED: 3180 head
- CALEBS BORN: 1156
- PERMITS IN: 243
- DECREASES
- DEATHS: 972
- MISSING: 72
- PERMITS OUT: 115

**TOTAL INCREASE:** 240

(Froms and Tos represent movements of Cattle from one herd to another within the same tank area and do not require permits.)
STATISTICS SHOWING THE INCIDENCE OF EAST COAST FEVER IN AREA OF SURVEY

A brief outline has been given above of the present system of veterinary field and laboratory procedure designed to increase our knowledge of the epizootology of East Coast Fever. The statistical results of this study are now presented.

(A) LABORATORY RESULTS

During the years prior to 1943 it was seldom possible to confirm the cause of deaths in cattle by examination of spleen smears. The present number of smears actually examined at Lilongwe for three years before and after the inauguration of the present scheme is shown in Table II.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Spleen Smears Examined</th>
<th>Spleen Smears showing Koch's Bodies</th>
<th>Per cent. Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>32</td>
<td>9</td>
<td>28.1</td>
</tr>
<tr>
<td>1941</td>
<td>118</td>
<td>43</td>
<td>36.4</td>
</tr>
<tr>
<td>1942</td>
<td>334</td>
<td>99</td>
<td>39.6</td>
</tr>
<tr>
<td>1943</td>
<td>7,601</td>
<td>425</td>
<td>5.6</td>
</tr>
<tr>
<td>1944</td>
<td>16,119</td>
<td>342</td>
<td>2.1</td>
</tr>
<tr>
<td>1945</td>
<td>10,067</td>
<td>331</td>
<td>3.3</td>
</tr>
</tbody>
</table>

(1 Records for January to July only)
The number of smears examined in 1940, 1941, and 1942 represent therefore a very small sample of the total cattle which died of disease. There was also a pronounced bias in the selection, as spleens were only submitted by a few of the more conscientious owners who had actually suspected disease. Under these conditions, 28 per cent. of the smears examined in 1940 were positive, 36.4 per cent. in 1941 and 39.6 per cent. in 1942.

From 1943 onwards, the total number of spleen smears examined increased considerably and the percentage of smears diagnosed as positive has markedly decreased. The 16,119 smears examined in 1944 does present an unbiased sample representative of the cattle dying either from disease or by slaughter during that year. The low percentage of positive smears - 2.1 per cent. - was therefore significant. With the increased number of smears examined, the percentage diagnosed as positive was expected to be lower than in previous years since approximately 40 per cent. originated from healthy slaughtered cattle. But the 1943 results represented a drop of 87 per cent. as compared with those of 1942. From the laboratory results above, therefore, the mortality from East Coast Fever appeared lower than was anticipated.

A certain seasonal prevalence of positive cases was also noted in the laboratory returns.
Table III shows the number of positive cases diagnosed each month. These originated from all the Tank areas in the Central Province.

**TABLE III**

Table showing total spleen smears examined, with total and percentage of the smears showing Koch's bodies during 1944-45.

<table>
<thead>
<tr>
<th></th>
<th>1944</th>
<th></th>
<th>1945</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Total</td>
<td>Posit.</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>smears</td>
<td>smears</td>
<td>positive</td>
<td>smears</td>
</tr>
<tr>
<td>Jan.</td>
<td>1499</td>
<td>62</td>
<td>4.13</td>
<td>1733</td>
</tr>
<tr>
<td>Feb.</td>
<td>1755</td>
<td>122</td>
<td>6.95</td>
<td>1688</td>
</tr>
<tr>
<td>Mar.</td>
<td>1538</td>
<td>75</td>
<td>4.87</td>
<td>1582</td>
</tr>
<tr>
<td>Apr.</td>
<td>1141</td>
<td>16</td>
<td>1.40</td>
<td>1447</td>
</tr>
<tr>
<td>May</td>
<td>1014</td>
<td>21</td>
<td>2.07</td>
<td>1050</td>
</tr>
<tr>
<td>June</td>
<td>1168</td>
<td>10</td>
<td>0.86</td>
<td>1200</td>
</tr>
<tr>
<td>July</td>
<td>1198</td>
<td>12</td>
<td>1.00</td>
<td>1367</td>
</tr>
<tr>
<td>Aug.</td>
<td>1261</td>
<td>5</td>
<td>0.38</td>
<td>1007</td>
</tr>
<tr>
<td>Sept.</td>
<td>1019</td>
<td>5</td>
<td>0.48</td>
<td>886</td>
</tr>
<tr>
<td>Oct.</td>
<td>1332</td>
<td>3</td>
<td>0.22</td>
<td>875</td>
</tr>
<tr>
<td>Nov.</td>
<td>1524</td>
<td>Nil</td>
<td>-</td>
<td>865</td>
</tr>
<tr>
<td>Dec.</td>
<td>1670</td>
<td>11</td>
<td>0.66</td>
<td>829</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16,119</td>
<td>342</td>
<td>23.02</td>
<td>14,529</td>
</tr>
</tbody>
</table>

The largest proportion of cases was diagnosed during the early months of the year and the largest number for any one month occurred in February. This seasonal incidence of cases showing Koch's bodies is more clearly shown in fig. I.
Fig. I.

Percentage of all smears showing Koch's Bodies each month 1944-45.

(B) FIELD RESULTS

(i) Actual mortality in different tank areas

The laboratory results of smear examinations given above merely reflect field phenomena. In Table IV a summary is given of the actual number of positive cases of E.C.F. diagnosed in the laboratory each month in eighteen different tank areas. In Table V these results are given as mortality per 10,000 head of population. Ten thousand head is taken as the standard as the numbers dealt with are small. The mortality each month is based on the actual cattle population alive at the beginning of that month and not on the mean annual population given in column one of Table IV. It will thus be seen that, over the whole year of 1943, only 46.7 cases per 10,000 head of population died showing Koch's blue bodies in the spleen smears. In 1944 the equivalent figure was 43.9.
<table>
<thead>
<tr>
<th>Month</th>
<th>1943</th>
<th>1944</th>
<th>1945</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>12</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Feb.</td>
<td>11</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Mar.</td>
<td>7</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Apr.</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>May</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>June</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>July</td>
<td>4</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Aug.</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Sept.</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Oct.</td>
<td>2</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Nov.</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Dec.</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total Number of Cases E.O.F. Diagnosed Each Month for 18 Tank Area**

