THE SEASONAL INCIDENCE OF IXODID TICKS OF CATTLE IN NORTHERN NIGERIA AND IN THE NETHERLANDS, WITH PARTICULAR REFERENCE TO THEIR ROLE IN THE TRANS-MISSION OF BOVINE PIROPLASMS

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ABSTRACT

THE SEASONAL INCIDENCE OF IXODID TICKS OF CATTLE IN NORTHERN NIGERIA AND IN THE NETHERLANDS, WITH PARTICULAR REFERENCE TO THEIR ROLE IN THE TRANSMISSION OF BOVINE PIROPLASMS.

1. INTRODUCTION

Ticks are Arthropods belonging to the order Acarina, Suborder Ixodoidea. They are ectoparasites of animals and may produce toxins which cause diseases in livestock. Their main importance however, is that they serve as biological vectors of all kinds of organisms which are pathogenic to man and animals. These organisms include Protozoa, Rickettsia and Rickettsia-like organisms, Bacteria, Fungi, Viruses and Spirochaetes.

Tick-borne diseases are world-wide in their occurrence. Their local distribution depends for an important part on the geographical distribution and seasonal activity of their tick-vector(s). Since tropical and subtropical climates provide a much more suitable environment for ticks than other climatical conditions, tick-borne diseases are much more important in tropical and subtropical climates, such as prevails in Nigeria.

Nigeria has a cattle population of 11,600,000 (F.A.O., 1972). The Veterinary workers that cater for the well-being of these animals have in the past directed their efforts to the more obvious epizootics such as rinderpest, pleuro-pneumonia and trypanosomiasis. These diseases have now been controlled to such an extent that attention should be devoted to other important diseases including those transmitted by ticks.

Only a few reports of studies on tick-borne parasites in Nigeria are available; these studies indicate a high prevalence of parasites in cattle, especially of Babesia and Anaplasma (Kuil, 1969). Most of these infections occur without clinical signs, but nevertheless serve as a reservoir of the parasites. Under certain conditions, this may result in a serious disease situation. The Annual Veterinary Report of 1929 indicated that piroplasmosis was a complicating factor of rinderpest vaccination, while in the early sixties, it was observed that under more intensive livestock management, bovine piroplasmosis could also become a serious problem. For example, in the controlled grazing scheme in Runka (Katsina Province), about 10% of the cattle had to be treated annually against this disease (Annual Reports, 1960-61; 1961-62; 1962-63).

The importation of non indigenous cattle breeds into Nigeria to improve livestock production, may also result in calamities when these cattle are exposed to tick-borne parasites.

In order to advise on control programmes on tick-borne parasites in Nigeria, it is imperative that the ticks involved are identified and that their biology in relation to disease transmission is understood.

The present investigations which are restricted to cattle, cattle ticks and bovine piroplasms include therefore:

1. identification of cattle ticks
2. determination of their predilection sites on cattle
3. studies on their seasonal incidence in different vegetation zones

4. prevalence studies of piroplasms in cattle
5. determination of the role of tick-species in the transmission of piroplasms.

Similar investigations were carried out in the Netherlands for comparative studies.

II. REVIEW OF THE LITERATURE RELATIVE TO THE PRESENT STUDY.

TICKS: INTRODUCTION

All ticks belong to the suborder IXODOIDEA. They are a highly specialised group of blood sucking arthropods that are obligate parasites of mammals, birds, reptiles and amphibia. There are two families, the IXODIDAE and the ARGASIDAE. The *IXODIDAE* with which we are concerned in this study, are further divided into two sub-families: the IXODINAE which comprise the genera Ixodes and Ceratixodes and the AMBLYOMMINAE which include Amblyomma, Aponomma, Boophilus, Dermacentor, Haemaphysalis, Hyalomma, Rhipicentor and Rhipicephalus (Balashov, 1972).

CATTLE TICKS IN NIGERIA

References to ticks of domestic animals in the northern parts of Nigeria are contained in reports by Simpson (1912 a,b), Johnston (1916), Benton (1939), Findlay & Elmes (1947), Nettam (1951), Unsworth (1949), Gambles (1951), Unsworth (1952) and Strickland (1961). These reports include data obtained from field collections regarding the species and their geographical distribution. On cattle, species of the genera Amblyomma, Boophilus, Hyalomma, Rhipicephalus and Haemaphysalis have been described.

Genus AMBLYOMMA

Hoogstraal (1956) reported about one hundred species of Amblyomma in the world, twenty of which occur in Africa.

The specific identity of most of these is no longer in doubt having been keyed by Rageau & Vervent (1953). A number of species are known to be of veterinary importance since they transmit disease. In addition, this genus, more than any other genus, causes substantial losses in hides and skins, (Plowright, 1956; Macadam, 1962; Yeoman & Walker, 1967).

Amblyomma ticks generally need three hosts to complete their lifecycle, which spans throughout the year producing a single generation only.

Amblyomma variegatum Fabricius, 1794; the tropical bont tick.

Distribution

This species is distributed throughout the Ethiopian Faunal Region (Chapin, 1932) which includes the continent of Africa south of the Tropic of Cancer. A.variegatum is absent in northern Sudan, most of South West Africa, Mozambique and the whole of South Africa (Hoogstraal, 1956).

Records of its occurrence in Nigeria date back from Neumann in 1899 (Hoogstraal, 1956). Simpson (1912 a,b), Johnston (1916), Robinson (1926), Beaton (1939), Nettam (1947; 1952), Unsworth (1949; 1952) and Strickland (1961) have also reported A.variegatum in Nigeria. Un worth (1952) referred to it as the most common tick of bovines, with universal occurrence.

Incidence

Matthysse (1954) reported that in areas with a single rainy season, the adults appeared at the end of the dry season, the males before the females. He observed a population increase during the rainy season and a decline during the dry season, when the larvae and nymphae were prevalent.

Any nymphae found during the rains are scarce (Hoogstraal, 1956).

Hosts

Nearly all references indicate that cattle and sheep are the principal hosts of all stages of A.variegatum (Strickland, 1961).

Predilection sites

Wilson (1948; 1949) reported that on cattle, adults and nymphae commonly occurred on the udder, scrotum, flanks, dewlap and brisket. Larvae were restricted to the ears and head.

Disease relations

A.variegatum is a vector of Cowdria ruminantium, the cause of heartwater disease in cattle (Daubney, 1930). The tick is a reservoir host of the rickettsia (Balashov, 1972). Morel (1958) described a case of "strike" by a Chrysomyia species on the mammary gland of a cow following engorgement by A.variegatum.

Amblyomma splendidum Giebel, 1877;

Distribution

This tick is a West African species. Its range extends from Sierra Leone through Ghana, Nigeria to the Congo. Unsworth (1952) recorded only 11 specimens from Yola, Nigeria. For this reason he questioned the statement of Bequaert (1931) that A.splendidum was commonly seen on cattle in West Africa. Hoogstraal (1956) reported that this species closely resembles the East African species, A.cohaerens Dönitz, 1909 and A.astrion Dönitz, 1909.

Incidence

A.splendidum exists only in regions with more than 50 inches rainfall per year (Hamadjoda, 1969).

Hosts

A.splendidum parasitizes buffalos and cattle (Robinson, 1926).

Predilection sites

Not specified.

Disease relations

Unstudied.

Genus BOOPHILUS

Minning (1934; 1935; 1936) proposed three subgenera in the genus Boophilus and proceeded further to create new "species". These sub-genera were Boophilus (sensu strictu), Uroboophilus and Palpoboophilus. However, later researchers (Cooley, 1946; Anastos, 1950) rejected the classification of Minning. Anatos suggested thatthere were only three Boophilus species the world over. These are B.annulatus, B.decoloratus and B.microplus. Hoogstraal (1956), while in agreement with Anastos, suggested that "a painstaking study of extensive, worldwide series of specimens will be necessary before any final judgement on all subspecies and related species may be vouchsafed". All Boophilus species are one-host ticks.

Boophilus annulatus Say, 1821 (=B.congolensis Minning, 1934), (=B.calcaratus Birula, 1894); the Texas fever tick.

B.annulatus is originally a North American tick. It has been recognised in Africa as early as 1905 by Bönitz. He named it B.australis inspite of the fact that he could not differentiate it from descriptions of the American species. The name B.australis is not valid any more. However, confusion was created in the minds of subsequent workers. For example, what Nuttall had initially identified as B.australis, appeared to be a mixture of B.annulatus and B.decoloratus (Hoogstraal, 1956). In Nigeria, B.annulatus has only been described by Johnston (1916), Hoogstraal (1954) and Strickland (1961).

Incidence

In North America, B.annulatus is a tropical and subtropical tick that fails to thrive under cold conditions. Strickland (1961) reported that in the Northern Guinea Vegetation Zone of Nigeria, it occurred all the year round with certain seasonal fluctuations in populations.

Hosts

B.annulatus is predominantly a parasite of cattle. Sheep and goats were found to be less frequently infested and occasionally specimens were obtained from donkeys (Strickland, 1961).

Predilection sites

Larvae attach to the legs, dewlap, belly or anywhere on the body (Hunter & Hooker, 1907).

Disease relations

These are unstudied in Africa. In North America, Smith and Kilborne (1893) incriminated this species as a vector of Babesia bigemina, the cause of Texas fever (red water) of cattle.

Boophilus decoloratus Koch, 1844; the blue tick.

Distribution

Hoogstraal (1956) gives the distribution of this tick as covering most of the Ethiopian Faunal Region of Africa except on the extreme southern and northern peripheries. It does not inhabit open dry areas or tropical forests. Numerous workers have recorded B.decoloratus from all parts of Nigeria, where it is said to be the second most common tick from domestic animals (Mettam, 1951).

Incidence

Theiler (1949) stated that the blue tick is limited in its occurrence only by aridity, i.e. where the annual rainfall is less than fifteen inches. In Rhodesia, Matthysse (1954) found B.decoloratus throughout the year and did not observe population build-up during the rainy season.

Hosts

Cattle are the chief hosts of this species (Hoogstraal, 1956).

Predilection sites

When larvae find a suitable host, they attach to the dewlap, neck and ears where they moult into nymphae. The nymphae have similar predilection

sites, while the adults usually move to the belly and flanks of the host (Hoogstraal, 1956).

Disease relations

Koch (1898) showed that B.decoloratus was a vector of Babesia bigemina, the cause of red water in cattle.

Boophilus geigyi Aeschlimann & Morel, 1965.

Distribution

B.geigyi was described as a new species by Aeschlimann & Morel (1965). They reported this tick from the southern parts of the Sudan and Guinea Vegetation Zones of Sierra-Leone, Guinea, Ivory Coast, Togo, Dahomey, Nigeria, Senegal and Central Africa. Morel (1972) identified some of our specimens from the Northern Guinea Vegetation Zone of Nigeria as B.geigyi.

Incidence

Unknown.

Hosts

B.geigyi is mainly a cattle tick.

Predilection sites

Not specified.

Disease relations

Unstudied.

Genus HYALOMMA

The genus Hyalomma was created by Koch (1844) when he described thirteen species in addition to three species which had previously been mentioned. Neumann (1911) reduced the genus to four species including a new one which he created. In addition, he described four subspecies.

For the following twenty years, most workers used H.aegyptium as a "catchall" name for all species of Hyalomma. H.aegyptium Linne, 1758 is now recognised as a distinct parasite of tortoises in the Mediterranean area and Near East (Hoogstraal, 1956).

The pioneer work on the classification of the genus Hyalomma was done by Delpy (1946). He obtained specimens from various sources and reared the progeny of individual females. In doing so, he was able to determine the range of variation within a species and to demonstrate that the "specific characteristics" of various species were infact minor differences among individuals of one species. Not long afterwards, Adler & Feldman-Muhsam (1946) also began to rear Hyalomma from Palestine. They and Delpy arrived at different conclusions regarding the names of individual species. After exhausative studies of Koch's identification, Feldman-Muhsam (1954) corroborated Delpy's earlier species with a few changes. Nowadays, the terminology of Feldman-Muhsam is generally accepted.

Hoogstraal (1956) reported that H.truncatum (= H.transiens) and H.rufipes were common in the drier areas of the Ethiopian Faunal Region, while H.impressum was restricted to the Equatorial Regions of Africa.

He described H.detritum and H.marginatum from North Africa and H.impeltatum from East and West Africa. All species have evolved from the Near East.

Many species of Hyalomma survive in severe environments and tolerate extremes in temperature and humidity (Hoogstraal, 1956). Hyalomma species are predominantly three-host ticks. Adults of most species are ectoparasites of domestic animals and hence are of considerable economic importance. They are also efficient vectors of disease-causing organisms. Larvae and nymphae of Hyalomma mainly parasitize rodents, hares and birds. Hoogstraal (1956) predicted that in future Hyalomma ticks will turn out to be among the economically most important of animal ectoparasites, to be found anywhere in the world.

Hyalomma dromedarii Koch, 1844; the camel Hyalomma.

Distribution

The camel Hyalomma ranges extensively north of 12°N. latitude wherever camels occur (Hoogstraal, 1956). The tick has been reported from cattle in Sokoto, Nigeria by Strickland (1961).

Incidence

Delpy & Gouchey (1937) reported that H.dromedarii was very tolerant of low humidities and extremes in temperature (0°C to 37°C). It has been mentioned by Hoogstraal (1956) as the most completely desert-adapted of all Ixodid ticks.

Hosts

H.dromedarii is a three-host tick that may parasitize two hosts only when exposed to unfavourable conditions (Delpy & Gouchey, 1937). The main hosts of the tick are camels but cattle and sometimes horses, sheep, goats and dogs may be attacked (Hoogstraal, 1956).

Predilection sites

Not specified.

Disease relations

H.dromedarii is involved in the transmission of Theileria spp. to cattle and camels (Hoogstraal, 1956).

Hyalomma impeltatum Schulze and Schlottke, 1930 (=H.brumpti Delpy, 1946); Kratz's Hyalomma. This species was redescribed by Kratz (1940).

Distribution

H.impeltatum is widely distributed over West and East Africa. Unsworth (1952) recorded this species in Nigeria but named it H.brumpti, occurring mainly in the Sudan Vegetation Zone. He stated that in this zone it is the most common Hyalomma species collected on cattle, and suggested that it requires drier conditions of climate than any other Hyalomma species.

Incidence

Males and females are found on cattle throughout the year with peaks at the end of the rainy season (Strickland, 1961).

Hosts

Adults are found on all domestic animals with cattle as the most important hosts while larvae and nymphae parasitize rodents, hares and birds (Hoogstraal, 1956).

Predilection sites

On cattle, H.impeltatum is found around the anus, udder, scrotum, dewlap and axilla.

Disease relations

These are insufficiently studied; Hoogstraal (1956) reported that H.impeltatum was not a vector of Theileria annulata of cattle.

Hyalomma impressum Koch, 1844; the West African Hyalomma.

Distribution

H.impressum is mainly a West African tick that does not extend south of the equator (Hoogstraal, 1956). It has been recorded from the northern parts of Nigeria by Unsworth (1952), although he referred to it as H.impressum rufipes. The identity of one of his samples, which was deposited in the British Museum of Natural History in London has been verified by Hoogstraal (1956).

Incidence

Similar to that of H.impeltatum (Strickland, 1961).

Hosts

The chief hosts of adult H.impressum are domestic cattle.

Predilection sites

Similar to those of H.impeltatum (Strickland, 1961).

Disease relations

Unstudied.

Hyalomma rufipes Koch, 1844; the hairy Hyalomma.

During the earlier years of the 1900's, Nuttall named the hairy Hyalomma, H.aegyptium impressum and many workers that followed, copied the precedent. It has also been confused by Schulze, Delpy and Feldman-Muhsam with H.impressum (see Hoogstraal, 1956). Gambles (1951) referred to it as H.impressum rufipes and Theiler (1956) as H.rufipes. The specimens of Gambles and Theiler have been re-examined by Hoogstraal (1956), who confirmd their identity as a distinctive species: H.rufipes.

Howard (1908) considered H.rufipes a two-host tick with a single generation per annum. Jack (1928) showed that the tick behaved both as a two and three-host tick. Theiler (1943) concluded that H.rufipes under laboratory conditions behaved as a two-host tick.

Distribution

H.rufipes is widely distributed in many drier parts of Africa, but it is rarely very common in any one locality (Hoogstraal, 1956). Unsworth (1952) recorded it in Nigeria as H.impressum rufipes and found that it had a wider range than either H.impeltatum or H.impressum.

Incidence

Theiler (1956) reported from southern Africa that H.rufipes occurred in all deserts and semidesert areas with rainfall up to thirty inches per annum. An increase in temperature associated with increase in relative humidity restricted the range of the hairy Hyalomma.

Hosts

Hoogstraal (1956) named cattle as the chief hosts of the adult tick.

Predilection sites

On cattle, the tail region was reported by Thorburn (1952) to be the main site of infestation. Matthysse (1954) referred to the perineal region, while Hoogstraal (1956) reported the flanks, genitalia, udder and perianal region.

Disease relations

Infestations of H.rufipes on cattle cause abscesses and sloughing of the skin. This predisposes the cattle to attacks by Chrysomyia bezziana causing myiasis (Hoogstraal, 1956).

Hyalomma truncatum Koch, 1844; the African Hyalomma.

Nuttall and his school had always referred to H.truncatum as H.aegyptium. In the early 1950's, most workers named this species H.transiens, citing Schulze (1919) and Delpy (1946) as their references. Feldman-Muhsam (1954) re-examined type specimens of Koch and found them to be identical with H.truncatum.

Distribution

According to Hoogstraal (1956), H.truncatum is the sole endemic representative of this genus that is widely spread throughout the Ethiopian Faunal Region and nowhere else. It commonly occurs in the drier parts of this Region and appears to increase in numbers towards and north of the equator. It is rare or absent in forests of western Africa.

H.truncatum has been reported in Nigeria as H.aegyptium by Simpson (1912 a,b), as H.impressum transiens by Unsworth (1949), as H.impressum sub sp. by Gambles (1951) and as H.transiens by Unsworth (1952). It was found to be the most common and widely distributed of the hyalommas in Northern Nigeria (Strickland, 1961).

Incidence

Hoogstraal (1956) asserted that H.truncatum like H.rufipes is xerophilic but that it probably differed from the latter in certain ecological requirements which are yet to be determined. Theiler (1956) reported that in southern Africa the tick was rarely present in those areas with more than 25 inches of annual precipitation. But Hoogstraal observed that the African Hyalomma tolerated a slightly higher range of rainfall. He suggested that a combination of factors including higher temperatures, prolonged dry seasons and lower relative humidities have a bearing on the occurrence of H.truncatum.

Unsworth (1952) did not find the tick in the high rainfall areas of southern Nigeria. All collections were from the more northerly areas.

Hosts

Numerous authors have recorded cattle as the most common hosts of adult H.truncatum (see Hoogstraal, 1956).

Predilection sites

Wilson (1946) noted that adults infest cattle in the brush of the tail, in between the hooves, in the inguinal region and perianal area, and on the scrotum and udder.

Disease relations

H.truncatum is not known to transmit any piroplasms to cattle, but it may cause sweating sickness (Hoogstraal, 1956).

Genus RHIPICEPHALUS

Continental Africa is the original home of Rhipicephalus ticks. Zumpt (1950) recognised 46 species and subspecies, 39 of which occur in the Ethiopian Faunal Region; two are oriental and five inhabit Northern Africa, Southern Europe and Russia. The genus contains more than twice as many endemic African species as any other genus of Ixodids (Hoogstraal, 1956). Pioneer work on this complicated genus has been done by Theiler (1947; 1949; 1950 a,b) who reared individual rhipicephalid species. Further efforts to revise the genus were by Feldman-Muhsam (1952), Theiler et al. (1956), Walker (1956), and Morel & Vassiliades (1962).

Rhipicephalid ticks can either be two- or three-host parasites, and they are known to parasitize a wide range of animal species.

They are quite restricted in their ecological requirements, several species being confined to forests, highlands, semi-desert regions or areas with high rainfall. The most critical limiting factor in their distribution is relative humidity (Hoogstraal, 1956). They are economically important as reservoirs and vectors of human and animal diseases.

Rhipicephalus appendiculatus Neumann, 1901; the brown ear-tick.

Distribution

R.appendiculatus ranges from its northern limit in southern Sudan and Ethiopia to Pretoria in South Africa. Within this range it is absent in deserts and in areas without shrub cover. It is common in the Congo but entirely absent in West Africa. However, Simpson (1912a) has reported it as occurring in Nigeria but this has never been corroborated by other workers.

Rhipicephalus compositus Neumann, 1897 (=R.ayeri Lewis, 1933); the East African highland brown tick.

Distribution

R.compositus is an East African Highland tick with scattered populations in the highlands of Central and West Africa. Morel (1964) refers to the Central and West African species as Rhipiciphalus cliffordi Morel, 1964. It has been reported in Nigeria by Unsworth (1949), Mettam (1950), Gambles (1951) and Theiler et al. (1956). Unsworth (1952) recorded it from the highlands of Bauchi plateau, but also found it in lower parts of Northern Nigeria.

He referred to this species as R.eyeri. Strickland (1961) only found this species around Kaduna.

Incidence

Matthysse (1954) observed largest numbers of R.compositus in the months before the rains set in.

Hosts

Cattle have been mentioned as hosts of the adult tick by several authors including Wilson (1948; 1950 a,b), Matthysse (1954) and Theiler et al.(1956).

Predilection sites

Unstudied.

Disease relations

According to Wilson (1953), R.compositus can transmit East Coast fever caused by Theileria parva. But Yeoman & Walker (1967) reported that this is unlikely since in nature immature stages of the tick have never been collected from cattle.

Rhipicephalus evertsi evertsi Neumann, 1897; the red tick.

Distribution

The red tick is widely distributed throughout the Ethiopian Faunal Region, but it is absent in certain areas of West Africa (Hoogstraal, 1956). Unsworth (1949; 1952) reported its occurrence in Nigeria, mainly from the extreme north-eastern part of the country and suggested that this species was confined to areas with an average annual rainfall of less than 45 inches.

Theiler & Robinson (1954) reported that the tick did not occur in very dry regions of Southwest Africa. This species has also been recorded in Nigeria by Mettam (1940; 1951), Gambles (1951) and Strickland (1961).

Incidence

Hoogstraal (1956) reported that the precise geographical limits of the red tick are yet to be determined and suggested that the annual rainfall required for the survival of this species varied with other existing climatical conditions.

Hosts

R.evertsi commonly occurs on several domestic animals including cattle. Hoogstraal (1956) considered it one of the few rhipicephalid ticks with a two-host type of life cycle.

Predilection sites

Yeoman & Walker (1967) named the peri-anal region.

Disease relations

Lounsbury (1906) proved that R.evertsi would transmit Theileria parva. Barnett was reported to have isolated T.parva from field specimens during an outbreak of East Coast fever, but he did not believe that the tick would also transmit benign theileriosis caused by T.mutans (see Yeoman & Walker, 1967).

R.evertsi is also known to transmit the spirochaete Borrelia theileri in cattle (Theiler, 1909).

Rhipicephalus longus Neumann, 1907 (= R.falcatus Neumann, 1908); the scimitar-shield cape brown tick.

Distribution

Hoogstraal (1956) pointed out that R.longus is mainly a West and Central African tick with a few populations scattered in East Africa and the northern part of southern Africa where the humidity is high. It has been recorded in Nigeria by Zumpt (1942) as R.falcatus and by Gambles (1951) as R.capensis longus. Unsworth (1952) found it in the Cameroons but not in Nigeria.

Incidence

R.longus is a tick of more humid areas. It is a rainy season species, whereas the closely related, R.capensis is a dry season form (Hoogstraal, 1956).

Hosts

Several workers have reported cattle among domestic animals as hosts of R.longus (see Hoogstraal, 1956).

Predilection sites

Unstudied.

Disease relations

These are unstudied.

Rhipicephalus pravus Dönitz, 1910 (= R.neavi Warburton, 1912); the East African convex-eyed brown tick.

Distribution

R.pravus primarily inhabits the drier parts of East Africa. Its distribution extends into central and southern Africa and also into the west African borders (Hoogstraal, 1956). In Nigeria, it was recorded as R.neavi punctatus by Gambles (1951) and Walker (1956). Unsworth (1952) recorded R.pravus from the Cameroons but not from Nigeria.

Incidence

Theiler & Robinson (1953) stated that R.pravus in South Africa preferred dry parklands to more humid parklands or open grasslands. It occurred in areas with a seasonal rainfall that alternated with long dry periods.

Hosts

Wilson (1950 b), Unsworth (1952) and Theiler & Robinson (1953) all mentioned cattle as hosts of the adult tick. However, Matthysse (1954) noted in Northern Rhodesia that the adults were more common on wild game than on domestic cattle. Walker (1956) showed that R.pravus had a three-host type of life cycle. Other workers (Wilson, 1950 b; Theiler & Robinson, 1953) were unable to rear it under laboratory conditions.

The immature stages of this species do not feed on large domestic animals.

Predilection sites

The great majority of specimens are found outside the earflap of the host (Yeoman & Walker, 1967).

Disease relations

Lewis et al. (1946) reported that R.pravus is an efficient vector of Theileria parva in the laboratory. But Yeoman & Walker (1967) contended that, because immature stages of the tick do not feed on cattle, the species is probably not a vector in nature.

Rhipicephalus sanguineus sanguineus Latreille, 1806; the kennel tick or brown dog-tick.

Distribution

R.sanguineus was first described from Southern France. For this reason many workers did not consider it a typical African species. However, Hoogstraal (1956) argued that because the species is typical of the genus Rhipicephalus which is undoubtedly of African origin, R.sanguineus was also typically African. The tick has been well adapted to the domestic dog, which is probably responsible for its world-wide distribution. It has been reported from Nigeria by several workers (Simpson, 1912 a,b; Connal & Coghill, 1917; Pearse, 1929; Philip, 1931 a,b; Nettam, 1940; Findlay & Elmes, 1947; Findlay & Archer, 1948; Fiasson, 1949; Gambles, 1951; Unsworth, 1952; Strickland, 1961). In an extensive study of the Rhipicephalids of the sanguineus group, Morel & Vassiliades (1962) concluded that there are five distinct species which are separated on the basis of their morphology, ecology, host preference and geographical distribution:-

(a) Rhipicephalus sanguineus which has its natural home in the

periphery of the Sahara desert and the Near East. The tick has been adapted to the domestic dog, and is now ubiquitous in its distribution.

(b) Rhipicephalus guilhoni which naturally inhabits the northern Sudan savannahs and sahelian plains from the Atlantic to east of Chad.

(c) Rhipicephalus sulcatus which naturally inhabits the Sudan and Guinea Vegetation Zones.

(d) Rhipicephalus turanicus which is a parasite of herbivores and carnivores in the Mediterranean region and in China.

(e) Rhipicephalus pusillus which is primarily parasitic on wild rabbits in the western Mediterranean region.

Three of these species, i.e. R.sanguineus, R.guilhoni and R.sulcatus appear to occur in Nigeria. They are all three-host ticks.

Incidence

R.sanguineus seems almost independent of its physical environment (Yeoman & Walker, 1967).

Hosts

R.sanguineus is the true dog tick but may occasionally be found on cattle which are in contact with dogs.

R.guilhoni and R.sulcatus are not restricted to any mammalian host and also parasitize cattle.

Predilection sites

On cattle, this group of ticks feeds mainly on the head, back and undersides (Strickland, 1961).

Disease relations

In nature, R.sanguineus is a very effective vector of various blood-parasites of dogs. Hoogstraal (1956) suggests that it transmits the spirochaete Borrelia theileri of cattle. Although species of the sanguineus group have been incriminated as vectors of several pathogens of bovine diseases through experiments, their role in nature is insufficiently known.

Rhipicephalus simus simus Koch, 1844; the glossy tick.

Distribution

R.s.simus is a three-host tick and is distributed throughout the Ethiopian Faunal Region. In West Africa, it was also named R.s.senegalensis. This tick has been reported in Nigeria by Simpson (1912 a,b), Unsworth (1949; 1952), Nettam (1950) and Strickland (1961).

Morel & Vassiliades (1964) and Morel (1972) have reclassified this group and suggested the following species:

R.simus, which is restricted to South and East Africa.

R.muhsamae, which only occurs in West Africa.

R.senegalensis, which belongs to West and Central Africa.

Morel (1972) confirmed that both R.muhsamae and R.senegalensis occur in Nigeria.

Rhipicephalus muhsamae Morel & Vassiliades, 1964.

Distribution

This species only occurs in the Sudan and Northern Guinea Vegetation Zones of West Africa. It is a three-host tick which has been recorded before in Nigeria as R.simus simus (Unsworth 1949, 1952; Strickland, 1961).

Incidence

R.muhsamae requires a habitat with a yearly rainfall between 20 and 50 inches.

Hosts

Adult ticks parasitize cattle while larvae and nymphae are mainly found on game animals (Hamadjoda, 1969).

Predilection sites

On cattle, R.muhsamae engorges chiefly on the dewlap, behind the fetlocks and in the interdigital space.

Disease relations

Unknown.

Rhipicephalus senegalensis Koch, 1844; the scimitar-shielded glossy tick.

Distribution

R.senegalensis is a West and Central African tick with scattered foci in East Africa (Hoogstraal, 1956). This species belongs to the Guinea Vegetation Zones and has been recorded in Nigeria by various authors as R.simus. Unsworth (1952) only found it in the north eastern parts of Nigeria

and concluded that its distribution might be similar to that of R.muhsamae (quoted by him as R.s.sinus). But Morel (1972) is of the opinion that although the two species overlap each other, R.senegalensis is more hydrophile and therefore, has a more southern distribution.

Incidence

This three-host tick prefers regions with a minimum rainfall of 40 inches and remains active throughout the greater part of the year provided there is adequate humidity.

Hosts

Large game and domestic animals are infested by adult R.senegalensis. Cattle have been listed as hosts by Zumpt (1943), Rousselot (1951) and Unsworth (1952). Immature stages probably feed on rodents (Hoogstraal, 1956).

Predilection sites

Sites on cattle include the head, dewlap and perineum (Strickland, 1961).

Disease relations

There are no records of R.senegalensis as a natural vector of bovine piroplasmosis.

Rhipicephalus ziemanni Neumann, 1904.

R.ziemanni has been found in Nigeria by Unsworth (1952) but only in the rain forest of the south-western part of the country. Strickland (1961) found only one specimen in the extreme south of northern Nigeria. It appears to be completely absent elsewhere in the country. Hamadjoda (1969) has reported this species from cattle, sheep and game in the Cameroons.

Genus HAEMAPHYSALIS

Ticks belonging to the genus Haemaphysalis are small and inconspicuous and can be easily overlooked by collectors except when adults are in the engorged state (Hoogstraal, 1956). Furthermore, these ticks are mainly ectoparasites of hyraxes, birds and hedgehogs. Nuttall & Warburton (1915) were first to revise the genus, which in Africa is represented by the ubiquitous H.leachii leachii and about 45 other less well known species. Haemaphysalids are usually three-host parasites. The life history of H.l.leachii and of H.aciculifer have been studied in some detail in the laboratory. H.l.leachii may be a reservoir of Q fever.

Haemaphysalis aciculifer Warburton, 1913; the sharp-spurred Haemaphysalid.

Distribution

H.aciculifer inhabits the forests of West and Central Africa (Hoogstraal, 1956). Theiler (1945) suggested that this species has been established in South Africa through transportation of cattle. The tick has been reported in Nigeria by Unsworth (1949; 1952) and Gambles (1951). Unsworth (1952) found the majority of species in south-western Nigeria.

Incidence

H.aciculifer was found to occur in highland regions with a minimum annual rainfall of 30-40 inches.

Hosts

Antelopes, among other game are the most common hosts of H.aciculifer.

Lewis (1934), Theiler (1945), Wilson (1950 a), Unsworth (1952) and Yeoman & Walker (1967) have all reported that domestic cattle may serve as hosts of the adult tick.

Predilection sites

These have not been recorded.

Disease relations

These have not been studied.

Haemaphysalis leachii leachii Audouin, 1827; the yellow dog-tick.

Distribution

H.l.leachii is a ubiquitous tick of tropical and southern Africa (Hoogstraal, 1956). It was found to occur in Nigeria by Simpson (1912 a), Nuttall & Warburton (1915), Johnston (1916), Pearse (1929) and Strickland (1961).

Incidence

Theiler & Robinson (1953) reported that in South Africa the tick was limited in its spread by increasing aridity. It did not survive in regions with an annual rainfall of less than 20 inches irrespective of the vegetation type. But in the northern Sudan where rainfall is either nil or less than 10 inches annually, H.l.leachii is still common on foxes (Hoogstraal, 1956). In nature, the yellow tick may produce two generations annually.

Hosts

The domestic dog is the common host of the adult stage. Hoogstraal

(1956) reported that cattle may be attacked especially in areas where man, cattle and dogs sleep together.

Predilection sites

These are not specified for cattle.

Disease relations

H.l.leachii has been reported as a vector of canine piroplasmosis (Lounsbury, 1901).

Haemaphysalis parmata Neumann, 1905; the West African Antelope Haemaphysalid.

Distribution

H.parmata is common in Central and West Africa with pockets in forested highlands of eastern Africa. It is especially numerous in the Cameroons (Hoogstraal, 1956). The tick has been reported from Nigeria by Ziemann (1905), Neumann (1911), Simpson (1912 b) and Nuttall & Warburton (1915).

Incidence

H.parmata inhabits humid and forested regions of West Africa (Hoogstraal, 1956).

Hosts

Adult ticks chiefly parasitize antelopes but any domestic animal may be attacked. Cattle have been reported as hosts by Neumann (1905; 1911), Ziemann (1905; 1912), Nuttall & Warburton (1915; 1916), Nettam (1932), Schoenaers (1951), Rageau (1953) and Hoogstraal (1954).

Predilection sites

Not specified.

Disease relations

These have not been studied.

CATTLE TICKS IN THE NETHERLANDS

References to ticks in the Netherlands are very few. Arthur (1963) has included ticks of Western Europe in his review of British ticks. Two genera, Ixodes and Haemaphysalis occur in the Netherlands.

Genus IXODES Latreille, 1795.

The genus Ixodes has been reviewed by Nuttall & Warburton (1911) and by Nuttall (1913; 1916). The group consists of highly specialised three-host ticks which are parasites of small obscure hosts (Hoogstraal, 1956). Its phylogeny stems from the pre-ixodoidea stock. Twenty five species have been described from Africa, but none are known to be vectors of disease to cattle. I.rubicundus may however act as an important vector of sheep paralysis in South Africa.

About 16 species of Ixodes occur in Britain and the European Continent (Arthur, 1963). In this review we shall consider only those species that parasitize cattle in the Netherlands.

Ixodes ricinus Linnaeus, 1758; the castor-bean tick.

Distribution

Authur (1963) reported that this tick is widely distributed in Europe and Russia. It also occurs in north-west Africa. Reference to it in the Netherlands was made by Nuttall & Warburton (1911) and Arthur (1963). There are many more references in relation to disease transmission.

Incidence

I.ricinus is a three-host tick. Its biology has been extensively studied by numerous workers among whom are, Macleod (1939), Milne (1945; 1947; 1950), Campbell (1950) and Lees & Milne (1951). The life cycle of the tick may last for two or three years depending on climatic conditions. Its activity is mainly limited to the spring and autumn.

Hosts

Milne (1949) cited farm and domestic mammals as hosts of I.ricinus. Other hosts reported, include wild mammals and birds. Arthur (1963) has recorded nymphae and larvae on a shrew and mole in the Netherlands.

Predilection sites

On large animals including cattle, ticks attach on the facial region, the ears, snout and chin, and in the axillae and groins, usually decreasing in numbers from the fore-part of the body backwards (Arthur, 1963).

Disease relations

I.ricinus is a vector of louping-ill virus of sheep, tick-borne fever of cattle and bovine piroplasmosis (Arthur, 1963).

Ixodes hexagonus Leach, 1815.

Distribution

I.hexagonus is widely distributed in Europe and North-West Africa. It has been found to occur in the Netherlands (Arthur, 1963).

Incidence

The seasonal occurrence of I.hexagonus is closely geared to the hedgehog. Arthur (1963) reported that the periods of greatest infestation were April-May and August.

Hosts

I.hexagonus is mainly a nest - inhabiting tick, parasitizing hedgehogs and other small wild mammals, although the female ticks may parasitize cattle.

Predilection sites

These are unstudied on cattle.

Disease relations

The tick is not known to be a vector of any pathogen.

Genus HAEMAPHYSALIS Koch, 1844.

In Europe only five species have been described. Only one of these species occurs in the Netherlands.

Haemaphysalis punctata Canestrini & Fanzago, 1877.

Distribution

This species is the only representative of the genus in Britain and

Western Europe. It is not common in the British Isles, but is apparently mentioned to occur on the European Continent including the Netherlands (Arthur 1963). In the Netherlands as in West Germany, the species seems to be restricted to the coastal areas (Friedhoff, 1972).

Incidence

H.punctata is a three-host tick. Work by Russian scientists indicates that the tick is active on the host in spring and autumn. There have been reports of adults on the host throughout the winter and even continually throughout the year in southern Russia (Balashov, 1972). Barnett (1972) observed that in Britain this species may extend its lifecycle over two or three years.

Hosts

Arthur (1963) reported that adults of H.punctata preferred larger mammals such as cattle and sheep as hosts. The immature stages are commonly found on small mammals such as the hedgehog and on birds.

Disease relations

H.punctata has been reported by Stockman (1908) to play a role in the experimental transmission of babesiosis of cattle. It is also capable of transmitting Theileria mutans in the laboratory (Arthur, 1963). Brocklesby & Barnett (1970; 1972) reported that H.punctata collected from the field, transmitted Babesia major and Theileria mutans.

TICK-BORNE PARASITES: INTRODUCTION

A great impetus was given to the study of tick-borne diseases when Smith & Kilborne (1893) proved that the cattle tick Boophilus annulatus was the vector of Babesia bigemina, the cause of Texas fever. A continuous chain of infection from the infected to the clean animal, with the tick as the connecting link, was shown to occur. For the first time in the history of disease, a protozoan parasite was shown to be capable of transmission by a blood-sucking arthropod. As the list of diseases grew, it has gradually become recognised that infect ticks surpass all other arthropods, including the Insecta, in the number and variety of diseases which they transmit.

TICK-BORNE PARASITES OF CATTLE IN NIGERIA.

Several parasites including Protozoa, Rickettsia-like organisms and Spirochaetes which are known or considered to be transmitted by ticks, are found in Nigerian cattle. Macfie (1915) was the first to report the presence of Theileria mutans Theiler, 1906 and Babesia bigemina Smith & Kilborne, 1893 in the blood of cattle in Nigeria. Since then, veterinary workers have only referred to the existence of "piroplasmosis" of livestock in various annual reports of the Veterinary Division of the Ministry concerned with animal health. One obvious reason for this was their preoccupation with epizootic diseases such as rinderpest, pleuro-pneumonia and trypanosomiasis.

