

Species composition and geographic distribution of ticks infesting cattle, goats and dogs in Maputo Province, Mozambique

by

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Pretoria

2008

Declaration

Apart from the assistance received from my supervisor, Prof Ivan Horak, who helped with the identification of many of the ticks that were collected and also with editing the English in the manuscript, and the statistical analyses performed by Prof Johan Nöthling of the Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria, on the data presented in Chapter 3 of this dissertation, as well as assistance given by other persons and institutions that have been mentioned in the acknowledgements and in the appropriate places in the text, this dissertation represents the original work of the author.

No part of this dissertation has been presented for any other degree at any other university.

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Summary

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by

Carlos de Matos

Supervisor: **Prof. I.G. Horak**

Co-supervisor: **Dr. L. Neves**

Co-supervisor: **Dr. N.R. Bryson**

The primary objective of this study was to determine the species composition of ticks that infest domestic animals in Maputo Province and their geographic distributions. To this end a total of 145 cattle, 129 goats, 132 dogs and 63 drag-samples of the vegetation were examined at 30 localities distributed throughout the province, at each of which the geographic coordinates were recorded and later plotted.

A total of 15187 ixodid ticks belonging to 15 species were recovered. These were *Amblyomma hebraeum*, *Haemaphysalis elliptica*, *Haemaphysalis* sp., *Hyalomma rufipes*, *Ixodes cavipalpus*, *Rhipicephalus (Boophilus) microplus*, *Rhipicephalus appendiculatus*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus*

kochi, *Rhipicephalus longus*, *Rhipicephalus pravus* group, *Rhipicephalus sanguineus*, *Rhipicephalus simus*, *Rhipicephalus tricuspis* and *Rhipicephalus turanicus*. *R. (B.) microplus* and *A. hebraeum* were most abundant on cattle, while *H. elliptica* was most abundant on dogs. *H. elliptica*, *I. cavipalpus*, *R. longus* and *R. turanicus* can now be added to the lists of ixodid tick species previously published for Mozambique.

The geographic distributions of nine of the 15 tick species were mapped, and *A. hebraeum*, *H. elliptica* and *R. evertsi evertsi* were present throughout the province. No indigenous *Rhipicephalus (Boophilus) decoloratus* were recovered, whereas the introduced Asian tick, *R. (B.) microplus* was present in all districts. It would seem that *R. (B.) decoloratus* has been completely displaced by *R. (B.) microplus* in Maputo Province. Although *R. appendiculatus* was recovered at 24 of the 30 localities, it was present at only two of the seven localities in the south of the province. *R. sanguineus* was present on dogs in the districts of Boane, Naamacha and Manhiça, where the collections were made at the dog owners' homes. *R. simus* was present at 27 localities and *R. turanicus* was collected in the districts of Magude, Boane, Namaacha and Matutuine, in the north, centre and south of the province. Future surveys in Mozambique should focus on determining the extent to which *R. (B.) microplus* has displaced *R. (B.) decoloratus*.

A further objective of the study was to compare the prevalence of the five major tick species, namely *A. hebraeum*, *R. (B.) microplus*, *R. appendiculatus*, *R. evertsi evertsi* and *R. simus* on cattle and goats. It was possible to do this at 21 of the sampling sites, at each of which five cattle and five goats had been examined. These five ticks infested both cattle and goats, but the goats harboured larger numbers of immature ticks and fewer adults of some species, while large numbers of both adult and immature ticks were recovered from cattle. Furthermore, more cattle than goats at more localities were infested with adult ticks of each of the five species. Consideration should be given to

including goats in future tick control programmes applied to cattle on the same properties.

A total of ten ixodid tick species were recovered from dogs in Maputo Province. Of these *H. elliptica*, *R. sanguineus*, *R. simus* and *R. turanicus* can be considered major parasites of dogs, while large numbers of immature *A. hebraeum* and smaller numbers of immature *R. appendiculatus* infested these animals opportunistically.

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ACKNOWLEDGEMENTS

I wish to express my appreciation to the Directorate of Animal Science for permitting me and Mr C. Siteo to conduct this survey as part of our official duties.

I also wish to express my sincere thanks to Prof Ivan Horak, my supervisor, for his encouragement and assistance during the research that went into this project, for identifying many of the ticks that were collected, and his assistance with editing, particularly the English, in the manuscript.

Dr Luis Neves, my co-supervisor, helped smooth over many of the administrative hurdles that are associated with large projects of this nature. He also assisted with several of the tick collections and some of the identifications.

Dr Nigel Bryson, my other co-supervisor, assisted with the original lay-out of the project and with editing some of the chapters of this dissertation. Dr Rosa Costa, Dr Paula Dias, Dr Damiao Ngluve of the Directorate of Animal Science and Michel de Matos also assisted administratively towards the research that went into this project.

I am deeply indebted to Mr Carlos Siteo, of the Directorate of Animal Science, for the many hours he spent with me in the field assisting with the tick collections.

I am most grateful to the various cattle, goat and dog owners who made their animals available and who helped to collect ticks from the animals.

Dr Roy Williams of the ARC-Onderstepoort Veterinary Institute very kindly mapped the distributions of the ticks.

This project would not have been possible without the financial assistance of the Sida / Sarec Joint INIVE-Veterinary Faculty Research Project.

CHAPTER 1

General Introduction, Literature Review and General Materials and Methods

GENERAL INTRODUCTION

Ticks are obligate blood-feeding parasites of terrestrial vertebrates at some stage of their life cycles. Many species are of considerable interest and importance as vectors of a wide variety of pathogens to both humans and animals (Walker, Keirans & Horak 2000; Norval & Horak 2004).

Ticks and the diseases they transmit are widely distributed throughout the world, particularly in tropical and subtropical countries. It has been estimated that 80% of the world's 1, 226 million cattle are infested with ticks. Ticks are responsible for severe losses caused either by tick worry, blood loss, damage to hides and udders and the transmission of toxins, or through morbidity or mortality caused by the diseases they transmit (FAO 1984). Such losses are not the only costs for which ticks are responsible. The building and maintenance of dipping tanks and sprays, the labour needed for mustering stock and the purchase of acaricides for tick control and therapeutic agents against disease add greatly to the farmer's production costs (Howell, Walker & Nevill 1978).

Ticks and tick-borne diseases (TBD) are major constraints to the improvement of livestock production in Mozambique and adjoining southern African countries (Coetzer & Tustin 2004). The following genera of ixodid ticks have been described in southern Africa and parasitize domestic animals: *Amblyomma*, *Haemaphysalis*, *Hyalomma*, *Ixodes*, *Margaropus*, *Rhipicentor*, *Rhipicephalus* (*Boophilus*), and *Rhipicephalus* (Walker 1991). Members of the genera *Amblyomma*, which transmit *Ehrlichia* (*Cowdria*) *ruminantium*; *Rhipicephalus*

(*Boophilus*), which transmit *Anaplasma* spp. and *Babesia* spp.; and *Rhipicephalus*, which transmit *Theileria* spp. (Norval & Horak 2004), are the most important ixodid ticks in Mozambique.

A considerable amount of work on ticks, mainly of a taxonomic nature, with some attention to distribution, was done in Mozambique by Travassos Dias (1960, 1993). However, he paid little attention to their exact distribution in this country. Indeed, many collections of ticks of various species have been made in Mozambique, but few localities at which the ticks were collected were accurately identified and hence their geographic distributions are unknown in this country. Amongst the 59 species of ticks listed by Dias (1993) as occurring in Mozambique, 26 are listed as parasitizing domesticated animals.

Because of ever-increasing restricted access to much of the country during the war years (1980-1992) research on ticks and TBD's was interrupted. After political stability returned farmers were keen to replace livestock lost during the war and the drought of the early 1990's, and research on ticks and TBD's has resumed. Thus Neves, Afonso & Horak (2004) have listed the ticks that infest domestic dogs in southern Mozambique and have recorded the exact localities at which the ticks were collected. Interestingly one of these dogs was infested with a single *Rhipicephalus (Boophilus) microplus* female.

To achieve effective control of ticks and the diseases they transmit, accurate information on their geographic distribution within Mozambique is essential. The present dissertation describes a survey on the tick species infesting domestic cattle, goats and dogs as well as free-living ticks present on the vegetation and the geographic distribution of these ticks in Maputo Province, Mozambique.

LITERATURE REVIEW

Walker (1991) reviewed the ixodid ticks (Acari, Ixodidae) occurring in southern Africa and recorded 83 species. The geographic distributions of several of these ticks have been illustrated by Howell *et al.* (1978), Walker & Olwage (1987) and Walker *et al.* (2000).

According to Dias (1993) the following species of ticks parasitize domesticated cattle in Mozambique *Amblyomma hebraeum*, *Amblyomma pomposum*, *Amblyomma theilerae*, *Amblyomma variegatum*, *Boophilus decoloratus*, *Boophilus microplus*, *Haemaphysalis leachi*, *Hyalomma marginatum rufipes*, *Hyalomma truncatum*, *Rhipicephalus appendiculatus*, *Rhipicephalus capensis*, *Rhipicephalus compositus*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus lunulatus*, *Rhipicephalus maculatus*, *Rhipicephalus sanguineus* and *Rhipicephalus simus*. According to him goats are parasitized by *A. hebraeum*, *B. microplus*, *R. appendiculatus*, *R. evertsi evertsi* and *R. simus*, and dogs by *Amblyomma tholloni*, a parasite of African elephants, *Haemaphysalis humerosoides*, *Haemaphysalis leachi*, *Ixodes pilosus*, *Rhipicephalus appendiculatus*, *Rhipicephalus kochi*, *Rhipicephalus muelhensi*, *Rhipicephalus reichenowi*, *Rhipicephalus tricuspis*, *R. sanguineus* and *R. simus*. Two of the latter ticks, namely *H. humerosoides* and *R. reichenowi* are now considered synonyms of *H. leachi* and *Rhipicephalus planus*, respectively (Camicas, Hervy, Adam & Morel 1998; Walker *et al.* 2000), and Camicas *et al.* (1998) consider *A. theilerae* as a synonym of *A. hebraeum*. Ticks of the genus *Boophilus* have subsequently been placed in the subgenus (*Boophilus*) within the genus *Rhipicephalus* (Horak, Camicas & Keirans 2002), and the tick previously referred to in the southern countries of Africa as *H. leachi*, has been reinstated as *Haemaphysalis elliptica* (Apanaskevich, Horak & Camicas 2007). Apanaskevich & Horak (2008) have also recently raised the subspecies *H. marginatum rufipes* to species level, namely *H. rufipes*.

In southern Mozambique, Neves *et al.* (2004), recorded the geographic distributions of ixodid ticks on dogs and the following tick species were recovered *A. hebraeum*, *Amblyomma* sp., *H. leachi* (now *H. elliptica*), *Haemaphysalis spinulosa*, *R. (B.) microplus*, ticks of the *Rhipicephalus pravus* group, *R. sanguineus*, *R. simus*, *Rhipicephalus tricuspis* and *Rhipicephalus turanicus*. With the exception of *H. spinulosa* and ticks of the *R. pravus* group, which were not present, Horak, Emslie & Spickett (2001) recovered the same tick species plus *Haemaphysalis zumpti* from dogs in north-eastern KwaZulu-Natal, South Africa, just to the south of Maputo Province. Horak, Jacot Guillarmod, Moolman & De Vos (1987) collected 14 ixodid tick species from dogs on smallholdings near Grahamstown, Eastern Cape Province, South Africa, and *H. leachi* (now *H. elliptica*), *Ixodes pilosus* and *R. simus* were amongst the most abundant of the ticks that they recovered.