**Table IV**

<table>
<thead>
<tr>
<th>Area</th>
<th>1943</th>
<th>1944</th>
<th>1945</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samaluli</td>
<td>3</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Malindi</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Chilenda</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Jumpha</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Chisega</td>
<td>-</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Likuni</td>
<td>5</td>
<td>84</td>
<td>13</td>
</tr>
<tr>
<td>Namagya</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Naivi</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Chikuse</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Chiza</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Masila</td>
<td>4</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Kalilungu</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Namkota</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Malimbi</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Namiri</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Katembe</td>
<td>2</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>L. Bridge</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>L. Valley</td>
<td>-</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>29</td>
<td>71</td>
<td>55</td>
</tr>
</tbody>
</table>
## Table V

**INCIDENCE OF EAST COAST FEVER PER 10,000 HEAD OF CATTLE POPULATION**

<table>
<thead>
<tr>
<th>Month</th>
<th>1941</th>
<th>1944</th>
<th>1945</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1941</td>
<td>1944</td>
<td>1945</td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Jan.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes

- **Cattle Pop.**
- **Nil** indicates no data available.
A summary of Tables IV and V is given below:

### TABLE VI

**TOTAL ANNUAL MORTALITY FROM E.C.F. FROM 1943-45 FOR 18 TANK AREAS**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total cattle population</th>
<th>No. of cases of E.C.F. diagnosed</th>
<th>E.C.F. cases for 10,000 head of population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1943</td>
<td>62,363</td>
<td>314</td>
<td>46.7</td>
</tr>
<tr>
<td>1944</td>
<td>59,681</td>
<td>265</td>
<td>43.9</td>
</tr>
<tr>
<td>1945</td>
<td></td>
<td></td>
<td>Not fully available.</td>
</tr>
</tbody>
</table>

In Table VII the various tank areas are arranged according to the mean mortality rate for the years 1943 and 1944.

### TABLE VII

**MORTALITY RATE FROM E.C.F. PER 1000 HEAD OF POPULATION**

<table>
<thead>
<tr>
<th>Tank Area</th>
<th>Death rate[per 1000] in 1943</th>
<th>Death rate[per 1000] in 1944</th>
<th>Mean Death rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likuni</td>
<td>19.65</td>
<td>15.90</td>
<td>17.70</td>
</tr>
<tr>
<td>Masula</td>
<td>9.29</td>
<td>9.45</td>
<td>9.37</td>
</tr>
<tr>
<td>Kalumbu</td>
<td>5.39</td>
<td>12.01</td>
<td>8.70</td>
</tr>
<tr>
<td>Mbabzi</td>
<td>7.95</td>
<td>8.53</td>
<td>8.24</td>
</tr>
<tr>
<td>Nathenge</td>
<td>4.62</td>
<td>4.86</td>
<td>4.74</td>
</tr>
<tr>
<td>Magiga</td>
<td>6.07</td>
<td>3.26</td>
<td>4.66</td>
</tr>
<tr>
<td>Lintipe Bridge</td>
<td>3.28</td>
<td>4.84</td>
<td>4.06</td>
</tr>
<tr>
<td>Manjiri</td>
<td>4.94</td>
<td>2.61</td>
<td>3.77</td>
</tr>
<tr>
<td>Chilinda</td>
<td>1.49</td>
<td>5.39</td>
<td>3.44</td>
</tr>
<tr>
<td>Lombodzi</td>
<td>5.19</td>
<td>1.59</td>
<td>3.39</td>
</tr>
<tr>
<td>Malandi</td>
<td>4.20</td>
<td>1.64</td>
<td>2.92</td>
</tr>
<tr>
<td>Malimbwe</td>
<td>2.44</td>
<td>3.09</td>
<td>2.76</td>
</tr>
<tr>
<td>Jumpha</td>
<td>4.17</td>
<td>0.77</td>
<td>2.47</td>
</tr>
<tr>
<td>Namaguya</td>
<td>2.60</td>
<td>1.88</td>
<td>2.24</td>
</tr>
<tr>
<td>Chadla</td>
<td>2.57</td>
<td>0.65</td>
<td>1.61</td>
</tr>
<tr>
<td>Lintipe Valley</td>
<td>2.22</td>
<td>0.50</td>
<td>1.36</td>
</tr>
<tr>
<td>Namitete</td>
<td>1.19</td>
<td>1.43</td>
<td>1.31</td>
</tr>
<tr>
<td>Chikuse</td>
<td>0.63</td>
<td>0.64</td>
<td>0.64</td>
</tr>
</tbody>
</table>

**Mean Mortality** 4.88

4.39

4.89
<table>
<thead>
<tr>
<th>Tank Area</th>
<th>1943</th>
<th>1944</th>
<th>1945</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEBRIT</td>
<td>22</td>
<td>77</td>
<td>30</td>
</tr>
<tr>
<td>JEBBART</td>
<td>19</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>KALIDAI</td>
<td>-</td>
<td>-</td>
<td>26</td>
</tr>
<tr>
<td>HASHILA</td>
<td>14</td>
<td>22</td>
<td>26</td>
</tr>
</tbody>
</table>

TABLE VIII

PERCENTAGE OF ALL CATTLE DEATHS FROM WHICH SERUM SAMPLES WERE EXAMINED
The geographical relationship of most of these areas is shown in Map IV. The mortality rate at Likuni is distinctly higher than in any other area. Also the mortality rate in many areas in 1944 was less than in 1943, in spite of the fact that the detection system was more efficient in 1944.

(ii) Technical difficulties in diagnosis

Before proceeding further with the analysis of the above statistics some possible discrepancies which might falsify results are examined. The first and most obvious factor which would invalidate all results would be the failure of cattle-owners to submit spleen smears from animals which had died. In Table VIII the percentage of smears submitted by cattle owners is given for four Tank areas.

In the early months of 1943, large numbers of cattle died from disease or were slaughtered and no spleen smears were submitted to the laboratory. The number of cases of E.C.F. diagnosed during these months, therefore, are low. Just how low they are cannot really be assessed. Many of the 88 per cent. of cattle which died at Likuni, for example, in January, and from which no smears were received, were healthy cattle slaughtered for meat or died from natural causes. Owners at the beginning of the
scheme, had however, a habit of submitting smears only from beasts that had obviously died of disease. The results were therefore better than might be deduced from Table VIII. Later in 1943, and during 1944 and 1945 this error factor was largely eliminated and the percentage of smears received was as high as could be reasonably expected from any native area.