Folkers & Kuil (1967) carried out an investigation of tick-borne parasites, present in Nigerian cattle.

They observed the following organisms in four cattle which were splenectomized for this purpose:

Babesia bigemina Smith & Kilborne, 1893.

Babesia argentina, Lignières, 1909.

Theileria mutans Theiler, 1906.

Anaplasma marginale Theiler, 1910.

Haematoxenus veliferus Uilenberg, 1964.

Eperythrozoon wenyoni Adler & Ellenbogen, 1934.

Eperythrozoon teganodes Hoyte, 1962.

Kuil (1969) reported the presence of Cowdria ruminantium Cowdry, 1926 the causative agent of heartwater, in the brain of cattle slaughtered in Zaria.

One record of Haemobartonella bovis Donatien & Lestoquard, 1934 was reported by Buys & Folkers (1970), while Anaplasma centrale Theiler, 1910 was observed as a single infection on only one occasion, but was often found in what was considered a mixed infection with A.marginale (Leeflang, 1974).

Annual reports of the Veterinary Department (1927; 1929; 1930) mentioned the occurrence of spirochaetes in cattle, which were detected by blood smear examination. It is most likely that these spirochaetes refer to Borrelia theileri Laveran, 1903.

Kuil (1969) considered the two Babesia species, A.marginale and C.ruminantium as the most important tick-borne organisms in cattle in

Northern Nigeria.

Uilenberg (1972) suggested that the name Babesia argentina Lignières, 1909 be used for the small babesia species of the tropics and sub-tropics. B.berbera Sergent et al., 1924 and B.bovis Babés, 1888 are synonyms of B.argentina.

So far, no work has been done on tick transmission of bovine parasites in Nigeria. However, from the world-literature a list of tick-borne parasites relative to their vectors which occur in Nigeria, is given in Appendix V.

TICK-BORNE PARASITES OF CATTLE IN THE NETHERLANDS

Kuil (1967) listed for the Netherlands the blood parasites of cattle which are known or considered to be transmitted by ticks. These are:

Babesia divergens McFadyean & Stockman, 1911.

Babesia major Sergent et al., 1926.

Ehrlichia phagocytophilia Foggie, 1951.

Eperythrozoon wenyoni Adler & Ellenbogen, 1934.

Eperythrozoon teganodes Hoyte, 1962.

Since then, Eperythrozoon tuomii Uilenberg, 1965 was isolated in the Netherlands by Zwart et al. (1969), while Schillhorn van Veen & Leyendekkers (1971) reported the occurrence of Borrelia theileri Laveran, 1903 in yearling cattle on the island of Ameland.

The occurrence of a large Babesia in cattle was first described

in the Netherlands by De Jong (1902; 1903). The parasites were identified as Babesia bigemina Smith & Kilborne, 1893. In 1904, De Jong described the occurrence of a smaller Babesia, which he named Babesia bovis Babés, 1888 in Dutch cattle and even included a third species which he named Babesia rupturae lienalis because of the observed spleen ruptures in the course of infection.

Vrijburg (1918), among other workers, refused to accept that B.bovis in the Netherlands was infact B.divergens as described by McFadyean & Stockman (1911) in England. Confusion about the nomenclature of the small bovine Babesidae in Europe was finally solved when it was generally accepted that B.divergens was transmitted by Ixodes ricinus which occurred north of 44.5°N, while B.bovis was widely distributed south of 44.5°N, where its vectors Boophilus spp. and Rhipicephalus spp. occurred (see Bool et al., 1961). These genera of ticks do not occur in the Netherlands, hence the absence of this Babesia species in the country. Uilenberg (1972) suggested that the name B.bovis should not be used any more, but replaced by B.argentina, Lignières, 1909. The small Babesia described by De Jong in 1904 therefore, must have been B.divergens, whose vector Ixodes ricinus is the most common tick in the Netherlands.

Vrijburg (1918) confirmed the finding by De Jong (1902; 1903) of the large Babesia species B.bigemina in Dutch cattle, but no further reports on its occurrence in the Netherlands are available. Bool et al. (1961) studied the morphology of the large Babesia in Dutch cattle and identified

it as Babesia major. This was confirmed by Zwart et al. (1968), who used various methods to study the differences between B.bigemina and the large Babesia occurring in Dutch cattle. Sergent et al. (1945) assumed that Babesia rupturae lienalis, described by De Jong (1904) and Knuth & Meiszner (1911), was also Babesia major.

It was suggested by Knuth (1915) that B.major is transmitted by Haemaphysalis punctata and this could explain the rare occurrence of this Babesia species in the Netherlands (Bool et al., 1961). However, Wilson (1964) accumulated evidence to show that Ixodes ricinus also played a role in the transmission of B.major.

Tick-borne fever in cattle was first described in the Netherlands by Bool & Reinders (1964). The parasite, Ehrlichia phagocytophilia, is transmitted by Ixodes ricinus. Similar to Babesia spp., adult cattle are more susceptible to infection than calves.

In 1965, Eperythrozoon wenyoni was detected in the Netherlands in splenectomized calves that had been inoculated with blood from apparently healthy cattle and with a suspension of I.ricinus nymphae. The occurrence of E.teganodes was similarly detected (Kuil, 1967). This was followed by the isolation of E.tuomii by Zwart et al. (1969). Eperythrozoon spp. have little pathogenic significance.

Borrelia theileri has no pathogenic significance but is common in cattle in subtropical and tropical climates, where it is transmitted by Rhipicephalus and Boophilus ticks (Theiler, 1905; 1909). Its

occurrence in temperate climates had not been described until 1971 when Schillhorn van Veen & Leyendekkers observed the parasite in the blood of Dutch cattle on the island of Ameland where both I.ricinus and H.punctata are known to occur.

DEVELOPMENT OF BABESIA SPP. IN THE TICK VECTOR

Koch (1906) was the first to study the life cycle of Babesia bigemina in Boophilus australis, Rhipicephalus evertsi and Hyalomma aegyptium. He described the presence of pearshaped and amoeboid bodies in the tick gut and postulated some form of fusion of individuals. He recorded multiple division stages but was unable to relate these phenomena to the actual developmental cycle of the tick, even though he saw clavate parasites in the ova.

Dschunkowsky & Luhs (1910) confirmed the findings of Koch but gave no further details. So also did Crawley (1915) in his studies on Boophilus annulatus.

In his investigations, Rosenbusch (1927) was able to describe the development of B.bigemina in Boophilus microplus. He traced elongated forms in the gut and haemolymph which by multiple fission in the gut cells gave rise to infective forms in the salivary gland alveoli. Some of the elongated forms were located in the uterus and subsequently in the ova without any further multiplication. Further development occurred only after the outcoming larvae had engorged on blood. Rosenbusch was of the

opinion that B.microplus was the determinate host of B.bigemina and that its developmental cycle was independent of cattle.

Dennis (1932) reported various developmental stages of B.bigemina in the gut and ova of engorged B.annulatus and postulated that development commenced with the union of "isogametes" in the gut contents with the eventual formation of a motile "ookinete". This form entered the uterus and hence the ova. Here they formed "sporokinetes" which in the end invaded salivary gland alveoli where, by some form of divisions, they gave rise to small infective sporozoites. Thus, Dennis was the first worker to suggest the presence of sexual stages of Babesia in the tick vector. This was rejected by Regendanz (1936) who denied the presence of sexual reproduction in the vector and postulated that the development was comparable to that of B.canis in Dermacentor reticulatus, which according to Regendanz & Reichenow (1933) took place by a series of binary fissions with the formation of motile vermiform stages. These stages were also located in the ovaries. This was confirmed by Shortt (1936; 1973) and by Brumpt (1937).

In their study of the developmental cycle of B.bigemina in Boophilus calcaratus, (syn. Boophilus annulatus) Muratov & Kheisin (1959), like other workers described the formation of these "vermicules": the ingested parasites penetrated into gut epithelial cells of the tick where by schizogony they formed amoeboid or round "agamonts". These forms then entered the body cavity and invaded all organs of the tick where multiple fission occurred. Finally, these "vermicules" were observed in the egg in which reproduction

was also by multiple division. As the egg became older and the larvae developed, "vermicules" were observed in various tissues of these larvae. Muratov & Kheisin (1959) therefore, concluded that the development of B.bigemina was solely by asexual reproduction in the replete female tick and its larval progeny.

Another protogonist of sexual reproduction in the tick was Petrov (1941). He described the development of Babesiella bovis in Ixodes ricinus and asserted that the cycle was very similar to that described by Dennis (1932) for B.bigemina. He also reported transovarial transmission as well as stage-to-stage transmission of the parasite. However, Polyansky & Kheisin (1959) rejected the work of Petrov and concluded that the development of Babesiella bovis in Ixodes ricinus followed the same pattern as that described by Muratov & Kheisin (1959) for B.bigemina in B.calcaratus. Joyner et al. (1963) suggested that what Petrov (1941) called Babesiella bovis was perhaps B.divergens.

Li (1956), Markov & Abramov (1957) and Li (1958) studied the development of Babesia ovis in Rhipicephalus bursa. They all described clavate and oval forms of the parasite in various stages of development in the ovary and eggs of the tick.

Rick (1964) described the development of B.bigemina in B.microplus in detail. He worked out the development of the parasites in the replete female tick, in the larva and in the nymph. In another paper the life cycle of B.argentina in B.microplus was illucidated (Rick, 1966). From these studies,

Riek could not provide evidence of sexual reproduction in the tick although various forms were observed which could indicate anisogamy.

Friedhoff (1969) worked out the development of B.ovis in replete females of R.bursa. He described merozoites and fission bodies in the gut, haemolymph, ovary, eggs, epidermis, muscles and Malpighian tubules. He concluded that cycles of multiple fission occurred in all the organs, especially the ovary.

DEVELOPMENT OF THEILERIA SPP. IN THE TICK VECTOR

Gonder (1911) was the first worker that studied the development of Theileria parva in Rhipicephalus appendiculatus. He reported micro- and macrogametes and a mobile ookinete in the tick intestines and infective sporozoites in the salivary glands. Thus, he postulated a sexual reproductive cycle in the vector. Nuttall & Hindle (1913) could not agree with these findings. However, Cowdry & Ham (1932) were convinced of the presence of zygotes in the gut of nymphal ticks that had engorged on cattle infected with T.parva. They also reported motile ookinetes in the haemocoel and salivary glands, some 3 to 6 weeks post repletion. Further development took place only after the nymph had moulted, when a sporont was seen in the salivary glands of the adult tick. Sporozoites were detected after 3 days of feeding on a new host.

Reichenow (1940) completely rejected the findings of Cowdry & Ham. He asserted that no theilerial bodies could be detected in the tick until after moulting and the tick had commenced feeding. He described small

theilerial bodies in the secretory alveoli of the salivary gland cells and concluded that the only form of reproduction took place by repeated binary fission.

Martin et al. (1964) concurred with Reichenow but reported that reproduction was by multiple fission of a schizogony type rather than by repeated binary fission.

Barnett (1968) doubted the existence of a sexual stage in the tick. He observed limited multiplication, restricted to the salivary gland alveoli only, after the tick had moulted. This was followed by an intensive multiplication upon feeding. Consequently, Barnett provided a clue as to why transovarial transmission of Theileria does not occur in the tick vector.

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III A. SEASONAL INCIDENCE OF IXODID TICKS OF CATTLE IN THE SUDAN VEGETATION ZONE OF NORTHERN NIGERIA (RUNKA)

INTRODUCTION

The Sudan Vegetation Zone together with the Sahel Zone to the north east of it, has been aptly described by Wilson et al. (1963) as the most important livestock producing area in West Africa, because of the restricted distribution of Glossina spp. in that region.

In northern Nigeria, cattle form the bulk of the important livestock, and more than half of the total cattle population of the country is raised in Sokoto, Katsina, Kano and Borno Provinces which mainly lie in the Sudan Zone (Glover, 1961). This zone has been inhabited by humans for a very long time. Consequently, the vegetation has been tremendously modified by the agrarian habits of the people and by the grazing of large herds of livestock.

The Sudan Vegetation Zone has been described by Keay (1953). Among the taller trees are Anogeissus leiocarpus, Balanites aegyptiaca, Lannea microcarpa, Prosopis africana and Tamarindus indica. Other tree species and shrubs are exemplified by Combretum glutinosum, Strychnos spinosa, Piliostigma reticulata, Guiera senegalensis, Acacia species and Mimosa pigra (Davies, 1967). The grasses are generally short and of the finer variety and do not regenerate until just before the rains. Among the annuals are Loudetia togoersis, Andropogon pseudopticus and Pennisetum pedicellatum, the latter being the dominant species. Other grasses are Hyparthelia dissoluta, Andropogon gayarus and Hyparrhenia bagirmica (de Leeuw, 1973).

The climate is influenced by two distinct seasonal changes: a dry season which lasts from October to April and a wet season from May to early October. The early dry season begins in October and lasts till November. During this period the weather is hot and humid, the ground cover becomes hard and baked, the grasses are drier and their nutritional value falls drastically. The range between maximum and minimum diurnal temperatures becomes greater. From December to February the dry and dusty harmattan winds, blowing from the Sahara desert, keep temperature and relative humidity low. The late dry season commences in March and ends in April, during which period the range of diurnal temperatures is high.

The wet season begins in May and ends in early October. Early rains fall in May and June. The wettest months of the season are July and August, two thirds of the annual rainfall falling in these months. The late rains usher in September and dwindle in October (see Figure 1). The average annual rainfall is 625 mm. or 25 inches (Davies, 1967).

Grazing in the Sudan Vegetation Zone is necessarily limited to the wet months because it is only in the rainy season that the grasses will grow. During the dry season, drinking water for the cattle rearer and his livestock also becomes a scarce commodity. The Fulani cattle rearers are therefore forced to adopt the nomadic way of life as a means of their survival (Wilson et al., 1963).

Each year beginning in November, the Fulanis and millions of their cattle move southwards into the Guinea Vegetation Zone in search of grazing

and water. This movement commences slowly when the cattle graze on crop residues in farms by special arrangements with the Hausa farmers (Van Raay & de Leeuw, 1970). When the crop residues become depleted, the cattle move finally into the grazing areas bordering rivers Niger and Benue. During this movement, cattle are exposed to the tsetse fly and hence to the risk of contracting trypanosomiasis. This is one reason why the Fulanis move back with their livestock to their ancestral homes in the Sudan Vegetation Zone, at the end of the dry season.

In 1962, the Government of the former Northern Nigeria, in an effort to encourage the Fulani cattle rearers to abandon their nomadic way of life, set up the Rúma Kukar Jangarai Grazing Scheme at Runka in the Sudan Vegetation Zone. Runka is located at Lat. N 12^{o} 26' and Long. E 7^{o} 20'. This scheme is 400 square miles wide and consists of ten grazing ranges, each being divided into four sectors to allow rotational grazing. Each of the ranges has a dam which serves as a water catchment reservoir. The scheme, designed for 20,000 head of cattle, reached this target in 1967.

At present, a number of such grazing schemes exist throughout the northern part of the country as an inducement to settle the nomadic Fulani herdsmen. The success of such schemes not only depends on the all-year availability of grazing and water but also on acceptance of socio-economic changes by the Fulanis. Furthermore, concentration of cattle will require a different approach to disease prevention and control.

One of the problems observed at Runka was severe tick infestation on

the cattle, resulting in the propagation of tick-borne diseases. In fact, not very long after the establishment of the grazing scheme, serious outbreaks of babesiosis occurred (Annual Reports, Veterinary Division, 1960-61; 1961-62; 1962-63). It was therefore thought appropriate to conduct a survey of cattle ticks in the Ruma Kukar Jangarai Grazing Scheme. During this survey, tick infestation on cattle, and the seasonal incidence of cattle ticks and their predilection sites were evaluated.

MATERIALS AND METHODS

A. TICK INFESTATION RATES ON CATTLE.

This study was carried out in the dry season of 1967 to evaluate the percentage of cattle infested with ticks. Adult and nymphal ticks were collected from certain predilection sites, counted and identified to genera.

THE CATTLE

The cattle used, consisted of Zebu of the White Fulani Type (Payne, 1970). Twenty animals each were randomly chosen from the cattle in three of the ten ranges (Nos, 4, 6 and 7). Over a period of four months, these cattle were examined weekly for tick infestation.

COLLECTION TECHNIQUE

Because of the amount of work involved, tick collections were restricted to five predilection sites only, i.e. both ears, axilla, belly and dewlap, groin and the tail region. Ticks were picked off with blunt forceps and preserved in 70% alcohol to which 5% glycerine was added to minimize

evaporation of the alcohol. In the laboratory these ticks were counted, identified to genera and classified into males, females and nymphae.

B. SEASONAL INCIDENCE OF TICKS

THE CATTLE

Four adult White Fulani cattle were purchased in the vicinity of Runka and allowed to graze together with the cattle in Range 6. They were examined for ticks from 31st January 1968 to 15th January 1969.

COLLECTION TECHNIQUE

Once every fortnight, the four animals were cast down and properly restrained for the purpose of tick collection. The body of the animals was divided into ten regions which were thoroughly examined. These were both ears, head, neck and dewlap, thorax and abdomen, genitalia, tail, legs, hooves, back and anus (see Appendix II.) All collections were performed by the author and a field assistant. One side of the animal was systematically examined and all stages of ticks were carefully removed from each particular predilection site and placed into properly labelled bijou bottles containing 70% alcohol with 5% glycerin. The animal was then turned over and the other side similarly treated.

IDENTIFICATION

All specimens were counted and examined in the laboratory in Zaria using a sterescopic microscope. Ticks were identified to species by reference to Hoogstraal (1956). A cross section of the material was later on re-examined in the Institut d'Elevage et de Medecine Veterinaire des Pays

Tropicaux in Paris under the supervision of Dr. P.C. Morel.

RESULTS

The results are presented under two sections. Section I covers the tick infestation rates among the cattle in ranges 4, 6 and 7. Section II deals with the seasonal incidence of the tick species and their predilection sites on the cattle.

SECTION I

A total of 420 estimations were made from 60 cattle (20 in each range), between 24th March and 27th June 1967. Two thousand and fourty ticks including nymphae were collected. The tick infestation rates are given in Table I. In 292 of the 420 estimations, ticks were found on the cattle resulting in an infestation rate of 69.5%.

Of all ticks collected, 82.4% were Hyalomma species, mostly H.impeltatum. Amblyomma variegatum and Boophilus decoloratus represented 11.0% and 5.0% of the collection respectively.

SECTION II

GENERAL

During the course of twelve months, a total number of 13,766 ticks were collected from the cattle at Runka. They comprised of four genera and twelve species. The genera were Boophilus, Amblyomma, Hyalomma and Rhipicephalus (Table 2). It can be seen from the table that all developmental stages of B.decoloratus were collected. This tick formed 55.95% of

the total. A.variegatum was next in abundance being 36.36%. All developmental stages of this tick were also collected. Five species of Hyalomma accounted for 6.45%. The genus Rhipicephalus was represented by five species forming 1.23% of the total collection. Immature stages of Hyalomma spp. and Rhipicephalus spp. were not found on the cattle.

SEASONAL INCIDENCE

BOOPHILUS DECOLORATUS Koch, 1844; the blue tick.

Adults

Male and female ticks occurred throughout the year with peaks in the middle of February, and in October. The lowest counts were made in June and July (Figure 2, Table 3). The preponderance of females over males was probably due to the fact that a part of the males, being quite small, escaped collection.

Nymphae

The nymphae occurred in three peaks; in January, April and between July and November. The lowest counts were made in early July and in December.

Larvae

Larvae were collected throughout the year but in relatively low numbers. Their incidence pattern seems to be similar to that of nymphae.

Predilection sites

4,492 adults, 2,989 nymphae and 221 larvae were collected during the

year. Their attachment sites, percentage-wise, are given below:

	Adults	Nymphae	Larvae
neck and dewlap	40.33	54.09	36.65
genitalia	13.61	17.16	4.07
throrax and abdomen	15.94	6.92	1.36
legs	13.76	2.21	0
ears	9.43	17.16	54.75
anus	0.67	0.03	0.45
tail	0.58	0.70	0
hooves	0.53	0.47	0.45
head	0.40	1.23	2.26
back	0.24	0	0

AMBLYOMMA VARIEGATUM Fabricius, 1794; the tropical bont tick.

Adults

During the year, only one generation of A.variegatum adults was observed. The adults were mainly active during the rainy season (April to September). Males increased in number from April and reached their peak in July. They decreased in September. The females followed a similar pattern but did not appear before June. Between October and March, a very low incidence of A.variegatum adults was observed, the males being predominant (Figure 3, Table 4).

Nymphae

Nymphae were observed all year round. The highest numbers were found immediately after the rains had stopped (end of October and November). As from December, the nymphae were present in small numbers until July when hardly any were collected. In August and September nymphae were found only accidentally until their population suddenly built up again in October.

Larvae

The larvae were collected during the year from August to the middle of December, with a peak in October.

Predilection sites

359 adults, 1,753 nymphae and 2,359 larvae were collected during the year. Their attachment sites, percentage-wise, are given below:-

	Adults	nymphae	larvae
neck and dewlap	11.99	10.30	44.33
genitalia	17.23	22.92	8.08
thorax and abdomen	28.99	24.63	10.30
legs	36.20	15.36	17.54
ears	0	0.40	16.28
anus	0.93	0	0.25
tail	0.47	0.80	0.08
hooves	3.33	24.69	2.68
head	0.81	0.28	0.42
back	0	0.63	0.04

HYALOMMA

This genus accounted for 61.45% of the total number of ticks collected; only adults were found on the cattle. The most abundant was H.impeltatum (576 out of 838), followed by H.rufipes (180), H.truncatum (66), H.nitidum (63) and H.impressum (3). This is the first record of Hyalomma nitidum in Nigeria (Figure 4, Table 5).

HYALOMMA IMPELTATUM Schulze and Schlottke, 1930; Kratz's Hyalomma.

The Kratz Hyalomma accounted for 64.86% of the total hyalommas. Adult ticks were found to occur on the cattle throughout the year. The sites of attachment were the anus, thorax and abdomen, and the genitalia.

HYALOMMA RUFIPES Koch, 1844; the Hairy Hyalomma.

The hairy Hyalomma formed 20.3% of the Hyalomma collection. They were found to occur throughout the year, with a population rise in August and September. Their predilection sites were around the anus, base of tail and on the genitalia.

HYALOMMA TRUNCATUM Koch, 1844; the African Hyalomma.

This species formed 7.4% of the total Hyalomma collected, most of the collection consisting of males. They occurred throughout the seasons. The primary attachment site was the base of the tail. A few were found on the genitalia and the legs.

HYALOMMA NITIDUM Schulze, 1919.

H.nitidum was only seen in two distinct periods of the year. It represented 7.1% of the total hyalommas. Both males and females were found on the cattle. Their predilection site was chiefly around the anus. Hoogstraal (1956) considers H.nitidum to be H.truncatum, but Morel (1972) examined the specimens from Runka and made a clear distinction between the two species.

HYALOMMA IMPRESSUM Koch, 1844.

Only three male specimens were collected at Runka.

RHIPICEPHALUS

From the total number of ticks collected, 1.23% were Rhipicephalus species. These species were: R.lunulatus (85 out of 170), R.muhsamae (44), R.guilhoni (31), R.senegalensis (7) and R.e.evertsi (3). Only adult ticks were found on the cattle (Figure 5, Table 6).

RHIPICEPHALUS LUNULATUS Neumann, 1907.

The only collections were made from May to July while females were more abundant than males. This species consisted of 50% of the total Rhipicephalus found. They were only picked from the hooves and around the anus.

RHIPICEPHALUS HUMERALE Morel & Vassiliades, 1964.

This tick was next in abundance. Males and females were collected accidentally all over the year. Nearly all the ticks were attached to the hoof region.

RHIPICEPHALUS GUILHONI Morel & Vassiliades, 1963.

Both males and females were collected in small numbers between June and September. They were found between the hooves of the cattle.

RHIPICEPHALUS SENEGALENSIS Koch, 1844.

Only seven specimens were seen throughout the survey and these occurred in June, August and September.

RHIPICEPHALUS EVERTSI Neumann, 1897.

Only three specimens were collected, in July and October.

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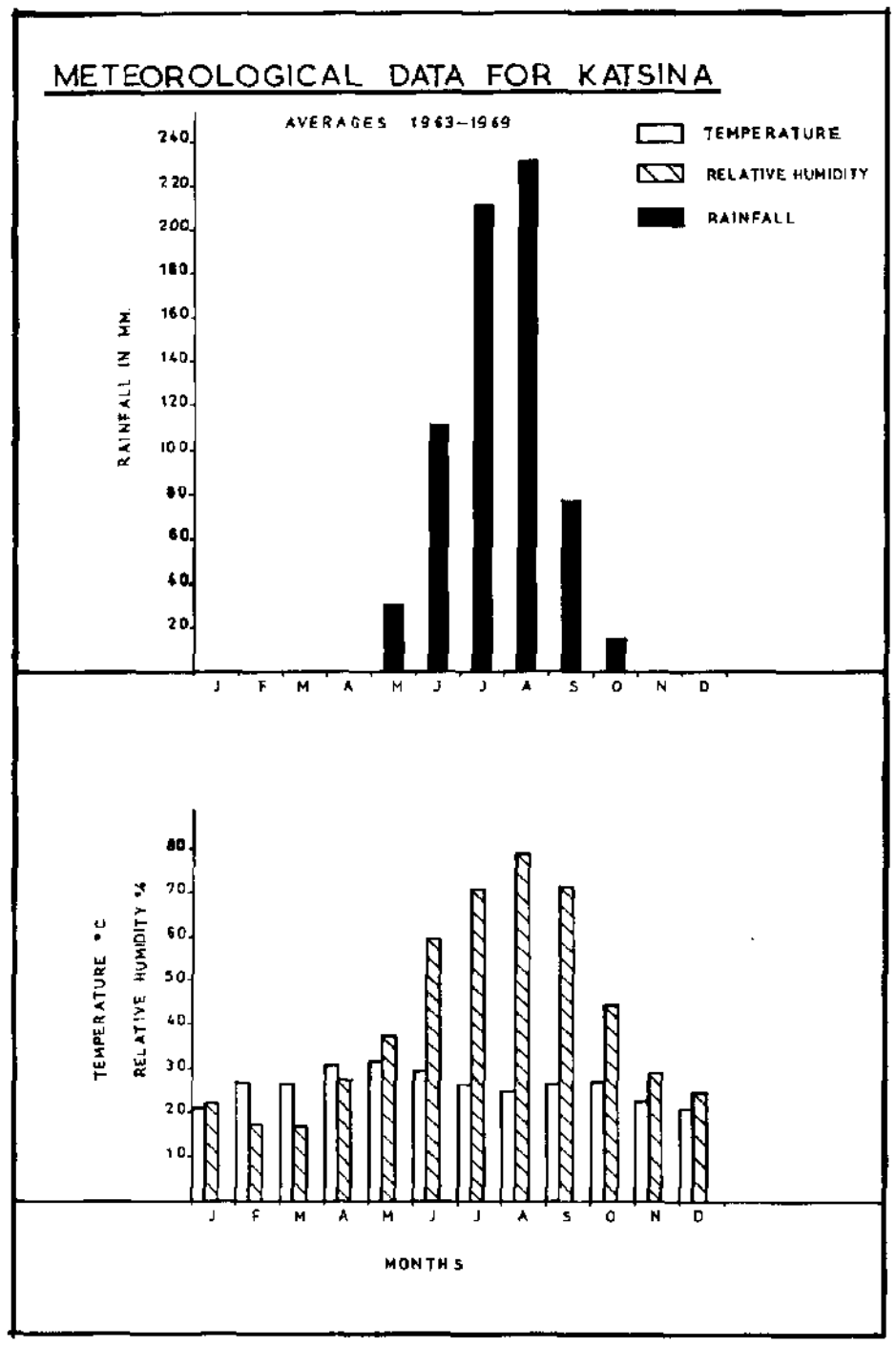

METEOROLOGICAL DATA FOR KATSINA
AVERAGES 1963–1969
TEMPERATURE
RELATIVE HUMIDITY
RAINFALL
RAINFALL IN MM.
240
220
200
180
160
140
120
100
80
60
40
20
J F M A M J J A S O N D
TEMPERATURE °C
RELATIVE HUMIDITY %
80
70
60
50
40
30
20
10
J F M A M J J A S O N D
MONTHS

TABLE 1

TICK INFESTATION RATES ON CATTLE IN RANGES 4, 6 and 7 AT RUNKA

(20 Cattle per range, examined between March and June 1967)

Range	Date	No. of cattle examined	No. of cattle infested	Number of ticks collected				Tick infestation rate %
				M	F	N	T	
4	25.4	20	3	16	8	0	24	15
	2.5	20	3	18	7	0	25	15
	9.5	20	10	38	17	16	71	50
	16.5	20	14	71	32	1	104	70
	23.5	20	15	82	21	2	105	75
	30.5	20	8	28	10	3	41	40
	6.6	20	11	30	13	2	45	55
	13.6	20	16	165	81	2	248	80
	20.6	20	18	136	70	0	206	90
	27.6	20	17	97	45	0	142	85
	TOTALS	200	115	681	304	26	1,011	
6	24.3	20	15	40	17	24	81	75
	31.3	20	14	30	15	11	56	70
	7.4	20	18	10	15	10	35	90
	14.4	20	15	13	30	20	63	75
	TOTALS	80	62	93	77	65	235	
7	27.3	20	20	200	61	79	340	100
	3.4	20	14	17	23	164	204	70
	10.4	20	19	22	18	41	81	95
	17.4	20	16	16	11	26	53	80
	24.4	20	17	43	4	4	51	85
	1.5	20	16	35	8	0	43	80
	8.5	20	13	12	8	2	22	65
	TOTALS	140	115	345	133	316	794	

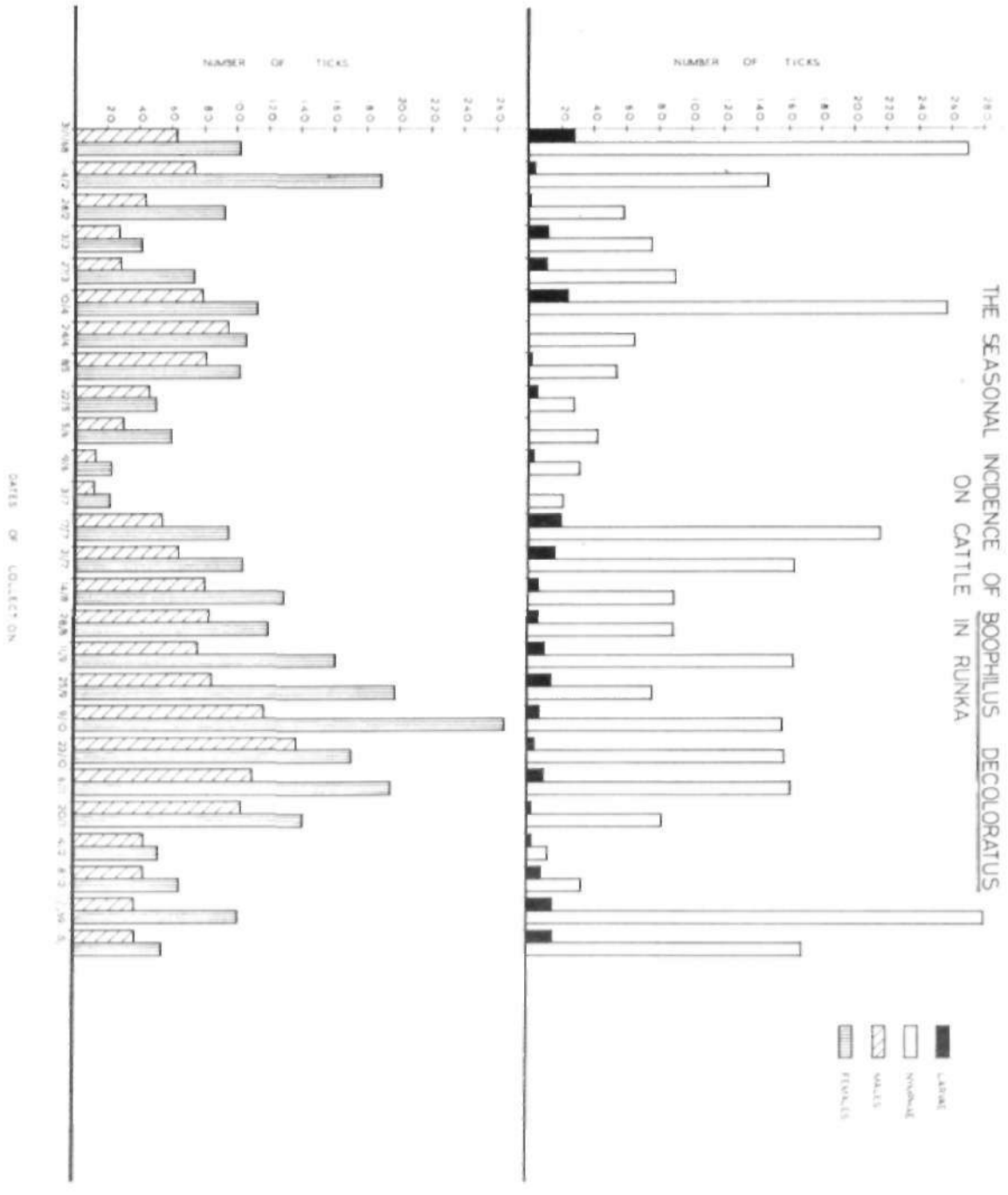
M = male, F = female, N = nymph, T = total.

TABLE 2

TOTAL NUMBER OF TICK SPECIES COLLECTED FROM THE FOUR WHITE FULANI CATTLE IN THE SUDAN VEGETATION ZONE (RUNKA).