In KwaZulu-Natal, South Africa, Baker & Ducasse (1967) recorded seven species of ixodid ticks from cattle, and *A. hebraeum*, *B. decoloratus*, *R. appendiculatus* and *R. evertsi evertsi* were the most important tick species collected from these animals. In the Nylsvley Nature Reserve, in the Northern Province, South Africa, Londt, Horak & Villiers (1979) studied the seasonal incidence of adult ticks on cattle and collected *R. appendiculatus*, *R. evertsi evertsi*, *H. marginatum rufipes*, *Boophilus decoloratus* and *Ixodes cavipalpus* in descending order of abundance. In a more thorough examination done at the same locality the species composition of the ticks was *R. appendiculatus* (79,6 %), *R. evertsi evertsi* (11,5%), *A. hebraeum* (6,1%), *H. truncatum* (1,2%), *H. marginatum rufipes* (1,2%), *B. decoloratus* (0,2%), *R. simus* (0,2%) and *Ixodes cavipalpus* (0,1%) (Horak 1982).

In the Eastern Cape Province, South Africa Horak, Knight & Williams (1991) recovered *A. hebraeum*, *Amblyomma marmoreum*, *B. decoloratus*, *Haemaphysalis silacea*, *H. marginatum rufipes*, *I. pilosus*, *R. appendiculatus*, *R. evertsi evertsi*, *Rhipicephalus exophthalmos*, (then referred to as *Rhipicephalus* sp. near *R. oculatus*), *Rhipicephalus glabroscutatum* and *R. simus* from Angora

goats. Mushi, Isa, Motheo, Gabarebolwe & Kesiameteswe (1996), in Gaborone, Botswana recorded five tick species from indigenous goats, and *R. evertsi*, *B. decoloratus* and *A. hebraeum* were the most abundant tick species collected. The majority of the ticks collected were adults and there were more males than females.

Ticks belonging to the following genera and species have been recorded on domestic animals in southern Africa.

The genus *Amblyomma*

Eight species of *Amblyomma* occur in southern Africa. These fall into two groups: four species whose known hosts are primarily mammals (*A. hebraeum*, *A. rhinocerinus*, *A. tholloni* and *A. variegatum*) and four that are basically, but not always exclusively, parasites of reptiles (*A. marmoreum*, *A. nuttalli*, *A. sparsum* and *A. sylvaticum*) (Walker & Olwage 1987). Economically *A. hebraeum* and *A. variegatum* number amongst the most important tick parasites of livestock. Howell *et al.* (1978) and Walker (1991) do not refer to the presence of *Amblyomma pomposum* in South Africa or southern Africa. Santos Dias (1993) mentioned that *A. pomposum* is present in Mozambique north of the 22° parallel, and Norval & Horak (2004) describe the occurrence of *A. pomposum* in parts of eastern Zambia, a region adjoining the western border of Mozambique. The latter three ticks are the vectors of *Ehrlichia* (*Cowdria*) *ruminantium*, the cause of heartwater in domestic as well as in some wild ruminants (Norval & Horak 2004).

The sub-genus *Rhipicephalus* (*Boophilus*)

I have chosen to use the name *Rhipicephalus* (*Boophilus*) spp. as proposed by Murrell & Barker (2003). Many people, however, prefer to retain *Boophilus* as a generic name. Members of this small, but economically important, sub-genus

are widely distributed in the Afrotropical and Oriental regions, Australia and the New World. In Mozambique Santos Dias (1993) recognized four species, namely *R. (B.) decoloratus* and *R. (B.) microplus* plus *Boophilus flavae* Travassos Dias and *Boophilus scheepersi* Travassos Dias (Dias 1993). The last mentioned two species are, however, not considered valid (Camicas *et al.* 1998; Horak *et al.* 2002). Only two species of this subgenus have been recorded in southern Africa, namely *R. (B.) decoloratus* and *R. (B.) microplus* (Howell *et al.* 1978; Walker 1991; Norval & Horak 2004).

Rhipicephalus (B.) decoloratus transmits *Babesia bigemina* the causative organism of redwater in cattle. It also transmits *Anaplasma marginale* the causative organism of anaplasmosis or gallsickness in cattle and possibly also *Anaplasma centrale*, as well as *Borrelia theileri* the cause of spirochaetosis in cattle, horses, sheep and goats. Large infestations can suppress the appetite of cattle and lead to a reduction in weight gain (Norval & Horak 2004). *Rhipicephalus (B.) microplus* transmits both *B. bigemina* and *Babesia bovis*, the causative organisms of bovine babesiosis or redwater. It also transmits *A. marginale*, the causative organism of bovine anaplasmosis (Norval & Horak 2004).

The genus *Haemaphysalis*

This is the second largest genus in the family Ixodidae. Ten species of these small, light brown, eyeless ticks are currently known to occur in southern Africa. These fall into four of the 14 subgenera discussed by Hoogstraal & Kim (1985), namely *Haemaphysalis (Ornithophysalis) (hoodi)*; *Haemaphysalis (Haemaphysalis) (silacea)*; *Haemaphysalis (Kaiseriana) (aciculifer, parmata)*, and *Haemaphysalis (Rhipistoma) (cooleyi, hyracophila, leachi, pedetes, spinulosa, zumpti)*. In Mozambique Santos Dias (1993) recognized the following species, *Haemaphysalis humerosoides* (now considered a synonym of *H. leachi*), *H. leachi*, *Haemaphysalis aciculifer*, *Haemaphysalis parmata*, *H. spinulosa*, *Haemaphysalis hoodi*, *Haemaphysalis muhsamae*, and

Haemaphysalis orientalis. However, the last two ticks are not included by Walker (1991) in her list.

So far the only *Haemaphysalis* in southern Africa proved to be a vector of any pathogens is *H. elliptica* (previously known as *H. leachi*). It transmits *Babesia canis*, causing canine biliary fever (Lewis, Penzhorn, Lopez-Rebollar & De Waal 1996), a disease of domestic dogs that is frequently fatal.

The genus *Hyalomma*

Members of this genus, one of the smaller ones in the family Ixodidae, occur in the Palaearctic, Oriental and Afrotropical regions. Individual species often show a great range of morphological variation. Two species belonging to this genus, namely *H. rufipes* and *H. truncatum* are wide-spread in the drier parts of southern Africa, while *Hyalomma marginatum turanicum* [now reinstated as *Hyalomma glabrum* by Apanaskevich & Horak (2006)] is virtually confined to the Karoo regions of South Africa (Apanaskevich & Horak 2006).

Hyalomma rufipes can transmit *A. marginale* and *Babesia occultans* to cattle (Norval & Horak 2004). Certain strains of *H. truncatum* contain a toxin in their saliva, which causes sweating sickness, an acute dermatitis, in cattle, particularly calves (Norval & Horak 2004). The damage caused by the long mouthparts of these ticks can lead to lameness in lambs and the wounds are also attractive to blowflies and can lead to myiasis (Howell *et al.* 1978). *Hyalomma* spp. and particularly *H. rufipes* can transmit Congo haemorrhagic fever virus to man (Horak, Swanepoel & Gummow 2002).

The genus *Ixodes*

This is the second largest genus in southern Africa (and in the global context by far the largest genus in the family Ixodidae). In southern Africa it contains 25

species plus several entities in the *Ixodes pilosus* group that are as yet undescribed. In general the *Ixodes* species remain poorly known. Four species (*I. catherinei*, *I. myotomys*, *I. spiculae*, and *I. transvaalensis*) are known only from the few specimens in the type collections. Only one species in southern Africa, namely *Ixodes rubicundus*, is economically important, as the females cause tick paralysis in various species of domestic and wild ruminants (Howell *et al.* 1978). The other species of importance, mainly because of their widespread distribution and wide range of hosts are *I. cavipalpus*, and ticks of the *I. pilosus* group (Theiler 1962; Walker 1991).

In Mozambique Santos Dias recognized five species, namely *Ixodes dornarthuri*, *Ixodes nicolasi*, *I. pilosus*, *Ixodes schilingsi*, and *Ixodes ugandanus* (Dias 1993). It is quite probable that the ticks that Santos Dias recognized as *I. pilosus* were actually *I. cavipalpus*.

The genus *Margaropus*

This Afrotropical genus contains only three species, of which one (*Margaropus winthemi*) occurs in South Africa and the other two (*Margaropus reidi* and *Margaropus wiley*, which are parasites of wildlife) in eastern Africa. No member of this genus has been reported by Dias (1993) as present in Mozambique.

The genus *Rhipicentor*

Rhipicentor is a three-host tick. The adults parasitize domestic dogs, hedgehogs and large wild felids (Fourie, Horak, Kok & Van Zyl 2002). It is an exclusively Afrotropical genus, containing only two species, *Rhipicentor bicornis* and *Rhipicentor nuttalli* (Walker 1991). *Rhipicentor nuttalli* can cause paralysis, which may be fatal, in dogs (Fourie *et al.* 2002). This genus has not been listed by Dias (1993) as present in Mozambique.

The Genus *Rhipicephalus*

According to Walker (1991) this is the largest genus in southern Africa. Several species of *Rhipicephalus* are vectors of pathogens affecting domestic and wild animals, and to a lesser extent man, in Africa (Walker *et al.* 2000; Norval & Horak 2004). By far the most important of these is the brown ear tick, *R. appendiculatus*, which is the primary vector of *Theileria parva parva*, the protozoon causing East Coast fever of cattle in East and Central Africa (Norval & Horak 2004). Other vectors of those *Theileria* spp. that affect cattle, are *Rhipicephalus zambeziensis*, which can also transmit the *T. parva* group of parasites plus *Theileria taurotragi*; *Rhipicephalus duttoni*, which transmits *T. parva lawrencei* in Angola; and *R. evertsi evertsi*, which can sometimes transmit *T. parva parva*, though it is apparently not a very efficient vector of this organism (Norval & Horak 2004). *Rhipicephalus sanguineus*, the most cosmopolitan member of the genus, is a vector of *Babesia canis*, *Ehrlichia canis*, and *Hepatozoon canis* in dogs, as well as *Rickettsia conorii* in man (Walker 1991).

Rhipicephalus appendiculatus, *R. zambeziensis*, *R. evertsi evertsi* and *R. sanguineus* are all present in Mozambique (Dias 1993), but there is no accurate information on their geographic distribution within the country. Dias (1993) records 24 species of *Rhipicephalus* in Mozambique, but of these *Rhipicephalus confusus*, *Rhipicephalus piresi*, *Rhipicephalus reichnowi* and *Rhipicephalus serranoi* are no longer recognized as valid species (Walker *et al.* 2000). One of the species not recorded by Dias (1993) is *R. turanicus*, which judging by the distribution map of Walker *et al.* (2000), in which *R. turanicus* occurs in all the surrounding countries, and the findings of Neves *et al.* (2004) on dogs in Maputo Province, definitely occurs in Mozambique.