A second important cause of error would arise if it were shown that East Coast Fever could exist without the presence of Koch's bodies in the spleen. Richardson (1930) suggested that East Coast Fever was caused by a virus or some unknown pathogen and Neitz (1943) brings forward further suggestive evidence in support of this hypothesis. If Koch's bodies in spleen smears are not considered sufficiently reliable per se, then post-mortem findings must be produced as additional evidence that the beast died of East Coast Fever. Thus, if it could be shown that cattle had died showing ulcerations of the abomasum, kidney infarcts, petechial haemorrhages of the endocardium and other typical East Coast Fever lesions but without showing Koch's bodies in spleen smears, then a post-mortem method of diagnosis other than spleen examination would become necessary. Unfortunately, the difficulties of making numerous post-mortems in native areas are often insurmountable. Distances are great and communications difficult, especially during the rainy season when East Coast Fever is most prevalent. Unless the post-mortem is done soon after death
pathological changes are difficult to recognise owing to the rapid putrefaction under tropical conditions; also carcases are consumed by the natives a few hours after death. During 1944, however, a special effort was made in three tank areas (Likuni, Nanjiri and Kalumbu) to correlate post-mortem findings with smear examination results. In no case was a typical East Coast Fever post-mortem observed where Koch's bodies were not present in the spleen. Several aspects of this important point are reviewed later (page 56).

The third possible cause of error is faulty laboratory diagnosis. This however, need not be considered here, since smears in the field were all made by trained African Veterinary assistants, and with well prepared smears and good staining technique, the recognition of Koch's bodies presents little difficulty. Smears were recorded as showing numerous, few, or rare Koch's bodies. Some smears were positively diagnosed where only one or two Koch's bodies were found.

(iii) Evidence in Field Results of a Seasonal Mortality

In Fig. II the total mortality of East Coast Fever in the 18 tanks per 10,000 head of cattle as shown in Table V is represented diagramatically. The increased incidence of East Coast Fever during January, February and March of each year is a striking feature of this diagram. In Fig. III the mortality rates of five tank areas are similarly analysed. As the graph scale is similar for all five areas the higher
incidence of East Coast Fever in the Likuni area, especially marked during February, 1944, should be compared with the generally lower incidence in the other four areas. The fall in the incidence to or near zero during the dry season is also clearly shown in these diagrams.

The high incidence of East Coast Fever in the Likuni area may be associated with the introduction of European cattle breeds by the Agricultural Experimental Station at Likuni.
FIG. 11.

NUMBER OF DEATHS SHOWING KOCH'S BODIES PER 10,000 HEAD OF CATTLE POPULATION

1943 - 1945

NO. OF CASES SHOWING KOCH'S BODIES PER 10,000 HEAD OF POPULATION
(IV) - THE MORTALITY IN INDIVIDUAL HERDS

It has been shown that mortality from East Coast Fever over a representative area including eighteen dipping tanks is exceptionally low. Examination of records from individual herds reveals the fact that mortality occurs in isolated cases and not in epizootic form. Maps II to III show the distribution of kraals in the Likuni tank area. Map I shows the villages in the area but in each village there may be several distinct cattle herds each registered under a separate owner. As changes of ownership may occur either through death or according to native custom it is more convenient to register each kraal under a number rather than a name. Thus in Likuni tank area (Maps II and III) there are 159 kraals in N.A. Malili's area and 39 in N.A. Kalumbu's area. The number of cattle in each kraal varies from 4 to 129 head, but the cattle in the whole area averaged 3741 head in 1943 and 3443 head in 1944 (Table III above). The actual number of cattle in each kraal is not of great significance as many of the herds mixed during the day on the communal grazing grounds and also during dipping days.

The mortality from East Coast Fever during the rainy season of 1944-45 is shown for each kraal. The prevailing number of deaths due to *T. parva* was one per herd, occasionally two or three, while in 1944 seven deaths were confirmed in kraal No.155. This kraal consisted of 118 head of cattle, owned by a European Mission and the seven deaths all occurred
CATTLE KRAAL IN LIKUNI TANK AREA

E. C. F. Diagnosed
JAN - MARCH 1944.

O = ONE CASE E.C.F.
CATTLE KRAAL

IN

LIKUNI TANK AREA

E. C. F. Diagnosed JAN.-MARCH 1945.

- One case E.C.F.
amongst a group of overworked adult oxen.

(V)-THE RELATIONSHIP OF EAST COAST FEVER MORTALITY TO THE MORTALITY FROM ALL DISEASES

It has already been noted that each cattle-owner when reporting deaths in his herd was required to state if the cause of death was disease, slaughter, accidents or attacks by wild animals. From these reports, which were in all cases confirmed by a Veterinary Assistant, Tables IX and X (pages 34-35) have been constructed to show the total number of deaths from disease including East Coast Fever in the same eighteen tank areas as have been considered with reference to E.C.F. mortality alone in Tables IV and V.

A summary of Tables IV, V, IX and X is given below in Table XI.

| TABLE XI |
| Summary of Tables IV, V, IX and X. |

<table>
<thead>
<tr>
<th>Year</th>
<th>Total average cattle population</th>
<th>Total deaths from disease</th>
<th>Average deaths from disease per 1000</th>
<th>Total Deaths from E.C.F.</th>
<th>Average deaths from E.C.F. per 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1943</td>
<td>62,363</td>
<td>5,538</td>
<td>82.3</td>
<td>314</td>
<td>4.67</td>
</tr>
<tr>
<td>1944</td>
<td>59,681</td>
<td>6,564</td>
<td>102.5</td>
<td>265</td>
<td>4.39</td>
</tr>
<tr>
<td>1945</td>
<td>Not fully available</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In 1943, of the 82.3 beasts per 1000 which died of disease, 4.7 beasts or only 5.7% died of East Coast Fever. In 1944, only 4.4% of all animals dying of disease per 1000 head of population showed
microscopic evidence of East Coast Fever. This general relationship of East Coast Fever to deaths from all diseases is shown diagramatically in Figs. IV and V. Fig. IV shows this relationship for the whole area while Fig V shows the relationship at Likuni tank area where East Coast Fever incidence was highest.
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**TABLE X**

NUMBER OF CAPTIVE DPERES OF INSECTA EACH MONTH PER 1,000 HEAD OF POPULATION
Fig. IV. - SHOWING RELATION OF E.C.F. (Table V) TO TOTAL DISEASE (Table X) PER 1000 HEAD OF CATTLE.
INCIDENCE OF INFECTION ACCORDING TO AGE

The sex and approximate age of all animals which died of disease is recorded on the laboratory smear form submitted with each smear by the Veterinary Assistants. Exact ages can not be given owing to practical difficulties, but each case is listed under one of three main age groups, i.e. adult, 1 to 3 years old, and 1 year or under. The number of cases diagnosed in each age-group is given in Table XII (page 38) for a 28 month period from January 1943 to April 1945. During the 28 months, 1019 cases were diagnosed and out of this number, 293 were adult cattle, 388 were immature beasts under 3 years old and 338 were calves 1 year old and under. The number of deaths in each age group is, therefore, in the proportion of 1: 1.32: 1.15. The cattle population is, however, predominately adult, and from many differential counts it has been found to be approximately composed of 47 per cent adults, 43 per cent 1-3 year old immature animals and 10 per cent calves. Therefore, in an enzootic area with all ages of cattle equally susceptible the distribution in the three age-groups of 1019 beasts dead of East Coast Fever might be expected to be 479 adults, 438 1 to 3 years old and 102 calves.
The position is summarised in Table XIII.