Species	L	N	M	F	T	%
A.splendidum	0	0	0	0	0	0
A.variegatum	2389	1758	572	287	5006	36.36
B.annulatus	0	0	0	0	0	0
B.decoloratus	221	2989	1664	2828	7702	55.95
H.impeltatum	0	0	342	234	576	4.18
H.impressum	0	0	3	0	3	0.02
H.nitidum	0	0	34	29	63	0.46
H.rufipes	0	0	124	56	180	1.31
H.truncatum	0	0	54	12	66	0.48
R.evertsi	0	0	1	2	3	0.02
R.guilhoni	0	0	15	16	31	0.23
R.lunulatus	0	0	30	55	85	0.62
R.muhsamae	0	0	24	20	44	0.32
R.senegalensis	0	0	3	4	7	0.05
R.sulcatus	0	0	0	0	0	0
TOTALS	2,610	4,747	2,866	3,543	13,766	100.00

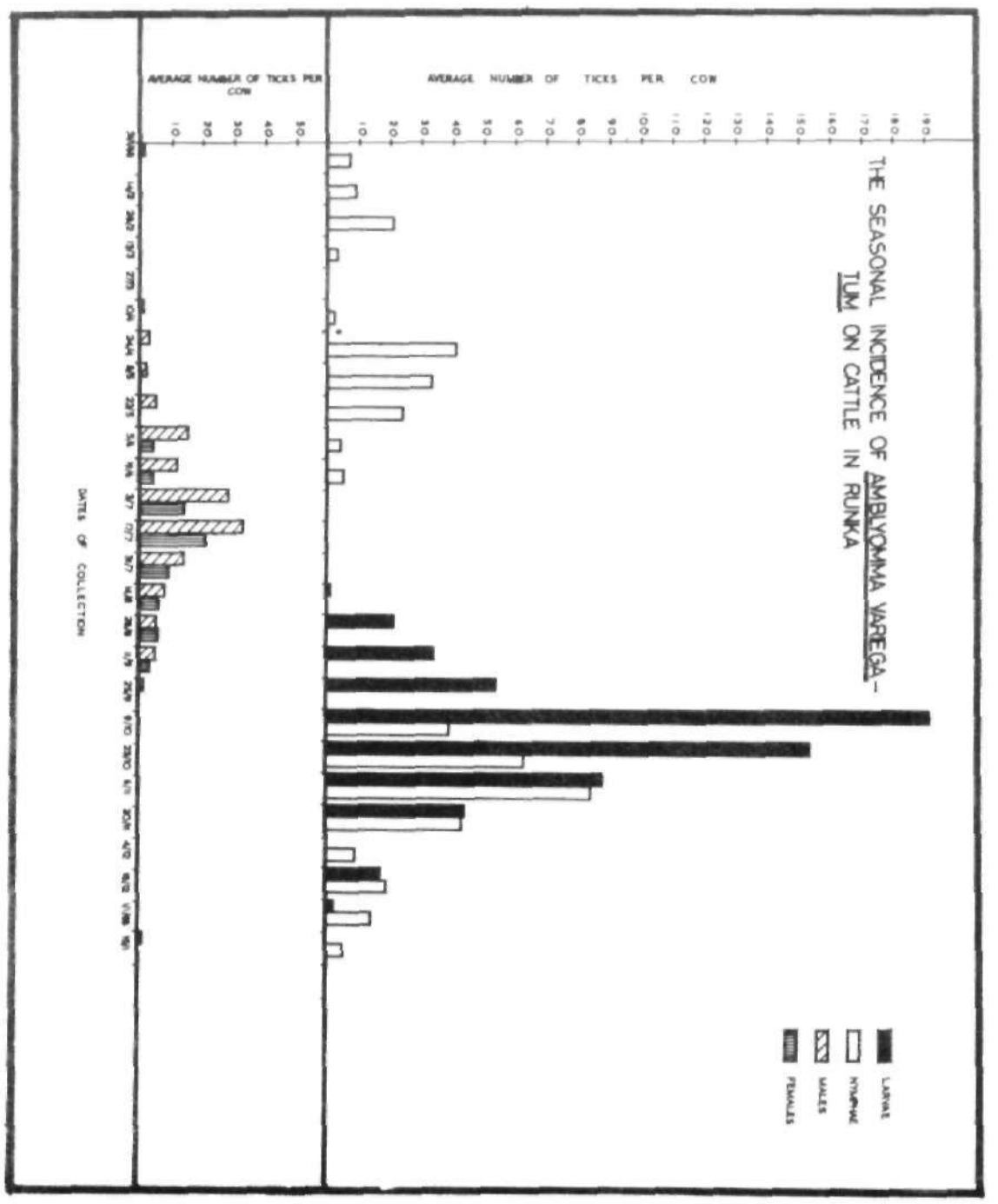
L = larvae
N = nymphae
M = male
F = female
T = total


THE SEASONAL INCIDENCE OF BOOPHILUS DECOLORATUS
ON CATTLE IN RUNKA
NUMBER OF TICKS
NUMBER OF TICKS
DATES OF COLLECTION
LARVAE
NYMPHAE
MALES
FEMALES

T A B L E 3

FORTNIGHTLY COLLECTIONS OF BOOPHILUS DECOLORATUS FROM FOUR WHITE FULANI CATTLE IN RUNKA

DATE	LARVAE	NYMPHAE	MALES	FEMALES
31/1/68	28	270	63	102
14/2/68	4	147	74	189
28/2/68	1	59	44	93
13/3/68	12	78	28	42
27/3/68	11	90	29	74
10/4/68	24	257	79	115
24/4/68	0	65	95	106
8/5/68	2	54	81	102
22/5/68	5	28	46	50
5/6/68	0	42	30	59
19/6/68	3	31	13	23
3/7/68	0	21	12	22
17/7/68	20	216	54	95
31/7/68	16	163	64	104
14/8/68	6	89	80	129
28/8/68	6	89	83	120
11/9/68	10	163	76	161
25/9/68	12	78	85	198
9/10/68	7	156	117	265
23/10/68	4	157	137	171
6/11/68	9	161	110	195
20/11/68	2	82	103	141
4/12/68	1	12	43	52
18/12/68	8	33	43	65
1/1/69	15	280	37	101
15/1/69	15	168	38	54
TOTALS	221	2,989	1,664	2,828

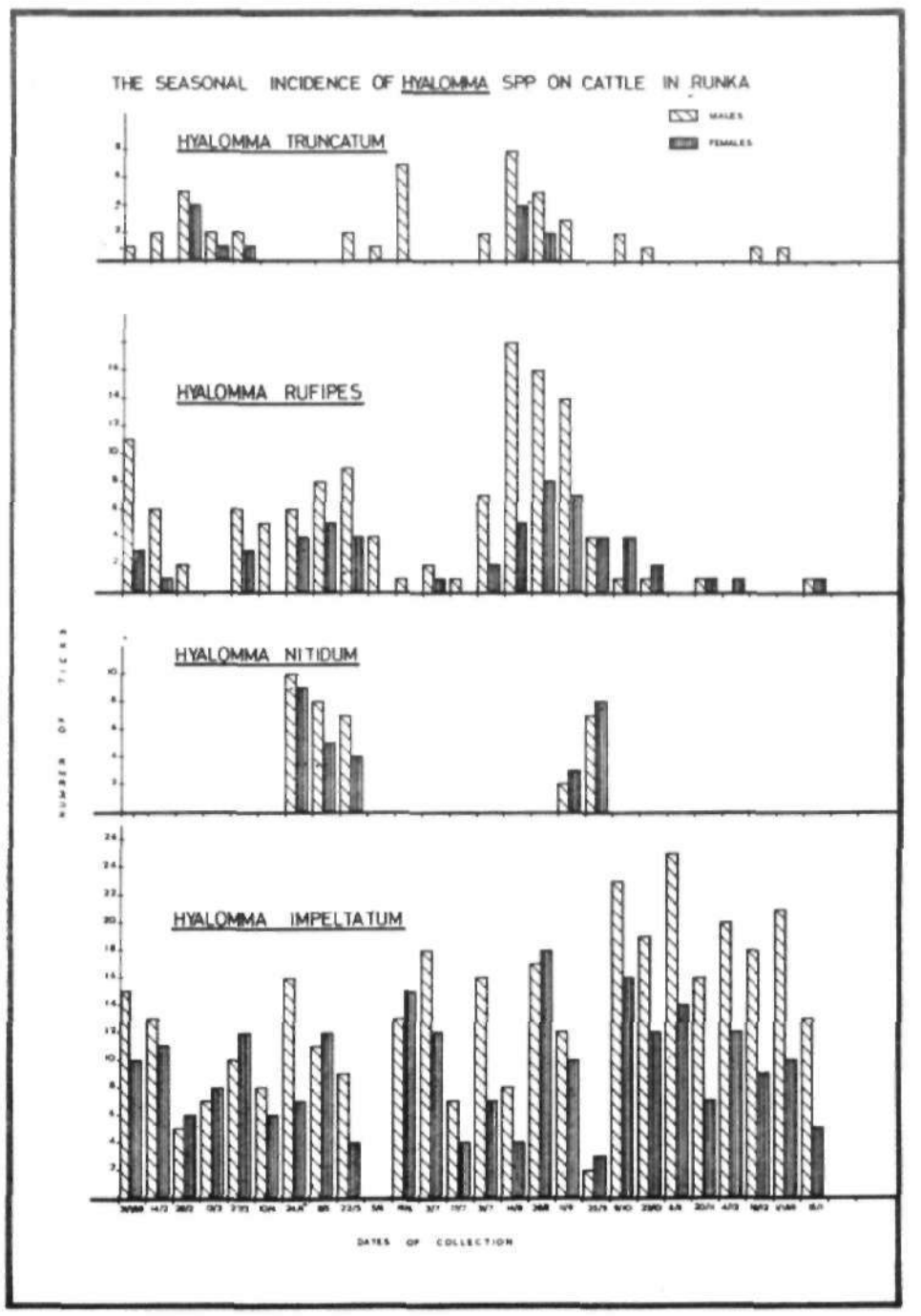

THE SEASONAL INCIDENCE OF AMBLYOMMA VARIEGA-
TUM ON CATTLE IN RUNKA
AVERAGE NUMBER OF TICKS PER COW
DATES OF COLLECTION
LARVAE
NYMPHS
MALES
FEMALES

T A B L E 4

FORTNIGHTLY COLLECTIONS OF AMBLYOMMA VARIEGATUM FROM FOUR WHITE FULANI CATTLE IN RUNKA

DATE	LARVAE		NYMPHAE		MALES		FEMALES	
	Total No.	Average	Total No.	Average	Total No.	Average	Total No.	Average
31/1/68	0	0	30	7.5	5	1.25	1	0.25
14/2/68	0	0	54	13.5	2	0.5	0	0
28/2/68	0	0	86	21.5	1	0.25	0	0
13/3/68	0	0	14	3.5	2	0.5	0	0
27/3/68	0	0	3	0.75	1	0.25	0	0
10/4/68	0	0	9	2.25	5	1.25	0	0
24/4/68	0	0	164	41.0	13	3.25	1	0.25
8/5/68	0	0	135	33.75	8	2.0	1	0.25
22/5/68	0	0	98	24.5	22	5.5	0	0
5/6/68	0	0	18	4.5	63	15.75	18	4.5
19/6/68	0	0	20	5.0	49	12.25	16	4.0
3/7/68	1	0.25	2	0.5	114	28.5	58	14.5
17/7/68	0	0	0	0	134	33.5	84	21.0
31/7/68	0	0	1	0.25	56	14.0	37	9.25
14/8/68	4	1.0	1	0.25	33	8.25	25	6.25
28/8/68	86	21.5	1	0.25	22	5.5	24	6.0
11/9/68	139	34.75	2	0.5	20	5.0	14	3.5
x 25/9/68	164	54.67	2	0.67	3	1.0	2	0.66
9/10/68	771	192.75	159	39.75	2	0.5	1	0.25
23/10/68	618	154.5	253	63.25	1	0.25	2	0.5
6/11/68	352	88.0	336	84.0	2	0.5	0	0
20/11/68	176	44.0	173	43.25	2	0.5	0	0
4/12/68	0	0	39	9.75	2	0.5	0	0
18/12/68	68	17.0	77	19.25	3	0.75	1	0.25
1/1/69	9	2.25	58	14.5	3	0.75	2	0.5
15/1/69	1	0.25	23	5.75	4	1.0	0	0

x) three animals only


THE SEASONAL INCIDENCE OF HYALOMMA SPP ON CATTLE IN RUNKA
MALES
FEMALES
HYALOMMA TRUNCATUM
HYALOMMA RUFIPES
HYALOMMA NITIDUM
HYALOMMA IMPELTATUM
NUMBER OF TICKS
DATES OF COLLECTION

T A B L E 5

FOURTNIGHTLY COLLECTIONS OF HYALOMMA SPP. FROM FOUR WHITE FULANI CATTLE IN RUNKA

D A T E	H.impeltatum		H.rufipes		H.nitidum		H.truncatum		H.impressum	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
31/1/68	15	10	11	3	0	0	1	0	0	0
14/2/68	13	11	6	1	0	0	2	0	0	0
28/2/68	5	6	2	0	0	0	5	4	0	0
13/3/68	7	8	0	0	0	0	2	1	0	0
27/3/68	10	12	6	3	0	0	2	1	0	0
10/4/68	8	6	5	0	0	0	0	0	0	0
24/4/68	16	7	6	4	10	9	0	0	2	0
8/5/68	11	12	8	5	8	5	0	0	0	0
22/5/68	9	4	9	4	7	4	2	0	0	0
5/6/68	0	0	1	0	0	0	1	0	0	0
19/6/68	13	15	1	0	0	0	7	0	0	0
3/7/68	18	12	2	1	0	0	0	0	0	0
17/7/68	7	4	1	0	0	0	0.	0	0	0
31/7/68	16	7	7	2	0	0	2	0	0	0
14/8/68	8	4	18	5	0	0	8	4	0	0
28/8/68	17	18	16	8	0	0	5	2	0	0
11/9/68	12	10	14	7	2	3	3	0	1	0
25/9/68	2	3	4	4	7	8	0	0	0	0
9/10/68	23	16	1	4	0	0	2	0	0	0
23/10/68	19	12	1	2	0	0	1	0	0	0
6/11/68	25	14	0	0	0	0	0	0	0	0
20/11/68	16	7	1	1	0	0	0	0	0	0
4/12/68	20	12	0	1	0	0	0	0	0	0
18/12/68	18	9	0	0	0	0	1	0	0	0
1/1/69	21	10	0	0	0	0	10	0	0	0
15/1/69	13	5	1	1	0	0	0	0	0	0
TOTALS	342	234	134	56	84	29	54	12	3	0

TABLE 6

FOURTNIGHTLY COLLECTIONS OF RHIPICEPHALUS SPP. FROM FOUR WHITE FULANI CATTLE IN RUNKA.

DATE	R.lunulatus		R.muhsamae		R.guilhoni		R.senegalensis		R.evertsi	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
31/1/68	0	0	0	0	0	0	0	0	0	0
15/2/68	1	0	0	0	0	0	0	0	0	0
28/2/68	0	0	0	0	0	0	0	0	0	0
13/3/68	0	0	0	0	0	0	0	0	0	0
27/3/68	0	0	0	0	0	0	0	0	0	0
10/4/68	0	0	0	0	0	0	0	0	0	0
24/4/68	1	1	2	0	0	0	0	0	0	0
8/5/68	2	1	0	0	0	0	0	0	0	0
22/5/68	1	0	0	0	0	0	0	0	0	0
5/6/68	11	5	0	0	2	1	0	0	0	0
19/6/68	8	38	1	3	0	0	1	0	0	0
3/7/68	5	10	1	1	0	1	0	0	0	0
17/7/68	0	0	1	0	0	1	0	0	0	0
31/7/68	0	0	0	0	1	2	0	0	0	1
14/8/68	0	0	0	0	1	1	1	1	0	0
28/8/68	0	0	0	0	5	2	1	2	0	0
11/9/68	0	0	2	0	4	3	1	0	0	0
25/9/68	0	0	4	0	0	2	0	0	0	0
9/10/68	0	0	1	0	0	2	0	0	1	1
23/10/68	0	0	0	0	0	0	0	0	0	0
6/11/68	1	0	8	7	0	0	0	0	0	0
20/11/68	0	0	1	2	0	0	0	0	0	0
4/12/68	0	0	2	6	0	0	0	0	0	0
18/12/68	0	0	0	0	0	0	0	0	0	0
1/1/69	0	0	1	0	1	0	0	0	0	0
15/1/69	0	0	0	1	1	1	0	0	0	0
TOTALS	30	55	24	20	15	16	4	3	1	2

III B. SEASONAL INCIDENCE OF IXODID TICKS OF CATTLE IN THE NORTHERN GUINEA VEGETATION ZONE OF NORTHERN NIGERIA (SAMARU)

INTRODUCTION

In Nigeria, the Guinea Vegetation Zone lies immediately south of the Sudan Vegetation Zone. Keay (1953) divides it into the Northern Guinea Zone and the Southern Guinea Zone. The latter merges somewhat abruptly into the coastal Forest Zone. The grazing potentialities of the Guinea Vegetation Zone are tremendous, but the risk of livestock coming into contact with tsetse-flies and contracting trypanosomiasis is great (Wilson et al., 1953) and has prohibited effective use of the grazing areas.

The vegetation of the Northern Guinea Zone is of the woodland type, characterized by Isoberlinia doka and I.tomentosa. These trees often grow to a height of 40 feet, and form a continuous cover. Other trees species are Monotes kerstingii, Uapaca togoensis, Lannea schimperi, Schwartzia madagascariensis, Entada africana and Piliostigama thonningii. On moist grounds are Syzygium guineense, Raphia sudanica, Terminalia glaucescens, Vitex doniana and other species common in the Sudan and Southern Guinea Zones. The grasses are dominated by Andropogon spp. and Hyperrhenia spp. (Davies, 1967)

The climate in this zone is also influenced by two distinct seasonal changes: a dry season which lasts from November to March and a wet season from April to October. The early dry season is in November, December and January. During this period there is no rain at all. Temperatures are low

with a decline in relative humidity. This is the period when the harmattan winds blow. The late dry season is in February and March when the relative humidity is also low but temperatures begin to rise.

The wet season commences in April (although a few showers may already fall in March) and lasts till October. The months of April and May are characterized by a sharp increase in relative humidity, coinciding with the highest annual temperatures. The wettest months of the season are July, August and September. The rains suddenly stop in October (Figure 6). The average annual rainfall for Samaru is 1,090 mm. or 43.6 inches.

Every year in the middle of December, the grass is burnt, but such fires rarely damage the "islands" of taller grasses. Wilson et al. (1963) noted that a characteristic of this vegetational zone is the rapid regrowth of green grass soon after burning. This provides the much needed grazing for the thousands of cattle which move into the zone during the dry season. With the onset of the rains, the nomadic Fulani and their cattle rush back to their traditional homes in the Sudan Zone.

Many areas in the Northern Guinea Zone have been under continuous cultivation for a long time. In such places only a few economic trees such as Parkia oliveri, Vitex doniana and Afzelia africana are seen.

The experimental area was situated in Samaru at lat. N 11°11' and long. E 07°38', in the middle of Northern Guinea Vegetation Zone.

MATERIALS AND METHODS

THE CATTLE

The four bait cattle that were used to assess the seasonal incidence of ticks in Runka were trekked to Samaru, where a similar study was carried out for one year. These cattle grazed together with some herds of the Agronomy Section of the Institute for Agricultural Research. They were examined for ticks from 15th February 1969 to 14th February 1970.

COLLECTION TECHNIQUE

This was exactly similar to that in Runka.

RESULTS

GENERAL

A total of 20,561 ticks were collected from the cattle during the course of twelve months. These represented four genera and twelve species (Table 7). The genera were Amblyomma, Boophilus, Rhipicephalus and Hyalomma. It can be seen from the table that the most abundant species here was A.variegatum which was collected in all its developmental stages and which represented 51.95% of the total collection. Only two male specimens of A.splendidum were found. The genus Boophilus was second in abundance with B.decoloratus forming 42.20% of the total. All developmental stages of this tick were also collected. Only 82 specimens of B.annulatus were identified. The genus Rhipicephalus was represented by five species forming 4.43% of the total collection. Three species of Hyalomma accounted for 1.01% of the total.

Immature stages of Rhipicephalus spp. and Hyalomma spp. were not found on the cattle.

SEASONAL INCIDENCE

AMBLYOMMA VARIEGATUM Fabricius, 1794; the tropical bont tick.

Adults

One generation of A.variegatum adults was observed. They were mainly active between May and July coinciding with the early rains. Males were present throughout the year. They increased in number from April and reached a peak in the first week of June. Their numbers then decreased gradually until hardly any were found in October and November. Females were also collected throughout the year, but were less abundant than the males (Figure 7, Table 8).

Nymphae.

Nymphae were present all year round except in July and August. Their numbers began to increase in September; from October to January a heavy infestation was observed.

Larvae

Larvae were mainly active from August to December. Very few were collected during other months of the year, except during the early rains in May. The sudden build-up of the larval population in August was striking.

Predilection sites

5,011 adults, 2,816 nymphae and 2,855 larvae were collected during the year. Their attachment sites, percentage-wise, are given below:

	adults	nymphae	larvae
neck and dewlap	5.99	12.04	32.57
genitalia	30.72	28.94	6.16
thorax and abdomen	35.39	19.82	2.70
legs	24.73	12.75	5.53
ears	0.44	1.31	43.67
anus	0.06	0.01	0.01
tail	0.16	2.63	0.81
hooves	1.10	21.79	1.82
head	1.26	0.43	6.06
back	0.15	0.28	0.67

AMBLYOMMA SPLENDIDUM Giebel, 1877.

The two males of A.splendidum were collected from the legs of the cattle in October.

BOOPHILUS DECOLORATUS Koch, 1844; the blue tick.

Adults

Male and female ticks occurred throughout the year with the highest incidence in March and April. The lowest counts were made in late June and

early July (Figure 8, Table 9). A marked preponderance of females over males was observed.

Nymphae

The nymphae occurred in four peaks; in January, March, August and in October. The lowest counts were made in June and July.

Larvae

Larvae were collected throughout the year, in relatively low numbers. Their incidence pattern seemed to be similar to that of the nymphae although no increase in the number of larvae was observed in August when the nymphae were very active.

Predilection sites

5,745 adults, 2,344 nymphae and 589 larvae were picked from the cattle during the year. Their attachment sites, percentage-wise, are given below:

	adults	nymphae	larvae
neck and dewlap	29.90	46.29	24.45
genitalia	14.34	6.65	0.17
thorax and abdomen	18.68	8.36	0
legs	19.98	5.63	0
ears	11.35	29.48	75.21
anus	0.85	1.02	0
tail	1.24	0.73	0
hooves	2.16	0.73	0
head	0.68	0.68	0.17
back	0.32	0.43	0

BOOPHILUS ANNULATUS Say, 1821; (=B.congolensis Minning, 1934).

Adults

Relatively few specimens of B.annulatus were seen. The total collection amounted to 82 adults, made up of 15 males and 67 females. The collections were made during the months of March, May and June. No attempt was made to distinguish between the immature stages of this tick from those of the predominant B.decoloratus.

RHIPICEPHALUS

From the total number of ticks collected, only 4.43% were Rhipicephalus species. These were: R.senegalensis, 470 out of 910 (or 51.65%), R.muhsamae, 316 (or 34.75%), R.sulcatus 86 (or 9.45%), R.evertsi, 35 (or 3.86%) and R.lunulatus, 3 (or 0.32%). Only adult ticks were found on the cattle (Figure 9, Table 10).

RHIPICEPHALUS SENEGALENSIS Koch, 1844; the scimitar-shielded glossy tick.

This tick was only active during the rainy season from May to September. The attachment sites were the ears, hooves and tail regions.

RHIPICEPHALUS MUHSAMAE Morel & Vassiliades, 1964.

The activity of R.muhsamae was similar to that of R.senegalensis except that the tick was also collected during the dry season in January. The predilection sites of R.muhsamae were the hooves, ears, neck, legs and genitalia

RHIPICEPHALUS SULCATUS Neuman, 1903.

R.sulcatus was only collected from the cattle during the late dry season and during the early rains (March to June). The ticks were mostly picked from the ears.

RHIPICEPHALUS EVERTSI Neuman, 1897; the red tick.

This tick occurred on the cattle in very small numbers, both during wet and dry seasons. They were picked from the peri-anal region.

RHIPICEPHALUS LUNULATUS Neuman, 1907; the tricuspid glossy tick.

Only three specimens of this tick were collected in June. They were found attached to the region of the hoof.

HYALOMMA

This genus accounted for 1.01% of the total collection of 20,561 ticks; only adults were found on the cattle. The most abundant species was H.truncatum (173 out of 207), followed by H.nitidum (18) and H.rufipes (16) (Figure 10, Table 11).

HYALOMMA TRUNCATUM Koch, 1844; the African Hyalomma.

This species formed 83.57% of the total hyalommas collected. Both males and females occurred throughout the year except in October. Two peaks were observed; one during the dry season, in February and the other during

the wet season in July. The primary attachment site was the base of the tail. A few specimens were collected from the genitalia, hooves and legs.

HYALOMMA NITIDUM Schulze, 1919.

Both sexes of this tick were collected from the cattle only in May and August. They were found chiefly on the anal region.

HYALOMMA RUFIPES Koch, 1844; the hairy Hyalomma.

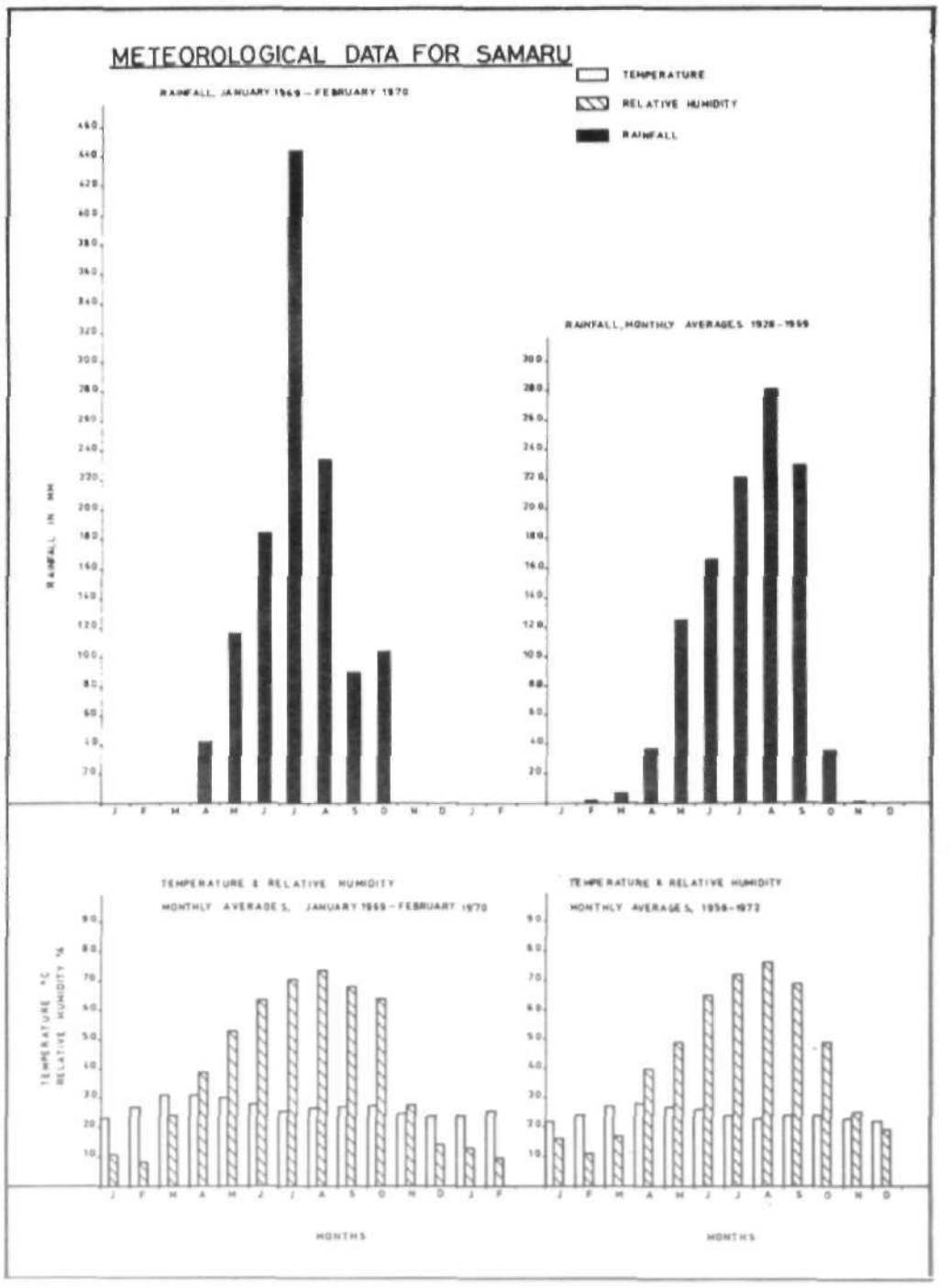
This tick accounted for 7.73% of the total hyalommas. Nearly all specimens were males, most of which appeared in small numbers from February to June. H.rufipes was restricted to the peri-anal region.

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METEOROLOGICAL DATA FOR SAMARU
TEMPERATURE
RELATIVE HUMIDITY
RAINFALL
RAINFALL, JANUARY 1969 – FEBRUARY 1970
RAINFALL IN MM
RAINFALL, MONTHLY AVERAGES 1928 – 1969
J F M A M J J A S O N D J F
J F M A M J J A S O N D
TEMPERATURE & RELATIVE HUMIDITY
MONTHLY AVERAGES, JANUARY 1969 – FEBRUARY 1970
TEMPERATURE °C
RELATIVE HUMIDITY %
MONTHS
TEMPERATURE & RELATIVE HUMIDITY
MONTHLY AVERAGES, 1958–1972
MONTHS

T AB L E 7

TOTAL NUMBER OF TICK SPECIES COLLECTED FROM FOUR WHITE FULANI CATTLE IN THE NORTHERN GUINEA VEGETATION ZONE (SAMARU).

Species	L	N	M	F	T	%
A.splendidum	0	0	2	0	2	0.01
A.variegatum	2,855	2,816	3,060	1,951	10,682	51.95
B.annulatus	0	0	15	67	82	0.40
B.decoloratus	589	2,344	1,396	4,349	8,678	42.20
H.impeltatum	0	0	0	0	0	0
H.impressum	0	0	0	0	0	0
H.nitidum	0	0	8	10	18	0.09
H.rufipes	0	0	15	1	16	0.08
H.truncatum	0	0	124	49	173	0.84
R.evertsi	0	0	25	10	35	0.17
R.guilhoni	0	0	0	0	0	0
R.lunulatus	0	0	1	2	3	0.01
R.muhsamae	0	0	174	142	316	1.54
R.senegalensis	0	0	247	223	470	2.29
R.sulcatus	0	0	47	39	86	0.42
TOTALS	3,444	5,160	5,114	6,843	20,561	100.00

L = larvae
N = nymphae
M = male
F = female
T = total



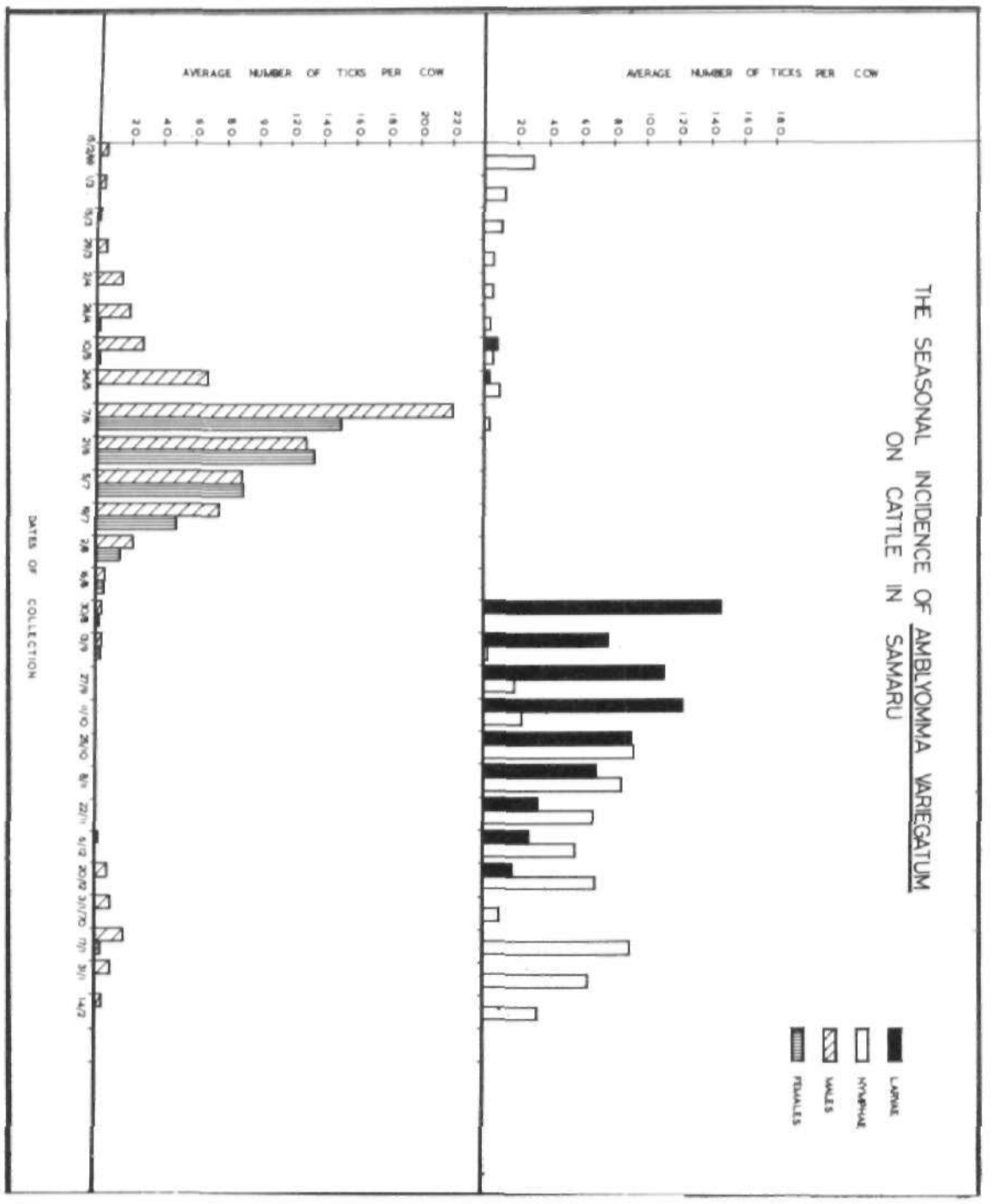

THE SEASONAL INCIDENCE OF AMBLYOMMA VARIEGATUM
ON CATTLE IN SAMARU
AVERAGE NUMBER OF TICKS PER COW
AVERAGE NUMBER OF TICKS PER COW
LARVAE
NYMPHAE
MALES
FEMALES
DATES OF COLLECTION

TABLE 8

FOURTNIGHTLY COLLECTIONS OF AMBLYOMMA VARIEGATUM FROM FOUR WHITE FULANI CATTLE IN SAMARU.

DATE	Larvae		Nymphae		Males		Females	
	Total No.	Average	Total No.	Average	Total No.	Average	Total No.	Average
15/2/69	6	1.50	121	30.25	21	5.25	2	0.50
1/3/69	0	0	52	13.0	17	4.25	0	0
15/3/69	0	0	45	11.25	9	2.25	0	0
29/3/69	0	0	25	6.25	23	5.75	1	0.25
12/4/69	0	0	23	5.75	75	18.75	7	1.75
26/4/69	5	1.25	17	4.25	87	21.75	11	2.75
10/5/69	35	8.75	22	5.50	116	29.0	9	2.25
24/5/69	13	3.25	39	9.75	277	69.25	49	12.25
7/6/69	0	0	14	3.50	882	220.50	626	156.50
21/6/69	0	0	3	0.75	521	130.25	542	135.50
5/7/69	0	0	0	0	361	90.25	366	91.50
19/7/69	1	0.25	0	0	304	76.0	202	50.50
2/8/69	2	0.50	5	1.25	92	23.0	62	15.50
16/8/69	0	0	0	0	18	4.50	17	4.25
30/8/69	586	146.50	2	0.50	17	4.25	11	2.75
13/9/69	307	76.75	4	1.0	17	4.25	15	3.75
27/9/69	445	111.25	74	18.50	6	1.50	2	0.50
11/10/69	491	122.75	92	23.0	2	0.50	0	0
25/10/69	367	91.75	368	92.0	2	0.50	0	0
8/11/69	277	69.25	341	85.25	1	0.25	0	0
22/11/69	135	33.75	271	67.75	4	1.0	2	0.50
6/12/69	108	27.0	225	56.25	10	2.50	1	0.25
20/12/69	71	17.75	275	68.75	30	7.50	3	0.75
3/1/70	0	0	45	11.25	37	9.25	3	0.75
17/1/70	3	0.75	360	90.0	70	17.50	12	3.0
31/1/70	1	0.25	259	64.75	45	11.25	5	1.25
14/2/70	2	0.50	134	33.50	16	4.0	3	0.75

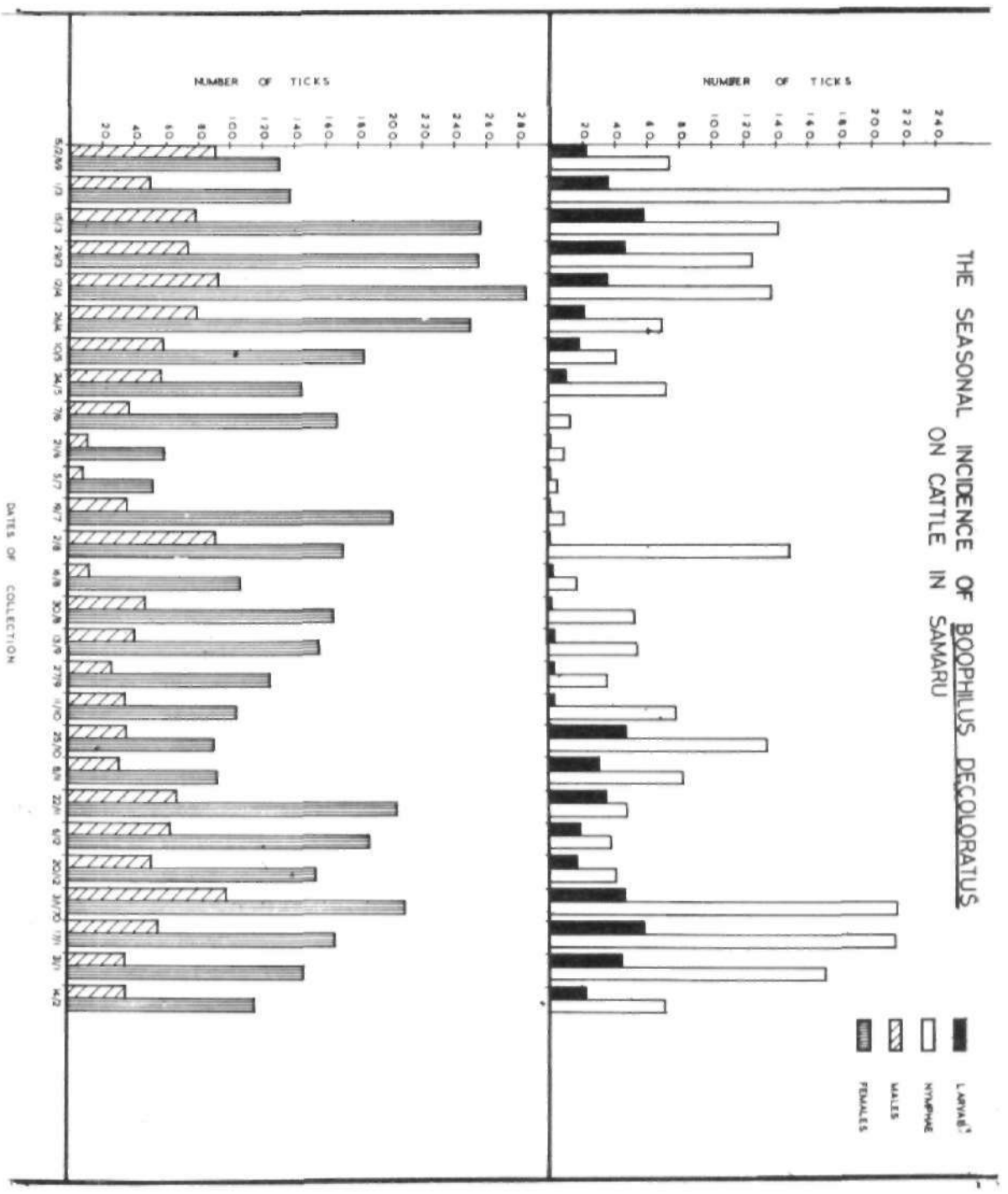

THE SEASONAL INCIDENCE OF BOOPHILUS DECOLORATUS
ON CATTLE IN SAMARU
NUMBER OF TICKS
NUMBER OF TICKS
DATES OF COLLECTION
LARVAE
NYMPHAE
MALES
FEMALES

TABLE 9

FOURTNIGHTLY COLLECTIONS OF BOOPHILUS DECOLORATUS FROM FOUR WHITE FULANI CATTLE IN SAHARU

DATE	LARVAE	NYMPHAE	MALES	FEMALES
15/2/69	22	74	91	131
1/3/69	36	248	50	138
15/3/69	59	142	79	257
29/3/69	47	126	74	256
12/4/69	34	129	93	286
26/4/69	22	71	80	251
10/5/69	19	42	59	185
24/5/69	11	73	58	146
7/6/69	0	14	38	168
21/6/69	1	10	12	60
5/7/69	1	6	9	53
19/7/69	1	10	37	203
2/8/69	1	150	92	172
16/8/69	3	18	13	118
30/8/69	2	54	48	166
13/9/69	4	55	42	157
27/9/69	3	36	27	126
11/10/69	3	69	35	105
25/10/69	48	135	26	91
8/11/69	31	83	32	93
22/11/69	35	48	68	205
6/12/69	19	38	64	188
20/12/69	17	41	52	155
3/1/70	46	215	89	210
17/1/70	58	214	56	166
31/1/70	44	171	36	147
14/2/70	22	72	36	116
TOTALS	589	2,344	1,396	4,349