GENERAL MATERIALS AND METHODS

Geography of Maputo Province

Maputo Province

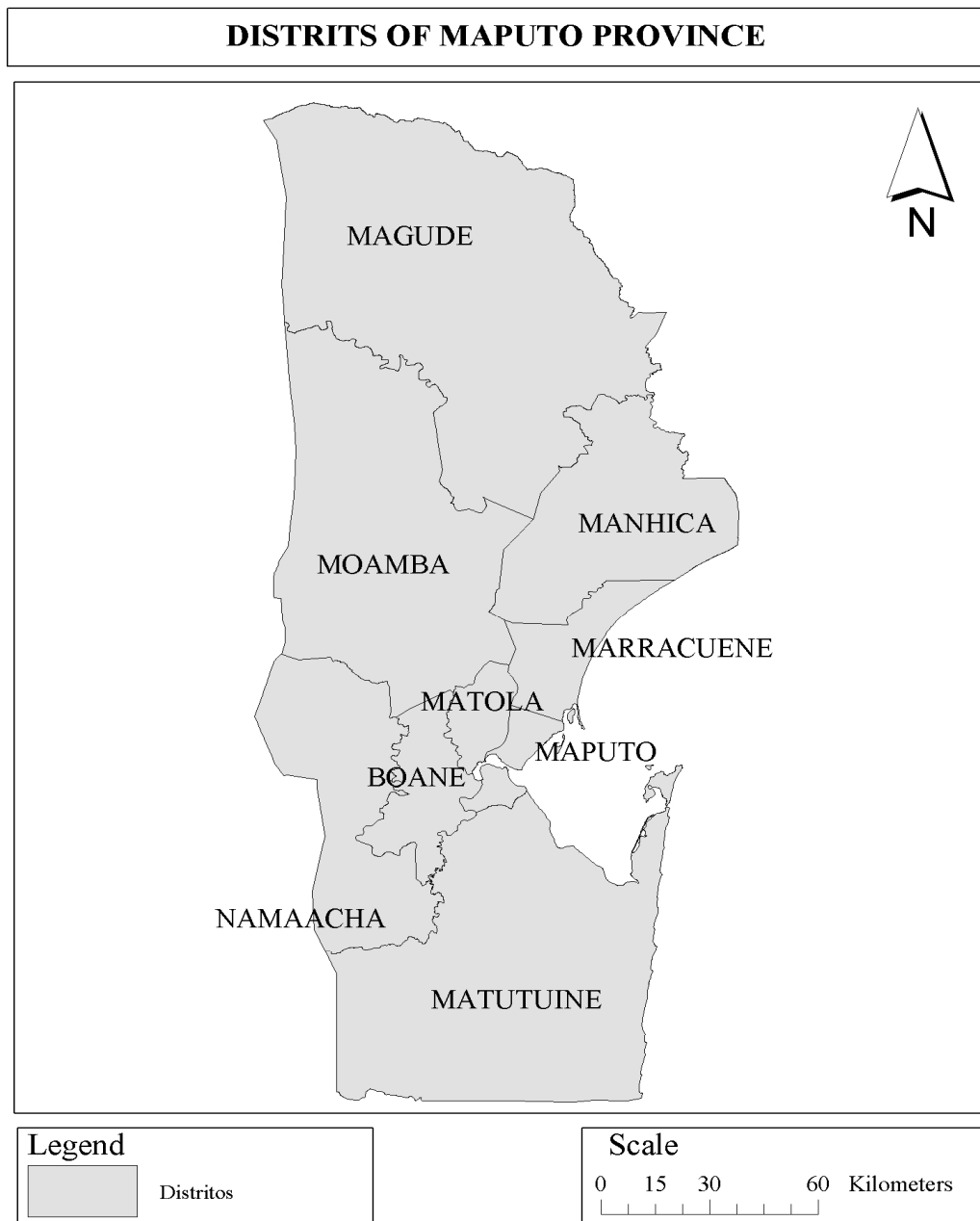


Fig. 1 Map of Maputo Province

Maputo Province covers an area of 26,058 km² and has a human population of 1,259,713 (2007 Census).

The varied climate throughout the country is strongly influenced by altitude, proximity to the sea and the south coast trade winds of the Indian Ocean. In the southern part of the country, south of 20° S latitude, including Maputo Province the temperatures range from 18 to 31°C. The rainy season in the Southern-Zone of the country is characterized by a subtropical anticyclone system and the main rains fall between October and March. Most of the country receives, on average, more than 1,000mm of precipitation per annum.

The province of Maputo has a seaboard of approximately 320 km and rises from the Indian Ocean to about 800 m above sea level. The vegetation along the coast is described as shrubland with patches of wetland, mangrove and deciduous trees along river shores and dunes. Inland it is dominated by woodland and associations of savannah and mopane (*Colophospermum mopane*) in the north-west district of Magude. The inland vegetation in the south is dominated by forest from the mountain district of Namaacha to the southern Mozambican border. The southern border of the province abuts on north-eastern KwaZulu-Natal Province, South Africa. The south-western border of the province abuts on the eastern border of Swaziland and the north-western border of Maputo Province abuts on the eastern border of the Kruger National Park, South Africa.

Much of the animal life was decimated during the years of conflict, but there are efforts underway to reintroduce many species to the country and to conserve the diverse wildlife, including the bird species, remaining larger mammals and the Indian Ocean coral reefs.

According to the census of 2004 Maputo Province had 87,672 cattle and 5.761 goats.

Survey localities

Thirty localities, the majority of which were cattle dip-tanks, distributed throughout the province of Maputo were visually selected from a map of the province. At the time that each tick collection was made the geographic coordinates of each locality were recorded and later mapped.

Survey animals

At each locality an attempt was made to collect ticks from five approximately one year- old cattle, five goats and from five dogs. An attempt was also made to collect free-living questing ticks, by dragging strips of flannel over the vegetation at each locality.

Tick collection

Parasitic ticks

Each bovine animal was cast with ropes before tick collection started. Ticks were collected from one half of each animal and particular attention was paid to the predilection sites of attachment of the various tick species on each animal, including the feet and the tail switch. As the project was aimed at determining the distribution of the various tick species and not their prevalence or intensity of infestation none of the collections were intended to be complete. Nevertheless visibly infested animals were chosen to ensure the maximum collection of ticks. The ticks collected from each animal were placed separately in 70% ethanol in an internally labelled bottle.

Adult ticks were collected from one side of the body of each of five goats. Each animal was laid on its side and properly restrained before collection commenced. The more visibly tick infested animals were selected if possible and the ticks of each animal were placed in 70% ethanol in a separate, internally labelled bottle. Complete collections of adult ticks were made from five dogs and stored separately as described above. Each dog was laid on its side and properly restrained before collection commenced.

Free-living ticks

In the grazing areas of the cattle at each sampling site, three separate 100 meter long drag-samples, at least 50 meters apart, were made over the vegetation as described by Spickett, Horak, Braack & Van Ark (1991). The ticks collected from the drag cloths were stored in 70% ethanol in separate internally labelled vials.

Sampling period

Ticks were collected at irregular intervals from June 2004 until July 2006.

Tick identification

The ticks were transported to the Directorate of Animal Science, Maputo where they were identified and counted using a stereoscopic microscope. All the ticks identified by myself were later validated by Prof I.G. Horak of the Department of Veterinary Tropical Diseases, Faculty of Veterinary Science, Onderstepoort South Africa.

Presentation of data

The dissertation has been divided into four separate chapters. The first chapter gives a general introduction and overview of the field covered and the general procedures followed. The second addresses the prevalence of the various tick species on host animals and the vegetation and also illustrates and discusses the geographic distribution of the tick species collected. The third chapter is devoted to a comparison of the host prevalence of the five major tick species infesting both cattle and goats in Maputo Province. The fourth chapter addresses the tick species infesting dogs in Maputo Province, and the final chapter consists of a general discussion of the data collected during the survey. Because Chapters 2, 3 and 4 are designed to be free-standing documents it is thus inevitable that some procedures, data and references will be repeated. However, with the exception of the references I have attempted to keep repetition to a minimum.

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CHAPTER 2

Species Composition and Geographic Distribution of Ixodid Ticks in Maputo Province

INTRODUCTION

Ticks transmit a greater variety of pathogenic micro-organisms than any other arthropod vector group, and are among the most important vectors of diseases affecting humans and animals (Jongejan, 2007). The three families comprising the superfamily Ixodoidea are the Argasidae, or soft ticks, with about 150 species in five genera, the Nuttalliellidae, a monospecific genus, and the Ixodidae, the hard or shield ticks with about 650 species in four subfamilies and 13 genera (Horak, Camicas & Keirans 2002). Most ticks of veterinary importance belong to the family Ixodidae (Hoogstraal, 1956).

Dias (1993) listed 59 species of ixodid ticks and their respective hosts that occur in Mozambique, and he recorded 26 of these as parasitizing domesticated animals. According to Dias (1993) 17 ixodid tick species infest cattle, namely *Amblyomma hebraeum*, *Amblyomma pomposum*, *Amblyomma theileri*, *Amblyomma variegatum*, *Rhipicephalus (Boophilus) decoloratus*, *Rhipicephalus (Boophilus) microplus*, *Haemaphysalis leachi*, *Hyalomma rufipes*, *Hyalomma truncatum*, *Rhipicephalus appendiculatus*, *Rhipicephalus capensis*, *Rhipicephalus compositus*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus lunulatus*, *Rhipicephalus maculatus*, *Rhipicephalus sanguineus* and *Rhipicephalus simus*. Of these *A. theileri* has been synonymized with *A. hebraeum* (Camicas, Hervy, Adam & Morel 1998), which is present in the southern half of Mozambique, while *A. variegatum* occurs in the north. We now know that *R. capensis* does not occur in Mozambique, and that in addition to

domestic animals *R. compositus*, *R. kochi*, *R. lunulatus* and *R. maculatus* also parasitize several species of wild mammals (Walker, Keirans & Horak 2000).

Although Dias (1993) listed *R. sanguineus* as infesting cattle, in our opinion the latter tick is more likely to be *Rhipicephalus turanicus*.

Dias (1993) also listed five species of ixodid tick that infest goats, namely *A. hebraeum*, *R. (B.) microplus*, *R. appendiculatus*, *R. evertsi evertsi* and *R. simus*. All of these are also considered to be important ticks of cattle. He also listed 12 tick species that infest dogs, namely *A. hebraeum*, *Amblyomma tholloni*, *Haemaphysalis humerosoides*, *H. leachi*, *Ixodes pilosus*, *R. appendiculatus*, *R. kochi*, *Rhipicephalus muehlensi*, *Rhipicephalus reichnowi*, *R. sanguineus*, *R. simus* and *Rhipicephalus tricuspis*. Of these *A. tholloni* is a tick of elephants (Walker & Olwage 1987), and probably only an accidental parasite of dogs as well as of cattle, sheep and goats in the vicinity of elephants (Norval 1983), *R. muehlensi* is a tick of wild antelopes (Dias, 1993; Walker, 1991), but is sometimes found on cattle, and very occasionally on sheep and goats (Walker *et al.* 2000). *H. humerosides* is considered a synonym of *H. leachi* by Camicas *et al.* (1998), and *R. reichenowi* is considered a synonym of *Rhipicephalus planus*, by Walker *et al.* (2000). Neves, Afonso & Horak (2004), in a more recent survey, collected nine species of ticks from dogs in Maputo Province, and a tenth species from outside the province, and added *Haemaphysalis spinulosa*, *R. (B.) microplus*, ticks of the *Rhipicephalus pravus* group, and *R. turanicus* to the species of ticks collected from dogs as listed by Dias (1993).

Several of Dias' studies on the ticks of Mozambique commenced approximately 50 years ago and although he probably encountered and listed all the tick species that occur in Mozambique during his surveys, he unfortunately did not always record the localities at which particular species were collected. Furthermore the civil war that ended 16 years ago and its consequences for humans, livestock and wildlife, and the drought of the 1990's and the restocking

program that followed have probably all had an effect on the composition of the tick population. This being the case, with the exception of the study taking the geographic distribution of ticks infesting domestic dogs in this country into account, which was done by Neves *et al.* (2004) in southern Mozambique, and who collected ten species of ticks and recorded their geographic distributions, there is currently no up to date information on the species of ticks that occur in Mozambique or on their geographic distributions.

The present study was undertaken in an attempt to rectify this situation. Starting with Maputo Province, the most southern of the ten provinces of Mozambique, a survey of the tick species infesting domestic cattle, goats and dogs, as well as of the free-living ticks questing for hosts from the vegetation was initiated. Further similar surveys are planned for the other provinces for the future.

MATERIALS AND METHODS

Survey localities

I have arbitrarily decided to divide Maputo Province into three regions, namely north, central and south, and that north of Moamba will be considered the north of the province and south of Boane the south. The region in between is thus the central region. Thirty localities, the majority of which were cattle dip-tanks, distributed throughout the province were visually selected from a map of the province (Fig.2.1). At the time that each tick collection was made the geographic coordinates of the particular locality were recorded.



Fig. 2.1 sampling sites

Survey animals

At each locality an attempt was made to collect ticks from five approximately one year- old cattle, five goats and from five dogs. An attempt was also made to collect free-living, questing ticks, by dragging strips of flannel over the vegetation at each locality.

Tick collection

Parasitic ticks

Each bovine animal was cast with ropes before tick collection started. Ticks were collected from one half of each animal and particular attention was paid to the predilection sites of attachment of the adults of the various tick species including the feet and the tail switch. As the survey was aimed at determining the species composition of the ticks infesting the survey animals and their geographic distributions and not their prevalence or intensity of infestation none of the collections were intended to be complete. Nevertheless visibly infested animals were chosen to ensure the maximum collection of ticks. The ticks collected from each animal were placed in 70% ethanol in separate internally labelled bottles.