TABLE XIII

Table showing expected mortality in each age-group and numbers actually diagnosed

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<thead>
<tr>
<th></th>
<th>Adult</th>
<th>1-3 yr. old</th>
<th>calves</th>
<th>Total</th>
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<tr>
<td>Numbers expected to die of East Coast Fever assuming all age-groups equally susceptible.</td>
<td>479</td>
<td>438</td>
<td>102</td>
<td>1019</td>
</tr>
<tr>
<td>Numbers actually diagnosed</td>
<td>293</td>
<td>338</td>
<td>338</td>
<td>1019</td>
</tr>
<tr>
<td>Per cent diagnosed compared to assumed cases.</td>
<td>61</td>
<td>87</td>
<td>330</td>
<td></td>
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</tbody>
</table>

It is thus evident that mortality amongst calves is three times higher than that assumed. This is not surprising in an enzootic area where calves contract the disease early and survivors have acquired an immunity which they may not lose throughout life. The relatively high adult mortality is therefore a somewhat unexpected feature of this survey and is more fully considered later in this paper (page 56).
TABLE XII

East Coast Fever Diagnosed

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<th>Adults</th>
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<th>1 year and under</th>
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(4 cases were unclassified in 1943)
1. From a study of the literature it was assumed that both *T. parva* and *T. mutans* infections occurred in the Central Province of Nyasaland.

2. From practical experience gained in an investigation of *T. parva* infections in the field, the presence of Koch's bodies is regarded as evidence of *T. parva* infections. Little evidence was found in the Central Province to support the theory that East Coast Fever was due to a supplementary "virus" or could occur in a fatal form without the occurrence of Koch's bodies in the spleen or lymphatic glands.

3. The changes carried out by enacting new legislation, in substituting a more complete and informative dipping return form for that in use prior to 1942, and the resultant increased laboratory work, are all briefly described.

4. In many areas, a spleen smear from almost every beast that dies was examined (Table VIII) and in the Lilongwe laboratory the number examined rose from a meagre 32 smears per annum to over 16,000 (Table II).

5. From all the evidence at our disposal, the mortality from East Coast Fever in the Central Province of Nyasaland amongst a cattle population of 62,000 head was 4.67 per 1000 in 1943 and 4.39 per 1000 in 1944, (Tables IV and V). The highest mortality occurred in the Likuni dipping tank area where 19.65 head per 1000 died of East Coast Fever in 1943 and 15.90 per 1000 died in 1944. Mortality
over the whole area in 1943 was higher than in 1944.

6. Both laboratory and field results clearly show that the greatest mortality from East Coast Fever occurs during the hot wet months of January, February and March of each year.

7. In some herds, mortality in any one year seldom exceeded one beast, while in many herds there was no mortality from East Coast Fever.

8. When mortality from East Coast Fever is compared with the mortality due to all diseases (Table XI), the relative unimportance of East Coast Fever is recognised.

9. Mortality from East Coast Fever occurred amongst cattle of all ages, but mortality was relatively higher amongst calves under 1 year old.
THE INTERPRETATION AND DISCUSSION OF FOREGOING RESULTS

There are two questions which require to be considered; first, the low recorded mortality in herds infected with East Coast Fever, and second, the marked seasonal incidence of the disease.

(A) THE LOW MORTALITY FROM EAST COAST FEVER

In most countries where T. parva infections have been studied, the mortality even in herds in enzootic areas has been high. Thus in the enzootic areas of Uganda, Mettam and Carmichael (1936) suggest that under native conditions and especially when climatic conditions are adverse, 40 per cent of the calves may succumb annually to this disease. In Nyasaland where 10 per cent of the total population consists of calves, the above mortality would represent at least 40 deaths per 1000 head of population.

In Tanganyika, where the disease is again enzootic, Hornby (1934) estimated that 16,000 head of cattle or 50 per cent of the total cattle population died in one district in 1933. In South Africa, during epizootics, 90 per cent of the infected herds may perish.

In Nyasaland however, a mortality of over 8 deaths per 1000 occurred in only 3 relatively small areas, while in the great majority of the areas mortality was 4 deaths or less per 1000 head of population. Not only is the annual mortality low over the whole area but mortality in each individual outbreak is severely restricted. In this regard, it has never been suggested that T. parva can become
attenuated even after repeated passage. Further it has been shown from the tick survey that dipping has not successfully controlled the tick-vector. We might therefore assume that pure *T. parva* infections do not occur in Nyasaland and the *Theileria* infections as shown by the presence of Koch's bodies may be caused by one of the less pathogenic species of *Theileria* e.g. *T. mutans* or *T. annulata*. The reasons why this assumption was not considered are given below.

(a) **Mortality from *T. parva* in non-resistant animals**

During the dry season of 1935 permission was given to a European Stock-owner (Mr A. F. B.) to move 97 head of cattle from Southern Province (Makoko Estate, Zomba) to Central Province (Mbabzi Estate, Lilongwe). The movement, therefore, was from an area free of East Coast fever into an enzootic area. The herd consisted of a good quality, grade stock of mixed ages, some cows being pure Friesland while the young beasts were a mixture of Friesland, Shorthorn and native breeds, i.e. *Bos taurus* - *Bos indicus* cross breeds. The animals were driven along a specified route for a total distance of 200 miles in easy stages, and were dipped at frequent intervals at Government dipping tanks along the route. They arrived in good condition and were grazed with native cattle.

Eight days after arrival or 26 days after leaving Makoka estate, deaths commenced and in a few weeks reached serious proportions. The herd was
visited on the 13th October 1935 and the disease was then well established with one or two beasts dying each day. Ticks of the species *Rhipicephalus appendiculatus*, *R. capensis*, *Amblyomma variegatum* (males), and *Boophilus* spp. were common on all the beasts. Deaths in many cases occurred within 24 hours after the beast had been reported ill, the longest illness being that of a young bull which was reported ill on the 21/9/35 and died on the 27/9/35. There was little unusual noted in the nature of the symptoms. In all cases, the parotid glands were swollen, temperatures varied from 105°F. to 107°F. and many of the sick animals became dangerous to handle as the disease progressed.