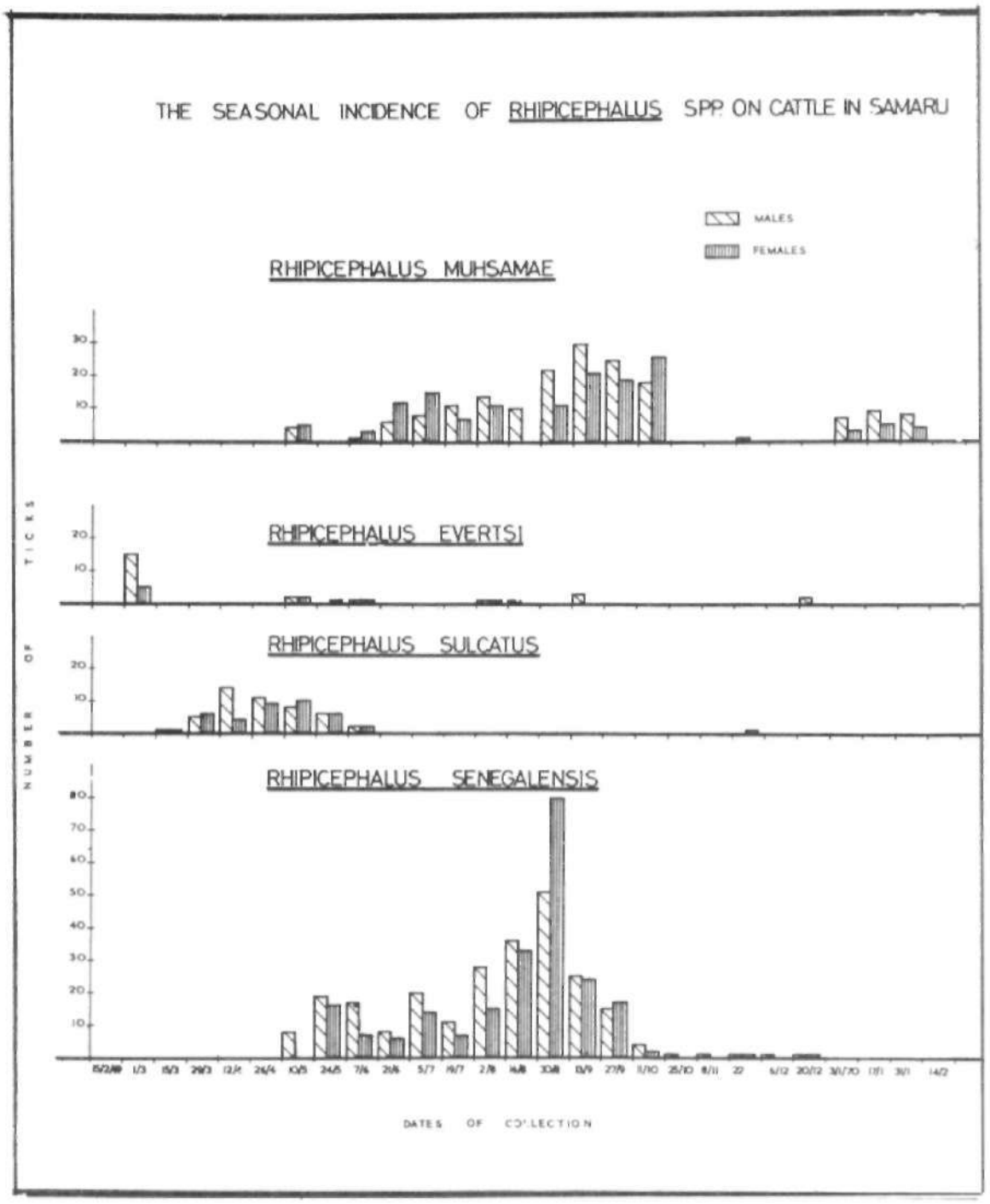
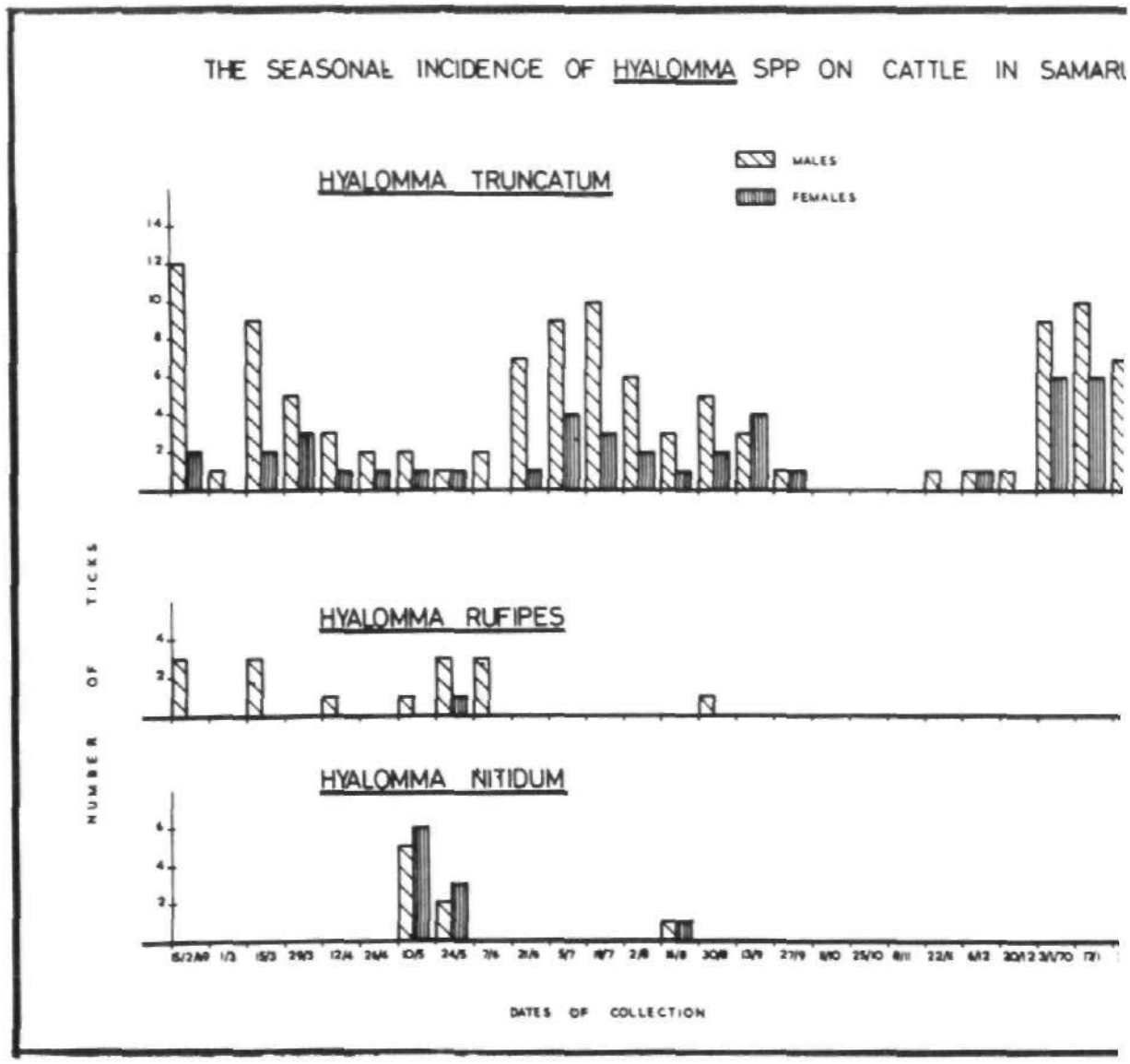

THE SEASONAL INCIDENCE OF RHIPICEPHALUS SPP. ON CATTLE IN SAMARU
MALES
FEMALES
RHIPICEPHALUS MUHSAMAE
RHIPICEPHALUS EVERTSI
RHIPICEPHALUS SULCATUS
RHIPICEPHALUS SENEGALENSIS
NUMBER OF TICKS
DATES OF COLLECTION

TABLE 10

FOURTNIGHTLY COLLECTIONS OF RHIPICEPHALUS SPP. FROM FOUR WHITE FULANI CATTLE IN SAMARU.

DATE	R.senegalensis		R.muhsamae		R.sulcatus		R.evertsi		R.lunulatus	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
15/2/69	0	0	0	0	0	0	0	0	0	0
1/3/69	0	0	0	0	0	0	15	5	0	0
15/3/69	0	0	0	0	1	1	0	0	0	0
29/3/69	0	0	0	0	5	6	0	0	0	0
12/4/69	0	0	0	0	14	4	0	0	0	0
26/4/69	0	0	0	0	11	9	0	0	0	0
10/5/69	8	0	4	5	8	10	2	2	0	0
24/5/69	19	16	0	0	6	6	0	1	0	0
7/6/69	17	7	1	3	2	2	1	1	0	0
21/6/69	8	6	6	12	0	0	0	0	1	2
5/7/69	20	14	8	15	0	0	0	0	0	0
19/7/69	11	7	11	7	0	0	0	0	0	0
2/8/69	28	15	14	11	0	0	1	1	0	0
16/8/69	36	33	10	0	0	0	1	0	0	0
30/8/69	51	30	22	11	0	0	0	0	0	0
13/9/69	25	24	30	21	0	0	3	0	0	0
27/9/69	15	17	25	19	0	0	0	0	0	0
11/10/69	4	2	18	26	0	0	0	0	0	0
25/10/69	1	0	0	0	0	0	0	0	0	0
8/11/69	1	0	0	0	0	0	0	0	0	0
22/11/69	1	1	1	0	0	1	0	0	0	0
6/12/69	1	0	0	0	0	0	0	0	0	0
20/12/69	1	1	0	0	0	0	2	0	0	0
3/1/70	0	0	7	3	0	0	0	0	0	0
17/1/70	0	0	9	5	0	0	0	0	0	0
31/1/70	0	0	8	4	0	0	0	0	0	0
14/2/70	0	0	0	0	0	0	0	0	0	0
TOTALS	247	223	174	142	47	39	25	10	1	1


THE SEASONAL INCIDENCE OF HYALOMMA SPP ON CATTLE IN SAMARI
HYALOMMA TRUNCATUM
MALES
FEMALES
HYALOMMA RUFIPES
HYALOMMA NITIDUM
NUMBER OF TICKS
DATES OF COLLECTION

T A B L E 11

FOURTNIGHTLY COLECTIONS OF HYALOMMA SPP. FROM FOUR WHITE FULANI CATTLE IN SAMARU.

D A T E	H.truncatum		H.nitidum		H.rufipes	
	Male	Female	Male	Female	Male	Female
15/2/69	12	2	0	0	3	0
1/3/69	1	0	0	0	0	0
15/3/69	9	2	0	0	3	0
29/3/69	5	3	0	0	0	0
12/4/69	3	1	0	0	1	0
26/4/69	2	1	0	0	0	0
10/5/69	2	1	5	6	1	0
24/5/69	1	1	2	3	3	1
7/6/69	2	0	0	0	3	0
21/6/69	7	1	0	0	0	0
5/7/69	9	4	0	0	0	0
19/7/69	10	3	0	0	0	0
2/8/69	6	2	0	0	0	0
16/8/69	3	1	1	1	0	0
30/8/69	5	2	0	0	1	0
13/9/69	3	4	0	0	0	0
27/9/69	1	1	0	0	0	0
11/10/69	0	0	0	0	0	0
25/10/69	0	0	0	0	0	0
8/11/69	0	0	0	0	0	0
22/11/69	1	0	0	0	0	0
6/12/69	1	1	0	0	0	0
20/12/69	1	0	0	0	0	0
3/1/70	9	6	0	0	0	0
17/1/70	10	6	0	0	0	0
31/1/70	7	4	0	0	0	0
14/2/70	15	3	0	0	0	0
TOTALS	124	49	8	10	15	1

IV. SEASONAL INCIDENCE OF IXODID TICKS OF CATTLE IN NORTHERN NIGERIA

DISCUSSION

The study of ticks in Nigeria commenced in the early 1900's with pioneer works by Simpson (1912 a,b) and Johnston (1916). Most of Simpson's collections were from horses in the Guinea Vegetation Zones; some were from dogs and goats but none from cattle. Johnston collected all his specimens from animals around Kaduna.

Gambles (1951), Unsworth (1949; 1952) and Strickland (1961) were the first to study ticks of cattle. The species recorded by these authors are given in Table 12. The results are compared with those of the present study.

Gambles (1951) examined 41,487 specimens which were sent to him from all over Nigeria, including the Cameroons.

Unsworth (1952) examined some 60,000 specimens with the sole objective of identifying the species and determining their geographical distribution. He reported fourteen species from cattle, in the whole of Nigeria. Infact, he was dealing with sixteen species according to the present classification.

Strickland (1961) attempted to check on Unsworth's findings. He selected twenty collecting stations spread throughout the northern parts of Nigeria, including the Sudan, Northern Guinea and Southern Guinea Vegetation Zones. Apart from his own collections, tick specimens were sent to him at irregular intervals by Veterinary Staff, working in the provinces. He examined 20,000 ticks, which represented four genera and fifteen species. Using the present classification, he was actually dealing with sixteen species.

In the present study a total number of 34,327 ticks, representing four genera and fifteen species have been identified from cattle in the Sudan and Northern Guinea Vegetation Zones of Nigeria (Tables 12 & 13). Their seasonal incidence and predilection sites on cattle have also been determined. While in previous studies ticks were randomly picked from cattle, in this study all ticks from a limited number of cattle were collected and examined.

In the present investigation, the bait cattle were used for one year in Runka and trekked to Samaru where a similar study was performed. If the cattle had built up an immunity against tick infestation in the Sudan Vegetation Zone, the tick infestations recorded in the Northern Guinea Zone may infact have been higher if fresh bait animals had been used. In that case, comparison of the tick infestations in the two zones could lead to wrong conclusions. However, infestations of *R.variegatum* in the Northern Guinea Vegetation Zone were double to that of the same species in the Sudan Vegetation Zone. Consequently, it is doubtful if the bait cattle had built up an immunity against this tick or any of the other species.

The tick infestation rates of the cattle in Runka (ranges 4,6 and 7) suggested that whenever cattle are grouped together in large numbers, the phenomenon of ectoparasitism by ticks becomes more obvious. This is possibly explained by the fact that hosts become readily available and hence the chances of ticks completing their development successfully, is enhanced.

For Samaru, the climatological data for the study period were compared with the average data for the period 1928-69 (Figure 6). It appeared that

in 1969 the rainfall was less equally distributed during the rainy period than in other years. However, there was no indication that the results of the one-year study period were influenced by abnormal climatological conditions A similar comparison for Runka could not be made in the absence of data.

Unsworth (1952) reported that A.variegatum and B.decoloratus were the most common species found on cattle in Nigeria. This was confirmed in the present study. In the Sudan Vegetation Zone, the commonest tick parasitizing cattle was B.decoloratus. It accounted for 55.95% of the total collection of 13,766 ticks in that zone (Table 13). In the Northern Guinea Vegetation Zone this tick was second to A.variegatum in abundance and accounted for 42.20% of the total collection of 20,561. A.variegatum represented 36.36% and 51.95% of the two collections respectively. Strickland (1961) regarded the two as Guinea Zone species "that have become adapted to the Sudan Vegetation Zone, where they are common in large numbers only during the wet season".

It is suggested that B.decoloratus being a one-host tick and therefore continually feeding, is more tolerant of the severe conditions of the Sudan Vegetation Zone. This tick was collected from both zones in about equal numbers. A.variegatum on the other hand, being a three-host tick, is more open to hazardous climatic conditions at each stage of its development, and hence has less chances of survival. The number of A.variegatum found in the Northern Guinea Vegetation Zone was double to that obtained in the Sudan Vegetation Zone over the same period of time (Table 13).

Of the two vegetation zones, the Northern Guinea therefore appears to be more habitable to A.variegatum, while B.decoloratus seems to thrive in either of the zones. It can be concluded from the present investigation that A.variegatum and B.decoloratus are the two most important ticks parasitizing cattle in the north of Nigeria.

Adult and immature stages of A.variegatum mainly utilize the bovine as host. We have seen that the adults and larvae were active on cattle only once a year during the rainy season, the adults preceding the larvae which could be found on the cattle until the early dry season. Nymphae were predominant during the early dry season, but a diminishing population of nymphal ticks could still be found on cattle until the beginning of the next rainy season. A similar observation has been made by Wilson (1946) in Nyasaland and by Matthysse (1954) in areas of Northern Rhodesia which also have a single rainy season. Strickland (1961) reported a similar pattern in Northern Nigeria.

The predilection sites of the various developmental stages of A.variegatum on cattle have been determined by Wilson (1948; 1949), Strickland (1961) and Yeoman & Walker (1967). In the present study, similar attachment sites to those previously mentioned by other workers have been observed. In addition, the legs and hooves (interdigital space) represented important attachment sites both for adults and nymphae. This fact has been overlooked by previous workers in Nigeria, probably because their investigations were not performed on selected sites of individual cattle. Not only ears but also the neck and dewlap appeared to be important predilection sites of larvae.

Infestations of A.variegatum often led to ulcers on the primary sites because in such areas the ticks congregated together to feed. When the ticks had dropped off upon repletion, these ulcers became sites of secondary infection by flies. Morel (1958) has reported a case of "strike" caused by the blowfly Chrysomyia on the mammary gland of a cow, following engorgement by A.variegatum. Hides and skins are seriously damaged by this tick and consequently they are rendered valueless on the world market. Infestations of nymphae of A.variegatum in the interdigital cleft of the hoof often result in lameness.

The attachment sites of A.variegatum larvae on cattle from the Sudan and Northern Guinea Vegetation Zones have revealed slight differences in terms of percentages. These were not considered significant since the primary sites in both vegetation zones were the same.

Two male specimens of A.splendidum were removed from the cattle in Samaru, in the Northern Guinea Vegetation Zone. Unsworth (1952) reported eleven male specimens of this tick from Yola, in the Sudan Vegetation Zone. Strickland (1961) did not find this tick species in Northern Nigeria. The occurrence of this species on cattle in Nigeria is obviously not significant. Our specimens were re-examined by Morel (1972) who confirmed the validity of the determination.

Gambles (1951) and Unsworth (1952) did not report the occurrence of B.annulatus in their collections. However, Strickland (1961) reported that this species formed 4.6% of his collection. He further stated that the tick

occurred in the Guinea Vegetation Zones throughout the year, but only during the dry cold weather in the Sudan Vegetation Zone. We could not confirm the presence of B.annulatus in the Sudan Vegetation Zone. However, we identified very few specimens in the Northern Guinea Zone during the early rains.

Boophilus geigyi was not observed in the present study nor has it been mentioned by previous workers in Nigeria. However, a few specimens were collected by the author from another part of the Northern Guinea Vegetation Zone. This determination was confirmed by Morel (1972). When Aeschlimann & Morel (1965) first described this new species, they observed that it occurred in the southern parts of the Sudan and in the Guinea Vegetation Zones of West Africa. It would appear that further work on this species is required, to determine its geographical range in Nigeria.

Infestations of B.decoloratus on cattle were observed throughout the year in each of the two vegetation zones studied. Certain seasonal fluctuations occurred which were more marked in the Sudan Vegetation Zone. Thus, our observations were generally similar to those reported by Strickland (1961). It should be realised that B.decoloratus is a one-host tick with an infestation period of approximately three weeks. Therefore, our bi-weekly assesments may have affected the actual tick infestation. Consequently, the observed occurrence of B.decoloratus on the experimental animals does not necessarily reflect the seasonal activities of this species.

The attachment sites of the developmental stages of B.decoloratus on cattle were essentially the same as those reported by Hoogstraal (1956) and

He reported five species which consisted of H.rufipes, H.truncatum, H.dromedarii, H.impeltatum and H.impressum.

The presence of H.dromedarii on cattle could not be confirmed during this investigation. It is concluded therefore, that cattle are incidental hosts of this tick, and only in areas where camels are numerous.

In this investigation, five species of Hyalomma have been identified from the Sudan Vegetation Zone and only three from the Northern Guinea Vegetation Zone. It is suggested that H.impeltatum and H.rufipes are part of an established population that is indigenous to the Sudan Vegetation Zone. H.impeltatum was not found to occur at all in the Northern Guinea Vegetation Zone, while the few H.rufipes seen in this region were largely males which could only have been introduced by migrating cattle.

On the other hand, H.truncatum appears to be fully adapted to both zones. Strickland (1961) has made a similar observation. Although Strickland reported that H.impressum was the second most numerous species of the hyalommas in his collection, only three specimens of this tick were collected in the present study, from the Sudan Vegetation Zone.

H.nitidum was found in both zones but in limited numbers. In previous studies, this species was reported as part of H.truncatum. The two species are distinguished on the basis of distinctness or otherwise of the annulations in their legs, and by the structure of the gonopore of the females. Morel (1972) has re-examined some of our specimens of H.nitidum and confirmed the validity of the determination.

The collection of Hyalomma spp. is considered too small to elaborate on the seasonal incidence of representatives of this genus on cattle. The results suggest that H.impressum, H.rufipes and H.truncatum occur all year round.

The predilection sites of the Hyalomma spp. in the present study were similar to those described in the literature (see Chapter II). The primary sites are the anal region, genitalia and tail.

Hoogstraal (1956) reported that Rhipicephalus ticks were also restricted in their distribution by relative humidity. However, whereas Hyalomma spp. were restricted by high relative humidity, most of the Rhipicephalus spp. could only thrive above a certain minimum relative humidity. Five species of the genus Rhipicephalus were identified from both the Sudan and the Northern Guinea Vegetation Zones.

Unsworth (1952) reported that R.muhsamae and R.senegalensis had similar distributions in Northern Nigeria. This was confirmed in the present study. We found the bulk of R.muhsamae and R.senegalensis in the Northern Guinea Vegetation Zone while relatively low numbers were picked in the Sudan Vegetation Zone. Thus, the contention of Strickland (1961) that the two were sharply divided into Sudan and Guinea Zone species respectively, is disputable.

Unsworth (1952) observed that R.sanguineus occurred fairly regularly in Nigeria, but only in small numbers on cattle. Strickland (1961) reported that the tick was common throughout the country, especially in the Guinea Vegetation Zones but also occurred in the Sudan Vegetation Zone during the wet season.

Morel & Vassiliades (1962) have re-grouped Rhipicephalus of the sanguineus group into five distinct species (see Chapter II). Of these, R.guilhoni and R.sulcatus are found on cattle in Nigeria while R.sanguineus is mainly restricted to dogs. In the present investigation, the first two species have been identified on cattle, and were found to be sharply divided in their distribution R.guilhoni was confined to the Sudan Vegetation Zone while R.sulcatus inhabited the Northern Guinea Vegetation Zone only. Both ticks however, are not considered important parasites of cattle since their numbers were small.

Unsworth (1952) recorded R.lunulatus from Katsina province as well as from the Cameroons. We collected this species mostly from the Sudan Vegetation Zone and only three specimens were obtained in the Northern Guinea Vegetation Zoen. Both collections were identified as R.lunulatus. The identification was confirmed by Morel (1972). R.lunulatus must therefore, be considered as a Sudan species.

R.evertsi was reported by Unsworth (1952) from Mubi in Adamawa province, where the tick formed 60% of the Rhipicephalus collection; it was also found in small numbers from the northerly provinces. Unsworth suggested that this tick was confined to areas with an average annual rainfall of less than 45 inches. Strickland (1961) reported that R.evertsi occurred in the Sudan Vegetation Zone only during the rainy season, but throughout the year in the Northern Guinea Vegetation Zone. In the present study, specimens of R.evertsi were collected from both zones in small numbers only and their distribution was similar to that described by Strickland.

We have not been able to confirm the occurrence of five species of Rhipicephalus, previously reported as occurring in Nigeria; these are:-

R.appendiculatus, reported by Simpson (1912a).

R.cliffordi, reported by Strickland (1961) as R.compositus, and by Gambles (1951) and Unsworth (1952) as R.ayeri.

R.longus, reported by Zumpt (1942) and Gambles (1951) as R.capensis longus.

R.pravus, reported by Zumpt (1942), Gambles (1951) and Walker (1956) as R.naevi punctatus.

R.ziemanni, reported by Unsworth (1952) and Strickland (1961).

It is doubtful that R.appendiculatus is a Nigerian tick. Since the report of Simpson (1912a), no other author has recorded this tick.

In West and Central Africa the name R.compositus should be replaced by R.cliffordi (Morel, 1964). This species was recorded by Unsworth (1952) from Bauchi, Plateau, Niger and Zaria provinces. Strickland (1961) found the tick in Kaduna. The species is a highland tick which inhabits areas between 4,000 and 8,000 feet (Yeoman & Walker, 1967). This explains why R.cliffordi was not found in the present study.

R.longus was collected in Nigeria by Zumpt (1942) and Gambles (1951) probably from areas with high humidity. This tick is restricted to regions with high humidity (Hoogstraal, 1956) and was not collected in the present study.

R.pravus was identified in Nigeria as R.neavi punctatus (Gambles, 1951). The same species was reported by Unsworth (1952) from the neighbouring Cameroons.

According to Hoogstraal (1956), R.pravus primarily inhabits East Africa. Yeoman & Walker (1967) and Morel (1972) have made a similar observation.

R.ziemanni was reported by Unsworth (1952) as occurring only in the Western State of Nigeria. This area is characterized by high humidity. Strickland (1961) found only one specimen in Okene, a town that lies deep in the Southern Guinea Vegetation Zone and therefore outside our study areas.

An elaborate discussion on the seasonal incidence of both Hyalomma spp. and Rhipicephalus spp. is impossible because numbers encountered were insufficient. However, it may be worthwhile to note that for the rhipicephalids, the most numerous species collected i.e. R.muhsamae and R.senegalensis, were mainly active during the wet season. A similar observation has been made by Strickland (1961).

The predilection sites of most Rhipicephalus species studied, consisted of ears, neck, hooves, genitalia and the anal region. Similar attachment sites have also been mentioned by various authors (see Hoogstraal, 1956).

SUMMARY

The seasonal incidence of cattle ticks in Northern Nigeria was studied in two vegetation zones. In the Sudan Vegetation Zone, the study was carried out in the Ruma Kukar Jangarai Grazing Scheme (Runka, Katsina province), while in the Guinea Vegetation Zone the investigation was performed in Samaru (Zaria province) (Chapters IIIA & IIIB). In each zone, four White Fulani cattle were kept for one year and used as bait animals. Ticks were removed

from ten predilection sites at fourtnightly intervals. They were identified to species. Their geographical distribution in Nigeria was discussed and compared with reports of previous workers. The names of certain species have been revised in the light of current knowledge. Although not included in the present collection, Boophilus geigyi has been reported in Nigeria for the first time.

In the Sudan Vegetation Zone, 13,766 ticks were collected. They comprised of four genera and twelve species. The commonest species was Boophilus decoloratus which represented 55.95% of the total collection. Amblyomma variegatum was next in abundance being 36.36%. Developmental stages of both tick species were collected. Five species of the genus Hyalomma formed 6.45% of the total collection. The genus Rhipicephalus was also represented by five species which together comprised of only 1.23% of the total. Immature stages of species of these two genera were not found on the cattle.

In the Northern Guinea Vegetation Zone, 20,561 ticks, also comprising of four genera and twelve species were collected. The most abundant species here was A.variegatum which represented 51.95% of the total collection while B.decoloratus formed 42.20% of the total. Immature stages of both tick species were collected. The genus Rhipicephalus comprised of five species, forming 4.43% of the total, while three species of Hyalomma accounted for 1.01% of the collection. Immature stages of the species of both genera were not found on the cattle.

In both vegetation zones, all developmental stages of B.decoloratus

were seen on cattle throughout the year, but with seasonal fluctuations. However, there was only one generation of A.variegatum per year. Adult ticks were active during the rainy season, while larvae became numerous at the height of the rains (Samaru) or at the end of the rains (Runka). The incidence of the nymphae followed that of the larvae, but nymphal ticks could still be found on cattle until the late dry season.

Hyalomma spp. appeared to be mainly restricted to the Sudan Vegetation Zone whereas Rhipicephalus spp. were more common in the Northern Guinea Vegetation Zone.

The predilection sites of B.decoloratus and A.variegatum were extensively studied. A general knowledge of these sites was considered important for the evaluation of population dynamics of ticks on cattle.

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T A B L E 12

COMPARATIVE TABLE OF CATTLE TICKS IN NIGERIA

S P E C I E S	Unsworth (1949-1952)	Gambles (1951)	Strickland (1961)	Mohammed (1974)
Amblyomma variegatum	x	x	x	x
Amblyomma splendidum	x	-	-	x
Boophilus annulatus	-	-	x	x
Boophilus decoloratus	x	-	x	x
(Palpoboophilus decoloratus)	-	x	-	-
Haemaphysalis aciculifer	x	x	-	-
Hyalomma dromedarii	-	-	x	-
Hyalomma impeltatum	-	-	x	x
(H. brumpti)	x	x	-	-
Hyalomma impressum*	-	-	x	x
(H. impressum rufipes)	x	x	-	-
Hyalomma rufipes*	-	-	x	x
(H. impressum rufipes)	x	x	-	-
Hyalomma truncatum	-	-	x	x
(H. impressum transiens)	-	x	-	-
(H. transiens)	x	-	-	-
Hyalomma nitidum**	-	-	-	x
Rhipicephalus cliffordi	-	-	-	-
(R. ayeri)	x	x	-	-
(R. compositus)	-	-	x	-
Rhipicephalus evertsi	x	x	x	x

TABLE 12 (Cont'd)

SPECIES	Unsworth (1949; 1952)	Gambles (1951)	Strickland (1961)	Mohammed (1974)
Rhipicephalus guilhoni***	-	-	-	x
(R. sanguineus)	x	x	x	-
Rhipicephalus longus	-	-	-	-
(R. capensis longus)	-	x	-	-
Rhipicephalus lunulatus	-	-	-	x
(R. tricuspis)	x	x	x	-
Rhipicephalus muhsamae	-	-	-	x
(R. simus simus)	x	-	x	-
Rhipicephalus pravus	-	-	-	-
(R. naevi punctatus)	-	x	-	-
Rhipicephalus senegalensis	-	x	-	x
(R. simus longicoides)	-	x	-	-
(R. simus senegalensis)	x	-	x	-
Rhipicephalus sulcatus***	-	-	-	x
(R. sanguineus)	x	x	x	-
Rhipicephalus ziemanni	x	x	x	-

* Previous workers recorded both H. impressum and H. rufipes as H. impressum rufipes

** H. nitidum was identified as H. truncatum by previous workers

*** Previous workers recorded both R. guilhoni and R. sulcatus as R. sanguineus.

TABLE 13

TOTAL NUMBER OF TICK SPECIES COLLECTED FROM FOUR WHITE FULANI CATTLE IN NORTHERN NIGERIA

SPECIES	Sudan Vegetation zone (Runka)		Northern Guinea Vegetation Zone (Samaru)	
	Total	%	Total	%
Amblyomma splendidum	0	0	2	0.01
Amblyomma variegatum	5,006	36.36	10,682	51.95
Boophilus annulatus	0	0	82	0.40
Boophilus decoloratus	7,702	55.95	8,678	42.20
Hyalomma impeltatum	576	4.18	0	0
Hyalomma impressum	3	0.02	0	0
Hyalomma nitidum	63	0.46	18	0.09
Hyalomma rufipes	180	1.31	16	0.08
Hyalomma truncatum	66	0.48	173	0.84
Rhipicephalus evertsi	3	0.02	35	0.17
Rhipicephalus guilhoni	31	0.23	0	0
Rhipicephalus lunulatus	85	0.62	3	0.01
Rhipicephalus muhsamae	44	0.32	316	1.54
Rhipicephalus senegalensis	7	0.05	470	2.29
Rhipicephalus sulcatus	0	0	86	0.42
TOTALS	13,766	100.00	20,561	100.00

V. PREVALENCE OF BOVINE PIROPLASMS IN NORTHERN NIGERIA

INTRODUCTION

Barnett (1968) classified the piroplasms as suggested by Levine (1961) as follows:-

Class: Piroplasmea

Order: Piroplasmida

Family: Babesiidae	Family: Theileriidae
Genera: Babesia	Genera: Theileria
Nuttallia	Cytauxzoon
Echinozoon	Haematoxenus

Piroplasmosis of cattle in Nigeria has been reported in several Annual Reports of the Veterinary Department. In the Annual Report of 1928, it was stated that the disease was enzootic among indigenous cattle. Calves were assumed to contract the infection at an early age when protected by maternal antibodies or age resistance, and to develop immunity. This immunity was long lasting under continuous tick challenge and cattle did not show any clinical manifestation.

The disease became noticeable as a complicating factor of rinderpest vaccination (Annual Report, 1929). In a vaccination camp in Adamawa Province for instance, 40% of all the cattle which died following rinderpest vaccination, showed signs of piroplasmosis. At another camp, out of 324 deaths of calves following this vaccination, 186 or 57% died of clinical piroplasmosis. The local Veterinarian, discussing this mortality remarked: "I feel sure that

there is some other factor accountable for deaths besides the virus of rinderpest, and I am of the opinion that in a great many cases this other factor is piroplasmosis" (Annual Report, 1929).

Piroplasmosis was firstly referred to as a contaminant of the rinderpest vaccine because the infection was not observed outside the rinderpest vaccination areas (Annual Report, 1930). Later on, it was suggested that the cattle contracted piroplasmosis on their way to the immunization camps, or even inside the camps, through the agency of ticks (Annual Report, 1934).

Piroplasmosis was also reported in trade cattle as a result of heavy tick infestation (Annual Veterinary Report, North-Western State, 1968-1969). It was also observed that in livestock which was kept under more intensive management, bovine piroplasmosis could be a serious problem (Annual Report 1960-61; 1961-62; 1962-63). For example, in the Runka Grazing Scheme, about 10% of the cattle had to be treated annually against the disease and the installation of a spray race was considered.

The purpose of this investigation was to evaluate the prevalence of piroplasms among cattle in the Sudan and the Northern Guinea Vegetation Zones.

A. SUDAN VEGETATION ZONE (RUNKA)

MATERIALS AND METHODS

The study was carried out in the Ruma Fukar Jangarai Grazing Scheme at Runka, from March 1967 to December 1968 and from August to October 1973.

Agricultural Research, and of the Faculty of Veterinary Medicine were used for this experiment. In 1973, samples from 100 different local cattle were examined.

BLOOD AND BRAIN SMEARS

Thick and thin blood smears were prepared as described for Runka. In 1973, in addition, brainsmears were prepared from 100 cattle by the method described by Leeflang (1972).

SEROLOGY

As in Runka, sera from 100 cattle were prepared in 1973 and sent to Utrecht for the immunofluorescence antibody test against B.argentina and B.bigemina.

RESULTS

A total of 241 cattle were examined. The results are presented in Tables 16 and 17. At bloodsmear examination, 68.05% of the cattle showed T.mutans only. Mixed infections of T.mutans and B.bigemina were found in 3 animals (or 1.24%). One animal was positive for B.bigemina only. B.argentina was observed as a mixed infection with T.mutans in one animal (or 0.42%), while in 72 (or 29.87%) of the cattle no parasites were found. Brain smears of the 100 cattle sampled in 1973, were prepared and examined for parasites. In 5 smears, B.argentina was detected, including one animal that was positive for B.argentina both, at blood and brain smear examination.

The immunofluorescence antibody test revealed that 26% of the cattle had an antibody titre against B.bigenina and also 26% against B.argentina.

These percentages included 6 cattle that showed antibodies against both parasites. The titres ranged from 1:160 to 1:640.

DISCUSSION

The most common piroplasm of cattle in the vegetation zones studied was T.mutans. It is of little pathogenicity (Leeflang, 1974). Folkers & Kuil (1967) and Folkers et al. (1970) also reported that T.mutans was prevalent in cattle in Nigeria. T.mutans has a wide geographical range and consequently is suspected of being transmitted to cattle by a diversity of ticks (Barnett, 1968). The presence of A.variegatum may be sufficient to explain the widespread occurrence of T.mutans in Nigeria (Uilengberg et al. 1974).

The detection of the Babesidae by blood smear examination of intact animals may lead to results which are different from those of the indirect immunofluorescence antibody test. This may be explained either by the limitation of the blood examination method or by the presence of sterile immunity. Folkers et al. (1970) found that only 1.8% of Nigerian cattle presented for treatment against trypanosomiasis showed B.bigemina in their blood. In another experiment, Folkers & Kuil (1967) splenectomized four cattle and found that three were positive for B.bigemina and one for B.argentina while blood examination before splenectomy had revealed neither of these parasites.

The prevalence of B.argentina to the brains of cattle has been described before. Folkers et al. (1967) examined brainsmears from 313 slaughter cattle in Zaria and found 11.18% positive for B.argentina. In the present study, five cattle showed B.argentina in brainsmears (5%) while only one of the matching blood samples was found positive. However, 26 serum samples showed antibodies against this parasite.

The prevalence of B.bigemina among the cattle from both vegetation zones did not differ greatly. This parasite has been proved to be transmitted by Boophilus species (Smith & Kilborne, 1893). The prevalence of B.argentina was markedly greater in the Northern Guinea Vegetation Zone than in the Sudan Vegetation Zone. This could not be explained. In the present study, it was confirmed that B.bigemina is transmitted by B.decoloratus (see Chapter VI).

SUMMARY

An investigation on the prevalence of bovine piroplasms was made in the Sudan and Northern Guinea Vegetation Zones by means of blood and brainsmear examination, and the indirect immunofluorescence antibody test. In both vegetation zones, the prevalence of T.mutans in cattle was high.

The detection of the Babesidae by bloodsmear examination alone has its limitations as revealed by the results of the immunofluorescence antibody test. The prevalence of B.argentina was markedly higher in the Northern Guinea Vegetation Zone.

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TABLE 14

PREVALENCE OF PIROPLASMS AMONG WHITE FULANI CATTLE IN THE SUDAN VEGETATION ZONE (RUNKA), BLOOD EXAMINATION

DATE	Number of cattle examined	T. mutans		B. bigemina		T. mutans and B. bigemina		Negative	
		No.	%	No.	%	No.	%	No.	%
14/3/67	34	30		0		1		3	
28/4/67	22	16		0		6		0	
31/5/67	13	7		1		4		1	
30/7/67	34	31		0		2		1	
21/12/67	28	24		0		4		0	
15/1/68	21	20		0		0		1	
15/2/68	23	19		0		1		3	
15/3/68	24	21		1		0		2	
15/4/68	23	20		0		0		3	
15/5/68	22	20		0		0		2	
15/6/68	24	19		0		2		3	
15/7/68	20	15		0		0		5	
15/8/68	21	13		0		0		8	
13/9/68	21	17		0		0		4	
16/10/68	20	14		0		0		6	
8/11/68	20	17		0		0		3	
5/12/68	19	12		0		0		7	
28/8/68	15	9		0		0		6	
29/8/73	15	9		0		0		6	
11/9/73	15	10		0		0		5	
26/9/73	40	21		0		0		19	
9/10/73	15	8		0		1		6	
TOTALS	489	372	76.07	2	0.41	21	4.30	94	19.22

T A B L E 15

PREVALENCE OF PIROPLASMS AMONG 100 CATTLE IN THE SUDAN VEGETATION ZONE (RUNKA)

Name of parasite	Bloodsmear examination		Immunofluorescence test for Babesidae	
	No.	%	No.	%
T. mutans	57	57	-	-
B. bigemina	0	0	25	25
B. argentina	0	0	7	7
T. mutans and B. bigemina	1	1	1	1
B. argentina and B. bigemina	0	0	2	2

TABLE 17

PREVALENCE OF PIROPLASMS AMONG 100 CATTLE IN THE NORTHERN GUINEA VEGETATION ZONE (SAMARU)

Name of parasite	Bloodsmear examination		Brainsmear examination		Immunofluorescence test for Babesidae	
	No.	%	No.	%	No.	%
T.mutans	71	71	0	0	-	-
B.bigemina	0	0	0	0	20	20
T. mutans and B.argentina	1	1	5	5	20	20
T. mutans and B.bigemina	1	1	0	0	0	0
B.argentina and B.bigemina	0	0	0	0	6	6

VI. TRANSMISSION OF BOVINE PIROPLASMS IN NORTHERN NIGERIA

INTRODUCTION

The piroplasm often seen in the blood of cattle in Nigeria is Theileria mutans. It is of little pathogenic importance to cattle. Babesia spp. are also present, but are not so common (see Chapter V), although they can be the cause of disease and even death (Leeflang, 1974).