Adult ticks were collected from one side of each of the five goats. Each animal was laid on its side and properly restrained before collection commenced. When possible the more visibly tick infested animals were selected and the ticks of each animal were placed in 70% ethanol in a separate, internally labelled bottle. Whenever possible complete collections of adult ticks were made from five dogs and stored separately as described above. Each dog was laid on its side and properly restrained before collection commenced.

Free-living ticks

Three separate 100 meter long drag-samples, at least 50 meters apart, were done with flannel strips over the vegetation in the areas grazed by cattle at each sampling locality, as described by Spickett, Horak, Braack & Van Ark (1991). The ticks collected from the drag cloths were stored in 70% ethanol in separate internally labelled vials.

Treatment of data

The parasitic ticks and the free-living ticks that had been collected at each locality were transferred to a laboratory where they were identified and quantified under a stereoscopic microscope.

Using the geographic coordinates recorded at each sampling locality, and the species of ticks collected at each site the distributions of the tick species that infest domestic animals or that quest from the vegetation in Maputo Province were plotted.

RESULTS AND DISCUSSION

A total of 14 ixodid tick species identified to species level and one identified to genus level were recovered from cattle, goats, dogs and the vegetation in Maputo Province. Namely *A. hebraeum*, *Haemaphysalis elliptica*, *Haemaphysalis* sp., *Hyalomma rufipes*, *Ixodes cavipalpus*, *R. (B.) microplus*, *R. appendiculatus*, *R. evertsi evertsi*, *R. kochi*, *Rhipicephalus longus*, *R. pravus* group, *R. sanguineus*, *R. simus*, *R. tricuspis* and *R. turanicus*.

Ticks collected from cattle

A total of 11 ixodid tick species were recovered from cattle (Table 2.1), of these *A. hebraeum*, *R. (B.) microplus*, *R. appendiculatus*, *R. evertsi evertsi* and *R. simus* can be considered major species. Dias (1993) recorded 17 ixodid tick species, including *Hyalomma truncatum* that infest cattle in Mozambique. The latter tick was not recovered in the present survey, but Dias (1993) reported that

it is widely distributed throughout nearly the entire country, and that it parasitizes a large variety of animals, both domestic and wild, including birds.

In this study four tick species, not mentioned before by Dias (1993), were identified, namely *I. cavipalpus*, *R. longus*, ticks of the *R. pravus* group and *R. turanicus*.

Dias (1993) reported that *Ixodes pilosus* was widespread in Mozambique, but this was possibly incorrect and many of the ticks that he identified as *I. pilosus* can probably be accepted as *I. cavipalpus*. Many of the ticks that Dias (1993) identified as *R. sanguineus*, particularly if they came from animals other than domestic dogs, were probably actually *R. turanicus*. Walker *et al.* (2000) have plotted only two localities at which *R. turanicus* has been reported in Mozambique, while Neves *et al.* (2004) collected it from dogs at two rural settlements close to the city of Maputo.

Table 2.1: Ticks collected from 145 cattle at 30 localities in Maputo Province

Tick species	No. of localities infested	No. of cattle infested	No. of ticks collected	Proportion (%)
<i>Amblyomma hebraeum</i>	30	136	1 588	15,04
<i>Hyalomma rufipes</i>	1	1	1	0,01
<i>Ixodes cavipalpus</i>	1	1	1	0,01
<i>Rhip. (Boophilus) microplus</i>	29	129	6 790	64,31
<i>Rhipicephalus appendiculatus</i>	23	95	1 222	11,57
<i>Rhipicephalus evertsi evertsi</i>	29	103	593	5,61
<i>Rhipicephalus kochi</i>	5	5	9	0,09
<i>Rhipicephalus longus</i>	1	1	1	0,01
<i>Rhipicephalus pravus</i> group	1	3	8	0,08
<i>Rhipicephalus simus</i>	25	102	336	3,18
<i>Rhipicephalus turanicus</i>	5	7	9	0,09
Total			10 558	

Ticks collected from goats

A total of 11 ixodid tick species were recovered from the goats, of these *A. hebraeum*, *R. (B.) microplus*, *R. appendiculatus* and *R. evertsi evertsi*, can be considered major species (Table 2.2). Almost the same species of ticks recovered from cattle were recovered from the goats. All the species reported by Dias (1993) as parasitizing goats in Mozambique were recovered in the present survey, while species such as *I. cavipalpus*, *R. kochi*, *R. longus*, ticks of

the *R. pravus* group, *R. tricuspis* and *R. turanicus* are herein reported to occur on goats in Mozambique for the first time. In addition the presence of *R. tricuspis* on a domestic animal could possibly be considered a rarity, as it is more commonly a parasite of certain wild animals (Walker *et al.* 2000).

Table 2.2: Ticks collected from 129 goats at 26 localities in Maputo Province

Tick species	No. of infested localities	No. of goats infested	No. of ticks collected	Proportion (%)
<i>Amblyomma hebraeum</i>	26	118	1 130	43,93
<i>Ixodes cavipalpus</i>	1	4	7	0,27
<i>Rhip. (Boophilus) microplus</i>	16	43	351	13,65
<i>Rhipicephalus appendiculatus</i>	17	47	514	19,98
<i>Rhipicephalus evertsi evertsi</i>	22	83	513	19,94
<i>Rhipicephalus kochi</i>	4	8	21	0,82
<i>Rhipicephalus longus</i>	1	1	3	0,12
<i>Rhipicephalus pravus</i> group	2	2	2	0,08
<i>Rhipicephalus simus</i>	13	16	27	1,05
<i>Rhipicephalus tricuspis</i>	1	1	3	0,12
<i>Rhipicephalus turanicus</i>	1	1	1	0,04
Total			2 572	

Ticks collected from dogs

A total of ten ixodid tick species were recovered from the dogs, of these *A. hebraeum*, *H. elliptica*, *R. sanguineus* and *R. simus* can be considered major species (Table 2.3). Dias (1993) reported 12 species of ixodid ticks on dogs in Mozambique. Several of the species he reported are ticks that infest wildlife, and two of the species, as mentioned in the Introduction, have subsequently been synonymized. Most of the species recovered from dogs in the present study were also reported by Dias (1993). Neves *et al.* (2004) recovered nine species of ixodid tick from dogs in southern Mozambique, and to their list must now be added two species, namely *I. cavipalpus* and *R. evertsi evertsi*, which have not been reported from dogs in Mozambique before.

Table 2.3: Ticks collected from 132 dogs at 27 localities in Maputo Province

Tick species	No. of infested localities	No. of dogs infested	No. of ticks collected	Proportion (%)
<i>Amblyomma hebraeum</i>	16	33	210	16,90
<i>Haemaphysalis elliptica</i>	25	62	447	35,99
<i>Haemaphysalis</i> sp.	2	2	2	0,16
<i>Ixodes cavipalpus</i>	1	1	3	0,24
<i>Rhipicephalus appendiculatus</i>	4	6	7	0,56
<i>Rhipicephalus evertsi evertsi</i>	2	3	4	0,32
<i>Rhipicephalus pravus</i> group	1	3	2	0,16
<i>Rhipicephalus sanguineus</i>	6	17	153	12,31
<i>Rhipicephalus simus</i>	24	69	346	27,85
<i>Rhipicephalus turanicus</i>	9	18	68	5,47
Total			1 242	

Ticks collected from the vegetation

A total of six ixodid tick species were recovered from the vegetation, and of these *A. hebraeum*, *R. (B.) microplus* and *R. appendiculatus* were the most numerous (Table 2.4). The six species recovered are the same as those collected in abundance from the animals that were examined at the various localities and are also considered to be the most important ticks infesting these animals.

Compared to the number of tick species recovered from domestic animals the number collected from the vegetation represents only 37.5 % of the total number of tick species collected during the study. This could possibly be ascribed to the fact that several of the collections were made during the summer months, when there are few larvae of various species questing on the vegetation. Some of the collections were also made when the vegetation was moist from dew or rain, which may also have affected the efficacy of the sampling method. Furthermore, the larvae of several species do not quest for hosts from the vegetation and can thus not be collected by drag-sampling.

Table 2.4: Ticks collected from the vegetation at 23 localities in Maputo Province

Tick species	No. of positive localities	No. of ticks collected	Proportion %
<i>Amblyomma hebreum</i>	10	200	24,57
<i>Haemaphysalis elliptica</i>	1	2	0,25
<i>R. (Boophilus) microplus</i>	17	345	42,38
<i>Rhipicephalus appendiculatus</i>	13	245	30,09
<i>Rhipicephalus evertsi evertsi</i>	9	19	2,33
<i>Rhipicephalus simus</i>	3	3	0,37
Total		814	

IXODID TICK SPECIES COLLECTED FROM DOMESTIC ANIMALS

A total of 14 373 ixodid tick belonging to 14 species were recovered from cattle, goats and dogs during the present study (Table 2.5). The majority of these were *R. (B.) microplus*, followed by *A. hebraeum*, *R. appendiculatus*, *R. evertsi evertsi*, *R. simus* and *H. elliptica*. The latter six species can thus be considered as the major species that infest domestic animals in Maputo Province. Dias (1993) listed 26 species (of which two have subsequently been synonymized) that had been collected from these animals throughout the whole of Mozambique. Several of the latter 26 species are parasites of wildlife and were probably accidental infestations on the domestic animals that Dias (1993) examined.

Table 2.5: Species and total numbers of ticks collected from a total of 406 cattle, goats and dogs in Maputo Province

Tick species	No. of localities infested	No. of animals infested	No. of ticks collected	Proportion (%)
<i>Amblyomma hebraeum</i>	30	283	2 928	20,37
<i>Haemaphysalis elliptica</i>	25	62	447	3,10
<i>Haemaphysalis</i> spp.	4	2	2	0,01
<i>Hyalomma rufipes</i>	1	1	1	0,01
<i>Ixodes cavipalpus</i>	1	6	11	0,08
<i>Rhip. (Boophilus) microplus</i>	29	172	7 141	49,68
<i>Rhipicephalus appendiculatus</i>	24	148	1 744	12,13
<i>Rhipicephalus evertsi evertsi</i>	29	189	1 110	7,72
<i>Rhipicephalus kochi</i>	5	13	30	0,21
<i>Rhipicephalus longus</i>	1	2	4	0,03
<i>Rhipicephalus pravus</i> group	2	8	12	0,08
<i>Rhipicephalus sanguineus</i>	6	17	153	1,06
<i>Rhipicephalus simus</i>	27	187	709	4,93
<i>Rhipicephalus tricuspis</i>	1	1	3	0,02
<i>Rhipicephalus turanicus</i>	11	26	78	0,54
Total			14 373	

Amblyomma hebraeum

This tick has a three-host life cycle, with larvae, nymphs and adults feeding on separate hosts. On completion of feeding, engorged ticks leave the host and seek shaded microhabitats in which to moult or lay eggs. The developmental periods off the host are long and according to Norval (1977) the life cycle may take longer than one year to complete under field conditions in the Eastern Cape Province of South Africa. The pattern of seasonal occurrence is dependent on climate and varies considerably throughout the distributional range of the tick. In the Eastern Cape Province, which is one of the southernmost distribution localities of the tick, the adults are generally most numerous in summer, the larvae in autumn and winter and the nymphs during winter and spring (Horak 1999). In north-eastern KwaZulu-Natal, South Africa, just south of Maputo Province, and in the Kruger National Park, South Africa, just west of Maputo Province, no clear pattern of seasonality is evident and all stages of development appear to be present throughout the year (Horak, Boomker, Spickett & De Vos 1992; Horak, Boomker & Flamand 1995). A similar situation exists in Zimbabwe, with a slight increase in the numbers of adults during the late summer (Norval 1983).