The post-mortem changes were typical of those recorded for East Coast Fever. Ulceration of the 4th stomach occurred in every case and in addition there was a general inflammation of the intestinal mucous membrane which extended throughout the duodenum into the small intestine. In the intestinal mucosae, these inflammatory areas often occurred as longitudinal streaks and resembled, in their intensity, the inflammatory changes seen in rinderpest infections. Petechial pen-point haemorrhages occurred on the kidney surfaces, but white infarcts were not seen, possibly owing to the acute nature of the disease. The spleen was usually normal, the lungs often oedematous and small haemorrhages were common on the endocardium of the left ventricle of the heart. Small piroplasms were
numerous in the red blood cells and Koch's bodies common in spleen smears. From the blood smears forwarded to him for examination the Director of Veterinary Services suggested (March 10, 1936) a pure T. parva infection and from further material examined during a visit to the Onderstepoort Veterinary Laboratories in March - April 1936, there was little hesitation in confirming this diagnosis. From 10th October until the 31st of November, 1935, 56 individuals of the herd had died and with further deaths during the rains only 10 head approx. finally survived, i.e. a mortality of 90 per cent. Throughout the course of this outbreak there was no increase in the incidence of East Coast Fever in the surrounding indigenous cattle. This event proved that T. parva was present and had in no way lost its pathogenicity. Further, since the peak of the epizootic occurred early in the outbreak, i.e. 56 head died during the first 7 weeks, the infection did not develop from within the herd but was contracted by many of the beasts simultaneously from outside sources. And as this infection occurred without any evidence of the disease in native herds, it was then suspected that T. parva could be sub-lethal in indigenous cattle. The fact that this epizootic occurred during October and November when mortality amongst native herds is lowest is also significant. It may also be noted that in all deaths suspected as being due to East Coast Fever, Koch's bodies were easily demonstrated in spleen smears.
Finally, in the absence of experimental evidence, this outbreak pointed to the fact that *T. parva* can retain its virulence even after repeated passage through relatively resistant cattle hosts.

More recently it has been shown that under certain conditions mortality may occur, even amongst indigenous Zebu cattle. In February 1943, twenty-two head of small cattle for slaughter, the average age being about 3 to 4 years old, were purchased in Fort Manning district and kraaled near Lilongwe. Within a few weeks East Coast fever broke out with four deaths within one week whilst others showed signs of fever with swollen parotid glands. Again, only this imported herd was affected, and to prevent a total loss the herd was moved on to the Veterinary Farm at Bwemba and sold as soon as possible to local butchers. Although this herd was in contact with the veterinary herd at Bwemba, and allowed to graze on the same paddocks no deaths occurred in the Bwemba herd.

Fort Manning together with the neighbouring area of Fort Jameson (Turnbull 1926), is regarded as free of East Coast Fever, and these cattle, although indigenous Zebu (*Bos indicus*) breeds, were susceptible to *T. parva* at Lilongwe.

(b) Resistance to *T. parva* shown by indigenous cattle in enzootic areas.

This evidence of the presence of *T. parva* was proved by testing indigenous cattle reared in an enzootic area with a known virulent strain of *T. parva*. For this purpose, the Director of
Veterinary Services, Onderstepoort, kindly sent me, on the 12th of April 1945, eleven tubes of infected R. appendiculatus nymphs. These nymphs had moulted on the 31st of December 1944 from Batch No. 1755A larvae, fed on Bovine 830 from the 29th November to 2nd December, 1944. Three batches of nymphs were first fed on two adult cows and a bull. The two cows, known experimentally as Kachawa No.1 and No.3, originated from an area where E.C.F. was prevalent and they had been admitted to Bwemba Farm as demonstration subjects for the African Veterinary Staff. Cow No.1 suffered from chronic metritis while No.3 had a large chronic abscess on the right hind-quarter. Both cows were therefore in poor condition, and it was reasonable to expect that their immunity to further infections might be lowered. Although the infected nymphs became engorged, no subsequent reaction occurred in these animals. A temperature chart of beast No.1 is given below. The temperature was taken at 6 a.m. and 5 p.m. each day and the high evening temperatures are not regarded as significant.

Temperature Chart No.1 - Kachawa No.1
The bull showed a more interesting reaction. A batch of infected nymphs were fed on the left ear on 1st May 1945. On the 13th day the parotids were noticed to be swollen and this swelling had become well developed by the 15th day when the photograph below was taken.

![Photograph shows swollen parotid glands on 15th day after feeding infected ticks.](image)

The temperature chart below, showed however little significant change. On the 16th day the morning temperature was $102^\circ F$, while the evening temperatures on the 15th, 16th, 18th, 19th and 26th were $104^\circ F$. or over. But these temperatures cannot be regarded as feverish nor did the beast show any signs of distress but continued to graze normally with the herd.
Throughout the reaction no Koch's bodies were detected in gland smears and only on one day - the 16th - were a few small piroplasms found in the blood.

The whole reaction of this bull was typical of that seen on numerous occasions in native cattle, i.e. cattle with swollen parotid glands but temperature and blood findings negative or indefinite. On one occasion a bull with swollen parotid glands and a mid-day temperature of 105°F. was castrated in the hope that the resulting haemorrhage and shock might intensify the Theileria reaction. But the result was disappointing in that the beast recovered without showing any increase of small piroplasms in the Red Blood Corpuscles.

The result of this part of the experiment seemed to show that adult indigenous cattle in Nyasaland may possess a strong immunity to a known virulent South
Africa strain of T. parva.

As a further test, four batches of the infected Onderstepoort nymphs were fed on four beasts aged one to two years old. One lot, fed on the tail of calf No. 9062, failed to attach and caused no reaction. Three other batches, fed on calves No. 9078, 9060 and 9061, engorged and caused subsequent reactions. The temperature chart of Calf No. 9078 is shown below. This calf aged 18 months at the time of the experiment had a mild Theileria infection in March. Onderstepoort nymphs were fed on the 16/4/45, and the animal showed a high morning temperature on the 28/4/45 with swollen parotid glands. Small piroplasms in the blood were common but not abundant, while Koch's bodies were not common in the gland smears. The calf remained in fair condition and was allowed to join the herd on the 16/5/45 and death, which occurred on the 17/5/45 was unexpected.

Temperature Chart III - Calf No. 9078.
Post mortem examination showed typical E.C.F. ulcerations on the fundus mucosae of the abomasum, there were petechial haemorrhages on the endocardium of the left ventricle of the heart and an abscess on the right apical lobe of the lung. But spleen, kidneys, and intestines were normal. Spleen smears taken during the post-mortem were negative and death may therefore have been due either to some complicating cause or to an organic weakness caused by the T. parva reaction.