In nature, both parasites are transmitted through the agency of ticks but the mode of transmission in each case is radically different (Balashov, 1972). It has been proved that T.mutans is transmitted by Rhipicephalid ticks, only from stage to stage (Neitz 1956; 1959). That is, the ticks pick up the infection as larvae or nymphae and transmit it in the adult stage or less often in the nymphal stage (Barnett, 1968). Uilenberg et al. (1974) demonstrated the transmission of T.mutans by A.variegatum from the larval to the nymphal stage and suggested that the presence of A.variegatum may be sufficient to explain the widespread occurrence of T.mutans in large parts of Africa. The Babesia species on the other hand, have the exceptional ability of passing through the eggs of the female tick and consequently establishing themselves in the larval progeny. This type of transmission is known as transovarial transmission. Babesia spp. are transmitted transovarially by one-host ticks of the genus Boophilus (see Chapter II).

The purpose of this investigation was,

(1) to identify B.bigemina in B.decoloratus and determine the role of the tick as a vector of the parasite in Nigeria.

(2) to attempt experimental transmission of T.mutans by H.impeltatum and H.truncatum, since species of the genus Hyalomma are known to transmit another theileria (T.annulata) (Barnett, 1968).

All smears were fixed in methanol and stained in 1:1 May-Grunwald solution for three minutes followed by a 5% Giemsa solution for thirty minutes. They were examined with x10, x40 (dry) and x100 (immersion oil) objective and a x10 eyepiece of a Leitz microscope. In the case of haemolymph smears, the level of parasitaemia was graded into 4 categories using the x10 objective:

\+ less than 5 merozoites per whole smear

\++ less than 50 merozoites per field

\+++ more than 50 merozoites per field

\++++ whole field densely covered with merozoites

All techniques used were essentially the same as those described by Friedhoff (1969; 1973).

Experimental transmission of B.bigemina by B.decoloratus.

One tick showing a ++++ parasitaemia in its haemolymph was selected and its larval progeny applied to a nine months' old Zebu (Calf 922). This calf had been born and reared in our tick-proof stable. The larval progeny of the replete females were again applied to another clean calf (No. 919).

Larvae from another female that had shown a similar parasitaemia in its haemolymph were shipped to the Institut fur Parasitologie de Tierärtzlichen Hochschule in Hannover, West Germany for experimental transmission in a Babesia-free calf.

Experimental transmission of T.mutans by Hyalomma spp.

Partially engorged males and females of H.impeltatum and H.truncatum were

collected from bait cattle at Runka and Samaru respectively, and sent to Hannover for experimental transmission of T.mutans in calves. The shipment consisted of 50 adults of each species, the sexes being in equal numbers.

RESULTS

Identification of Babesia in the tick

Out of a total number of 389 engorged females of B.decoloratus collected in Samaru, 39 (or 10.03%) were found to harbour merozoites of Babesia in the haemolymph.

181 B.decoloratus females were collected from cattle at Runka. Probably due to the dipping programme, the ticks were never in the engorged state, and as a result less than one third of them laid eggs, very few of which were viable. Only in 4 cases were very few merozoites detected in the haemolymph. The eggs laid by these infected ticks failed to produce enough larvae for transmission trials.

Babesia in haemolymph of replete female ticks

Basically three types of merozoites were observed free in the haemolymph: those with granules but no polar cap (Figure 11), those with granules and polar cap (Figure 12) and those without granules but with a polar cap and vacuoles (Figure 13). Some of these merozoites had a distinct thickenning in the anterior end, that resembled the head of an arrow (Figure 14).

All the types of merozoites described above were present in the haemolymph at the same time, except that one form might be more preponderant than another.

They were elongated in shape and at average measured 11.9 mu in length (range 10.0-15.0) and 2.4 mu in width (range 2.0-2.9) at their broadest end.

Schizonts were also seen quite often in both granulated and non-granulated haemocytes. The most abundant were the amoeboid forms in granulated haemocytes (Figure 15). The chromatin and cytoplasm formed a limiting membrane, while the bulk of the parasite appeared as an "empty" space. At this time the nucleus and granules of the host cell were still distinct. Later on, the "empty" space became full of small chromatin dots (Figure 15).

The so-called plasmodium phase of the schizogony (Friedhoff, 1969) was identified in haemocytes of four of the infected ticks (Figure 16). Figure 17 shows a mature schizont suggesting that merozoites were emerging.

Of the 39 ticks originating from Samaru which were found infected with merozoites in the haemolymph, five did not reveal any intracellular stages of the parasite.

Babesia in the eggs of infected B.decoloratus females

All the 39 infected ticks laid eggs but only eggs from 20 females were examined, the remainder having been discarded because they were not viable. Egg smears from 17 females showed merozoites which were either elongated or round. The elongated forms resembled those seen in haemolymph smears but they were bulkier. The chromatin was situated in the middle of the merozoites but it often assumed a position at the extreme anterior end making it difficult to recognise the polar cap (Figures 18 & 19). In the round forms the cytoplasm

was limited to the circumference of the ring and the chromatin pushed to the side. A polar cap could not be distinguished. Irregularly shaped merozoites were also seen but these were considered to have arisen during the squashing process (Friedhoff, 1969).

Babesia in the ovary of infected B.decoloratus females

Upon dissection, the five female ticks which showed a parasitaemia of ++++ in their haemolymph smears also showed a high infection of merozoites in the smears made from the ovary. Both elongated and round merozoites were observed in the peri-tracheal cells (Figure 20).

Babesia in the larval progeny of infected B.decoloratus females.

The larval progeny of 15 out of 20 infected females showed merozoites in squash preparations. The forms observed in the larvae were identical to those in the eggs although they were bulkier (Figure 21).

Experimental transmission of B.bigemina by B.decoloratus.

Calf No. 922, infested with larval progeny of one infected female tick on the 8th September 1973 became positive for B.bigemina on 25th September 1973. The time interval indicated that the parasite was transmitted by the nymphal stage of the tick. The larval progeny of the replete females that were harvested from this calf also transmitted B.bigemina to a clean calf (No. 919). The transmission was also by nymphae. Elongated and round merozoite

were seen in larval stage of the next generation.

The larval progeny of another infected tick (which had also shown a ++++ parasitaemia in the haemolymph (Figure 22)) was applied to Bull No. 108 in Hannover on 9th November 1973. It also became positive for B.bigemina only. The preinfestation serum of this calf did not show antibodies against B.argentina and B.bigemina. On 9th December 1973, a titre of 160 against B.bigemina was recorded, while the titre against B.argentina was negative. On 4th January 1974, the titre against B.bigemina was 320 but that against B.argentina was still negative.

Experimental transmission of T.mutans.

The transmission of T.mutans by either H.truncatum or H.impeltatum was unsuccessful.

DISCUSSION

Haemolymph smears of replete B.decoloratus females examined in Samaru revealed an infection rate of 10.03%. Although this figure is apparently high, it should be realised that Mahoney & Ross (1972) reported that Babesial infections in ticks depended on two factors: environmental temperatures and the infectivity of the bovine blood. Hence, the significance of the infection rate of ticks in the Samaru area has still be be evaluated.

Since it was not the intention of this investigation to study the development of Babesia spp. in B.decoloratus, we did not examine haemolymph smears of

ticks immediately after repletion. Friedhoff (1969; 1973) reported that merozoites were not detected in the haemolymph earlier than on day 5 post repletion and suggested that examination be performed from day 7 onwards. For the same reason eggs were examined from day 3 after incubation.

In the present study merozoites of Babesia spp. which morphologically conformed to those described by Riek (1964) and Friedhoff (1969) have been observed, in the haemolymph, ovary, eggs and larvae.

The significance of the polar cap on some merozoites has been explained by Friedhoff (1969) who asserted that only those with polar caps possessed the ability to penetrate into the haemocytes and undergo schizogony.

It would appear that we were dealing with merozoites of B.bigemina since the larval progeny of three infected ticks transmitted only B.bigemina to Babesia-free calves both in Samaru and in Hannover.

The experimental transmission of T.mutans by H.truncatum and H.impeltatum was unsuccessful. These ticks were removed from cattle with T.mutans, in the semi-engorged state and allowed to complete engorgement on fully susceptible calves.

SUMMARY

A study on the transmission of Babesia spp. by Boophilus decoloratus was carried out in the Northern Guinea Vegetation Zone (Samaru) and the Sudan Vegetation Zone (Runka) of Nigeria.

389 replete B.decoloratus females were collected from bait cattle in Samaru from 21st July 1973 to 23rd October 1973. They were incubated at 28°C and +80% relative humidity. 39 (or 10.03%) of the ticks were infected with merozoites of Babesia in their haemolymph. Intracellular stages were also seen in the haemocytes. Smears of eggs, ovary and larvae of a majority of the ticks also revealed the presence of merozoites. The larval progeny of three infected ticks was applied to Babesia-free calves which came down with B.bigemina infection. No B.argentina was involved.

181 B.decoloratus females were collected at Runka from 29th August 1973 to 9th October 1973. These ticks were semi-engorged and therefore laid only a few eggs which were not viable. Haemolymph smears from 4 of them showed merozoites of Babesia spp.

The experimental transmission of T.mutans by H.truncatum and H.impeltatum from both Vegetation Zones was unsuccessful.

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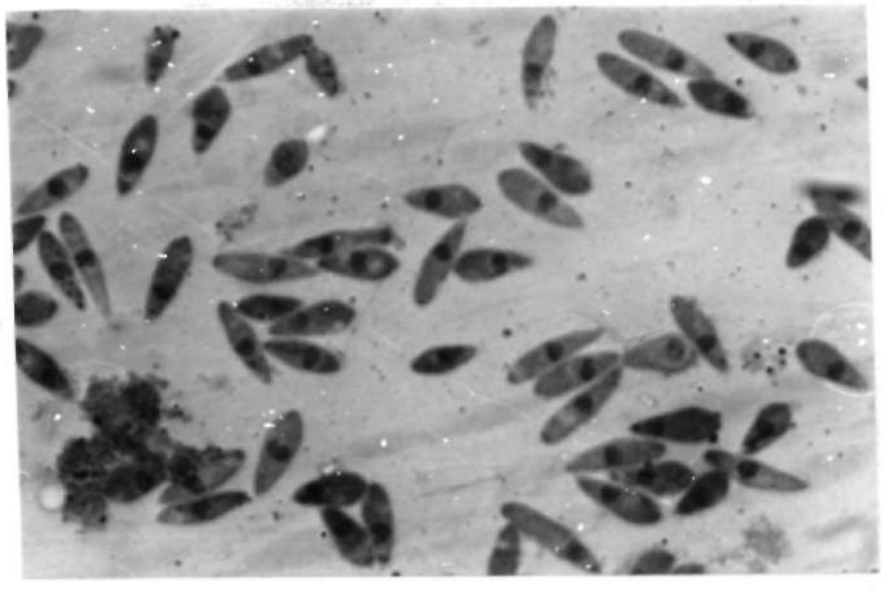
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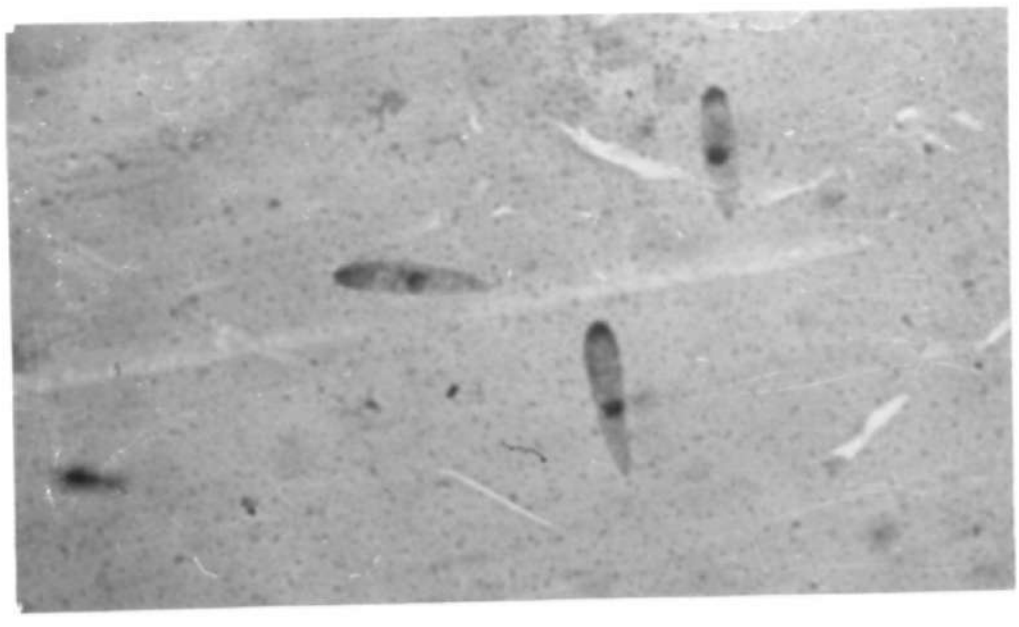
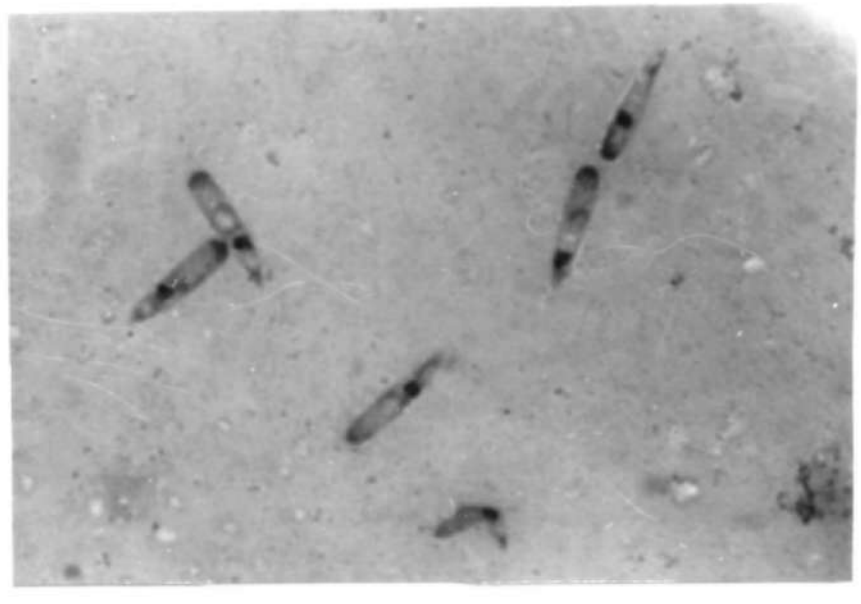


Fig. 13.
Fully differentiated merozoites of Babesia spp. in the haemolymph smear of a replete Boophilus decoloratus female showing polar caps and vacuoles but no granules. Giemsa stain; x 1500.

Fig. 14.
Fully differentiated merozoites of Babesia spp. in the haemolymph smear of Boophilus decoloratus showing "arrow heads". Giemsa stain; x 1500.



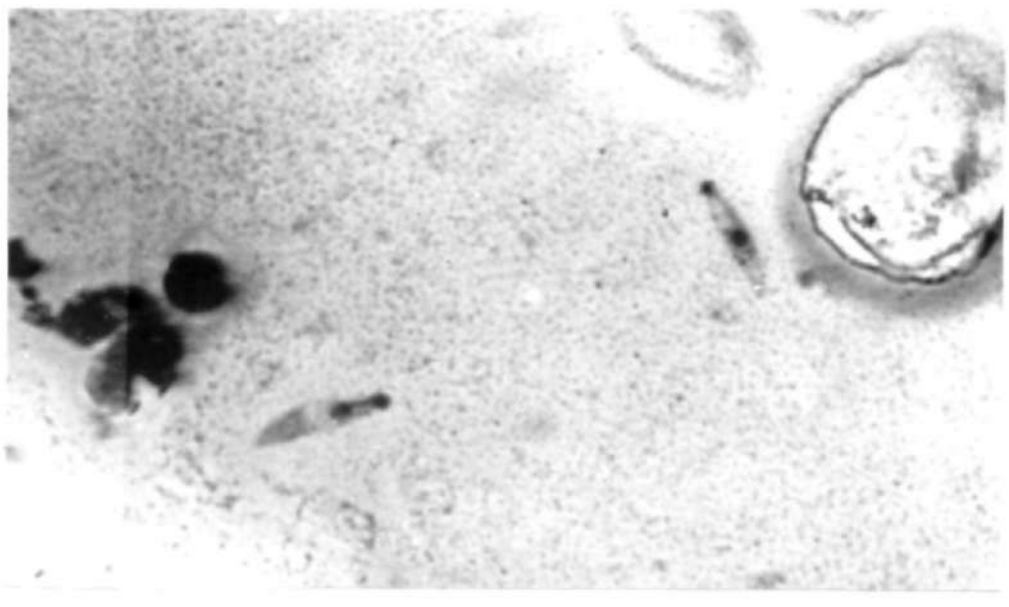
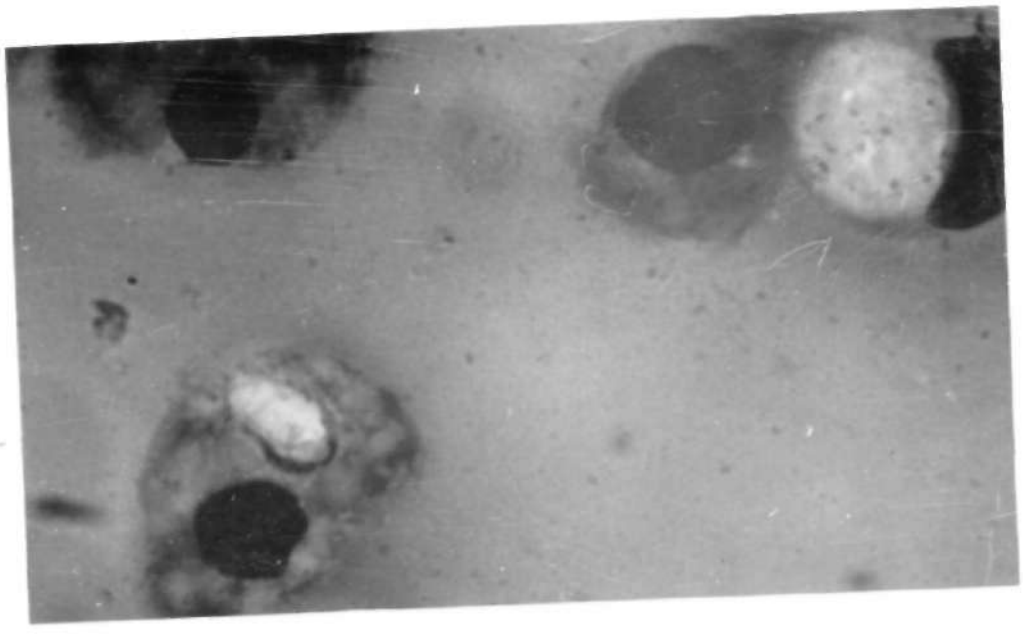


Fig. 15.

Showing an amoeboid form in a granulocytic haemocyte (left) and a polynuclear form in a haemocyte (right). Giemsa stain; x 1500.

Fig. 16.

Haemolymph smear of a replete Boophilus decoloratus female showing a "plasmodium phase" in a haemocyte. Giemsa stain; x 1500.



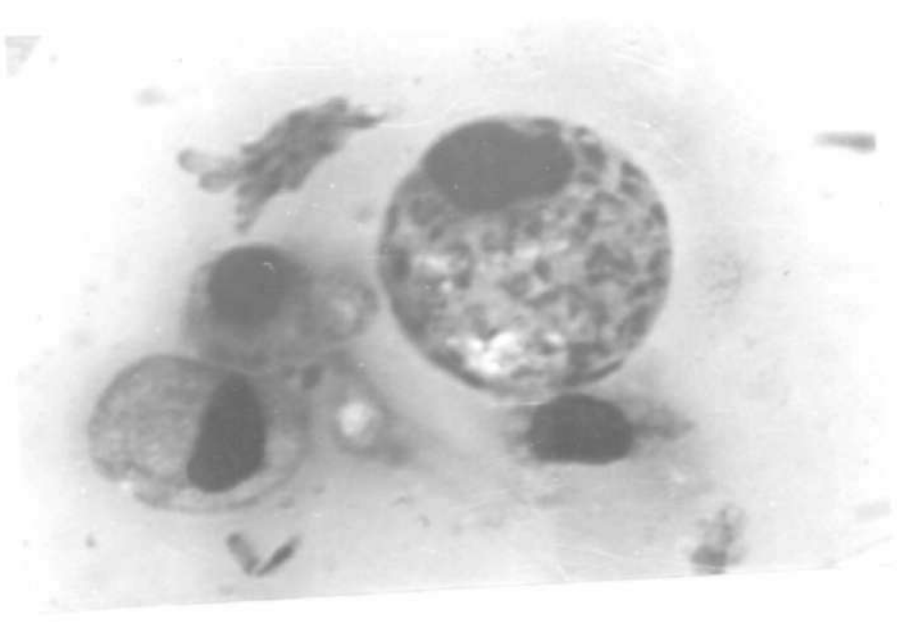
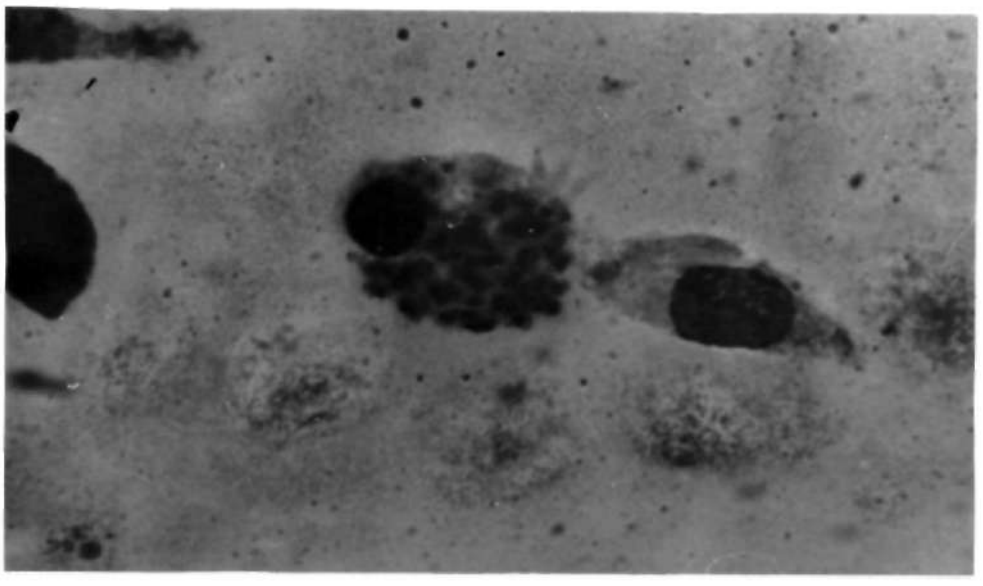


Fig. 17.
Haemolymph smear of a replete Boophilus decoloratus female showing merozoites emerging from a schizont. Giemsa stain; x 1500.

Fig. 18.
Showing elongated merozoites of Babesia spp. in egg smear. Giemsa stain; x 1500.



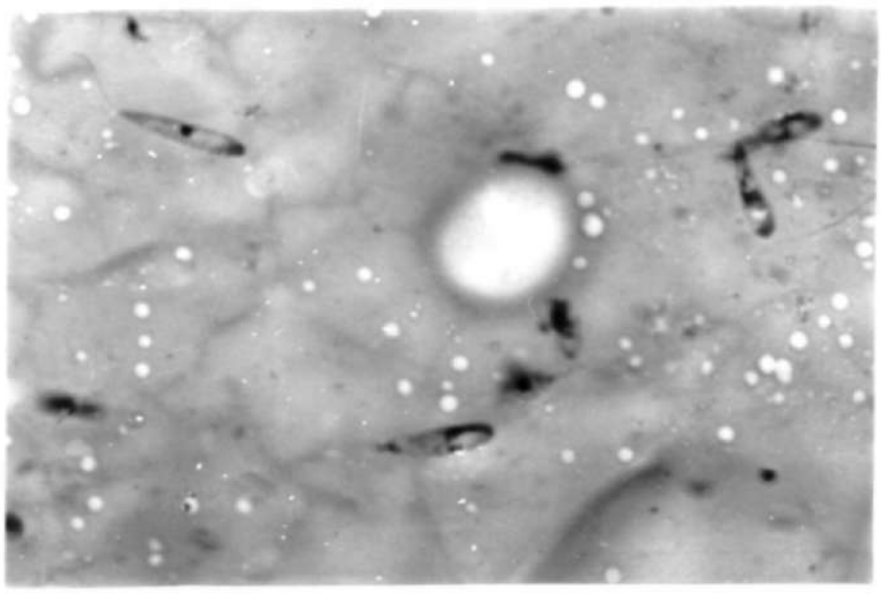
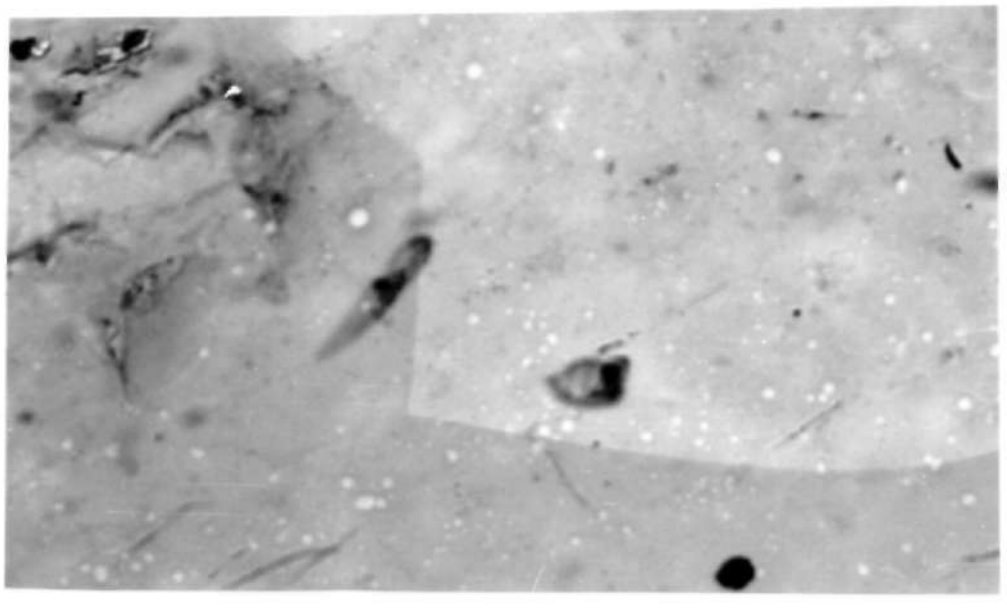


Fig. 19.
Showing elongated and irregularly shaped merozoites of Babesia spp. in egg smear. Giemsa stain; x 1500.

Fig. 20.
Showing merozoites of Babesia spp. in peritracheal cells of ovary of replete B.decoloratus female. Giemsa stain; x 1500.



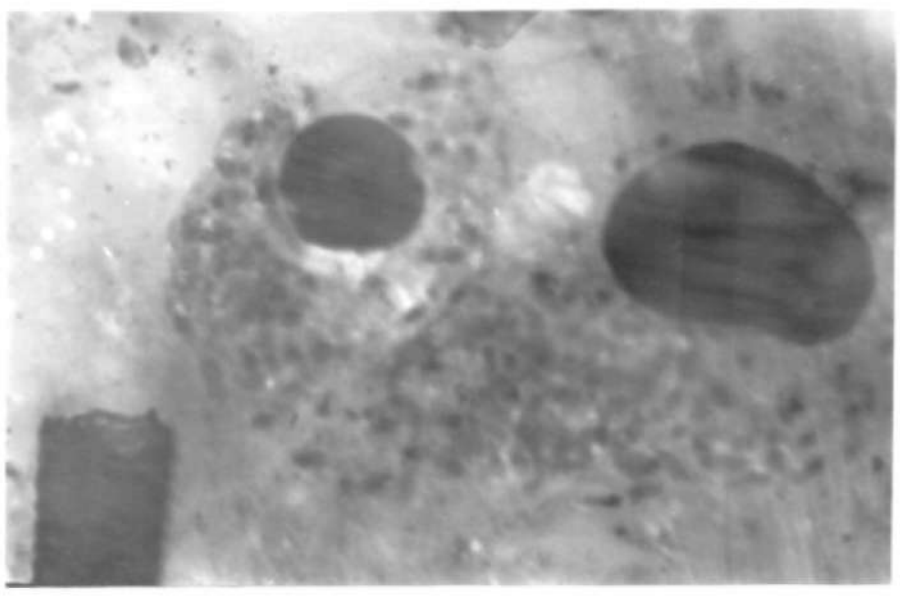
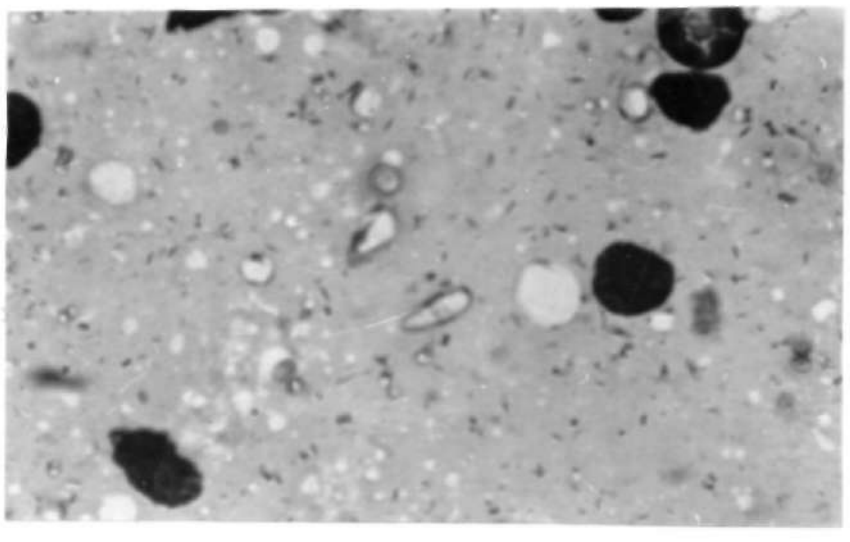


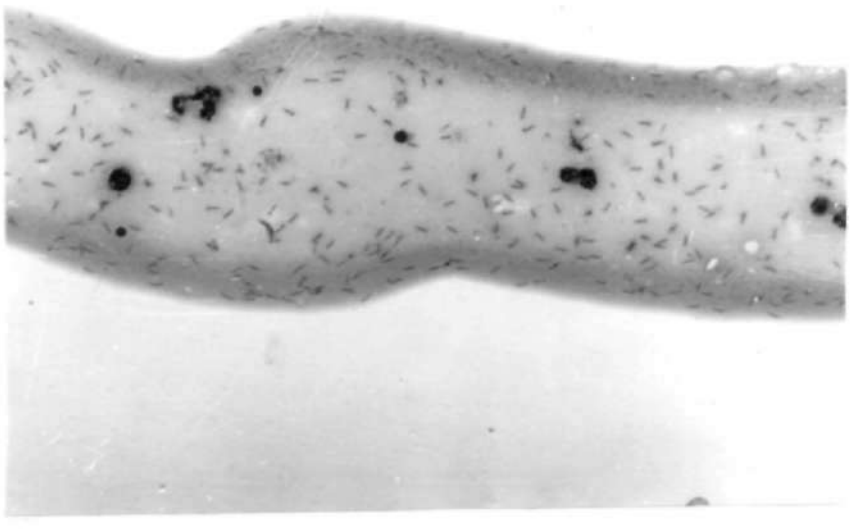
Fig. 21.

Showing elongated and round merozoites of Babesia spp. in a squash smear of larvae of B.decoloratus. Giemsa stain; x 1500.

Fig. 22.

Showing ++++ parasitaemia of Babesia spp. in the haemolymph smear of a replete female B.decoloratus. Giemsa stain; x 1500.





VII. SEASONAL INCIDENCE OF IXODID TICKS IN THE NETHERLANDS.

INTRODUCTION

The Netherlands (Holland) lies in the north-western corner of the European Continent at latitude 51 - 54°North. The total area of the country is 15,865 square miles, just about the size of Kano State in Nigeria. The climate is essentially temperate and is greatly influenced by the warm Gulf Stream. This Stream passes close to the Western Coast of the European Continent imposing cool summers and generally not too severe winters.

The Netherlands has one of the world's most prosperous dairy farming and cattle breeding industries. The national cattle population in 1971 was 4,201,000 (F.A.O., 1972). These are made up of three breeds of which the Black and White Friesian and the Meuse-Rhine-Ysel cattle (MRY) are predominant. Most of these animals live on clay soils in Friesland, North Holland and along the main rivers. The pastures are pure grassland intersected by canals and ditches for drainage. Ticks and consequently piroplasmosis are rarely observed. A considerable number of cattle, however, are kept on the sandy soils in the eastern and southern parts of the country where the vegetation is more varying and where farmland and pasture are interspaced by some moorland, fringes and woods. These are the areas where vector ticks are present and outbreaks of tickborne disease occur periodically.

The purpose of this investigation was:

1. to determine the seasonal occurrence of Ixodes ricinus in three different locations in the Netherlands i.e. Ameland in Friesland, Heino in Overysel and Maarn in Utrecht Province.

2. to report on the occurrence of Haemaphysalis punctata.

DESCRIPTION OF THE AREAS

Ameland

General

This is one of the islands situated on the Northern coast of the Netherlands. Consequently, the soil consists of sand dunes, but there are pastures for cattle grazing. One such pasture - the Oerd - has an area of 500 hectares and is situated on the eastern side of the island. Sand dunes are scattered over the pasture the main part of which is subject to floods. The Oerd, together with a wood in the neighbourhood of the town of Nes, formed the experimental area.

Climate

The climate is influenced by the sea. The average annual temperature is 9°C with 16°C in the summer and 2°C in the winter. The annual precipitation is about 700 mm with an even distribution of rainfall throughout the year. The driest season is the spring. The prevailing wind is south-westerly but during the spring dry northerly winds predominate (Dutch Agriculture, 1959).

Vegetation

The pasture of the Oerd consists of light coloured low grass represented by Amerion maritimae, Agrostis spp. and Festuca rubra. In addition, there are outcrops of high brown grass such as Juncus maritimus and Ammophila arenaria. Mosses such as Pseudoscleropodium purum and Dicranum scoparium are found growing in between the grasses. The vegetation on the sand dunes is made

up of Salix spp, Hippohide spp. and other shrubs. The wood in Nes consists of Pinus nigra and some grasses for instance Dactylis glomerata (vs) and Carex arenaia. In some areas the shrub, Sorbus acuparia is abundant (Braun-Blanquet & de Leeuw, 1936).

Husbandry

About 300 calves belonging to some 40 farmers are brought into the Oerd around 15th April each year. They remain here till 15th November when they are herded back into the stables.

Heino

General

Heino is situated in the Province of Overijsel on the mainland. The topography is flat and the soil is sandy. The experiment was carried out on a farm that is typical of farms in this area, with pasture lands surrounded by woods and fringes.

Climate

The average annual rainfall is about 750 mm. Average temperatures vary from $1^{o}C$ in the winter to $18^{o}C$ in the summer.

Vegetation

The pasture land consists of grasses made up of Poo-Lolietum association and is surrounded by woods and fringes. The fringes are almost devoid of grasses but are made up of trees such as Fraxinus quercus and shrubs for example, Sambucus spp, Prunus spp., Sorbus spp., Lonicera and Alnus spp.

The woodland consists of trees such as Pinus sylvestris, Quercus petraca, Betula pubescens and Fagus sylvatica and shrubs which include Amelanchier laevis, Sorbus aucuparia and Rubus spp. (Westhoff & Den Held, 1969).

Husbandry

There were 78 HRY milking cows and some calves on the farm. Most of the cattle graze out from April to November. With the approach of the winter, they are returned to the stables.

Maarn

General

The farm on which the experiment was conducted was also situated on a sandy soil which was extremely acidic. The grazing land contained some 15 cattle. The pasture was bordered on three of its sides by conifer or mixed woodland.

Climate

Same as in Heino.

Vegetation

As in Heino, the pasture land, consisted of an association of Poo-Lolietum grasses. The conifer woodlands were made up of Pinus, Picea and Quercus rubra trees. There were no shrubs, and herbs were few, represented only by some ferns. There were some mosses of the genus Atrichum and grasses such as Deschampsia flexuosa. The mixed woodland was made up of the same trees as mentioned above, but also consisted of shrubs such as Betula pubescens and a few ferns. The soil in this area was almost completely covered by

Deschampsia flexuosa. This grass formed a loose mat, which helped to retain the moisture of the soil. Intermingled with it was a layer of raw, humid partly decomposed plant litter (Westhoff & Den Held, 1969).

MATERIALS AND METHODS

Ameland

The Oerd was divided into 21 study blocks each of which was about 23 hectares in size, and covering the different vegetation types as much as possible (see Figures 32, 33 and Appendix IV). Ticks were surveyed once every fourtnight by dragging flannel blankets. Each blankets was 88 cm long and 80 cm broad. A piece of wood was hemmed to each of the shorter sides, while on one end a rope was fixed in a semi-circular fashion for dragging. The blankets were dragged over 25 meters of the vegetation, and turned over; they were then examined thoroughly for ticks before dragging was resumed. The investigation covered the periods from 28th April 1971 to 28th October 1971, and from 11th April 1972 to 25th October 1972. A similar survey was carried out in 1972 in the wood at Nes, but this site was not demarcated into study blocks.

Heino

The survey was conducted on cattle and on the vegetation. Four bait cattle were randomly choosen from the herd. These were examined at fourtnightly intervals when all ticks seen were removed and kept in water in small bottles, until arrival at the laboratory in Utrecht. The study on the

vegetation was confined to the edges of wood bordering the pastures, path leading to the pastures and the grazing pastures. The cattle trekked through the path twice daily for milking at the farm house. Ticks were again surveyed by dragging flannels every fourtnight as in Ameland. The investigation lasted from 23rd May 1972 to 14th November of that year.

Maarn

The tick survey here was confined to the vegetation only. Blanket drags were made specifically on grasses at the wood boarders (Figure 36), grasses in the wood, leaves on the ground in the wood and pasture with cattle grazing on it. Visits to this site were made at irregular intervals whenever the other experimental areas were not being investigated. The dragging technique was the same as in Heino and Ameland. The study lasted from 18th April 1972 to 24th October 1972 and consisted of twenty-one visits.