The preferred hosts of the adults are large animals such as cattle and large wild ruminants, particularly giraffes, buffaloes, elands and rhinoceroses (Norval 1983; Horak, MacIvor, Petney & De Vos 1987a; Horak, Golezardy & Uys 2007). They do, however, also infest sheep and goats (Baker & Ducasse 1968; Horak, Williams & Van Schalkwyk 1991). The adults prefer the hairless areas under the tail, in the lower perineal region, on the udder, around the genitalia and in the axillae of cattle (Baker & Ducasse 1968), as well as around the feet of sheep and goats. The immature stages feed on the same large hosts as the adults and also on small antelopes, scrub hares, helmeted guineafowls, and tortoises (Horak *et al.* 1987a, 2007). The adults and nymphs are hunters, scuttling along

the ground when a suitable host is in the vicinity (Bryson, Horak, Venter & Yunker 2000). Only when sexually mature males are present will the females attach. The pheromones secreted by the mature male ticks not only attract female ticks but other males as well as nymphs (Bryson *et al.* 2000), which all attach to the host, usually in the vicinity of the mature males. The males and females mate and the females engorge and detach. After detaching, the engorged female can lay up to 20 000 eggs. These eggs hatch and the larvae wait for hosts on the vegetation (Spickett *et al.* 1991). The males may remain on the host animal for two months or longer (Jordaan & Baker 1981).

Amblyomma hebraeum occurs in a variety of climatic regions from South African Mediterranean and temperate regions, through savanna to steppe. It requires moisture and warmth, brush and bush, and does not survive in open grassland. The tick is confined to south eastern Africa. In South Africa it is found along the coastal belt in the east and inland in the north (Howell, Walker & Nevill 1978). It is also commonly found in eastern Swaziland, southern Mozambique, and eastern Botswana and in southern and eastern Zambia as well as parts of Zimbabwe (Walker & Olwage 1987).

This species is the main vector in southern Africa of *Ehrlichia ruminantium*, the causative organism of heartwater in domestic and some wild ruminants, and its long mouthparts are a cause of direct damage to its host's tissues (Walker, Bouattour, Camicas, Estrada-Pena, Horak, Latif, Pegram & Preston 2003; Norval & Horak 2004).

Amblyomma hebraeum was collected in all districts of Maputo Province (Fig. 2.2), and from all domestic animals involved in the study and also from the vegetation. More ticks were collected from cattle than from goats and relatively few from dogs. More adult ticks were recovered from cattle than from goats, confirming that the adults of this tick prefer large hosts.



Fig. 2. 2 Distribution of *Amblyomma hebraeum*

Although the present survey was designed to collect adult ticks, some larvae and a fairly large number of *A. hebraeum* nymphs were collected, undoubtedly because of the latter's large size, particularly when they are engorged.

Haemaphysalis elliptica

Haemaphysalis elliptica has been collected from dogs in all the surveys conducted in South Africa as well as the previous one conducted in Mozambique (Neves *et al.* 2004). It was not only present on dogs at all but two of the 27 localities at which ticks were collected from dogs in the present survey, but was recovered from 62 of the 132 dogs examined. Free-ranging domestic dogs and the larger wild felids are particularly susceptible to

infestation with *H. elliptica* (Horak, Braack, Fourie & Walker 2000; Horak, Emslie & Spickett 2001; Neves *et al.* 2004).

Subsequent to the survey on the ticks infesting dogs in Mozambique conducted by Neves *et al.* (2004), and during the present survey, *Haemaphysalis leachi*, one of the most commonly encountered ticks on dogs in southern Africa, was reinstated as *H. elliptica*, an old taxon from the Cape of Good Hope (Apanaskevich, Horak & Camicas 2007). The majority of ticks identified as *H. leachi* in the survey of Neves *et al.* (2004) have been re-examined and re-identified as *H. elliptica* (Apanaskevich *et al.* 2007), as have all the ticks in the present study.

Haemaphysalis elliptica was the most abundant tick species recovered from dogs in the current survey (Table 2.3). It was present on dogs throughout Maputo Province, from south to north and east to west (Fig. 2.3). Two ticks were also collected from the vegetation (Table 4).



Fig. 2. 3 Distribution of *Haemaphysalis elliptica*

At the time that Dias was conducting his surveys of ticks in Mozambique *H. elliptica* was considered a synonym of *H. leachi*, and he recorded the latter species in all regions of Mozambique. It would, however, now appear that both *H. elliptica* and *H. leachi* are present in Mozambique, with the former tick concentrated more in the south of the country and the latter in the north, with an area of overlap in the central regions (Apanaskevich *et al.* Horak 2007). Lewis, Penzhorn, Lopez-Rebollar & De Waal (1996) were able to experimentally transmit *Babesia canis rossi*, the cause of virulent babesiosis in domestic dogs in South Africa, with a tick they thought to be *H. leachi*. It is now apparent that they conducted their experiments with *H. elliptica* and that it is this tick that is the vector of *B. canis rossi*, and that the vector status of *H. leachi* is now uncertain

Hyalomma rufipes

Apanaskevich & Horak (2008) have recently raised the subspecies *Hyalomma marginatum rufipes* to specific status as *H. rufipes*. This tick has a two-host life cycle. The adults are most numerous in the early part of the wet season and the immature stages in the dry season (Norval 1982; Van Niekerk, Fourie & Horak 2006). Adults parasitize domestic and wild ungulates, showing a preference for the larger species (Norval 1982). The immature stages are parasitic on birds and scrub hares (Horak & Fourie 1991; Van Niekerk *et al.* 2006). *H. rufipes* is widely distributed in much of Africa and has been recorded from every climatic region from desert to rain forest. However its distribution is patchy and it is probably commoner in the drier areas. The infestation of birds by the immature stages of this tick contributes to its extensive distribution. It also occurs in southern Europe and extends eastwards to central Asia.

This tick is the most important vector in southern Africa of the virus causing Crimean-Congo haemorrhagic fever in humans (Swanepoel & Burt 2004). It also transmits the bacterium *Anaplasma marginale* and the protozoan *Babesia occultans* to cattle, and the bacterium *Rickettsia conorii* to humans (Walker *et al.* 2003; Norval & Horak 2004).

In this study only a single tick of this species was recovered from a bovine at Kulula in Namaacha district in the central region of the province. According to Dias (1993) the distribution of *H. rufipes* is restricted to the drier regions of Mozambique, namely in the provinces of Inhambane, Sofala, Tete and Niassa, where it parasitizes several wild mammals and birds as well as cattle.

Ixodes cavipalpus

In this survey *I. cavipalpus* was collected only in the district of Boane. Although Dias (1993) listed five species of *Ixodes* that occur in Mozambique, he did not include *I. cavipalpus* amongst these. According to Walker (1991) *I. cavipalpus* is possibly the most widely distributed *Ixodes* sp. in the Afrotropical region, and has been collected from a variety of hosts including carnivores (Theiler 1962). In the present survey small numbers of ticks were collected at the Mahubo locality between Boane and Bela Vista in the south of the province, from a bovine, goats and dogs, confirming the tick's wide host range.

Rhipicephalus (Boophilus) spp.

Making use of molecular analyses, supported by an analysis of morphological characters Murrell, Campbell & Barker (2000) and Beati & Keirans (2001) came to the conclusion that the genus *Rhipicephalus* is paraphyletic in respect of the genus *Boophilus*. Consequently Murrell & Barker (2003) proposed the use of the nomenclature *Rhipicephalus (Boophilus) spp.* for ticks belonging to this grouping. I have decided to follow their suggestion, although many people prefer to retain *Boophilus* as a generic name.

Rhipicephalus (B.) decoloratus and *R. (B.) microplus* are two of the economically most important tick species that infest cattle in southern Africa. *R. (B.) decoloratus* is indigenous to the continent, while *R. (B.) microplus* is of Asian origin. It has been suggested that *R. (B.) microplus* was introduced into east and South Africa from Madagascar, where it had originally arrived with cattle from southern Asia (Hoogstraal 1956). In Africa it has become established in much of East and southern Africa and is widespread in Madagascar (Walker *et al.* 2003).

It soon became apparent from the numerous reports of its occurrence, particularly in the Eastern Cape Province of South Africa (Baker, Jordaan & Robertson 1979) that *R. (B.) microplus* was in the process of increasing its distribution range. Later reports confirmed this and indicated that *R. (B.) microplus* was displacing *R. (B.) decoloratus* in some southern African countries (Mason & Norval 1980; Berkvens, Geysen, Chaka, Madder & Brandt 1998; Tonnessen, Penzhorn, Bryson, Stoltz & Masibigiri 2004).

The reasons for this displacement are probably numerous, but in southern Mozambique one of the major reasons for the disappearance of *R. (B.) decoloratus* was the civil war and the hardships that accompanied it. One of these hardships was the lack of food with the resultant killing of both domestic and wild animals, and with the wild animals also their accompanying tick fauna, especially *R. (B.) decoloratus*. When restocking with cattle commenced after the war *R. (B.) microplus* was probably introduced or reintroduced on these animals, whereas the larger wildlife species, and hence *R. (B.) decoloratus*, have still not returned to Maputo Province.

Furthermore the total life cycle of *R. (B.) microplus* is slightly shorter than that of *R. (B.) decoloratus* (Arthur & Londt 1973; Londt & Arthur 1975), and moreover

females of *R. (B.) microplus* lay slightly more eggs than *R. (B.) decoloratus* females (Spickett & Malan 1978). The steady spread of *R. (B.) microplus* is thus assisted by its shorter life cycle and higher reproductive potential. This enables it to compete successfully against *R. (B.) decoloratus* wherever these ticks occur together in warm moist climates that are favourable for the survival of the former tick (Mason & Norval 1980; Berkvens *et al.* 1998).

Rhipicephalus (B.) microplus also represents more of a threat to cattle farming than *R. (B.) decoloratus* because it transmits both *Babesia bovis* and *Babesia bigemina*, the cause of redwater or babesiosis in cattle, whereas the latter tick transmits only *Babesia bigemina*, the less pathogenic of the two protozoans (Norval & Horak 2004).

Rhipicephalus (Boophilus) decoloratus

Rhipicephalus (B.) decoloratus is an indigenous African tick, and has a one-host life cycle. The three developmental stages spend a total of about three weeks on the same host (Arthur & Londt 1973), and the life cycle including the non-parasitic phase, can be completed in approximately two months. More than one generation per annum can be completed (Walker *et al.* 2003). The major differences between it and *R. (B.) microplus* in southern Africa are that it has a wider host range and a wider distribution (Howell, Walker & Nevill 1978; Mason & Norval 1980; Walker 1991). *R. (B.) decoloratus* frequently parasitizes horses, donkeys, sheep and goats, and is commonly found on several wild ungulate species including impalas (*Aepyceros melampus*), kudu (*Tragelaphus strepsiceros*), eland (*Taurotragus oryx*) and sable antelopes (*Hippotragus niger*) (Mason & Norval 1980, Walker 1991, Horak *et al.* 1992; Horak, Gallivan, Braack, Boomker & De Vos 2003). The preferred feeding sites of all stages on cattle are the head, including the poll, the neck, including the dewlap, and the body (Baker & Ducasse 1967). In the present study no ticks of this species were recovered from cattle, goats, dogs, or the vegetation. According to Dias, (1993), *R. (B.) decoloratus* was at the time he compiled his list of the ticks of

Mozambique, very common in all regions of the country, wherever there were cattle, and it was also a parasite of several wild mammals. This no longer seems to be the case in Maputo Province, where it appears to have been completely displaced by *R. (B.) microplus*.

Rhipicephalus (Boophilus) microplus

Rhipicephalus (Boophilus) microplus also has a one-host life cycle. The time spent on the host, from the attachment of unfed larvae until the detachment of engorged females, is just short of three weeks (Londt & Arthur 1975). Because of this short life cycle the tick is able to pass through several generations in one year (Walker *et al.* 2003). Most ticks are encountered during the warm summer and autumn months, with smaller numbers present during the rest of the year. Low winter temperatures probably synchronize egg development and hatching, as in the case with *R. (B.) decoloratus*, so that the greatest number of larvae are usually present on pastures after the weather warms up in spring (Walker *et al.* 2003). Cattle are the major hosts of *R. (B.) microplus* and other livestock species and wild ungulates are rarely parasitized, and then only when there are infested cattle in the vicinity (Walker *et al.* 2003). However, in this survey and in a similar survey conducted in the eastern region of the Eastern Cape Province, South Africa a large number of goats were infested (Table 2.2; Nyangiwe & Horak 2007), and many goats harboured engorging female ticks, implying that *R. (B.) microplus* could complete its life cycle on goats. Infestations are found on the belly, dewlap, shoulders and flanks (Walker *et al.* 2003).