The course of the reaction in calf No. 9061 is shown in Chart IV below.

Temperature Chart IV - Calf No. 9061, (April-May)

This beast showed an increased morning temperature with swollen parotids on the 27th April, or 12 days after infected ticks had been fed. Blood and gland smears and post-mortem findings indicated
As an uncomplicated *T. pyrogenes* infection, death took place 18 days after the original reaction.

Calf 9060 - Temperature Chart V below was 23 months old, and showed a comparatively mild transient reaction followed by a complete recovery.

Calf No. 9060. (April - May)

The temperature charts of the two calves are shown below, i.e. calves number 9067 and 9073.

The general reaction in this age-group of calves was, therefore, much more severe than in the adult group.

To complete the experiment, 3 further lots of ticks were fed on two calves under one year old and one newly born calf. Temperature charts of the two calves are shown below, i.e. calves number 9067 and 9078.
The reaction with this calf (9067) was never severe and the blood remained negative. With Calf No. 9073, the reaction was more definite and severe, and small piroplasms were numerous in the blood on the 28th May or 20 days after the ticks had attacked. But here again recovery was uneventful.

Temperature Chart VII - Calf No. 9073.
The infected ticks fed on the newly born calf caused no reaction. This corresponds with field results as during 1944 only one positive to East Coast Fever was found in a very young calf about 3 weeks old.

Table No.XIV showing brief summary of the results of the above experiment

<table>
<thead>
<tr>
<th>Experimental Number of Animal</th>
<th>Age</th>
<th>Reaction</th>
<th>Temperature Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kachawa No.1</td>
<td>Adult Cow</td>
<td>No reaction</td>
<td>Chart No.1</td>
</tr>
<tr>
<td>2. Kachawa No.3</td>
<td>&quot; &quot;</td>
<td>&quot; &quot;</td>
<td>Not included</td>
</tr>
<tr>
<td>3. No expt. number</td>
<td>Adult Bull</td>
<td>swollen parotids complete recovery</td>
<td>Chart No.2</td>
</tr>
<tr>
<td>4. 9078</td>
<td>18 months old</td>
<td>Definite reaction and death</td>
<td>Chart No.3</td>
</tr>
<tr>
<td>5. 9061</td>
<td>17 months old</td>
<td>Definite reaction and death</td>
<td>Chart No.4</td>
</tr>
<tr>
<td>6. 9060</td>
<td>23 months old</td>
<td>Mild reaction and recovery</td>
<td>Chart No.5</td>
</tr>
<tr>
<td>7. 9067</td>
<td>9 months old</td>
<td>Mild reaction and recovery</td>
<td>Chart No.6</td>
</tr>
<tr>
<td>8. 9073</td>
<td>10 months old</td>
<td>Definite reaction and recovery</td>
<td>Chart No.7</td>
</tr>
<tr>
<td>9. -</td>
<td>1 week old</td>
<td>No reaction</td>
<td>-</td>
</tr>
<tr>
<td>10.</td>
<td>1-3 yrs. old</td>
<td>No reaction</td>
<td>-</td>
</tr>
</tbody>
</table>

*Fed on a heifer 1-3 years old in my absence and result only recorded.

This experiment was of limited scope including, as it did, only 3 adult beasts, 3 beasts between one to two years old, 3 calves under one year and 1 immature beast of indefinite age; thus conclusions must be made with some caution. Except for the two
adult cows, which were selected because of their poor condition, the animals tested were chosen at random and may be accepted as representative of any herd in the area. The adult bull was not isolated and isolation of the other affected beasts was only partial so that if the Bwemba Farm cattle and those in neighbouring herds had been very susceptible, an epizootic might have been expected. No increased incidence of East Coast Fever has, however, occurred. The main conclusion from the experiment therefore was that indigenous Zebu cattle in the Lilongwe area possess a considerable resistance to *T. parva* infections; a resistance sufficient in itself to explain the recorded low mortality from East Coast Fever in the Central Province of Nyasaland. The resistance was highest in adult cattle and lowest in calves one to two years old. A secondary tentative conclusion was formed that this herd resistance was not broken down, especially in the dry season, by the occasional infected tick picked up from the pastures. A relatively heavy infestation of infected ticks such as the experimental animals were subjected to with the Onderstepoort infected ticks may, however, cause a relatively high mortality rate. The resistance of the herd may be partly genetic in origin and may be partly an active immunity naturally acquired through constant re-infection from infected ticks.

Whatever the manner of its acquirement, the undoubted presence of this immunity has several important results, the first and most obvious of
which is the decreased mortality from East Coast Fever as shown by the Lilongwe cattle mortality statistics. The second result is a practical one in that the resistance which the Lilongwe Zebu cattle possess appears to inhibit the production of Koch's bodies and, therefore, restricts the abundance of small piroplasms in the red blood cells. Thus in calves No. 9078 and 9061, which ultimately died, Koch's bodies were not numerous, while in the adult bull and calves 9060, 9067 and 9073, Koch's bodies were rare or absent. These experimental results correspond with the general field results.

In susceptible cattle (Mr. A. F. B.'s herd noted above) Koch's bodies and small piroplasms were numerous in all affected cases. Amongst indigenous cattle many clinical cases are seen which because of the presence of swollen parotid glands and slight temperature reaction have usually been suspected as chronic sub-lethal cases of East Coast Fever but generally no Koch's bodies can be found in gland smears. As noted above (page 48) the adult bull was a typical example of such a case. Daubney (1936) records cases in infected herds which have shown a transient temperature followed by recovery and no Koch's bodies have been found. On the other hand, calf No. 9078 passed through a stage when Koch's bodies were present, but they were absent at actual time of death. Similar cases have been seen in Karonga lake-plane area but seldom in the present highland survey area.

As a result of this inhibited production of
Koch's bodies there is difficulty in detecting chronic, sub-lethal cases microscopically and it does seem probable that some cases may die undetected without showing Koch's bodies though, from post-mortem evidence, this number must be small (page 29) and have little effect on the total numbers diagnosed (Table IV).

A further result of the herd resistance to *T. parva* infections is the "cleansing" effect immune adult cattle and very young calves may have on infected pastures since infected ticks that engorge on such animals loses their infection.