Climatological data for the three experimental sites were collected from the Royal Netherlands Meteorological Institute at De Bilt. Mean readings of temperature, relative humidity and wind from 0900 to 1500 hours G.M.T. on the days of tick collection were used. For Ameland, the synoptic station was Hoorn on the neighbouring island of Terschelling, some 25 km WSW of Nes. For Heino, Dedemsvaart some 20 km away to the NE was the synoptic station for recording temperatures and relative humidities, while Diepenveen 15 km to the SSW was used for recording wind force. The synoptic station nearest to Maarn was De Bilt, 10 km to the NW (see Figures 23-26).

Monthly means of temperature, relative humidity and rainfall for the three synoptic stations for the years 1951-1960 are given in form of histograms to show the pattern of the climate (see Figures 27-29). It was not possible to obtain data for the decade ending 1970 because they were still in preparation.

RESULTS

Ameland

In the course of 1971, it appeared that the prevalence of ticks was mainly restricted to study blocks 1, 7 and 8. Further studies were mostly limited to these 3 blocks. A total of 522 (or 81.6%) Ixodes ricinus and 118 (or 18.4%) Haemaphysalis punctata were collected from the Oerd in 1971. The corresponding figures for 1972 were 540 (or 97.5%) and 14 (or 2.5%) respectively (Figure 30, Table 18). All stages of I.ricinus were found over the two years but for H.punctata only larvae and adults were found in 1971 while nearly all the collections in 1972 consisted of nymphae. During six visits to Nes in 1972, 615 I.ricinus ticks were found in the wood, representing all developmental stages. No H.punctata ticks were found (Table 19).

SEASONAL INCIDENCE OF I.RICINUS

LARVAE

In 1971 on the Oerd, larvae were found to occur in July, that is during summer but the bulk were found in the autumn. In the following year, the

highest numbers were collected in May and in the autumn. Only 8 larvae were found in June.

Larvae were found in large numbers on the forest mat in the wood in May but they were also collected in the autumn.

NYMPHAE

During the 1971 survey on the Oerd, nymphae appeared only from September to October with a peak in September. In 1972 they were collected in the months of April to October.

As in the case of the larvae, the nymphae were mainly found on the sand dunes. In the wood, nymphae were also collected between April and October with a peak in May.

ADULTS

On the Oerd in 1971 male and female ticks appeared in April and lasted till July with a peak in the first week of that month. A very small rise was again observed in September. In the succeeding year, male and female ticks appeared in May and diminished in July. The peak was in May. In the wood adult ticks were mainly collected in May.

HAEMAPHYSALIS PUNCTATA

This tick occurred only on the Oerd where it was limited in distribution to blocks 1 and 8 which are situated in the borders of the Oerd (see Appendix IV).

The total number of specimens collected during the two year study period was only 118 specimens in 1971 and 13 in 1972 (Table 19). In 1971, larvae formed

the bulk of the collection in the total absence of nymphae. In 1972, only nymphae and 1 male were found; larvae and females were absent.

Heino

A total number of 3 larvae, 256 nymphae and 15 adults of I.ricinus were collected from the vegetation in Heino. The edges of wood were the most infested areas followed by the cattle pastures and the path leading to the pastures (Figure 34, Table 20). Very light infestations of I.ricinus adults were observed on the bait cattle. Larvae and nymphae were not found to parasitize the cattle. The seasonal incidence of the tick in Heino was restricted to the spring and the autumn.

Maarn

Only 406 nymphae of I.ricinus were collected from the vegetation in Heino over 6 months of survey (Figure 34, Table 21). The regions of highest infestation were the grasses at the boarders of the wood, followed by the leaves on the ground in the wood. Only three nymphae were collected from grasses inside the wood. No ticks were seen on the pastures. Their incidence was restricted to the spring.

DISCUSSION

The seasonl incidence of I.ricinus in the United Kingdom has been studied by several authors such as Macleod (1932; 1939), Milne (1945; 1947; 1950), Campbell (1950), Edwards & Arthur (1947), Evans (1951) and Lees & Milne (1951). On continental Europe, especially in Russia a great deal of work has also

been done on the seasonal incidence of the tick. A few examples are: Babenko (1956), Belozerov (1964), Kheisin (1955), Balashov (1972) and Bauch (1971; 1972) According to these reports, I.ricinus has an exclusively 3-host type of development. The larvae and nymphae parasitize small rodents, insectivores and birds, while the adults frequently feed on cattle, wild ungulates, hares and hedgehogs. Sequential investigations have shown that each developmental stage takes at least one year to complete. The minimum length of the life cycle is 3 years but may continue for as long as 6 years.

Our investigations in the Netherlands were only pilot trials in different habitats, conducted in a two-year period which is too short to justify a detailed evaluation of the seasonal incidence of I.ricinus in that country. However, this study has confirmed that the most abundant ixodid tick present in the Netherlands is I.ricinus. Arthur (1963) has reported that this tick is widely distributed in Europe and Russia. It was observed in both Ameland and Heino that I.ricinus was mainly active from March to May (spring) and from September to October (autumn). There was very little activity in August (summer). The spring activity was always greater than that in autumn. These findings are in agreement with those of Macleod (1932; 1939) and Milne (1945) who referred to the phenomenon as a bimodal type of activity. Bauch (1972) has also reached a similar conclusion in Eastern Germany.

In Maarn however, a unimodal type of activity was observed, which was similar to the findings of Arthur (1948) in mid-Wales. More work is required in Maarn to determine if ticks are really inactive in autumn.

The present study suggested that relative humidity and temperature regulate the activity of I.ricinus. We have also observed that during a strong breeze (force 6) ticks were hardly collected. In Heino, only adult ticks were seen to occur on the cattle, even though larvae and nymphae were collected from the vegetation at the same time. The immature stages of I.ricinus would therefore appear to favour small mammals as host. It was also observed that the edges of wood were the sites of greatest infestation by I.ricinus, followed closely by the cattle pastures and the paths leading to them. It is suggested therefore that woods surrounding pastures constitute important foci of infestation by I.ricinus.

On the Oerd in Ameland, ticks were very much restricted to study blocks 1, 7 & 8 and to sand-dune type of vegetation. Block I (Figure 32) was especially rich in thorny shrubs, reeds, grasses and mosses. Consequently these provide a suitable micro-climate for ticks. It is this area that yielded the greatest catches of I.ricinus. Block 8 (Figure 33) was characterized by high and low grass and an abundance of mosses. Many ticks were also collected here.

The wood in Nes (Figure 31) was densely covered by a mat of pine needles. There was an abundance of ticks in this area, especially larvae and nymphae.

Only nymphae were collected in Maarn. Their primary habitat was the grass bordering the wood (Figure 35). This grass consisted of Deschampsia flexuosa which formed a mat that conserved moisture necessary for the survival of ticks. Similarly, the leaves of the coniferous forest formed a suitable

microhabitat on the ground.

It was suggested by Friedhoff (1973) that Haemophysalis punctata is a coastal tick of the European Continent. This was confirmed in the present study where the species was only found on the Oerd of Ameland. Its absence in the wood on the same island could suggest that small mammals are not important hosts of this tick. The very localized and incidential finding of H.punctata on the Oerd might indicate that birds play an important role in its life cycle and distribution.

SUMMARY

The seasonal incidence of Ixodes ricinus was studied in three localities in the Netherlands viz, Ameland, Heino and Maarn in 1971 and 1972. In Ameland and in Maarn the survey was done on various types of vegetation, while in Heino cattle infestations were also studied.

I.ricinus was present in all three areas. Its incidence in Ameland and Heino suggested a bimodal type of activity. Only adult ticks were found on the cattle, suggesting that small mammals are the most important hosts of the immature stages. It was observed that the sand dunes in Ameland and the woods surrounding the pastures in Heino and Maarn are favourable foci of infestation by I.ricinus.

Studies in the three areas on the prevalence of Haemaphysalis punctata confirmed that this is a coastal tick species. Birds may play an important role in its life cycle and distribution.

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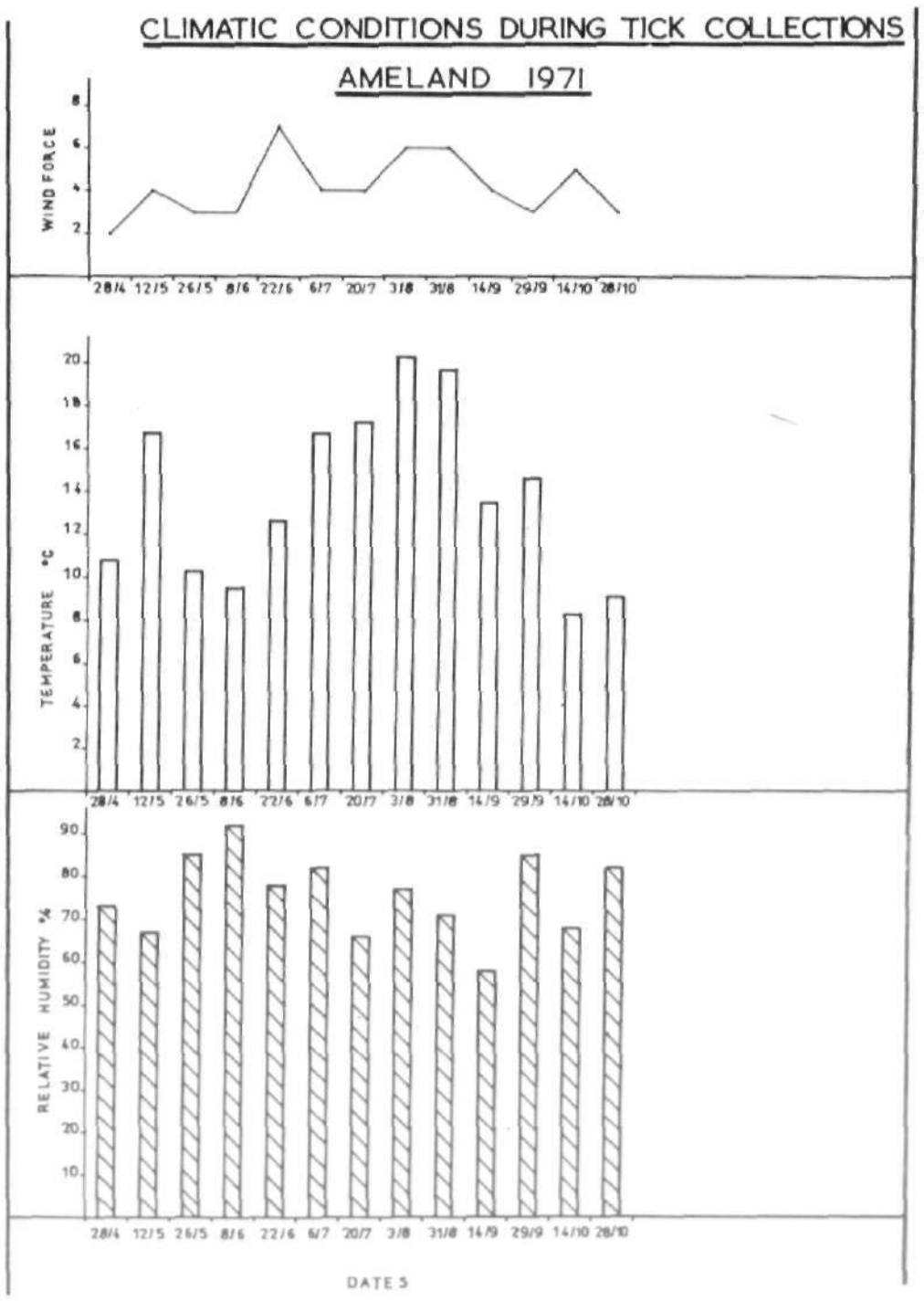
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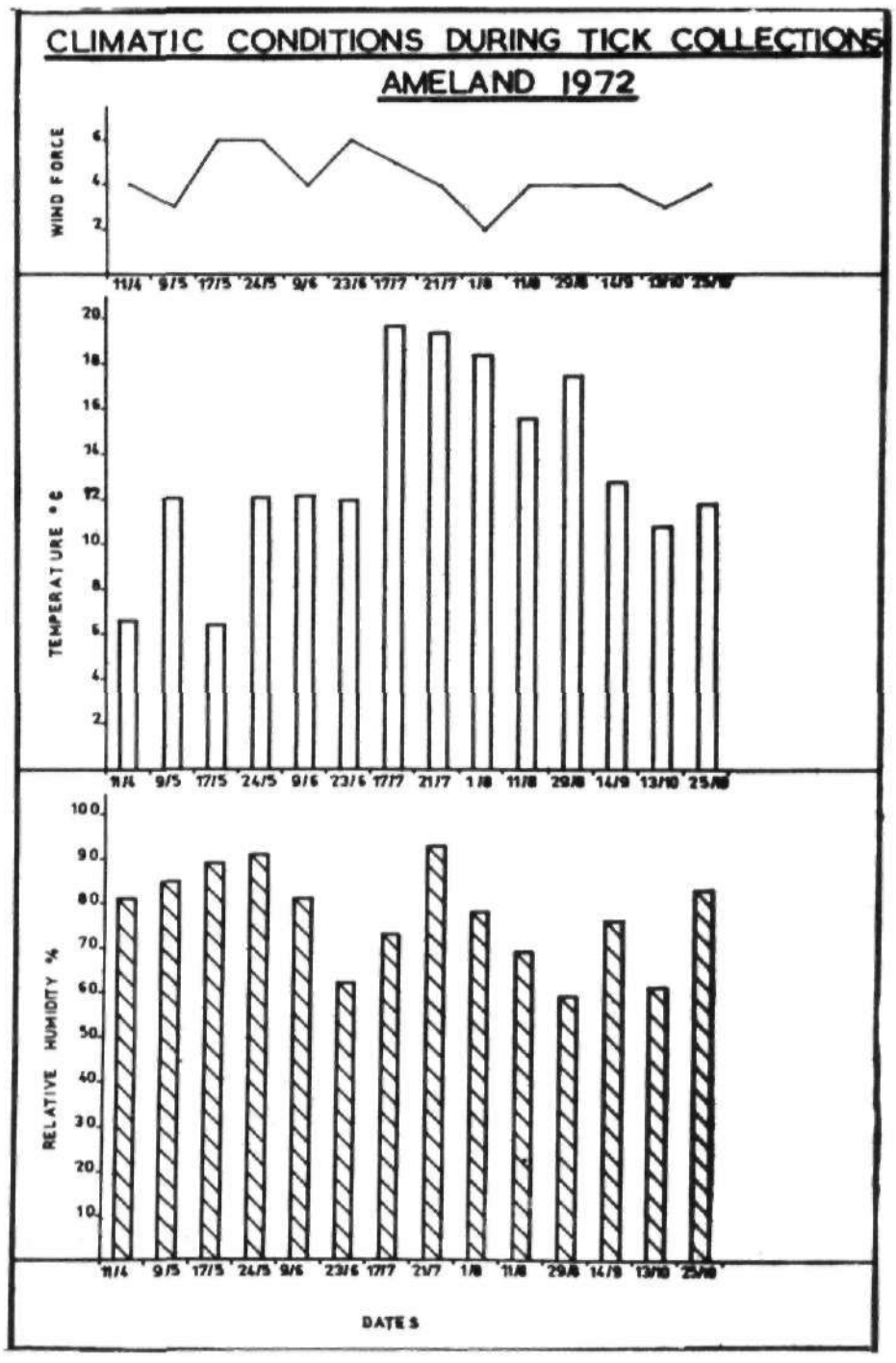
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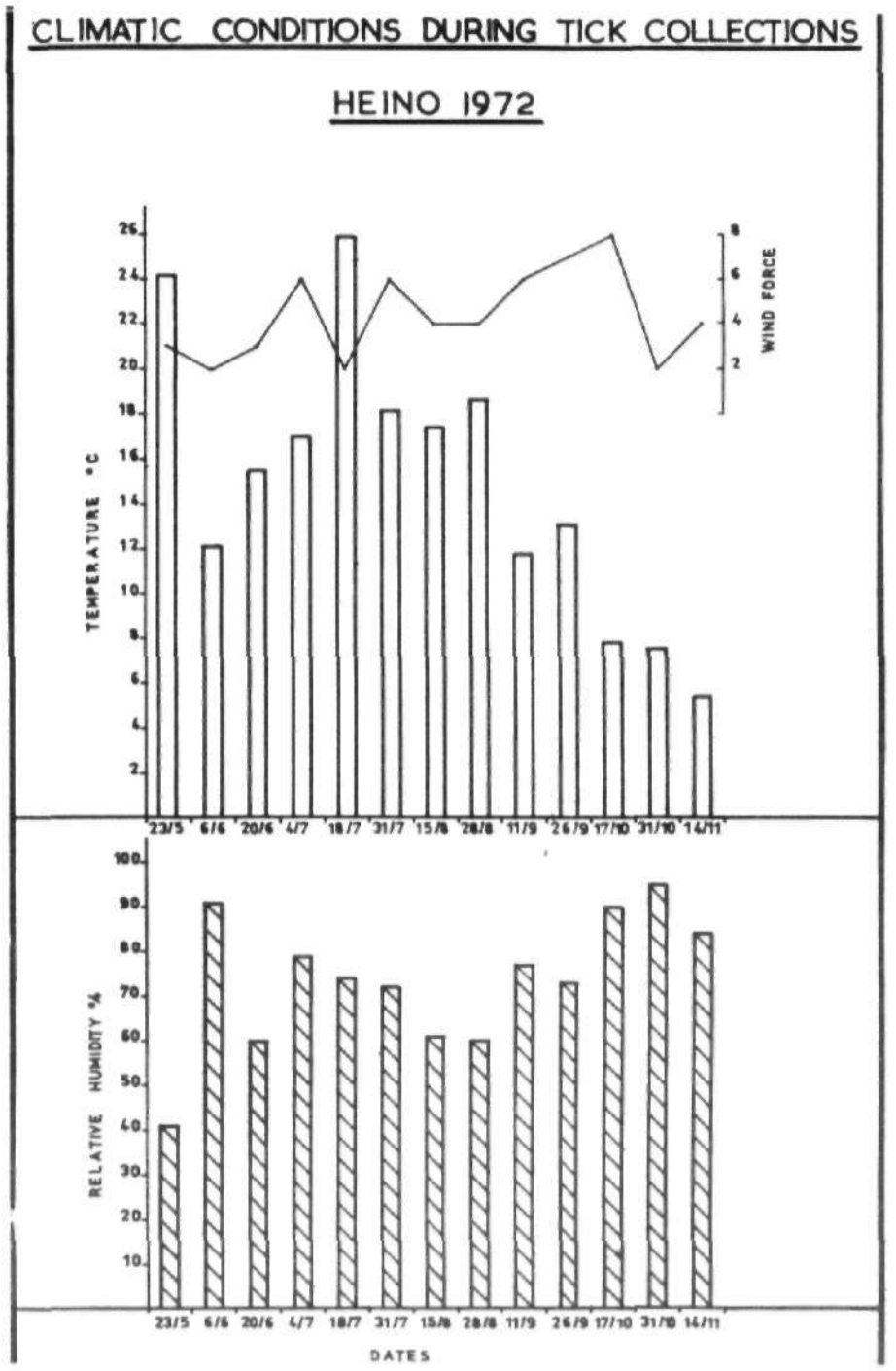
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CLIMATIC CONDITIONS DURING TICK COLLECTIONS
AMELAND 1971
WIND FORCE
TEMPERATURE °C
RELATIVE HUMIDITY %
28/4 12/5 26/5 8/6 22/6 6/7 20/7 3/8 31/8 14/9 29/9 14/10 28/10
DATE S


CLIMATIC CONDITIONS DURING TICK COLLECTIONS
AMELAND 1972
WIND FORCE
TEMPERATURE °C
RELATIVE HUMIDITY %
11/4 9/5 17/5 24/5 9/6 23/6 17/7 21/7 1/8 11/8 29/8 14/9 13/10 25/10
DATES


CLIMATIC CONDITIONS DURING TICK COLLECTIONS
HEINO 1972
TEMPERATURE °C
WIND FORCE
RELATIVE HUMIDITY %
23/5 6/6 20/6 4/7 18/7 31/7 15/8 28/8 11/9 26/9 17/10 31/10 14/11
DATES

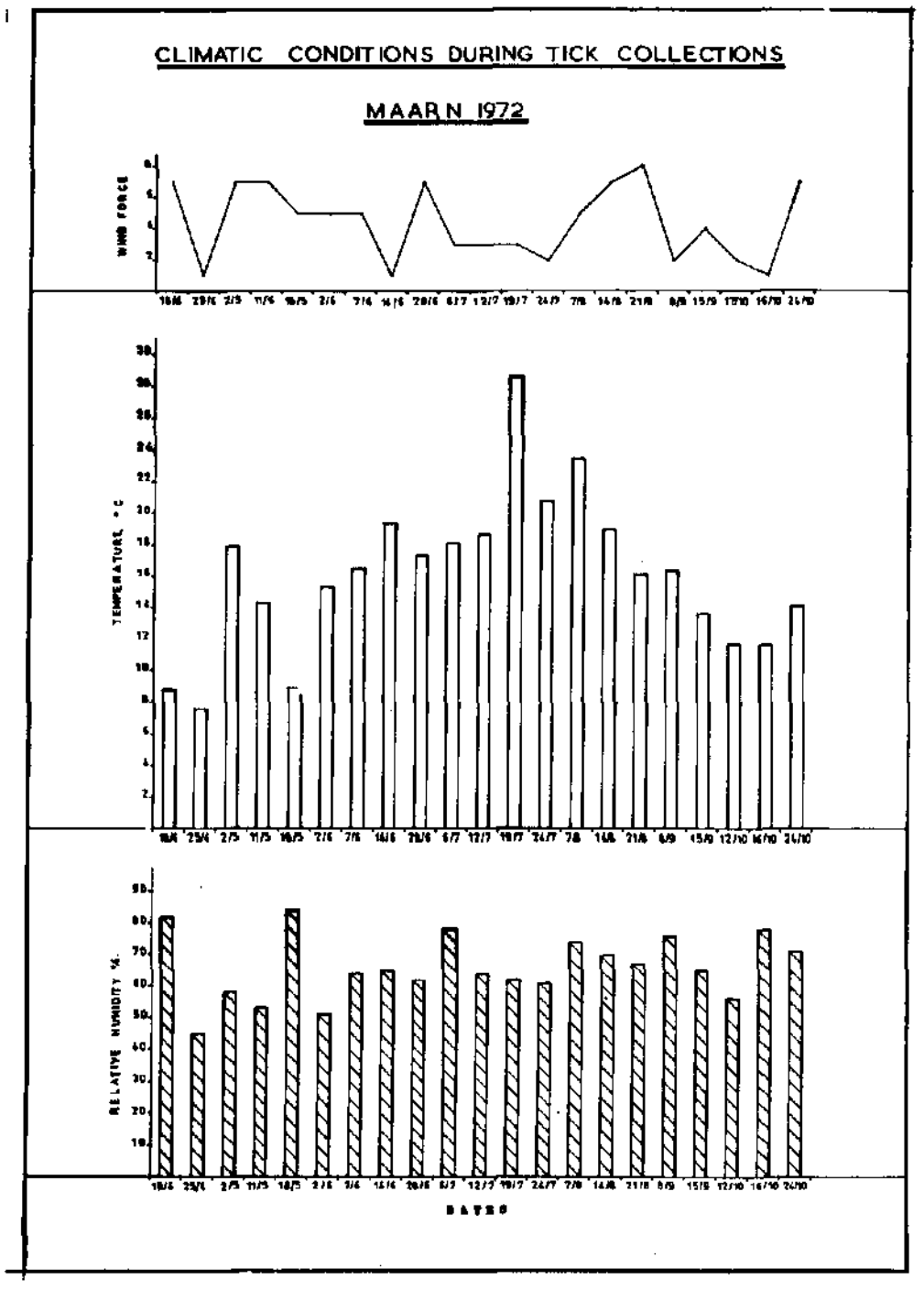

CLIMATIC CONDITIONS DURING TICK COLLECTIONS
MAARN 1972
WIND FORCE
TEMPERATUREL °C
RELATIVE HUMIDITY %.
DATES

Fig. 27. Monthly averages of temperature, relative humidity and rainfall for Hoorn on the island of Terschelling for 1951-1960. Terschelling lies to the west of Ameland.

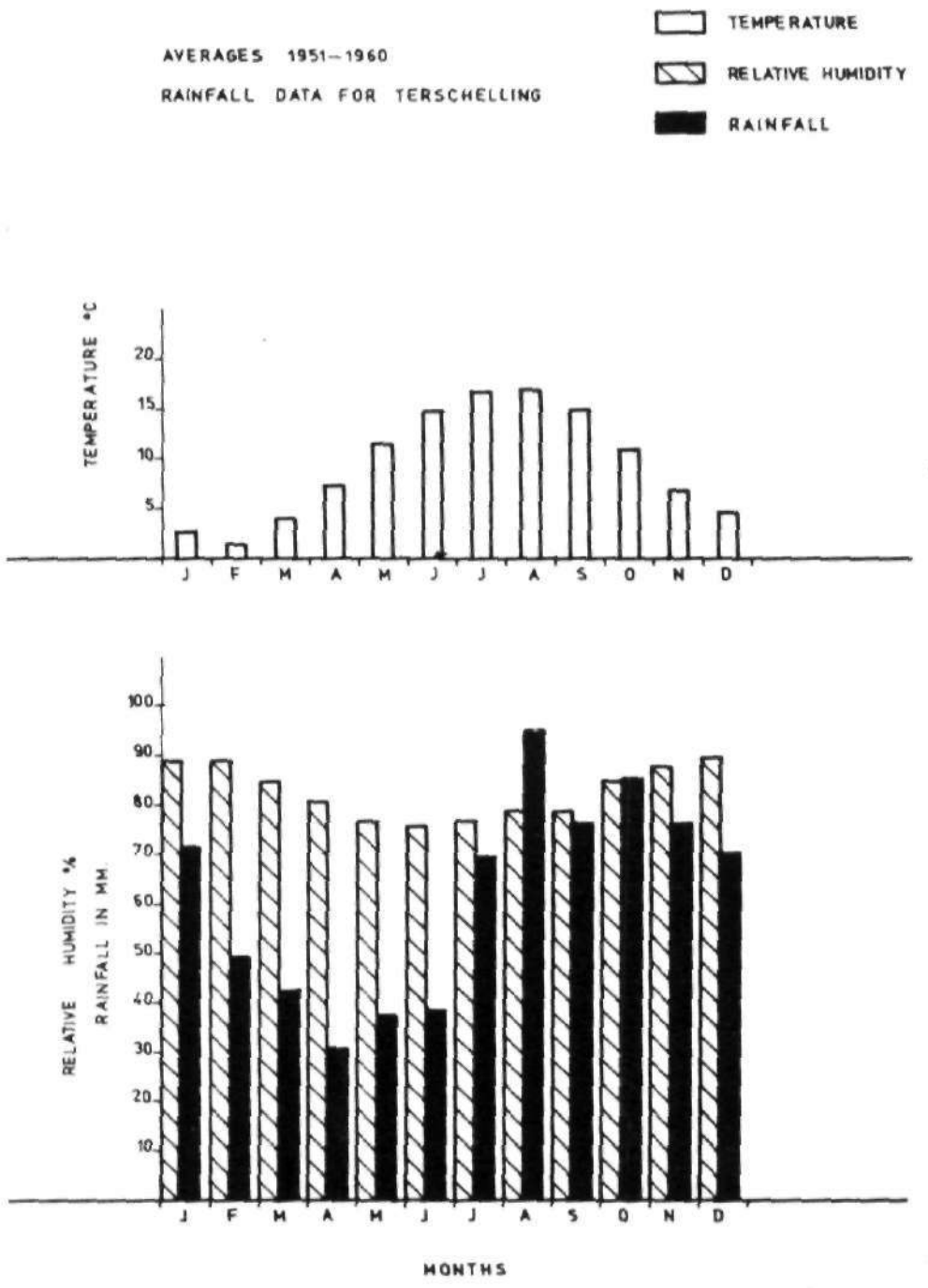

AVERAGES 1951–1960
RAINFALL DATA FOR TERSCHELLING
TEMPERATURE
RELATIVE HUMIDITY
RAINFALL
TEMPERATURE °C
20
15
10
5
J F M A M J J A S O N D
RELATIVE HUMIDITY %
RAINFALL IN MM
100
90
80
70
60
50
40
30
20
10
J F M A M J J A S O N D
MONTHS

Fig. 28.

Monthly averages of temperature, relative humidity and rainfall in Dedemsvaart for 1951-1960. Dedemsvaart is the synoptic station nearest to Heino.

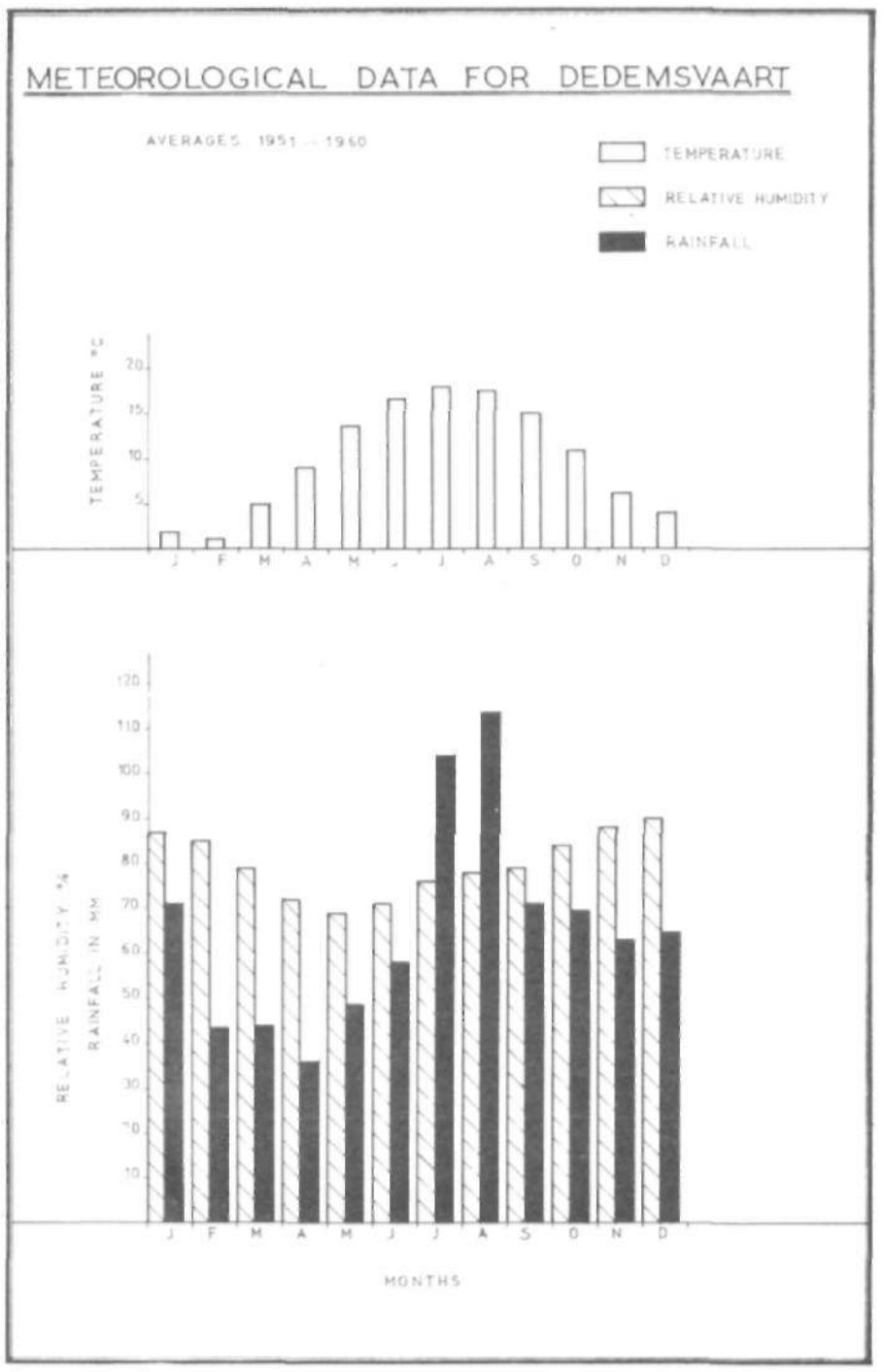

METEOROLOGICAL DATA FOR DEDEMSVAART
AVERAGES 1951 - 1960
TEMPERATURE
RELATIVE HUMIDITY
RAINFALL
TEMPERATURE °C
20
15
10
5
J F M A M J J A S O N D
120
110
100
90
80
70
60
50
40
30
20
10
RELATIVE HUMIDITY %
RAINFALL IN MM
J F M A M J J A S O N D
MONTHS

Fig. 29.
Monthly averages of temperature, relative humidity and rainfall in De Bilt for 1951-1960. De Bilt is the synoptic station nearest to Maarn.

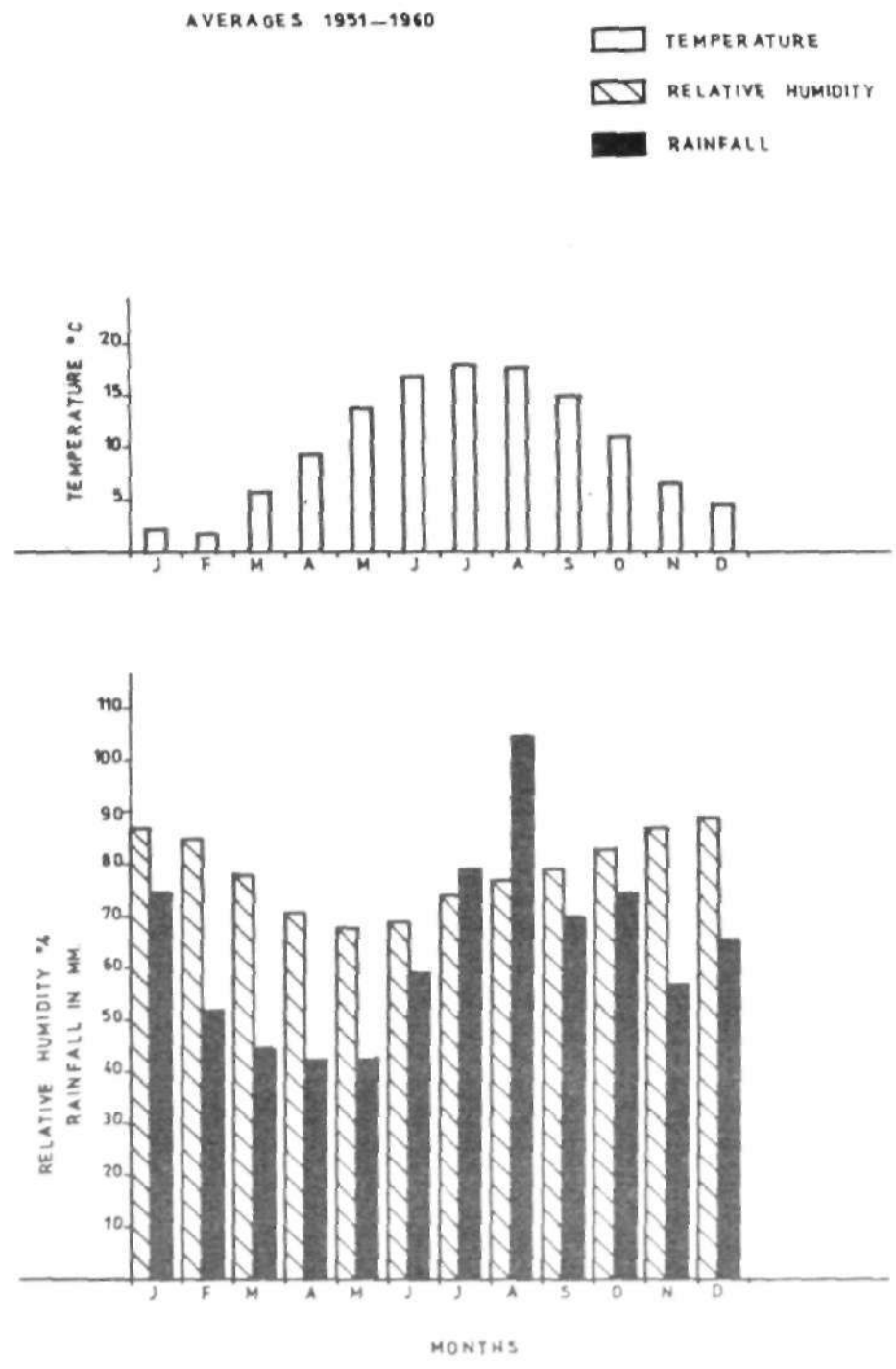

AVERAGES 1951—1960
TEMPERATURE
RELATIVE HUMIDITY
RAINFALL
TEMPERATURE °C
20
15
10
5
J F M A M J J A S O N D
110
100
90
80
70
60
50
40
30
20
10
RELATIVE HUMIDITY %
RAINFALL IN MM
J F M A M J J A S O N D
MONTHS

Fig. 30.
The seasonal incidence of Ixodes ricinus on the Oerd in Ameland. (1971 & 1972)

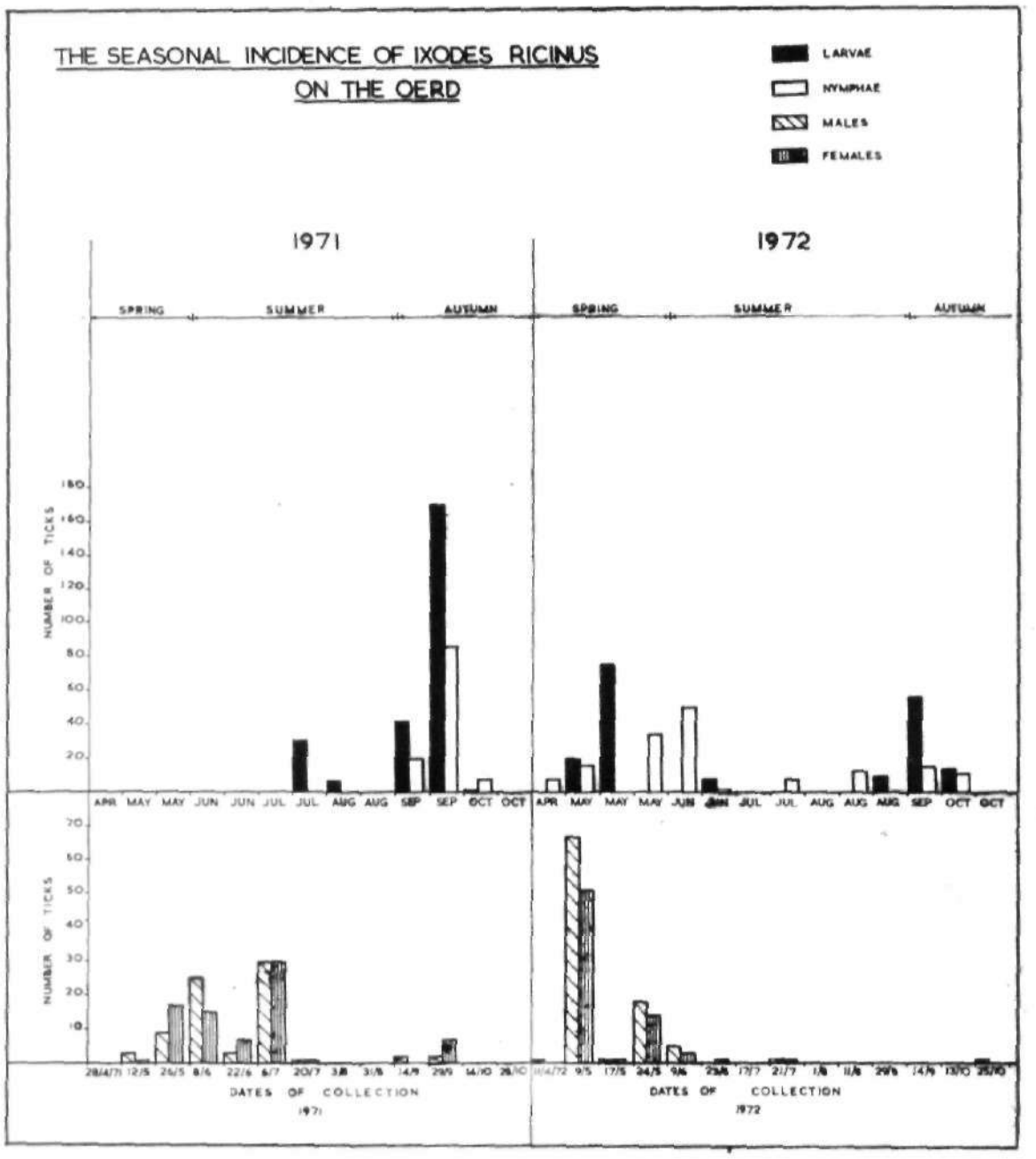

THE SEASONAL INCIDENCE OF IXODES RICINUS
ON THE OERD
LARVAE
NYMPHAE
MALES
FEMALES
1971
1972
SPRING
SUMMER
AUTUMN
NUMBER OF TICKS
APR MAY MAY JUN JUN JUL JUL AUG AUG SEP SEP OCT OCT
APR MAY MAY MAY JUN JUL JUL AUG AUG SEP OCT OCT
28/4/71 12/5 26/5 8/6 22/6 6/7 20/7 3/8 31/8 14/9 29/9 14/10 28/10
DATES OF COLLECTION
1971
11/4/72 9/5 17/5 24/5 9/6 17/7 21/7 1/8 11/8 29/8 14/9 13/10 25/10
DATES OF COLLECTION
1972

TABLE 18

SEASONAL INCIDENCE OF IXODID TICKS ON THE OERD (1971 & 1972)

	IXODES RICINUS					HAEMAPHYSALIS PUNCTATA				
DATE	L	N	M	F	T	L	N	M	F	T
28/4/71	0	0	0	1	1	0	0	1	1	2
12/5/71	0	0	3	1	4	0	0	1	1	2
26/5/71	0	0	9	17	26	0	0	0	23	23
8/6/71	0	0	25	15	40	0	0	2	2	4
22/6/71	0	0	3	7	10	0	0	0	0	0
6/7/71	0	0	30	30	60	0	0	2	2	4
20/7/71	32	0	1	1	34	0	0	0	1	1
3/8/71	7	0	0	0	7	0	0	0	0	0
31/8/71	1	0	0	0	1	82	0	0	0	82
14/9/71	42	20	2	0	64	0	0	0	0	0
29/9/71	170	86	2	7	265	0	0	0	0	0
14/10/71	2	8	0	0	10	0	0	0	0	0
28/10/71	0	0	0	0	0	0	0	0	0	0
TOTALS	254	114	75	79	522	82	0	6	30	118
11/4/72	0	8	1	0	9	0	0	0	0	0
9/5/72	20	16	67	51	154	0	1	0	0	1
17/5/72	75	1	1	1	78	0	0	0	0	0
24/5/72	0	35	18	14	67	0	0	1	0	1
9/6/72	0	50	19	21	90	0	8	0	0	8
23/6/72	8	2	0	1	11	0	4	0	0	4
17/7/72	0	0	0	0	0	0	0	0	0	0
21/7/72	0	8	1	1	10	0	0	0	0	0
1/8/72	0	1	0	0	1	0	0	0	0	0
11/8/72	0	13	0	0	13	0	0	0	0	0
29/8/72	10	0	0	0	10	0	0	0	0	0
14/9/72	56	15	0	0	71	0	0	0	0	0
13/10/72	14	11	0	0	25	0	0	0	0	0
25/10/72	0	0	1	0	1	0	0	0	0	0
TOTALS	183	160	108	89	540	0	13	1	0	14

L = larvae
N = nymph
M = male
F = female

TABLE 19

INCIDENCE OF IXODES RICINUS

IN THE WOOD - NES

DATE	L	N	M	F	T
11/4/72	0	8	1	0	9
24/5/72	356	108	18	14	496
11/8/72	0	13	0	0	13
14/9/72	56	15	0	0	71
13/10/72	14	11	0	0	25
25/10/72	0	0	1	0	1
TOTALS	426	155	20	14	615

L = larvae

N = nymph

M = male

F = female

T = total

Fig. 31.
Vegetation of the wood at Nes, Ameland showing the forest mat.