According to Walker *et al.* (2003) this tick species occurs in savanna regions in which there are habitats of wooded grassland used as cattle pasture. In South Africa it is now established in scattered areas along the southern and eastern coasts of the Western and Eastern Cape Province and of KwaZulu-Natal

(Howell *et al.* 1978; Baker *et al.* 1979). In the interior it is found in Mpumalanga and Northern Provinces (Tonnessen *et al.* 2004). Further north it occurs in parts of the eastern and central provinces of Zambia (Berkvens *et al.* 1998), throughout Malawi and to the east and north of Lake Malawi into Tanzania. It is also present in the coastal regions of Tanzania (Lynen, Zeman, Bakuname, Di Giulio, Mtui, Sanka & Jongejan 2008), and has spread into the southern coastal strip of Kenya. The full extent of its distribution in Mozambique is unknown.



Fig. 2.4 Distribution of *Rhipicephalus (Boophilus) microplus*

Rhipicephalus (Boophilus) microplus was recovered in all three regions of Maputo Province at 29 localities of the 30 localities surveyed in the study. The only place at which it was not recovered was Tinonganine in Matutuine district. This was the most abundant tick species collected from cattle and from the vegetation in all districts of Maputo Province (Table 2.1, 2.4; Fig. 2.4). It was present on 128 cattle of the 145 examined and on 43 goats of the 129

examined. No ticks were recovered from dogs. Dias (1993) lists *R. (B.) microplus* from cattle and goats in Mozambique. The single tick of this species collected from a domestic dog by Neves *et al.* (2004), must be considered an accidental infestation at a locality in which infested cattle were present.

Rhipicephalus appendiculatus

Rhipicephalus appendiculatus is a three-host tick, and all stages of development engorge within 4 to 7 days. It has an extremely wide host range, and parasitizes all species of domestic animals, especially cattle and the larger wild ruminants (Walker *et al.* 2000), on which very large infestations may occur (Horak *et al.* 2007). Sheep and goats are of lesser importance, and dogs and cats are rarely infested. This tick is well adapted to domestic cattle and all stages feed on these animals. Immature ticks can feed on smaller antelopes and scrub hares (Walker, 1991; Walker *et al.* 2000).

In the present study *R. appendiculatus* was collected from cattle, goats, dogs and the vegetation (Tables 2.1-2.4). A greater proportion of cattle than goats were infested, while few dogs harboured ticks of this species. The adults prefer the ears of their hosts (Baker & Ducasse 1967), but in severe infestations adults may also be found on other parts of the body. The immature stages attach to the ears as well as to other parts of the body, particularly those parts that come into contact with the vegetation on which these ticks are questing, namely the head, legs and dewlap (Baker & Ducasse 1967).

In southern Africa *R. appendiculatus* has a strictly seasonal life cycle, adults occur during the rainy period (December to March), larvae in the late summer and cool period after the rains (March to July) and nymphs in the winter and early spring (June to October) (Baker & Ducasse 1967; Londt, Horak & De Villiers 1979; Horak 1982b; Zieger, Horak & Cauldwell 1998; Horak *et al.* 1992). The pattern of seasonal occurrence is regulated by the unfed adult ticks, which

enter diapause and may not engage in host-seeking until the rains start (Short & Norval 1981).

Rhipicephalus appendiculatus is an inhabitant of savanna and temperate climatic regions, ranging from hot coastal areas to cool highland plateau provided there is adequate humidity (Walker *et al.* 2000). It tends to die out if overgrazing occurs and it does not survive on open plains. It is found from southern Sudan, through to the south eastern coast of South Africa (Walker *et al.* 2000). There is controversy over how far west it extends, but it is reliably recorded from western Zambia and central Democratic Republic of Congo (Walker *et al.* 2000). Dias (1993) concluded that *R. appendiculatus* was a common parasite of cattle in all regions situated to the south of the Save river. The extent of its distribution in the coastal regions of Mozambique is unknown (Walker *et al.* 2003). However, the current study reveals that it is present nearly throughout Maputo Province (Fig. 2.5).



Fig. 2. 5 Distribution of *Rhipicephalus appendiculatus*

It was present in 24 of 30 localities sampled, and was not recovered at Mahubo (Boane district), Mahele (Magude district), and excluding Catuane and Mahau it was not present in four of six localities of Matutuine district in the south of the province (Fig. 2.5).

The distribution map for this tick published by Walker *et al.* (2000) also indicates only one locality of collection in northern, north-eastern KwaZulu-Natal, South Africa, immediately to the south of the southern Mozambican border. It would thus appear as if this region is not as suitable as a habitat for *R. appendiculatus* as are the regions further north in Maputo Province and further south in KwaZulu-Natal.

Rhipicephalus appendiculatus transmits the protozoan *Theileria parva*, the cause of East Coast fever in cattle, and it transmits the various strains of *T. parva* that cause Corridor or Buffalo disease and Zimbabwean theileriosis (Lawrence, Perry, & Williamson 2004a, b). It also transmits *Theileria taurotragi* causing benign bovine theileriosis, and the bacteria *Ehrlichia bovis* and *Rickettsia conorii* (Norval & Horak 2004). No cases of theileriosis have been reported in cattle in Maputo Province.

Rhipicephalus evertsi evertsi

Rhipicephalus evertsi evertsi has a two-host life cycle in which the larvae moult to nymphs on a single host, and these detach and moult to adults, which then infest the second host. This tick can complete more than one generation per annum (Horak *et al.* 1991). All stages are present on hosts throughout the year,

although their abundance may vary from season to season (Norval 1981; Horak *et al.* 1991).

The preferred hosts of the adults are Equidae (horses, donkeys mules and zebras), although cattle, sheep, goats and a number of wild antelope species are also frequently parasitized (Norval 1981; Horak *et al.* 1991; Walker *et al.* 2000). Walker (1991) reports that *R. evertsi evertsi* parasitizes all domestic herbivores, especially horses, donkeys and cattle, but rarely dogs, and not cats. *R. evertsi evertsi* was collected from all domestic animals involved in the present study and from the vegetation. More cattle were infested than goats. As we can see from Table 2.3, only three dogs were infested and these harboured only four ticks, indicating that they were probably only accidentally infested. Dias (1993) also collected this species from cattle and goats in Mozambique.

Adults of *R. evertsi evertsi* attach in the perianal area of their ungulate hosts, and larvae and nymphs feed deep in the ear canal (Baker & Ducasse 1967).

The tick tolerates a wide range of climatic conditions and is present throughout most of the eastern regions of southern Africa. The main factor limiting its distribution in the west is increasing aridity, with the critical rainfall level being about 250 to 280 mm per annum (Howell *et al.* 1978). *R. evertsi evertsi* was collected in all districts of Maputo Province (Fig. 2.6), and was recovered in 29 of 30 localities sampled. The only locality at which it was not collected was at Mapulanguene, Magude district in the northern region of Maputo Province.



Fig. 2. 6 Distribution of *Rhipicephalus evertsi evertsi*

Rhipicephalus evertsi evertsi transmits the protozoans *Babesia caballi* and *Theileria equi* to horses (De Waal & Van Heerden 2004), and *Anaplasma marginale* to cattle (Norval & Horak 2004).

Rhipicephalus kochi

This species occurs south of the equator in parts of eastern, central and southern Africa. It is widespread in Tanzania, Zambia, Malawi and Mozambique, but has so far been found only in the south-eastern regions of Kenya, in the Democratic Republic of Congo and Zimbabwe and in north-eastern South Africa (Walker *et al.* 2000). *R. kochi* has been collected from antelopes and from scrub hares in north-eastern Limpopo Province and north-eastern KwaZulu-Natal Province, South Africa at the extreme limit of its southern distribution in southern Africa (Walker *et al.* 2000). Both of these provinces share a common border with Mozambique.

Rhipicephalus kochi is found in areas that range in altitude from a few meters above sea level to about 1 800m, with annual rainfalls between approximately 500mm and 1 300mm. It is primarily an inhabitant of the East African coastal mosaic as well as miombo, scrub and undifferentiated woodland, and deciduous bush-land and thicket (Walker *et al.* 2000). In the present study it was recovered from five cattle and eight goats and not from dogs. In addition to hares and antelopes Walker *et al.* (2000) record 199 collections of this tick from cattle, nine from goats and a single collection from a dog. They also report *R. kochi* as being present in three separate regions of Mozambique, namely in the south, the centre and in the north of the country. In the present survey it was collected at Pessene in the district of Moamba, in the central region of Maputo Province, and at Mahele and Panjane in the district of Magude in the north of the province.

Rhipicephalus longus

Rhipicephalus longus occurs in a broad belt across Africa, from the Cameroon, Gabon, the Congo and democratic Republic of Congo eastwards to western Ethiopia and thence south-wards to Zambia, Malawi and Mozambique (Walker *et al.* 2000). It is present at medium altitudes of about 500m to 1 500m with a hot humid climate and a well-distributed annual rainfall of over 1 000mm to 1 250mm. The vegetation in much of its habitat comprises various types of lighter forest and woodland (Walker *et al.* 2000). This tick was recovered on cattle and goats at only one locality in Maputo Province, namely Machubo in Marracuene district, in the central region of the province

***Rhipicephalus pravus* group**

Ticks belonging to this group appear to be parasites mainly of scrub hares, with Walker *et al.* (2000) recording 74 collections from these animals. They have, as

is the case in the present study, also been collected from cattle, goats and dogs (Walker *et al.* 2000). Their distribution is illustrated as northern Namibia, northern Botswana, northern South Africa and the southern half of Mozambique (Walker *et al.* 2000), and the collections made in the present survey fall within this distribution range (Fig. 2.7).

Dias (1993) mentions the recovery of *R. pravius* from wildlife and its presence in all provinces of Mozambique. He does, however, not distinguish between true *R. pravius*, which may occur in the far north of Mozambique on the border with Tanzania, and the *R. pravius*-like tick that I have currently collected. In the present study the latter tick was recovered at only two localities, namely at Mahubo, Boane district and at Machubo in the Marracuene district in the central region of Maputo Province.



Fig. 2.7 Distribution of *Rhipicephalus pravius* group

Rhipicephalus sanguineus

Rhipicephalus sanguineus is commonly known as the kennel tick or the pan-tropical dog tick. It has become the most widespread tick throughout the tropics and sub-tropics because of the preference of all its developmental stages for domestic dogs (Walker *et al.* 2000). According to Howell *et al.* (1978) and Walker (1991) it is primarily a parasite of dogs, and is only occasionally found on other hosts (Walker *et al.* 2000). The behaviour of this tick is both domestic and generally monotropic. It is always associated with domestic dogs and the man-made structures in which they live, and is not present in the wild (Bryson, Horak, Höhn & Louw 2000; Neves *et al.* 2004). It is usually only found on other host species if these are in close association with dogs. Horak *et al.* (2000) examined 23 species of wild carnivores throughout South Africa and recovered no *R. sanguineus* from any of them, whereas domestic dogs examined in the Provinces of Gauteng, North-West, KwaZulu-Natal, Free State and the Western Cape were infested with this tick (Horak 1995; Bryson *et al.* 2000; Horak *et al.* 2001; Jacobs, Fourie, Kok & Horak 2001; Horak & Matthee 2003). Although Dias (1993) listed *R. sanguineus* as infesting a variety of hosts in Mozambique and made no mention of *R. turanicus*, it seems likely that he failed to distinguish between the two ticks and assumed that they were all *R. sanguineus*. Neves *et al.* (2004), however, did make this distinction and collected both *R. sanguineus* and *R. turanicus* from dogs in Maputo Province.