The numerous goat-herds increase this effect and so the number of infected ticks actually present in any given tick population may be limited. This aspect of the problem has been previously discussed (Wilson, 1945), but should not be over-emphasised as owing to the number of sub-lethal reactions similar to those shown by the adult bull and calves No.9060, and 9067, the number of infective ticks in any tick population will bear no relation to the number of cattle which die showing Koch's bodies in their spleen smears. It may, however, account for the relatively large number of adult cattle diagnosed (page 37) as these cattle may pass through their immature life without infection. An alternate explanation would be that the resistance of these adult cattle is broken down by a heavy infestation of infective ticks (page 54).

The effects of cattle dipping in limiting the mortality from East Coast Fever are not immediately
obvious since *R. appendiculatus* ticks are still abundant in areas where dipping has been in operation for over 15 years. If it could be proved that the herd resistance can be broken down by heavy infestations of infective ticks, then dipping would be useful if it limited the infestation, even though complete eradication was impossible. The danger, however, of producing arsenical-resistant species of ticks must however be considered.
It has been shown that, without exception, the greatest mortality from East Coast Fever occurs during the months of January, February and March amongst indigenous cattle in zoonotic areas. From field observations it was also evident that sub-lethal infections in calves are also more prevalent during this season. The meteorological data given in Figs. VI or VII shows that during these three months rainfall and relative humidity are highest for the year and the mean monthly maximum and minimum temperatures are also high. During December, temperature, rainfall and humidity are high without, however, a corresponding rise in the incidence of East Coast Fever. Further, the high maximum temperatures and increased intensity of sunshine that occur in October and November with low relative humidities have never been associated with an increased incidence of East Coast Fever.

In the past, the disease has always been associated with the rainy season (Stannus, 1910; Wilson, 1944). During these months the cattle of the Achewa tribe in the Central Province are herded during the night in open pens, often standing in mud many inches deep. Since no shelter is provided in the communal grazing grounds, cattle are, therefore, exposed continually to all extremes of weather. One might, therefore, assume that these conditions lower the resistance of the cattle to general infections since the disease graph (Fig. IV) shows that the incidence of all diseases increases during these
FIG. VII. - SHOWING MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURES AND RELATIVE ATMOSPHERIC HUMIDITIES 1933-45.

- - - - = Mean Maximum Temperature.
- - - - - = Minimum
- - - - - - = Relative Atmospheric Humidity
Fig. VII. SHOWING RAINFALL IN INCHES EACH MONTH - 1942-1945.
months. When, however, the mortality rate amongst cattle kept under relatively improved conditions, such as on European farms, is compared with that occurring in native herds no significant difference can be detected. Also, by comparison to the Achewa tribe, the Akonde tribe in the Northern Province have a more advanced system of animal husbandry, and the cattle in this area are housed in clean dry roofed sheds. But from the data available East Coast Fever would appear to be more severe in this area than it is in Lilongwe. It would, therefore, appear that bad methods of animal husbandry alone will not cause an increased seasonal incidence of East Coast Fever.

It may also be noted that during the months when East Coast Fever is prevalent, grasses are at their growing and most nutritious stages and animals are generally in better condition than during the previous dry months. No nutritional factors is therefore suspected.

The effect of an intercurrent or superimposed infection of Clostridium chauvoei in an enzootic East Coast Fever area was studied during October to December 1944. During both the course of the epizootic and the subsequent campaign of immunisation no increased incidence of East Coast Fever was recorded. Again during the several Rinderpest immunisation campaigns, when the reactions in cattle may be severe, no increase in East Coast Fever mortality was recorded. It may be significant that both the black-quarter epizootic and the Rinderpest immunisation campaigns occurred during the dry months of the year. It is therefore concluded
that superimposed infections are not in themselves sufficient to cause an increased incidence of East Coast Fever, nor was there any evidence of an increased incidence of *T. mutans* infections.

A recognised factor inducing an increased incidence of disease, would be a sudden influx of susceptible immigrants into an enzootic area. For this reason the seasonal incidence of calving has been closely studied, but only the relevant details are given here. In Table XV and Fig. VIII below, the eighteen tank areas dealt with in Tables IV to V are divided into two groups - Group "A" includes the tank areas north of Lilongwe while Group "B" includes those south of Lilongwe.
### TABLE XV

Number of calves born and births per 1000 of population in two endemic East Coast Fever Areas

<table>
<thead>
<tr>
<th></th>
<th>GROUP &quot;A&quot;</th>
<th>GROUP &quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Cattle Population</td>
<td>Total Calves Born</td>
</tr>
<tr>
<td>1943</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J.</td>
<td>24813</td>
<td>228</td>
</tr>
<tr>
<td>F.</td>
<td>26810</td>
<td>260</td>
</tr>
<tr>
<td>M.</td>
<td>35790</td>
<td>286</td>
</tr>
<tr>
<td>A.</td>
<td>33286</td>
<td>433</td>
</tr>
<tr>
<td>N.</td>
<td>34113</td>
<td>563</td>
</tr>
<tr>
<td>J.</td>
<td>34248</td>
<td>1047</td>
</tr>
<tr>
<td>J.</td>
<td>34573</td>
<td>1118</td>
</tr>
<tr>
<td>A.</td>
<td>35005</td>
<td>1071</td>
</tr>
<tr>
<td>S.</td>
<td>35257</td>
<td>1129</td>
</tr>
<tr>
<td>O.</td>
<td>36066</td>
<td>1048</td>
</tr>
<tr>
<td>N.</td>
<td>36639</td>
<td>817</td>
</tr>
<tr>
<td>D.</td>
<td>36562</td>
<td>616</td>
</tr>
<tr>
<td>1944</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J.</td>
<td>36248</td>
<td>372</td>
</tr>
<tr>
<td>F.</td>
<td>35685</td>
<td>372</td>
</tr>
<tr>
<td>M.</td>
<td>36691</td>
<td>287</td>
</tr>
<tr>
<td>A.</td>
<td>34095</td>
<td>465</td>
</tr>
<tr>
<td>M.</td>
<td>35679</td>
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<tr>
<td>J.</td>
<td>33909</td>
<td>1238</td>
</tr>
<tr>
<td>J.</td>
<td>34354</td>
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<td>A.</td>
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<td>1584</td>
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<tr>
<td>S.</td>
<td>35829</td>
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<tr>
<td>O.</td>
<td>36152</td>
<td>1391</td>
</tr>
<tr>
<td>N.</td>
<td>36584</td>
<td>965</td>
</tr>
<tr>
<td>D.</td>
<td>36374</td>
<td>440</td>
</tr>
<tr>
<td>1945</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J.</td>
<td>35756</td>
<td>453</td>
</tr>
<tr>
<td>F.</td>
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</tr>
<tr>
<td>M.</td>
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<td>334</td>
</tr>
<tr>
<td>A.</td>
<td>33670</td>
<td>464</td>
</tr>
</tbody>
</table>
FIGURE VIII
Monthly Calving Rate per 1000 head of Population
1943-1945 in two areas as shown in Table XV.
It is thus evident that the great majority of calves are born during June to October with June, July and August as the peak months. Calves born during these latter months will have reached the age of 6 or 18 months during the subsequent periods of January, February and March when East Coast Fever incidence is high. There is some evidence to show that calves are born with a strong immunity. They may suckle the mother until they are 8 to 12 months old. From the experiment with Onderstepoort infected ticks the most severe reactions occurred in calves of 1 to 2 years old. From field experience, however, (Table XII), the greatest relative incidence of deaths occurred in calves under 1 year old, though mortality did occur in all age-groups. It could not be proved that calves of 6 or 18 months old were more susceptible than any other age-group. Also, a high calving rate was seen in some areas in October without any subsequent definite increased incidence of East Coast Fever in April. It was, therefore, concluded that the seasonal calving incidence bore no definite relation to the seasonal incidence of East Coast Fever.