Fig. 32.
Vegetation of study block I in the Oerd, Ameland.





Fig. 33.
Vegetation of study block 8 in the Oerd, Ameland.



Fig. 34.

The seasonal incidence of Ixodes ricinus on cattle and on the vegetation in Heino.

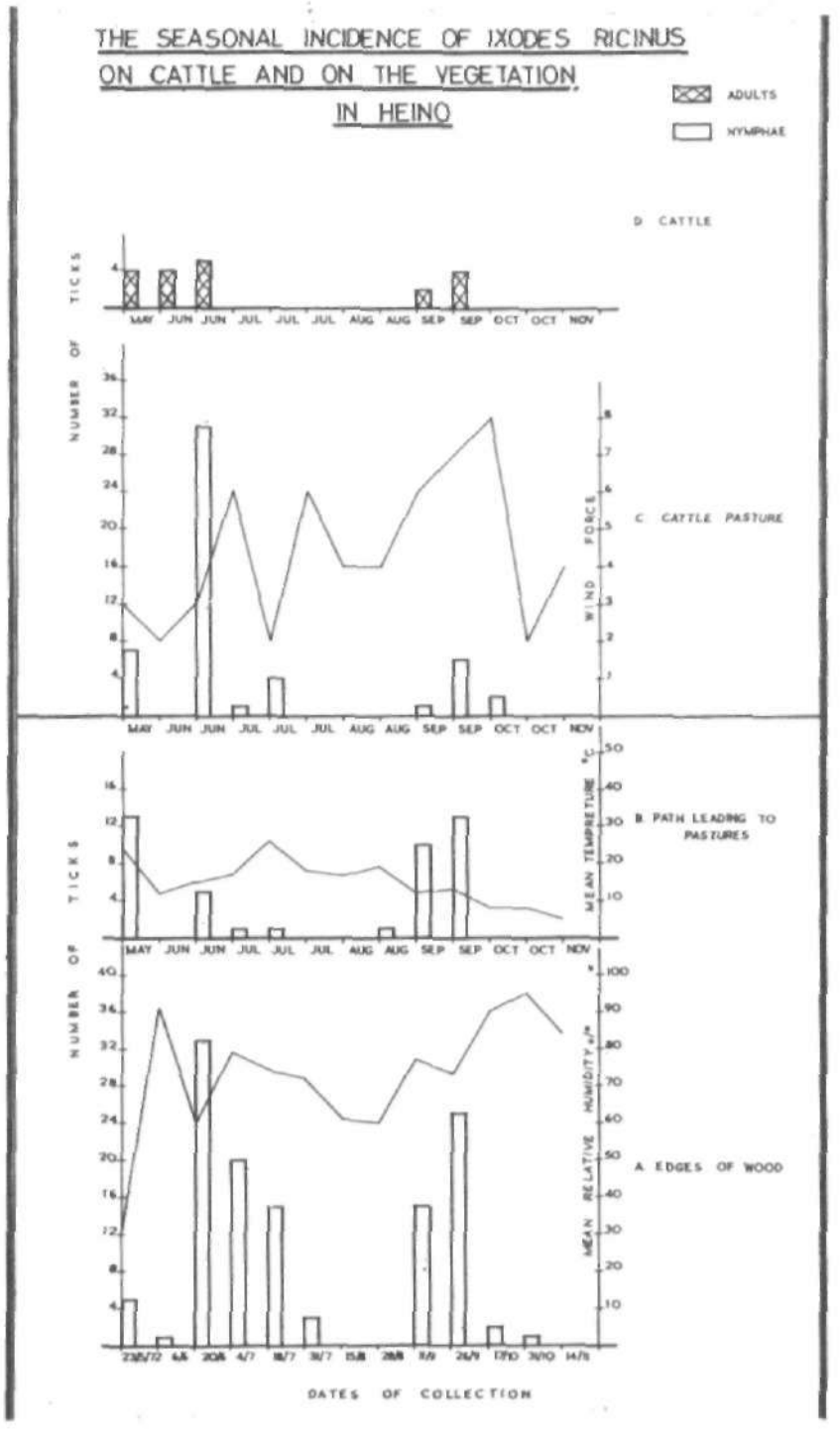

THE SEASONAL INCIDENCE OF IXODES RICINUS ON CATTLE AND ON THE VEGETATION IN HEINO
ADULTS
NYMPHAE
D CATTLE
NUMBER OF TICKS
MAY JUN JUN JUL JUL JUL AUG AUG SEP SEP OCT OCT NOV
C CATTLE PASTURE
WIND FORCE
B PATH LEADING TO PASTURES
MEAN TEMPRETURE °C
A EDGES OF WOOD
MEAN RELATIVE HUMIDITY %
23/5/72 6/6 20/6 4/7 18/7 31/7 15/8 28/8 11/9 26/9 17/10 31/10 14/11
DATES OF COLLECTION

TABLE 20

THE SEASONAL INCIDENCE OF IXODES RICINUS ON CATTLE AND ON THE VEGETATION IN HEINO

DATE	CATTLE																VEGETATION											
	LETTA 3				LETTA 11				LETTA 13				LETTA 19				EW				PLP				CP			
	L	N	M	F	L	N	M	F	L	N	M	F	L	N	M	F	L	N	M	F	L	N	M	F	L	N	M	F
23/5/72	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	5	0	0	0	13	0	0	0	7	1	0
6/6/72	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	1	1	1	0	0	0	0	0	0	0	0
20/6/72	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	2	33	1	1	0	5	0	0	0	31	0	0
4/7/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	1	0	0	0	1	0	0
18/7/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	1	0	0	0	4	0	0
31/7/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
15/8/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28/8/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0
11/9/72	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	15	0	2	0	10	0	0	0	1	0	0
26/9/72	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	25	0	0	0	13	0	0	0	6	4	2
17/10/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0
31/10/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14/11/72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	0	0	2	5	0	0	1	1	0	0	0	2	0	0	0	7	3	120	2	5	0	44	0	0	0	52	6	2

EW = Edges of wood
PLP = Path leading to pasture
CP = Cattle pasture

L = Larva
N = Nymph
M = Male
F = Female

Fig. 35.
The seasonal incidence of Ixodes ricinus nymphae on the vegetation in Maarn.

THE SEASONAL INCIDENCE OF IXODES RICINUS NYMPHAE ON THE VEGETATION IN MAARN

(FOUR PERSONS EACH DRAGGING A BLANKET FOR FOUR HOURS)

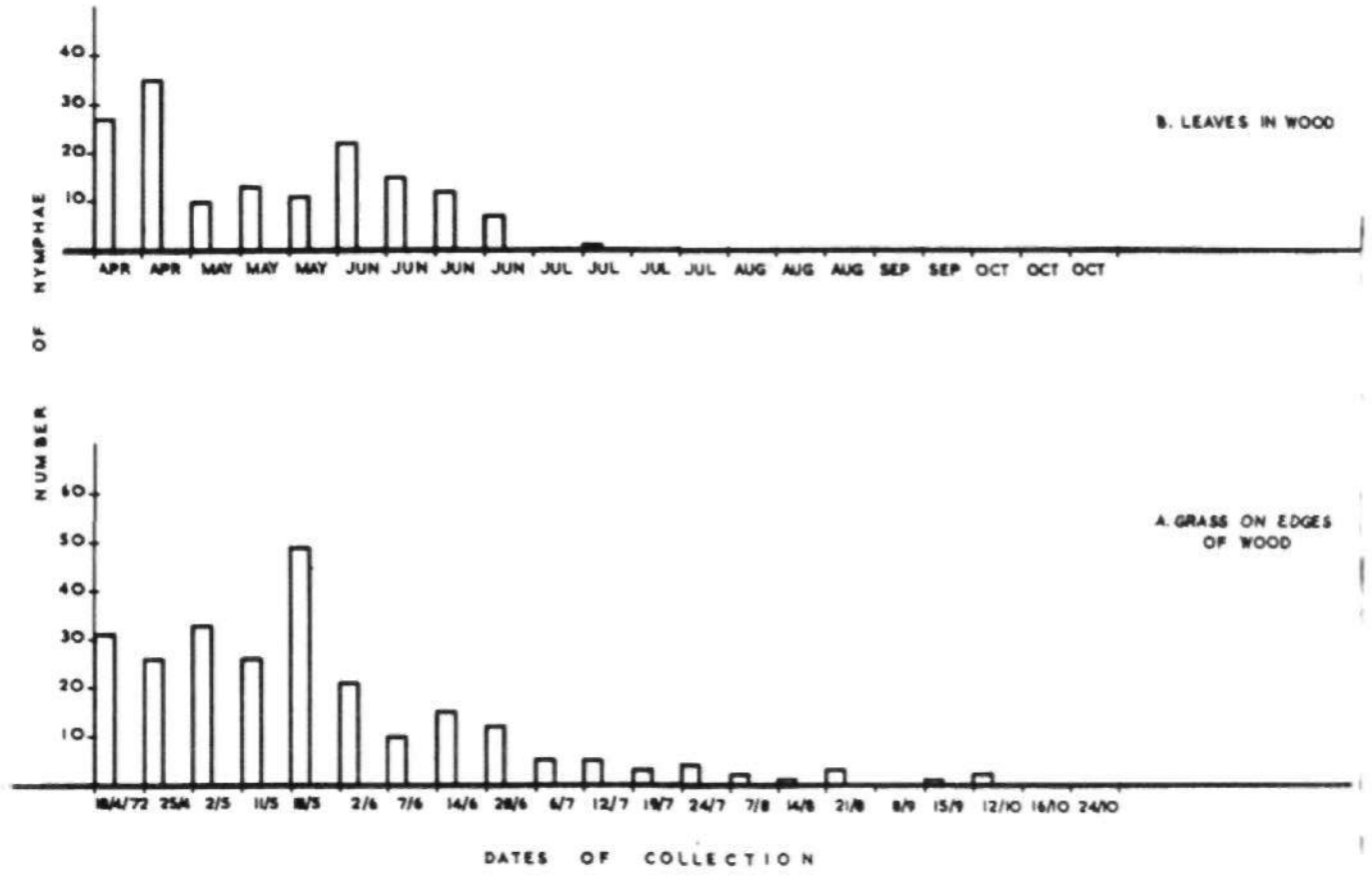


TABLE 21

SEASONAL INCIDENCE OF IXODES RICINUS NYMPHAE ON THE VEGETATION IN HAARN

DATE	grasses at wood boarders	grasses in the wood	leaves on ground in wood
18/4/72	31	0	27
25/4/72	26	0	35
2/5/72	33	0	10
11/5/72	26	0	13
18/5/72	49	2	11
2/6/72	21	1	72
7/6/72	10	0	15
14/6/72	15	0	12
28/6/72	13	0	7
6/7/72	5	0	0
12/7/72	5	0	1
19/7/72	3	0	0
24/7/72	4	0	0
7/8/72	2	0	0
14/8/72	1	0	0
21/8/72	3	0	0
8/9/72	0	0	0
15/9/72	1	0	0
12/10/72	2	0	0
16/10/72	2	0	0
24/10/72	0	0	0
TOTALS	250	3	153

Fig. 36. Vegetation type on the edges of the wood in Maarn, showing the grass Deschampsia flexuosa.



VIII. PREVALENCE AND EXPERIMENTAL TRANSMISSION OF BOVINE PIROPLASMS IN THE NETHERLANDS

INTRODUCTION

Ruil (1967) listed the blood parasites of cattle in the Netherlands and included

Babesia divergens McFadyean & Stockman, 1911

Babesia major Sergent et al., 1926

Ehrlichia phagocytophilia Foggie, 1951

Eperythrozoon wenyoni Adler and Ellenboger, 1934

Eperythrozoon teganodes Hoyte, 1962

Since then *Eperythrozoon tuomii* Uilenberg, 1962 was isolated by Zwart et al. (1969) and *Borrelia theileri* Laveran, 1903 by Schillhorn van Veen & Leyendekkers (1971).

Wilson (1964) evaluated the occurrence of the two *Babesia* species of cattle in different provinces in the Netherlands by pooling blood and inoculating it into splenectomized calves at the Institute for Tropical and Protozoan Diseases in Utrecht. He concluded that both *B.major* and *B.divergens* occurred among the cattle in Ameland, Groningen and Zeeland. Hommerij (1964) also isolated *B.divergens* from cattle grazing on a permanent pasture in the centre of Ameland.

The purpose of this investigation was:

(i) to determine the prevalence of piroplasms and other blood parasites in cattle in Ameland, Heino and Heppel (see Appendix III).

(ii) to rear ticks for transmission studies

(iii) to study the role of field and laboratory reared ticks in the transmission of B.major and B.divergens.

MATERIALS AND METHODS

a) Pooled blood inoculation

Blood was collected from 20 Friesian calves in Ameland on 10th August 1971 and 17th December 1971 i.e. after the cattle have been exposed to the spring and autumn activities of ticks (see Chapter VII). Heparin 10IU/ml[x] was used as an anticoagulant. Thick and thin blood smears were also made from the ears of the cattle bled.

Individual blood samples were stored in a coolbox during the journey back to Utrecht. There, they were pooled and inoculated intravenously into splenectomized calves (Table 22). Pre-inoculation, blood values such as Haemoglobin, White Cell Counts and Packed Cell Volume (PCV) were determined. After inoculation, thin blood smears from the calves were made daily and PCV readings were taken regularly from the appearance of parasites. Temperature was recorded daily. Each calf was controlled for a minimum of 21 days after inoculation. In addition, a total number of six inoculations of pooled blood collected from cattle in Meppel and Meino were done between 30th July 1971 and 4th November 1972 (Table 22).

b) Transmission trials with field ticks

Ticks were sampled from the vegetation by dragging flannel blankets.

[x] Sodium heparin U.S.P.

Seven batches of ticks originated from Ameland, while one came from Heino. Out of the eight batches seven were I.ricinus and one was H.punctata adults. Out of the seven batches of I.ricinus three consisted of adults, three of nymphae and one of larvae (Table 23). The ticks were fed on splenectomized calves in ear bags. The calves were controlled as above.

c) Laboratory maintenance of ticks.

Incubation

A breeding chamber made of perspex material and measuring 45 cm x 20 cm was provided with a false bottom of rust-free iron netting to a height of 6 cm The bottom was filled with a 41% solution of Potassium hydroxide in order to provide a relative humidity of +80% inside the chamber. A Lambrecht hygrometer and a thermometer (scale -20°C to +35°C) recorded the relative humidity and temperature respectively. The temperature in the breeding chamber was not thermostatically regulated, but varied between 15°C and 25°C. I.ricinus and H.punctata were bred in the chamber which was supplied with fluorescent light for a minimum of 18 hours daily.

Ticks collected from the field or those engorged on laboratory hosts were first washed in physiological saline and thoroughly dried on tissue paper. They were then transferred to labelled perper tubes measuring 5 cm high and diameter 3.4 cm. The top of each tube was covered with a piece of netting and a plastic cork which was perforated to allow air in. In order to avoid fungal infestation, the ticks and their tubes were washed in physiological saline monthly.

Feeding

The hedgehog, Erinaceus roumanicus and calves were used as host. The hedgehog was infested with either larvae or nymphae in a bag in which it was restrained for 30 minutes. At the end of this period most of the ticks attached to the animal, which was then returned to its cage over a tray of water. Searching the water for engorged ticks commenced on the third day after infestation.

Ticks were fed on calves by allowing them to attach to the ear in bags. Wherever possible, an equal number of males and females not exceeding 50 individuals of either sex was applied to the ear. The number of nymphae per ear was limited to 750. The precise number of larvae applied to each ear was not determined. However it was assumed that a fully engorged female produced about 2000 larvae, and not more than the larval progeny from two females were applied to each ear.

RESULTS

a) Pooled blood inoculations

The results presented in Table 22, show that cattle in Ameland harboured B.major and E.phagocytophilia in their blood. The first isolation of these parasites was confirmed when the blood was sub-inoculated into calf 172 on 16th August 1971.

[redacted]

b) Transmission trials with field ticks.

No parasites were detected from the blood of the calves except for E.phagocytophilia seen in calf 188 and transmitted by nymphae of I.ricinus (Table 23). The adults that moulted from these nymphae did not transmit E.phagocytophilia.

c) Laboratory maintenance of ticks

Feeding of ticks

A total of 42 batches of I.ricinus were fed either on calves or on the hedgehog. Table 24 shows that adult ticks fed on calves for 6-9 days with one exception of 11 days. The percentage of engorged ticks recovered varied from 10.71% to 100.00%. When the same calf was used again for feeding within a period of four weeks, tick recovery was markedly poor (see batch 4, compared to batch 3).

Nymphae became replete on calves in 3-7 days. However, when large numbers were applied to the ear, recovery of engorged ticks was not always very satisfactory (Table 25). Recovery was poor from calf 193 which was used

December, at a time it was about to go into natural hybernation, no replete ticks were recovered even though the animal was maintained at 22°C.

Oviposition to hatching

Table 27 shows the duration of oviposition and larval emergence of replete individual females from batches 3, 6 & 5 which were incubated in the breeding chamber under similar conditions of temperature and relative humidity, but varying degrees of photoperiodicity.

Metamorphosis: larva to nymph to adult

Moulting from larva to nymph and from nymph to adult was greatly influenced by photoperiodism. Table 28 shows that the premoulting period of larvae lasted from 73 to 161 days in the absence of light. When artificial light was supplied for 18 hours a day, the premoulting period was 30-48 days. The results suggested that the percentage moult was not affected by light. Similarly the premoulting period of nymphal to the adult stage was 83-105 days in the absence of artificial light, but 22-36 days when light was made available. Again the percentage moult was high in all cases irrespective of light except in batch 14 (Table 29).

Ten batches of all developmental stages of H.punctata were fed on calves. Table 30 shows that the duration of feeding of adult ticks varied from 10-25 days, and the percentage recovery of replete females was poor in three of the four batches. Nymphae engorged in 4-10 days while larvae took 4-12 days. Recovery of engorged ticks was below 60% in seven of the ten batches.

Fourteen replete females of H.punctata from batches 1, 2 & 3, were incubated in the tropical room in the dark at 25°C and 70-80% relative humidity. The pre-oviposition and pre-hatching periods are shown below:

Batch 1	Female No.	Pre-oviposition period in days	Pre-hatching period in days
	1	5	25
	2	5	20
	3	5	20
	4	5	20

Batch 2	Female No.	Pre-oviposition period in days	Pre-hatching period in days
	1	10	-
	2	10	-
	3	10	-
	4	10	-
	5	10	-
	6	10	-
	7	10	-

Batch 3	Female No.	Pre-oviposition period in days	Pre-hatching period in days
	1	31	55
	2	31	55
	3	31	55

In batch 2 eggs from all the females were attacked by a fungus and were therefore discarded. When 293 larvae from batches 1-3 were incubated in the tropical room, 218 (or 74.4%) nymphae moulted in 11-27 days.

96 nymphae from batches 5 & 6 (Table 30) were similarly incubated, and 91 adults (or 94.70%) emerged in 18-21 days. They consisted of 29 males and 62 females.

d) Transmission trials with laboratory reared ticks

I.ricinus larvae, nymphae and adults which were collected from Ameland and fed on splenectomized calves 192, 193 & 189 respectively, with negative results (Table 23) were reared in the laboratory and their progeny used for experimental transmission of B.divergens and B.major.

Figure 37, Table 31, show that two attempts were made to initiate infections of B.divergens in larvae and one each in nymphae and adults by feeding the ticks on infected calves. Batches 3 & 4 were fed on calves 184 and 188 respectively, and engorged larvae were recovered coinciding with the height of parasitaemia. The nymphae that moulted from these larvae were fed on splenectomized calf 208. At the end of the 21 day control period no B.divergens was detected in the blood of this calf (Table 33). Similarly engorged nymphae of batch 7 were recovered during patent parasitaemia from calf 192. Adult ticks that moulted from these nymphae did not transmit B.divergens when infested on calf 214 (Table 34).

36 replete females (batch 9) recovered from calf 188 that was infected with B.divergens by needle passage (Table 31),were individually examined for

merozoites in the haemolymph on alternate days after engorgement. The eggs laid by these females were also examined. On day 41 after repletion, structures that looked like merozoites of Babesia were seen in egg smears laid by five females (positive ticks) (Figure 38). Up till then haemolymph smears from all ticks were negative. But on day 51 merozoites of B.divergens were observed in the haemolymph of female number 5 (Figure 39). Eggs laid by the five females were pooled together and on hatching the larvae were infested on calf 205 (Figure 37, Table 32). Seven days later B.divergens was detected in the blood of the calf. 600 nymphae that moulted from these infected larvae were infested on calf 215 (Table 33). Again seven days after infestation B.divergens was detected in its blood (Figure 37). Adults moulting from these nymphae did not pass on the infection.

It can be seen from Figure 40, Table 31 that four attempts were made to initiate infections of B.major in larval, nymphal and adult stages of I.ricinus by feeding them on infected calves (two with larvae, and one each with nymphae and adults). Squash smears of engorged larvae and nymphae from calf 193 were made 24 hours after they had dropped and then daily for three weeks (batches 6 & 8). Merozoites of B.major some of which differred from blood forms were seen during the first two weeks after repletion (Figures 41 & 42). Squash smears made later indicated that the parasites were undergoing degeneration. The nymphae and adults that moulted from these batches were tested on calves 210 and 214 with negative results (Tables 33 & 34).

The larval progeny of replete females (batch 10) that engorged on calf

186 (B.major) were tested on calf 206 with negative results (Table 32, batch 10). A second attempt to infect calf 206 with larvae of the same batch also failed. Some of the engorged larvae recovered were crushed in physiological saline and injected intravenously into the same calf, still with negative results. When this calf was challenged with blood known to be infected with B.major it developed a high temperature and parasites were subsequently detected. It was felt that most of the replete females that engorged on calf 186 (Figure 40) had reached repletion when parasitaemia was not patent and were consequently uninfected. A second attempt to infect adult ticks with B.major on calf 212 was therefore made. Engorged ticks were recovered during very high parasitaemia (Figure 40), but these laid only a few eggs many of which eventually died.

Larvae and nymphae of H.punctata were allowed to feed on separate ears of calf 172 which was infected with B.major (Table 31). The nymphae and adults that moulted from these were tested on calves 167 and 165 respectively. No parasites were detected in calf 167, but calf 165 was positive for T.mutans (Table 34).

DISCUSSION

Wilson (1964) reported that B.major was apparently widespread in cattle in the Netherlands. He isolated the parasite from cattle in such widely separated but all coastal areas as Ameland, Groningen and Zeeland. B.divergens was also isolated from these areas. He observed that B.divergens was

more difficult to isolate even in splenectomized calves, and that both parasites were transmitted by I.ricinus. During our limited investigations in Ameland, Meppel and Heino, we isolated B.major and B.phagocytophilia from healthy calves in Ameland on two occassions. No isolations of B.major or B.divergens were made from cattle in Meppel and Heino even though there had been reports of outbreaks of piroplasmosis from these areas.

I.ricinus has been maintained at Weybridge, England for the experimental transmission of B.divergens. Details of the methods used were reported by Joyner (1971) who kept the ticks at a high relative humidity by means of a mixture of wetted plaster of paris and animal charcoal. However this induced fungal infections, which had to be remedied by washing the ticks in merthiolate which was later replaced by mycostatin. In our method, a very high humidity was maintained by a 41% solution of Potassuim hydroxide. Fungal infections were minimal probably because the ticks were periodically washed in physiological saline.

It has also been observed that when a calf was used more than once for feeding ticks, recovery of engorged ticks from it became very unsatisfactory. This type of acquired resistance by vertebrate hosts to ticks has been reported by Trager (1939; 1940). Riek (1962) has also observed a similar phenomenon. He reported that there was a local oedema followed by an intense infiltration of cells chiefly eosinophils, which extended deep into the dermis as early as 48 hours after attachment. As a result the ticks died. On the other hand, when ticks fed on susceptible animals the leukocytic infiltration did not

In this investigation, all attempts to transmit B.major by I.ricinus either from stage to stage, or transovarially had failed. Brocklesby & Morzaria (1974) have made several attempts to transmit B.major transovarially by I.ricinus but were never successful. They also had no success in transmitting B.major from stage to stage by H.punctata, when they induced the infection by blood inoculation.

Although it is unlikely that Swart et al. (1971) made a mistake in their transmission trials, the role of I.ricinus in the transmission of B.major requires further confirmation. Negative transmission experiments with B.major on the other hand, may be attributed to unknown factors leading to a degeneration of the parasites inside the ticks or their eggs. It should be noted that in I.ricinus ticks infected with B.divergens and kept under exactly the same conditions and at the same period as those infected with B.major, transovarial transmission did take place.

With field ticks collected from Ameland and Heino we failed to produce any infections of either B.divergens or B.major with all stages of I.ricinus and adults of H.punctata. Brocklesby & Barnett (1970) had reported that H.punctata collected from Kent and Essex in England successfully transmitted B.major. This same tick was also reported to be a vector of T.mutans in England (Brocklesby & Barnett 1972). It has been possible to demonstrate that adults of H.punctata that were collected as nymphae from Ameland transmitted T.mutans. This is the first report on the occurrence of T.mutans in the Netherlands.

The demonstration of transmission of B.divergens by larvae of I.ricinus and by the nymphae that moulted from these is in agreement with works of Kossel et al. (1904), Sudachenkov (1941) and Joyner et al. (1963). It has been proved that the infection was acquired trasovarially by the larvae and passed on to the succeeding nymphae through moulting. Hence there is maintenance of B.divergens from the larval to the nymphal stage. However, experiments to transmit B.divergens by infecting larvae and nymphae of I.ricinus were not successful.

It has been possible to identify the merozoites of B.divergens in haemolymph and egg smears of replete I.ricinus females. There has been no reported studies on the developmental stages of B.divergens in I.ricinus. However the works of Petrov (1941) and of Polyansky & Kheisin (1959) on the development of Babesiella bovis in I.ricinus might have been referring to B.divergens (see Joyner et al., 1963).

In many of our trials ticks were recovered during a patent parasitaemia. The assumption was made that at this time conditions were most favourable for initiating an infection. However Joyner et al. (1963) had pointed out that in nature cattle were mere carriers and rarely showed a patent parasitaemia. Larvae and nymphae that were recovered at the height of parasitaemia (Figure 37) failed to transmit B.divergens as nymphae and adults respectively.

SUMMARY

The prevalence of piroplasms of cattle in Ameland, Heino and Meppel,

was investigated. For the prevalence studies two methods were used. Blood was collected from the field, pooled together and inoculated into splenectomized calves. Ticks were also collected from Ameland and Heino and fed on similar calves. The calves were controlled for a minimum of 21 days. B.major and B.phagocytophilia were isolated twice from the blood cattle from Ameland. Field ticks from the three sites did not transmit piroplasms. B.phagocytophilia was transmitted by nymphae of I.ricinus from Ameland.

Transovarial and transstadial transmission trials of B.major and B.divergens using laboratory reared H.punctata and I.ricinus were carried out. All attempts to transmit B.major by I.ricinus and by H.punctata failed. Transovarial transmission of B.divergens by I.ricinus and the maintenance of the parasite to the nymphal stage was demonstrated. T.mutans was transmitted to a splenectomized calf by adults of H.punctata which were collected as nymphae from Ameland. This is also the first finding of T.mutans in the Netherlands.

The positive effect of photoperiodism on the moulting of larvae to nymphae and nymphae to adults was demonstrated.

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T A B L E 22

POOLED BLOOD INOCULATIONS INTO SPLENECTOMIZED CALVES

D A T E	Site	Number of cattle bled	Amount of inoculum (ml)	Tag. No. of calf inoculated	Result of blood smear examination
30/7/71	Meppel Farm I	8	125	168	-ve
	Meppel Farm 2	1	100	170	-ve
10/8/71	Ameland	20	20	171	+ve D.major +ve E.phagocytophilia
16/8/71	171	1	40	172	+ve D.major +ve E.phagocytophilia
23/9/71	Heino	9	100	170	-ve
17/12/71	Ameland	20	20	170	+ve D.major +ve E.phagocytophilia
27/3/72	Heino	78	50	189	-ve
4/7/72	Heino	20	20	184	-ve
14/11/72	Heino	40	50	189	-ve

T A B L E 23

TRANSMISSION TRIALS ON SPLENECTOMIZED CALVES USING FIELD TICKS

D A T E	Site	Species	Tag No. of calf	Number of ticks applied	Number of ticks recovered	%	Result of blood smear examination
26/6/71	Ameland	I.ricinus	158	11M,17F	2F	11.76	n.p.f.
23/5/71	Ameland	H.punctata	151	4M,22F	4F	18.18	n.p.f.
13/7/71	Ameland	I.ricinus	166	21M,19F	9F	47.36	n.p.f.
10/5/72	Ameland	I.ricinus	189	38M,38F	38F	100.00	n.p.f.
1/6/72	Ameland	I.ricinus	192	312L	142L	45.50	n.p.f.
1/6/72	Ameland	I.ricinus	193	73N	55N	75.30	n.p.f.
8/6/72	Heino	I.ricinus	189	51N	20N	39.20	n.p.f.
12/6/72	Ameland	I.ricinus	188	57N	47N	82.40	E.phagocytophilia

n.p.f. = no parasite found
M = male
F = female

T A B L E 24

I.RICINUS ADULTS FEEDING ON HOSTS

Batch No.	Tag No. of calf	Number of ticks applied	Date applied	RECOVERY		
				Days elapsed	Number of replete females	%
1	158	11M, 7F	28/5/71	7	2F	28.50
2	166	21M, 19F	13/7/71	7	9F	47.36
3	189	38M, 38F	10/5/72	6–8	38F	100.00
4	189	21M, 28F	7/6/72	6	3F	10.71
5	189	40M, 50F	25/8/72	6–7	36F	72.00
6	186	15M, 20F	8/9/72	6–8	17F	85.00
7	212	10M, 10F	5/2/73	6–9	7F	70.00
8	211	20M, 20F	8/2/73	8–9	12F	60.00
9	212	17M, 17F	8/2/73	7	12F	70.50
10	206	12M, 20F	2/3/73	6–8	4F	20.00
11	214	8M, 10F	12/3/73	7–9	9F	90.00
12	216	6M, 3F	21/3/73	8–11	3F	100.00

M = male

F = female

T A B L E 25

I.RICINUS NYMPHAE FEEDING ON HOSTS

Batch No.	Tag No. of Calf	Number of nymphae applied	Date applied	RECOVERY		
				Days elapsed	Number of engorged nymphae	%
13	193	72	1/6/72	4-6	55	76.30
14	189	51	1/6/72	3-4	16	31.30
15	189	57	12/6/72	4	47	82.40
16	HH	108	14/6/72	3-5	66	61.11
17	192	40	25/8/72	4	18	45.00
18	193	41	11/9/72	3-4	41	100.00
19	193	200	13/10/72	3-5	65	32.50
20	193	300	20/10/72	3-4	101	33.60
21	208	464	29/1/73	4-7	86	18.53
22	209	746	29/1/73	4-7	226	30.20
23	210	332	29/1/73	4-7	193	58.10
24	215	600	12/3/73	4	491	81.80
25	216	120	3/4/73	3-6	92	76.66

HH = hedgehog.