Rhipicephalus sanguineus is a three-host tick, and its life cycle can be completed in 10 weeks under ideal conditions (Jacobs, Fourie & Horak 2004). In those southern African countries where the winter is cold, all stages are found on dogs from October to May (Horak 1982a). In the present study *R. sanguineus* was collected from dogs in three districts of Maputo Province (Fig. 2.8), namely Boane, Naamacha and Manhiça, in the central regions of the

province, where the collections were made at the dog owners' homes. The full extent of the distribution of *R. sanguineus* in Maputo Province is, however, still unknown. According to Dias (1993), it is present throughout Mozambique.



Fig. 2.8 Distribution of *Rhipicephalus sanguineus*

Rhipicephalus sanguineus transmits the bacteria *Ehrlichia canis* and *Rickettsia conorii* and the protozoans *Babesia canis* and *Hepatozoon canis* (Walker *et al.* 2003).

Rhipicephalus simus

Rhipicephalus simus is a three-host tick. Adult *R. simus* infests monogastric animals such as domestic and wild carnivores, pigs and warhogs, and horses and zebras in preference to multigastric ruminant hosts (Norval & Mason 1981; Walker *et al.* 2000). The immature stages infest rodents (Walker *et al.* 2000).

This is a tick of regions with a savanna climate. It is widely distributed in the moderate to high rainfall regions of Angola, Zambia, Malawi, Mozambique and Zimbabwe in the north to South Africa in the south (Walker *et al.* 2000). Although it has a widespread distribution this tick is never encountered in very large numbers. Its distribution is distinct from that of *R. senegalensis* and *R. muhsamae*, which both occur in an overlapping band from West Africa to East Africa (Walker *et al.* 2000). *Rhipicephalus simus* occurs entirely to the south of this band. There may, however, be some overlap between the most southerly distribution of *R. praetextatus* and the most northerly distribution of *R. simus*. In the present study 102 out of 145 cattle, 69 out of 132 dogs, and 16 of 129 goats were infested (Tables 2.1-2.3). It was collected from the tail switch and from around the feet above the hooves of the cattle and from the necks of the dogs. According to Walker (1991) adults of this tick readily feed on cattle and dogs, but apparently rarely on other domestic animals, as is evident from the small number of goats infested. However, in the eastern regions of the Eastern Cape Province, South Africa, in a similar survey to the one described here, *R. simus* was collected only from dogs and not from cattle or goats (Nyangiwe, Horak & Bryson 2006; Nyangiwe & Horak 2007).

Although few large wild herbivores are present in Maputo Province, the comparatively large number of cattle and dogs infested with adult ticks in the present survey reflect an abundance of rodents in this province that serve as hosts for the immature stages. Adults are present on dogs during summer (Horak, Jacot Guillarmod, Moolman & De Vos 1987b), larvae on rodents in autumn and winter, and nymphs on rodents in winter and spring (Petney, Horak, Howell & Meyer 2004). In the present survey the tick was recovered at 27 localities throughout Maputo Province (Fig. 2.9). It was, however, not collected at Chiango and Tsalala in the Maputo district, nor Marracuene sede in the Marracuene district. Dias (1993) lists *R. simus* as a very common tick in Mozambique and that it parasitizes a large variety of domestic and wild mammals.



Fig. 2. 9 Distribution of *Rhipicephalus simus*

Rhipicephalus simus can transmit the bacterium *Anaplasma marginale* to cattle both transstadially, as well as intrastadially in the adult stage (Potgieter & Van Rensburg 1987). It can also transmit the bacterium *Rickettsia conorii* and can produce a toxin, which causes paralysis in calves and lambs (Walker *et al.* 2003).

Rhipicephalus tricuspis

This species is present in southern Africa, especially in Botswana, northern South Africa and southern Mozambique. Collections also exist from northern Namibia, Zimbabwe, Western Zambia and western Democratic Republic of

Congo (Walker *et al.* 2000). The vast majority of these collection sites are in various types of dry woodland. The presence of this tick species in Mozambique has also been reported by Dias (1993), but he considered it a rarity on domestic animals because of its preference for certain wild animals, particularly hares (*Lepus* spp.). In the present survey *R. tricusps* was recovered at only one locality, namely Zitundo in Matutue district in the south of Maputo Province.

Rhipicephalus turanicus

Rhipicephalus turanicus is a three-host tick. Cattle, sheep and dogs are the domestic animals from which adult *R. turanicus* have most frequently been collected in sub-Saharan Africa (Walker *et al.* 2000). In the present survey seven cattle, a single goat and 18 dogs were infested (Tables 2.1-2.3). In Zimbabwe this tick, then referred to as a *Rhipicephalus* sp. within the *R. sanguineus* group by Norval, Daillecourt & Pegram (1983), may infest sheep very heavily. It is sometimes found on horses. Its favoured wild hosts are the larger carnivores with some collections from zebras and warthogs, and several from scrub hares, as well as some of the larger ground-feeding birds (Walker *et al.* 2000). The hosts of the immature stages include hedge-hogs, shrews, gerbils, murid rodents and hares (Walker *et al.* 2000). In South Africa the adults are generally most numerous during the late rainy to early dry season (Horak, Spickett & Braack 2000) and in Zimbabwe in the cool dry season (Norval *et al.* 1983).

Rhipicephalus turanicus is a tick of savanna, steppe, desert and Mediterranean climatic regions. It occurs in the eastern regions of the African continent from Sudan, Ethiopia and Somalia in the north to South Africa in the south (Walker *et al.* 2000). However, several collections have also been made in northern Namibia. In North Africa *R. turanicus* occurs mainly in Morocco, Algeria and Tunisia, as well as in several other Mediterranean countries and in their

immediate neighbours, and also in Russia, India and Pakistan and through to China (Walker *et al.* 2000).

Rhipicephalus turanicus was collected in four districts of Maputo Province, namely Magude, Boane, Namaacha and Matutuine, in the north, centre and south of the province. In the north of the province it was collected at three of five localities in Magude district, Magude sede, Mahele and Pajane, in the central region it was recovered in all sample localities in Boane district and in the Mafuiane locality of Namaacha district, while in the south it was present in four of six localities sampled, namely Salamanga, Catuane, Mudada and Mahau (Fig. 2.10). Dias (1993) made no mention of this species in his list of ticks occurring in Mozambique.



Fig. 2.10 Distribution of *Rhipicephalus turanicus*

No *R. turanicus* were collected from the vegetation, but Horak *et al.* (2000) have collected several adult ticks of this species from the vegetation in the south-east of the Kruger National Park, South Africa, to the west of Maputo Province.

CONCLUSIONS AND FINDINGS

A total of 14 ixodid tick species were recovered from domestic animals in Maputo Province. Of these *A. hebraeum*, *R. (B.) microplus*, *R. appendiculatus*, *R. evertsi evertsi*, *R. simus* and *H. elliptica* can be considered major species, not only because of their prevalence, but because of the diseases that they transmit. With the exception of *H. elliptica* on dogs, these ticks are economically important parasites of cattle, and *A. hebraeum* also of goats. The latter animals are also good hosts of most of the tick species that infest cattle (Nyangiwe & Horak 2007).

The geographic distributions of nine of the 14 ixodid tick species were mapped and these indicated that the major species, namely *A. hebraeum*, *H. elliptica*, *R. (B.) microplus*, *R. appendiculatus*, *R. evertsi evertsi* and *R. simus*, were widespread throughout Maputo Province. The displacement on domestic animals of the indigenous *R. (B.) decoloratus* by the exotic *R. (B.) microplus* in Maputo Province appears to be absolute.

Haemaphysalis elliptica, *I. cavipalpus*, *R. longus* and *R. turanicus* can be added to the lists of ixodid tick species previously published for Mozambique.

RECOMMENDATIONS

Further surveys in the district of Matutuine, in the south of Maputo Province are recommended. These surveys should pay especial attention to the occurrence and the geographic distribution of *R. appendiculatus*, especially at those localities at which it was not recovered during this survey, and attention must also be paid to collecting ticks from other host species that may be infested by this tick.

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Species composition and geographic distribution of ticks infesting cattle, goats and dogs in Maputo Province,
Mozambique

Table 2.6: Tick species collected from cattle

Localities	<i>Amblyomma heb.</i>				<i>Booph. microplus</i>				<i>Rhip. append.</i>				<i>Rhip. evertsi</i>				<i>Rhip. simus</i>				<i>Rhip. turanic.</i>				Other ticks
Maputo	L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults		
			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀	
Chiango	0	16	45	5	0	34	80	92	0	29	0	0	0	0	13	10	0	0	0	0	0	0	0	0	1F.Ixod. cav
Tsalala	1	18	29	3	0	45	49	68	0	7	0	0	0	0	21	8	0	0	0	0	0	0	0	0	
Sub Total	1	34	74	8	0	79	129	160	0	36	0	0	0	0	34	18	0	0	0	0	0	0	0	0	
Boane																									
Matola Rio	0	1	8	1	0	31	38	88	0	2	2	0	0	4	22	6	0	0	2	1	0	0	1	0	1M H. rufipes, 3F2M R. kochi
Umpala	0	1	16	11	0	0	0	3	0	8	113	31	0	0	0	3	0	0	21	11	0	0	0	0	
Mahubo	1	4	21	6	0	4	17	48	0	0	0	0	0	0	10	13	0	0	8	3					
Sub Total	1	6	45	18	0	35	55	139	0	10	115	31	0	4	32	22	0	0	31	15	0	0	1	0	
Namaacha																									
Mafuiane	4	84	25	2	0	26	51	63	0	95	0	2	0	0	27	17	0	0	1	2	0	0	0	0	1F R. kochi
Kulula	0	41	19	3	0	18	41	74	0	3	2	0	0	0	29	8	0	0	3	3					
Sede	0	1	4	1	5	87	67	96	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	
Goba	1	27	18	1	0	18	23	19	0	3	0	0	0	2	10	3	0	0	4	0	0	0	1	1	
Sub Total	5	153	66	7	5	149	182	252	0	101	2	2	0	2	67	28	0	0	8	6	0	0	2	1	
Matutuine																									
Salamanga	0	2	1	1	0	57	77	207	0	0	0	0	0	7	21	13	0	0	2	1	0	0	1	0	
Tinonganine	0	12	22	13	0	0	0	0	0	0	0	0	0	0	10	5	0	0	1	0	0	0	0	0	
Mudada	0	26	15	3	5	31	56	163	0	0	0	0	0	0	15	11	0	0	21	13	0	0	0		
Catuane	0	17	19	8	0	6	24	64	0	0	1	0	0	0	16	11	0	0	12	6	0	0	0	0	
Mahau	0	0	1	1	0	6	19	87	0	0	2	0	0	0	12	16	0	0	2	5	0	0	0	0	
Zitundo	0	3	2	1	2	23	89	220	0	0	0	0	0	0	10	2	0	0	0	0	0	0	0	0	
Sub Total	0	60	60	27	7	123	265	741	0	0	3	0	0	7	84	58	0	0	38	25	0	0	1	0	