The climatic factors mentioned above, such as increased maximum temperatures, rainfall and atmosphere humidity do not act solely on the bovine host of the Theileria parasite. These same factors may influence the development of T. parva within the tick host, causing it to attain its most virulent phase during the wet months of the year. This is contrary to facts as in Nyasaland it has already been
shown that *T. parva* may be highly pathogenic to susceptible cattle during the dry months of October and November (i.e. in Mr. A.F.B's herd pages 42-45), and no other experimental evidence has yet been provided to show that the virulence of *T. parva* varies with the season.

The present tick survey has, however, shown that climatic factors have a considerable influence on tick development in Nyasaland. *T. parva* can be transmitted by five tick species (Neitz and du Toit, 1938), but in Nyasaland only *R. appendiculatus* may be considered (Wilson 1945). It has been shown (Wilson 1946) that while larvae and nymphs of *R. appendiculatus* occur during the dry months of the year, the adult stages are especially prevalent during the rains. The increased incidence of East Coast Fever coincides more particularly with the prevalence of engorging *R. appendiculatus* females.

There is little previous evidence to indicate that *R. appendiculatus* nymphs are less efficient vectors of *T. parva* than adults. Theiler and du Toit (1928) showed that *T. parva* could be transmitted to susceptible bovines by the intrajugular injection of emulsified nymphs and adults. While no failures are recorded from emulsified adults, not every batch of emulsified nymphs were infective nor was every nymph in any one batch capable of transmitting the disease. The authors blamed this relative failure with nymphs as being probably due to their emulsifying technique. In Nyasaland the following factors suggest that adult
R. appendiculatus ticks are more efficient in transmitting T. parva than the nymphs. During extensive tick collections in the field it was rare to find more than from 5 to 10 larvae engorging on any one animal and they appeared to engorge during only 3 to 4 months in the year. It was, therefore, assumed that these larvae had one or more alternate hosts, probably avian but still not definitely determined, and that cattle may not be the most favoured host. By comparison, it was common to collect hundreds of nymphs on any one animal and they fed throughout the dry season from April to November. It was evident, therefore, that many ticks must reach the nymphal stage free of infection, but during the nymphal stage they have a much greater chance of becoming infected and of passing on this infection to cattle as adults. Further, in Nyasaland, where indigenous cattle are highly resistant to T. parva infections, small piroplasms are not abundant in the peripheral blood system. Nymphs, which ingest larger quantities of blood than larvae, should stand a relatively greater chance of becoming infected.

At this juncture, however, the only conclusion that can be safely drawn is that the seasonal incidence of East Coast Fever is more closely associated with the seasonal incidence of the adult stage of the tick vector, R. appendiculatus, than with climatic factors.
SUMMARY

1. The statistical data as summarised on page 39 showed that the mortality from East Coast Fever was seasonal, occurring chiefly during the hot wet season, and also the mortality was unexpectedly low both for the whole area and also in the individual herds.

2. The full interpretation of these results presented certain difficulties. East Coast Fever had been enzootic in the area considered for many years. When susceptible cattle were brought into the area, mortality from undoubted T. parva infection was 90 per cent. When indigenous cattle in the enzootic area were infected with a known South African pathogenic strain of T. parva infection, mortality was 10 to 20 per cent when numerous infected ticks engorged on each experimental animal but no increased mortality occurred when local cattle grazed on the infected pastures. This strong herd resistance shown by local cattle to T. parva infections explains the low mortality shown by the statistics.

3. East Coast Fever is rarely demonstrated in very young calves in the field and a newly-born calf when tested with known infected ticks proved resistant. The herd resistance to T. parva infections may, therefore, be partly hereditary, but in an enzootic area active development of immunity must also occur.

4. Herd resistance to T. parva infections would appear to cause decreased production of Koch's bodies and therefore of small piroplasms.

5. Resistant cattle have a cleansing effect in an enzootic area, reducing the number of infected ticks in the area and thus limiting the number infecting any one animal at any given time. This may be an important factor in limiting mortality. The effect is further increased by goat herds and by regular cattle-dipping.

6. The seasonal prevalence of the disease does not appear to be due to climatic or nutritional factors and superimposed bacterial and virus infections did not increase the incidence, nor could the seasonal calving incidence be correlated. From the new facts brought to light concerning the life history of R. appendiculatus, the occurrence of T. parva infections coincides with the prevalence of adult ticks and more particularly with the prevalence of engorging females.
7. Several factors are suggested to show that in Nyasaland, nymphs may be more liable to become infected than larvae, and the disease, therefore, would be most commonly transmitted by adult ticks.

ACKNOWLEDGEMENTS

It is a pleasure to record my most grateful thanks to Professor James Ritchie, D.Sc., for so kindly providing me with facilities at the Zoology Department, Edinburgh University to enable me to complete this work. Also to Dr. A.E. Cameron, D.Sc., for his helpful criticism in the preparation of the text. My thanks are also due to the many African helpers, without whose assistance the accumulation of the statistical data would have been impossible.
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APPENDICES

Appendix I:-- Dipping return form in use prior to 1942. (Compare with Table I, p.10).

II:-- Map IV based on Table VII, page 26.

III:-- Map V - showing tank areas from which East Coast Fever Statistics were collected.
<table>
<thead>
<tr>
<th>Kazi kiwana</th>
<th>Doomakwe</th>
<th>2022-08-14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mungo</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Mosc</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
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05/18/2023

DATE 18/06/2023 18/06/2023 18/06/2023
CENTRAL AREA OF NYASALAND (NP)

Showing Tse-Tse and Cattle Areas