T A B L E 26

I.RIC"NUS - LARVAE FEEDING ON HOSTS

Batch No.	Tag No. of Calf	Number of larvae applied	Date applied	RECOVERY		
				Days elapsed	Number of engorged larvae	%
26	192	312	1/6/72	4-5	142	45.50
27	HH	≠2000	9/8/72	2-4	1586	79.30
28	HH	≠2000	21/8/72	2-4	1775	88.70
29	184	≠2000	25/8/72	4	800	40.00
30	188	≠2000	26/8/72	3-4	1050	52.50
31	HH	≠2000	5/9/72	2-4	1398	69.90
32	186	≠3000	8/9/72	4-5	1060	35.30
33	193	≠3000	11/9/72	3-4	2523	84.10
34	193	≠3000	13/10/72	3-4	103	3.43
35	193	≠3000	23/10/72	3	25	0.83
36	HH	≠2000	1/12/72	-	0	0
37	205	≠2500	2/1/73	3	2000	80.00
38	205	1000	2/1/73	4	500	50.00
39	206	≠2500	9/1/73	3-4	1090	43.60
40	206	≠3500	23/1/73	3-4	2550	72.80
41	211	1500	5/2/73	3	500	33.33

HH = hedgehog

T A B L E 27

EFFECT OF PHOTOPERIODISM ON PREOVIPOSITION AND PREHATCHING PERIODS OF REPLETE I.RICINUS FEMALES

Development	Batch 3 (13 females) no artificial light	Batch 6 (15 females) artificial light 18 hours/day	Batch 5 (27 females) artificial light 24 hours/day
Prevoviposition period (days)	8-19	15-21	15-25
Prehatching period (days)	35-58	48-49	60-61

T A B L E 28

I.RICINUS - EFFECT OF PHOTOPERIODISM ON METAMORPHOSIS OF LARVAL TO NYMPHAL STAGE

Batch No.	Number of larvae incubated	Premoulting period (days)	Number of nymphae recovered	% moult	Photo-period (hours of light)
26	129	48	82	63.56	18
27	604	45	512	84.70	18
29	800	161	32	40.00	0
30	484	114	449	92.70	0
32	750	111	744	99.20	0
33	352	110	332	94.30	0
34	103	72	100	97.00	0
35	25	73	24	96.00	0
37	718	31	600	83.50	18
38	417	31	400	95.90	18
39	800	31	141	17.60	18
40	450	30	223	49.50	18
41	500	30	383	76.60	18

TABLE 29

I.RICINUS - EFFECT OF PHOTOPERIODISM ON METAMORPHOSIS OF NYMPHAL TO ADULT STAGE

Batch No.	Number of nymphae incubated	Premoulting period (days)	Number of adults				Photoperiod (hours of light)
			M	F	T	% moult	
13	55	35	28	27	55	100.00	24
14	14	22	1	2	3	21.42	24
15	47	36	24	23	47	100.00	24
16	66	36	20	40	60	90.90	24
17	11	105	4	7	11	100.00	0
19	65	83	30	33	63	96.90	0
20	100	92	48	47	95	95.00	0
21	80	30	23	40	63	78.70	18
22	200	28	80	82	162	81.00	18
23	160	29	90	60	150	93.70	18

M = male

F = female

T = total

T A B L E 30

H.PUNCTATA - FEEDING ON CALVES

	Batch No.	Tag No. of calf	Number applied	Date applied	Days elapsed	No. of ticks recovered	%
ADULTS	1	151	4M, 22F	28/5/71	10-11	5F	22.72
	2	165	25M, 42F	8/10/71	19-25	7F	16.66
	3	172	10M, 20F	19/11/71	14	4F	20.00
	4	194	9F	24/8/72	12-16	6F	66.60
NYMPHAE	5	172	118	28/8/71	4-10	72	61.01
	6	167	39	22/9/71	6-8	24	61.50
	7	194	10	27/6/72	5-6	3	30.00
LARVAE	8	165	≠2500	13/7/71	5-7	304	12.16
	9	172	≠2500	17/8/71	4-7	71	2.84
	10	188	100	20/3/71	8-12	22	22.00

L = larva

N = nymph

M = male

F = female

TABLE 31

INITIATION OF INFECTION

Species	Batch No.	Tag No. of calf	Needle infection	Number of ticks applied	Number of ticks recovered	%
H.punctata	1	172	B.major	≠2000L	61 L	30.50
"	2	172	B.major	118N	72 N	61.01
I.ricinus	3	184	B.divergens	≠3000L	800 L	26.66
"	4	188	B.divergens	≠3000L	1000 L	33.30
"	5	186	B.major	≠3000L	1060 L	35.30
"	6	193	B.major	≠3000L	2523 L	84.10
"	7	192	B.divergens	40N	18 N	45.00
"	8	193	B.major	41N	41 N	100.00
"	9	188	B.divergens	40M, 50F	36 F	72.00
"	10	186	B.major	15M, 20F	17 F	85.00

L = larva

N = nymph

M = male

F = female

T A B L E 32

I.RICINUS - TRANSMISSION OF INFECTION BY LARVAE

Batch No.	Tag No. of calf	Number of ticks applied	Number of tick recovered	%	Result
9	205	≠2500	1000	40.00	B.divergens
10	206	≠2500	1090	43.60	n.p.f.

n.p.f. = no parasite found

T A B L E 33

I.RICINUS - TRANSMISSION OF INFECTION BY NYMPHAE

Batch No.	Tag No. of calf	Number of ticks applied	Number of ticks Recovered	%	Result
1	67	39	24	61.50	n.p.f.
3/4	208	464	88	18.96	n.p.f.
5	209	746	226	30.20	n.p.f.
6	210	332	193	58.10	n.p.f.
9	215	600	491	81.80	B.divergens

n.p.f. = no parasite found

T A B L E 34

TRANSMISSION OF INFECTION BY ADULTS

Batch No.	Tag No. of calf	Number of ticks applied	Number of ticks recovered	%	Result
2	165	25M, 42F	7F	16.66	T.mutans
7) 8)	214	8M, 10F	9F	90.00	n.p.f.

M = male

F = female

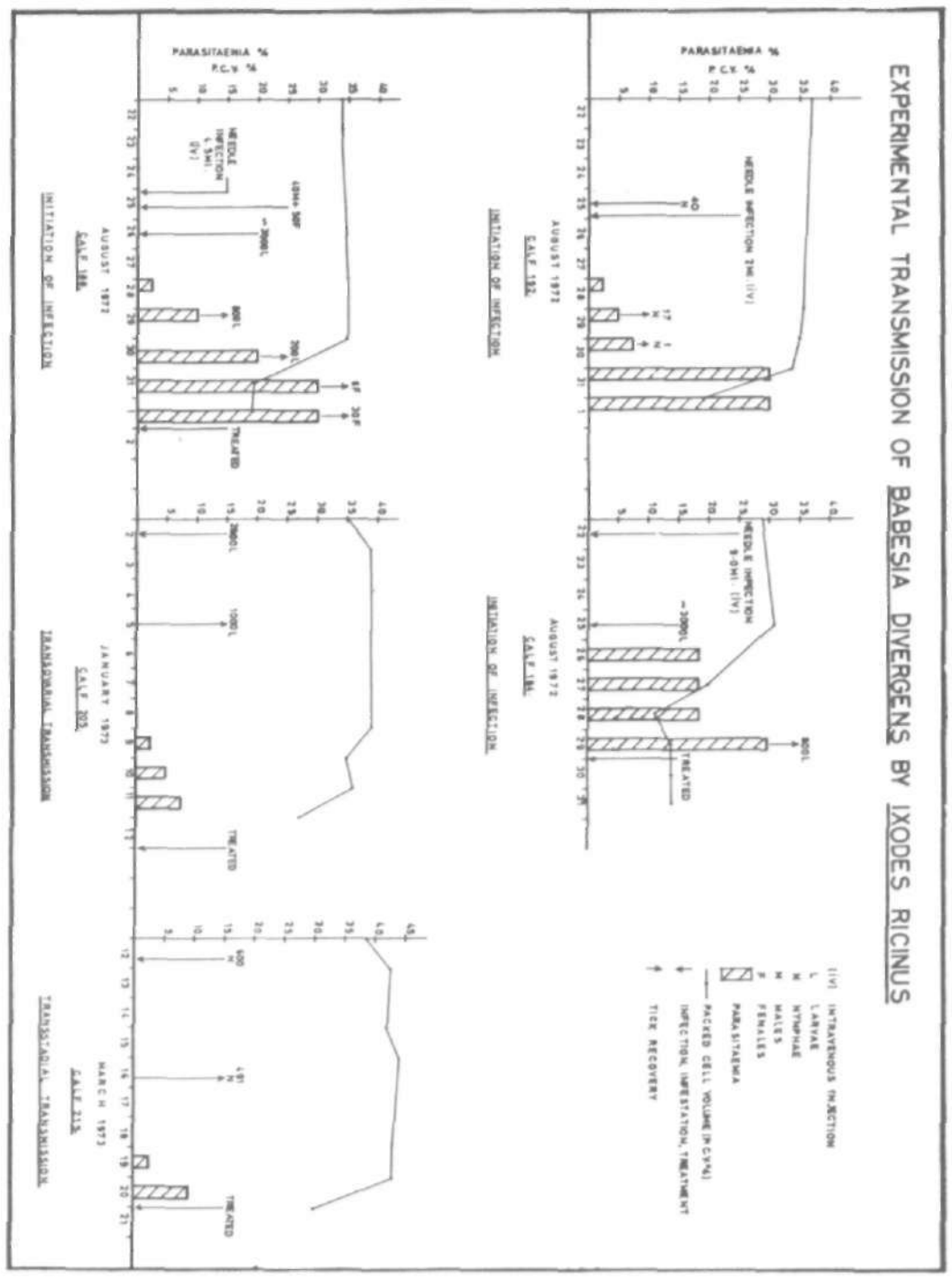

EXPERIMENTAL TRANSMISSION OF BABESIA DIVERGENS BY IXODES RICINUS
PARASITAEMIA %
P.C.V. %
HEDDLE INFECTION 1ML (IV)
40 N
17 NYMPHS
AUGUST 1972
CALF 182.
INITIATION OF INFECTION
HEDDLE INFECTION 8 OML (IV)
~20000L
800L
TREATED
PARASITAEMIA %
P.C.V. %
HEDDLE INFECTION 1 ML (IV)
40000+ 30NF
~20000L
800L
2000L
6F 30F
TREATED
AUGUST 1972
CALF 184.
INITIATION OF INFECTION
2000L
1000L
TREATED
JANUARY 1973
CALF 203.
TRANSDERMAL TRANSMISSION
600 N
181 N
TREATED
MARCH 1973
CALF 215.
TRANSSTADIAL TRANSMISSION
(IV) INTRAVENOUS INJECTION
L LARVAE
N NYMPHAE
M MALES
F FEMALES
PARASITAEMIA
PACKED CELL VOLUME (P.C.V.%)
INFECTION, INFESTATION, TREATMENT
TICK RECOVERY

Fig. 38.
Merozoites of B.divergens in egg smear of replete Ixodes ricinus females.
Giemsa stain; x 2500.

Fig. 39.
Merozoite of B.divergens in haemolymph smear of replete Ixodes ricinus females.
Giemsa stain; x 2500.



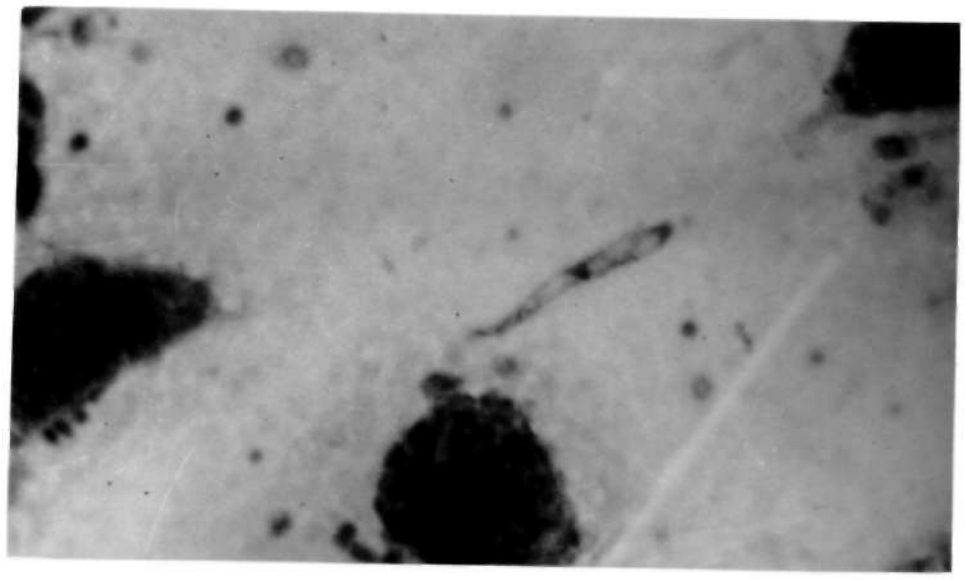
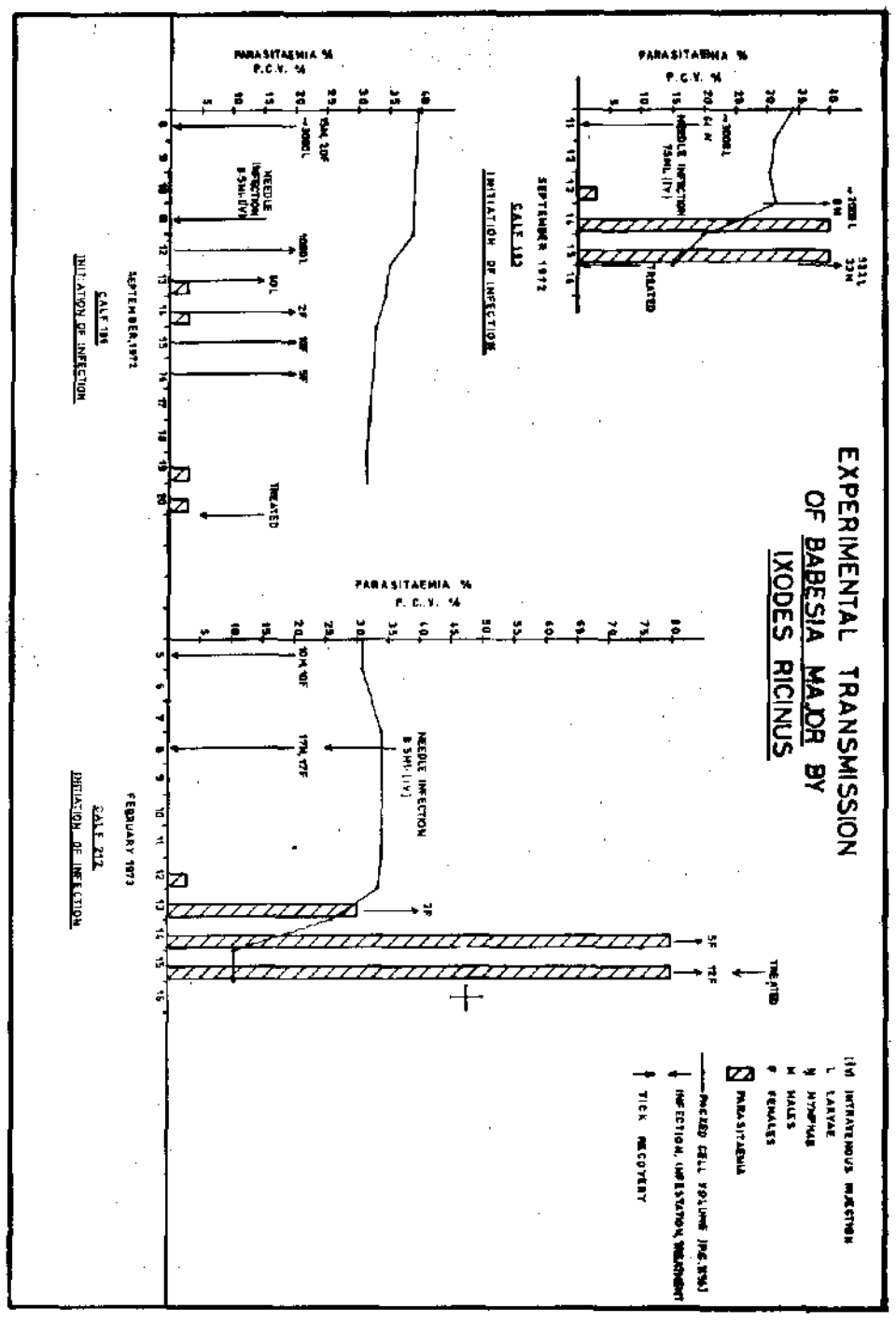
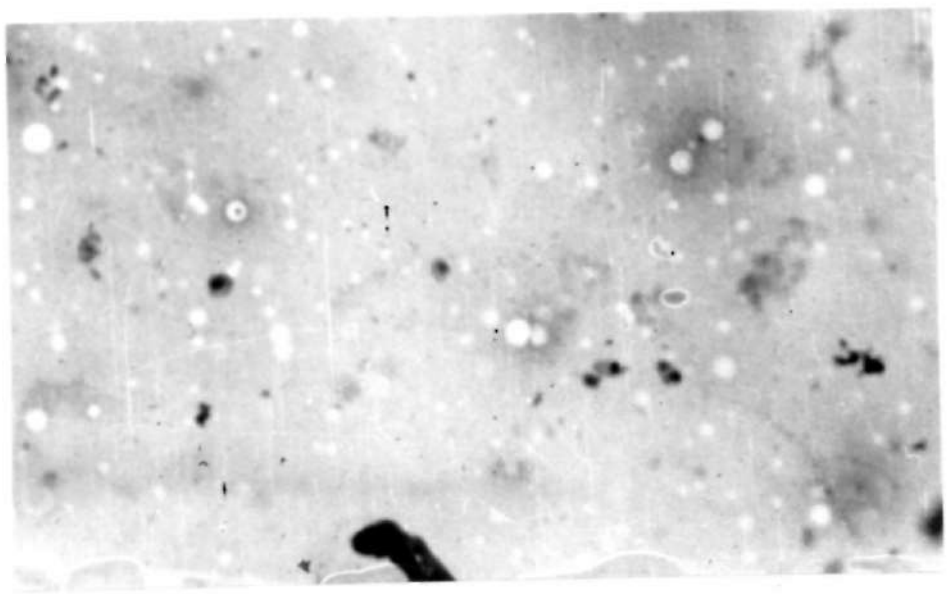
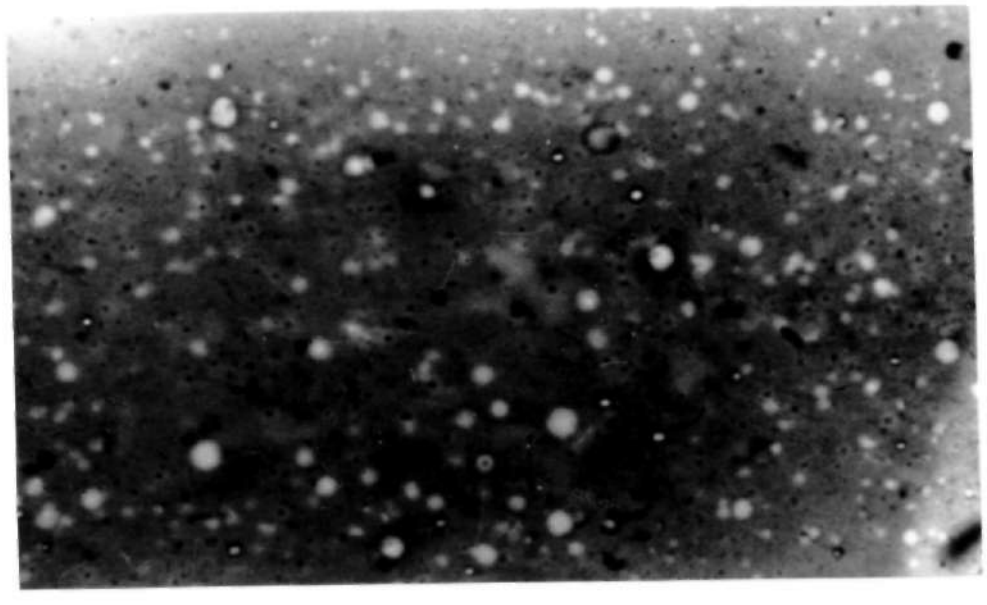


Fig. 40.
The experimental transmission of Babesia major by Ixodes ricinus.


EXPERIMENTAL TRANSMISSION
OF BABESIA MAJOR BY
IXODES RICINUS
PARASITAEMIA %
P.C.V. %
INITIATION OF INFECTION
CALF 183
SEPTEMBER 1972
NEEDLE INFECTION
TREATED
CALF 185
CALF 212
FEBRUARY 1973
TICK RECOVERY





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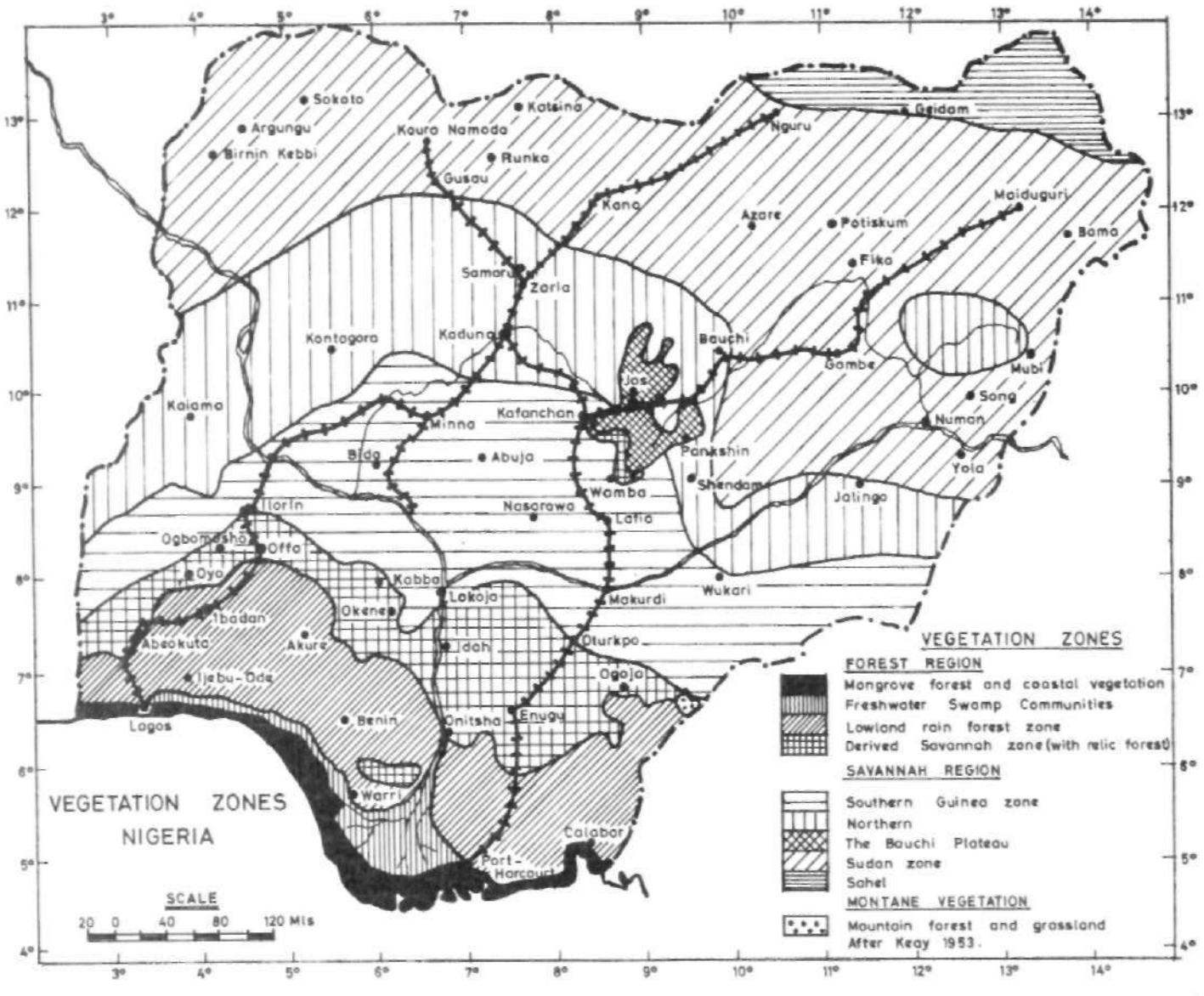
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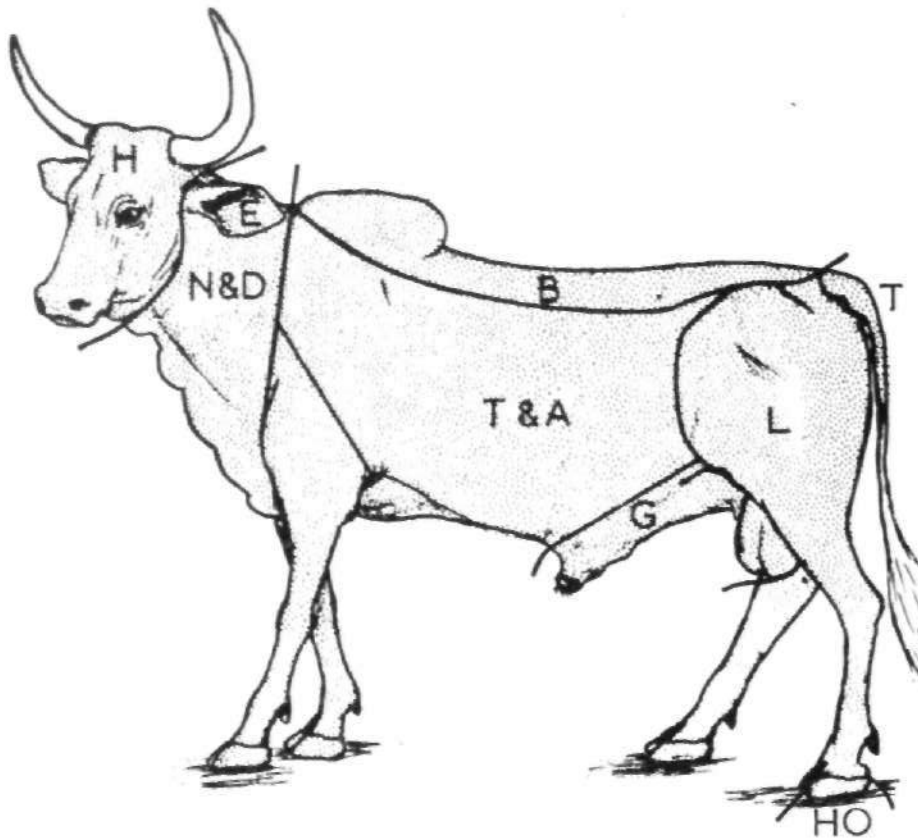
APPENDIX I.

MAP OF NIGERIA SHOWING VEGETATION ZONES.


Sokoto
Argungu
Birnin Kebbi
Kouro Namoda
Katsina
Gusau
Nguru
Gaidam
Kano
Azare
Potiskum
Maiduguri
Bama
Fika
Samaru
Zaria
Kontagora
Kaduna
Bauchi
Gombe
Mubi
Jos
Kaiama
Minna
Katanchan
Song
Numan
Yola
Bida
Abuja
Pankshin
Shendam
Jalingo
Ilorin
Nasarawa
Womba
Lafia
Ogbomosho
Offa
Oyo
Kabba
Lokoja
Makurdi
Wukari
Okene
Ibadan
Abeokuta
Akure
Idah
Oturkpo
Ijebu-Ode
Ogoja
Lagos
Benin
Onitsha
Enugu
Warri
Calabar
Port-Harcourt
VEGETATION ZONES
NIGERIA
SCALE
20 0 40 80 120 Mls
VEGETATION ZONES
FOREST REGION
Mangrove forest and coastal vegetation
Freshwater Swamp Communities
Lowland rain forest zone
Derived Savannah zone (with relic forest)
SAVANNAH REGION
Southern Guinea zone
Northern
The Bauchi Plateau
Sudan zone
Sahel
MONTANE VEGETATION
Mountain forest and grassland
After Keay 1953.

APPENDIX II.

COW SHOWING PREDILECTION SITES



E	EAR
H	HEAD
N & D	NECK AND DEWLAP
T & A	THORAX AND ABDOMEN
G	GENITALIA
T	TAIL
L	LEG
HO	HOOF
B	BACK

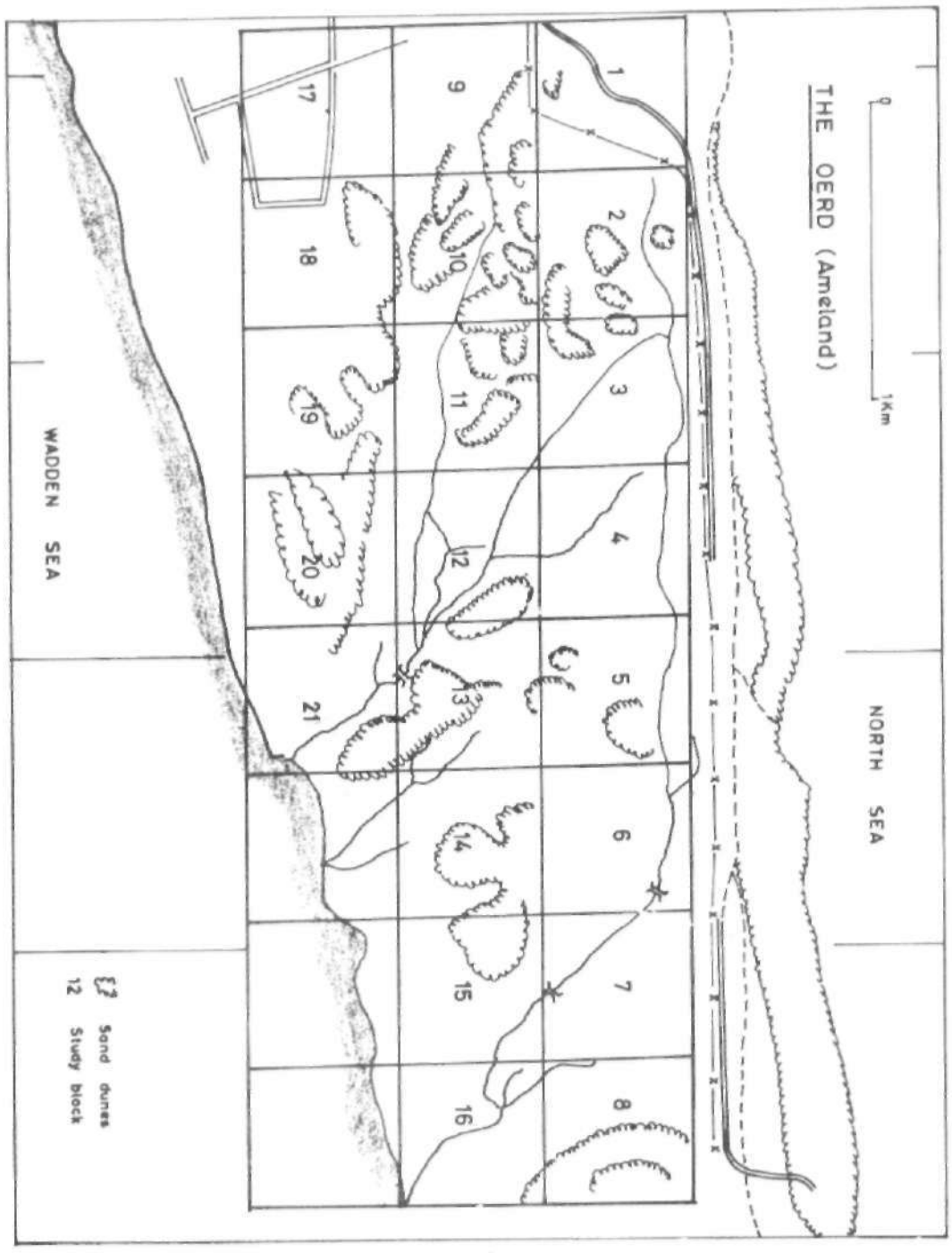
APPENDIX III.

MAP OF THE NETHERLANDS


THE NETHERLANDS
KEY
Provincial boundaries
NORTH SEA
TERSCHELLING
AMELAND
Nes
VLIELAND
TEXEL
WADDEN SEA
Leeuwarden
FRIESLAND
Groningen
GRONINGEN
Assen
DRENTE
Meppel
NORTH HOLLAND
Zwolle
Heino
OVERIJSEL
Haarlem
Amsterdam
SOUTH HOLLAND
Utrecht
Meorn
GELDERLAND
Arnhem
's-Gravenhage
Rotterdam
's-Hertogenbosch
NORTH BRABANT
Breda
Tilburg
Middelburg
Eindhoven
ZEELAND
LIMBURG
0 25 50 km
Maastricht

APPENDIX IV.

MAP OF THE OERD


THE OERD (Ameland)
0
1Km
NORTH SEA
WADDEN SEA
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
Sand dunes
Study block

APPENDIX V.

SHOWING A LIST OF TICK-BORNE PARASITES AND THEIR VECTORS THAT OCCUR IN NIGERIA.

TICK-BORNE PARASITES AND THEIR VECTORS THAT OCCUR IN NIGERIA

Parasite	Vectors(s)	Ticks stages involved: acquisition of infection	Ticks stages involved: transmission of infection	Country	References
Babesia bigemina	Boophilus annulatus (Say)	Larva, Nymph, Adult	Transovarially Larva	North America	Smith & Kilborne (1893)
				North Africa	Brumpt (1920)
				North Africa	Sergent, Donatien, Parrot & Lestoquard (1945)
	B.decoloratus (Koch)	-- do -	- do -	South Africa	Koch (1898) Laveran & Vallée (1905) Theiler (1907; 1909)
B.argentina	Boophilus spp.	Larva, Nymph, Adult	Transovarially, Larva	Argentina Australia	Lignieres (1909) Dodd (1910) Legg (1935)
B.berbera	Boophilus calcaratus (= B.annulatus)	Larva, Nymph, Adult	Transovarially, Larva?	North Africa	Sergent, Donatien & Lestoquard (1931)
Theileria mutans	B.annulatus (Say)	Larva? Nymph? Adult?	Transovarially, Larva? Nymph? Adult?	Germany (Ticks came from the USA)	Miessner according to Reichnow (1935)
	Rhipicephalus evertsi (Neum)	Larva, Nymph	Transstadially, adult	South Africa	Theiler (1909)
	Amblyomma variegatum	Larva	Nymph	Uganda	Uilenberg (1974)

TICK-BORNE PARASITES (Cont'd)

Cowdria ruminantium	Amblyomma variegatum (Fabricius)	Larvae	Adults Nymph	East Africa Madagascar	Daubney (1930) Uilenberg (1971)
Haematoxenus veliferus	Unknown	-	-	-	-
Anaplasma centrale	B.decoloratus (Koch)	?	?	South Africa	Theiler (1912)
Anaplasma marginale	B.decoloratus (Koch) B.annulatus	?	?	South Africa U.S.A.	Theiler (1910) Howell et al. (1943)
Eperythrozoon wenyoni	Unknown	-	-	-	-
E.teganodes	Unknown	-	-	-	-
Haemobartonella Bovis	Sucking lice, ticks and fleas	-	-	-	-
Borrelia Theileri	B.decoloratus (Koch)	?	?	South Africa	Theiler (1909)
	Rhipicephalus evertsi (Neum)	?	?	South Africa	Theiler (1909)
	Rhipicephalus sanguineus (Latreille)			-	Hoogstraal (1956)

THE SEASONAL INCIDENCE OF IXODID TICKS OF CATTLE IN NORTHERN NIGERIA AND IN THE NETHERLANDS, WITH PARTICULAR REFERENCE TO THEIR ROLE IN THE TRANSMISSION OF BOVINE PIROPLASMS

by

ADAMU NAYAYA MOHAMMED B.Sc., D.A.P. & E. (LONDON)

AN ABSTRACT OF A THESIS

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DEPARTMENT OF VETERINARY PARASITOLOGY AND ENTOMOLOGY

A U G U S T

1974

Bovine piroplasmosis has been mentioned by Veterinary workers in Nigeria since the 1920's. The disease was first noticed as a complicating factor of rinderpest vaccination. Later on it was associated with heavy tick burdens on the cattle, especially where livestock were kept under more intensive management. However, indigenous cattle rarely show clinical manifestations by virture of age resistance under continuous tick challenge. This fact, coupled with the great concern of Veterinarians for the more obvious epizootics such as rinderpest, pleuro-pneumonia and trypanosomiasis, was perhaps responsible for little attention being devoted to tick-borne diseases.

Investigations were carried out in this thesis on the seasonal incidence of Ixodid ticks of cattle in northern Nigeria with reference to their role in the transmission of bovine piroplasms. Similar investigations were carried out in the Netherlands for comparative studies.

In northern Nigeria, the study was confined to the Sudan and Guinea Vegetation Zones. These two vegetation zones are at present most important for the livestock industry in Nigeria. In the Sudan Vegetation Zone, the Ruma Kukar Jangarai Grazing Scheme at Runka, Katsina province, was investigated, while in the Guinea Vegetation Zone, Samaru in Zaria province formed the study area.

In Runka, 13,766 ticks were collected from bait cattle during a year's survey. These ticks comprised of four genera and twelve species. Boophilus decoloratus was found to be the most common species parasitizing cattle. It represented 55.95% of the total collection. Amblyomma variegatum was next

in abundance being 36.36%. All the developmental stages of these two tick species were found to occur on bovines. The genus Hyalomma formed only 6.45% while Rhipicephalus was represented by five species forming 1.23% of the total collection. Immature stages of these two genera were not found on cattle.

In Samaru, 20,561 ticks were collected from bait cattle during a year's survey. These ticks also comprised of four genera and twelve species. The most abundant species here was A.variegatum which represented 51.95% of the total collection, while B.decoloratus formed 42.20% of the total. The genus Rhipicephalus comprised of five species forming 4.43% of the total, while three species of Hyalomma accounted for 1.01% of the collection. Immature stages of the species of both genera were not found on cattle.

In both vegetation zones all the developmental stages of B.decoloratus were seen on cattle throughout the year, but with seasonal fluctuations. However, there was only one generation of A.variegatum per year. Adult ticks were more active during the rainy season, while larvae became numerous at the height of the rains (Samaru) or at the end of the rains (Runka). The incidence of nymphal ticks followed that of the larvae, but many could still be found on cattle even during the late dry season.

While A.variegatum and B.decoloratus were commonly collected from cattle in both vegetation zones, Hyalomma spp. appeared to be mainly restricted to the Sudan Vegetation Zone, whereas Rhipicephalus spp. were more common in the

Northern Guinea Vegetation Zone. An extensive study of the predilection sites of A.variegatum and B.decoloratus on cattle indicated that a knowledge of these sites could be important in evaluating population dynamics of ticks on bovines.

An investigation on the prevalence of bovine piroplasms by means of blood and brain smear examination, and the indirect immunofluorescence antibody test showed that the prevalence of Theileria mutans in both vegetation zones was high. The detection of the Babesidae by blood-smear examination alone, had its limitations as revealed by the indirect immunofluorescence antibody test. The prevalence of B.argentina was markedly higher in the Northern Guinea Vegetation Zone.

The role of B.decoloratus in the transmission of the Babesidae of cattle was studied. Replete female ticks were incubated and examined for the presence of Babesia spp. in the haemolymph, eggs, ovary and larvae. In the Samaru area 10.03% of the ticks were infected. The larval progeny of such infected ticks were applied to Babesia-free calves which came down with B.bigemina infection. No B.argentina was involved. Thus the transmission of B.bigemina by B.decoloratus ticks in Nigeria has been proved.

The experimental transmission of T.mutans by H.truncatum and H.impeltatum was unsuccessful.

A two-year study of the tick problem on an island and two other sites on the mainland of the Netherlands showed that only adults of Ixodes ricinus

were found to parasitize bovines. The infestations were markedly low, compared to the situation in northern Nigeria. Immature stages of the tick were only found on the vegetation suggesting that small mammals are the most important hosts.

Although the study was too short to allow evaluation of the complete seasonal activity of I.ricinus, there were indications of a bimodal type of activity. It was observed that the sand dunes on the island and the woods surrounding pastures were the most favourable foci of infestation.

The only other tick found was Haemaphysalis punctata which was only restricted to Ameland.

The prevalence of piroplasms of cattle in the Netherlands was investigated by bleeding cattle from Ameland and two other locations of the mainland and inoculating the pooled blood into splenectomized calves. Ticks were also collected from the vegetation and fed on similar calves. Babesia major and Ehrlichia phagocytophilia were isolated from the blood of cattle from Ameland. Field ticks did not transmit any piroplasms, although I.ricinus nymphae from Ameland transmitted E.phagocytophilia.

Transovarial and transstadial transmission of B.major and B.divergens using laboratory reared ticks was carried out. All attempts to transmit B.major by I.ricinus and by H.punctata failed. However transovarial transmission of B.divergens by I.ricinus and the maintenance of the parasite to the nymphal stage was demonstrated. T.mutans was also transmitted to a splenectomized calf by adults of H.punctata. This is the first finding of T.mutans in the Netherlands.