Moamba																									1F.R. long.1M1F R. prav.
Sede	1	43	50	7	0	61	52	57	3	227	0	2	2	12	27	12	0	0	12	7					
Sabie1	0	8	21	8	0	40	76	132	0	23	23	13	0	0	8	3	0	0	0	0	0	0	0	0	
Sub Total	7	52	122	28	0	124	289	408	3	255	30	17	2	14	38	16	0	0	14	7	0	0	0	0	
Marracuene																									1M R. kochi
Sede	0	2	22	2	9	259	280	487	0	0	12	5	1	2	13	9	0	0	0	0	0	0	0	0	
Machubo	1	27	59	29	6	49	64	155	0	0	18	6	0	2	20	11	0	0	3	3					
Sub Total	1	29	81	31	15	308	344	642	0	0	30	11	1	4	33	20	0	0	3	3	0	0	0	0	
Manhica																									1F R. kochi 1F R. kochi
Maluana	1	34	36	7	0	24	89	166	0	43	115	1	0	0	7	6	0	0	2	4	0	0	0	0	
Sede	8	91	47	10	0	8	12	19	0	36	24	8	0	0	13	1	0	0	6	1	0	0	0	0	
3 de Fevereiro	0	1	2	3	0	0	20	24	0	20	18	7	0	2	5	2	0	0	12	9	0	0	0	0	
Ilha Josina	0	0	3	1	13	65	166	176	0	9	7	1	0	0	4	2	0	0	13	6	0	0	0	0	
Calanga	0	13	15	5	4	122	174	143	0	7	23	6	0	0	16	7	0	0	14	14	0	0	0	0	
Sub Total	9	139	103	26	17	219	461	528	0	115	187	23	0	2	45	18	0	0	47	34	0	0	0	0	
Magude																									1M R. kochi
Sede	7	46	30	7	6	87	93	134	2	217	4	4	0	0	8	6	0	7	7	6	0	0	0	0	
Mahele	18	43	25	10	2	51	60	82	0	0	0	0	0	0	1	2	0	0	11	3	0	0	0	0	
Mapulanguene	0	3	27	2	0	95	141	148	0	1	0	0	0	0	0	0	0	0	9	5	0	0	0	0	
Motaze	0	27	17	2	0	69	78	82	0	2	0	0	0	1	26	9	0	0	17	13	0	0	1	0	
Pajane	0	83	34	14	0	14	19	35	0	21	0	0	0	0	0	2	0	0	14	13	0	0	2	1	
Sub Total	25	202	133	35	8	316	391	399	2	241	4	4	0	1	35	8	0	7	58	40	0	0	3	1	
Grand Total	49	675	684	180	52	1353	2116	3269	5	758	371	88	3	34	368	188	0	7	199	130	0	0	7	2	
Total number of ticks collected 10558																									

**Species composition and geographic distribution of ticks infesting cattle, goats and dogs in Maputo Province,
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Table 2.7: Tick species collected from goats

Localities	<i>Amblyomma heb.</i>				<i>Booph. microp.</i>				<i>Rhip. append.</i>				<i>Rhip. evertsi</i>				<i>Rhip. simus</i>				<i>Rhip. turanic.</i>			
Maputo	L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults	
			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀
Chiango	0	28	23	13	0	1	0	2	0	74	0	0	0	0	26	23	0	0	0	0	0	0	0	0
Tsalala	0	13	0	0	0	2	1	3	0	36	0	0	0	0	13	6	0	0	0	0	0	0	0	0
Sub Total	0	41	23	13	0	3	1	5	0	110	0	0	0	0	39	29	0	0	0	0	0	0	0	0
Boane																								
Matola Rio	0	7	1	0	0	9	2	4	6	84	0	0	1	30	3	2	0	0	0	0	0	0	0	0
Umpala	0	2	1	0	0	0	0	5	0	2	0	0	0	1	4	3	0	0	1	0	2♂5♀ I. cav; 1♂1♀ R. prav			
Mahubo	2	18	3	2	0	1	2	4	0	0	0	0	0	1	13	4	0	0	1	1				
Sub Total	2	27	5	2	0	10	4	13	6	86	0	0	1	32	20	9	0	0	2	1	0	0	0	0
Namaacha																								
Mafuiane	1	53	0	0	0	1	1	1	0	15	0	0	0	0	13	5	0	0	0	0	0	0	0	0
Kulula	0	29	1	0	0	0	0	0	0	5	0	0	0	2	10	6	0	0	0	0	0	0	0	0
Sede	0	19	0	0	0	0	0	0	0	34	0	0	0	0	1	1	0	0	0	1	0	0	0	0
Goba	13	124	0	0	0	0	0	1	3	12	0	0	0	2	15	2	0	0	1	0	0	0	0	0
Sub Total	14	225	1	0	0	1	1	2	3	66	0	0	0	4	39	14	0	0	1	1	0	0	0	0
Matutuine																								
Salamanga	22	11	0	0	0	1	1	1	0	0	0	0	0	6	24	14	0	0	0	0	0	0	0	0
Tinonganine	0	8	0	0	0	0	0	0	0	0	0	0	0	0	10	12	0	0	0	0	3♀ R. kochi			
Mudada	No goats				No Goats				No Goats				No Goats				No goats							
Catuane	1	15	1	0	0	8	1	0	0	0	0	0	0	6	33	23	0	0	1	0	0	0	0	0
Mahau	No goats				No Goats				No Goats				No Goats				No goats				No Goats			
Zitundo	0	26	0	0	0	16	12	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sub Total	23	60	1	0	0	25	14	20	0	0	0	0	0	12	67	49	0	0	1	0	0	0	0	1

Moamba																								
Pessene	2	124	9	0	0	0	0	0	0	21	0	0	0	0	13	6	0	0	0	0	5♂R. kochi			
Sede	No goats				No Goats				No Goats				No Goats				No goats				No Goats			
Sabie1	No Goats				No Goats				No Goats				No Goats				No Goats				No Goats			
Sub Total	2	124	9	0	0	0	0	0	0	21	0	0	0	0	13	6	0	0	0	0	0	0	0	
Marracuene																								
Sede	0	16	4	0	56	35	41	49	0	0	0	0	24	18	23	7	0	0	0	0	0	0	0	
Machubo	2	68	0	1	1	0	1	0	0	0	0	0	0	0	1	4	0	0	0	0	1♀R. long;			
Sub Total	2	84	4	1	57	35	42	49	0	0	0	0	24	18	24	11	0	0	0	0	0	0	0	
Manhica																								
Maluana	0	2	9	0	0	0	2	4	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	
Sede	0	78	4	2	0	0	0	0	0	8	0	0	0	0	20	1	0	0	1	1	0	0	0	
3 de Fevereiro	1	3	3	0	0	0	0	0	0	0	0	0	0	0	5	2	0	0	1	3	0	0	0	
Ilha Josina	0	7	0	0	5	21	2	4	1	2	0	0	0	0	11	2	0	0	0	0	0	0	0	
Calanga	No goats				No Goats				No Goats				No Goats				No goats				No Goats			
Sub Total	1	90	16	2	5	21	4	8	1	10	0	0	0	0	39	6	0	0	2	4	0	0	0	
Magude																								
Sede	26	104	1	0	0	1	1	1	5	204	0	0	11	21	4	0	0	0	1	0	0	0	0	
Mahele	1	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3♂6♀ R. kochi			
Mapulanguene	0	6	2	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	
Motaze	0	90	2	0	0	3	6	13	0	1	0	0	0	0	19	2	0	0	1	2	4F R. kochi			
Panjane	0	108	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	
Sub Total	27	326	5	0	1	4	10	16	5	206	0	0	11	21	23	2	0	0	8	7	0	0	0	
Grand Total	71	977	64	18	63	99	76	113	15	499	0	0	36	87	264	126	0	0	14	13	0	0	0	
Total number of ticks collected 2572																								

Species composition and geographic distribution of ticks infesting cattle, goats and dogs in Maputo Province,
Mozambique

Table 2.8: Tick species collected from dogs

Localities	<i>Amblyomma heb.</i>				<i>Booph. microp.</i>				<i>Rhip. append.</i>			<i>Rhip. evertsi</i>				<i>Rhip. simus</i>				<i>Rhip. turanic.</i>				<i>Haem. elliptica</i>					
Maputo	L	N	Adults		L	N	Adults		L	N	Adults	L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults			
			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀	
Chiango	3	25	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	
Tsalala	No dogs				No dogs				No dogs				No dogs				No dogs				No dogs				No dogs				
Sub Total	3	25	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2		
Boane																													
Matola Rio	2	4	0	0	0	0	0	0	R. sang. 4M,5F				0	0	0	0	0	0	2	2	0	0	2	1	0	1	7	4	
Umpala	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4	2	0	0	17	5	0	5	9	12	
					R. prav. 2F								I. cavi, 1M 2F																
Mahubo	0	4	4	1					R. sang 7M,3F								0	0	7	4	0	0	9	6	0	1	16	6	
Sub Total	2	8	4	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	13	8	0	0	28	12	0	7	32	22	
Namaacha																													
Mafuiane	0	0	0	0	0	0	0	0	R.sang. 18M,6F				0	0	0	0	0	0	12	7	0	0	0	0	0	0	12	15	
Kulula	16	6	0	0			0	0	0	0	0	0	0	0	0	0	0	0	5	2	0	0	1	0	0	0	14	23	
Sede	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	5	0	0	0	2	0	0	9	14	
Goba	0	2	0	0	0	0	0	0	R. sang 2N,53M,34F				0	0	0	0	0	0	1	0	0	0	6	4	0	0	22	21	
Sub Total	16	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	14	0	0	7	6	0	0	57	73	
Matutuine																													
Salamanga	0	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	9	15	
Tinonganine	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	
Mudada	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	
Catuane	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	19	11	0	0	2	4	0	0	8		
Mahau	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	10	0	0	3	2	0	0	0	0	
Zitundo	0	0	0	0					0	0	0	0	0	0	0	0	0	0	17	6	0	0	0	0	0	0	24	31	
Sub Total	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	51	29	0	0	5	6	0	0	41	46	

{PAGE }

Species composition and geographic distribution of ticks infesting cattle, goats and dogs in Maputo Province,
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Table 2.9: Tick species collected from vegetation

Localities	<i>Amblyomma hebr.</i>				<i>Booph. microplus</i>				<i>Rhip. appendicul.</i>				<i>Rhip. evertsi</i>				<i>Rhip. simus</i>				<i>Haem. elliptica</i>			
	L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults		L	N	Adults					
			♂	♀			♂	♀			♂	♀			♂	♀			♂	♀				
Maputo																								
Chiango	0	0	0	0	0	25	0	0	8	4	0	0	0	0	0	0	0	0	0	0				
Tsalala	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0				
Sub Total	0	0	0	0	0	25	0	0	8	6	0	0	1	0	0	0	0	0	0	0				
Boane																								
Matola Rio	16	0	0	0	5	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0				
Umpala		No Drag				No Drag				No Drag				No Drag				No Drag						
Mahubo		No Drag				No Drag				No Drag				No Drag				No Drag						
Sub Total	16	0	0	0	5	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0				
Namaacha		No Drag				No Drag				No Drag				No Drag				No Drag						
Matutuine																								
Salamanga	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0				
Tinonganine	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0				
Mudada	13	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	2	0				
Catuane		No Drag				No Drag				No Drag				No Drag				No Drag						
Mahau	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Zitundo	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Sub Total	16	0	0	0	13	0	1	0	0	0	0	0	6	0	0	1	0	0	2	0				
Moamba																								
Sede	0	0	0	0	3	0	0	0	9	1	0	0	0	0	0	0	0	0	0	0				
Pessene	0	0	0	0	12	0	0	0	102	5	0	0	1	0	0	0	0	0	0	0				
Sabie1	123	0	0	0	86	0	0	0	2	10	0	0	0	0	0	0	0	0	0	0				
Sub Total	123	0	0	0	103	0	0	0	113	16	0	0	1	0	0	0	0	0	0	0				

Marracuene																								
Sede	No Drag				No Drag				No Drag				No Drag				No Drag							
Machubo	10	0	0	0	11	0	1	0	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	
Sub Total	10	0	0	0	11	0	1	0	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	
Manhica																								
Maluana	7	0	0	0	10	0	0	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
Sede	0	0	0	0	0	0	0	0	31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
3 de Fevereiro	0	0	0	0	13	0	0	0	32	0	0	0	2	0	0	0	0	0	0	0	0	0	0	
Ilha Josina	0	0	0	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Calanga	No Drag				No Drag				No Drag				No Drag				No Drag							
Sub Total	7	0	0	0	25	0	0	0	71	1	0	0	3	0	0	0	0	0	0	0	0	0	0	
Magude																								
Sede	2	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Mahele	22	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Mapulanguene	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
Pajane	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Motaze	2	0	0	0	142	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	
Sub Total	26	0	0	0	162	0	0	0	25	0	0	0	4	0	0	0	0	0	1	0	1	0	0	
Grand Total	200	0	0	0	319	25	1	0	211	34	0	0	18	0	0	1	0	0	3	0	2	0	0	
Total number of ticks collected 814																								

CHAPTER 3

A Comparison of the Ixodid Ticks Infesting Cattle and Goats in Maputo Province

INTRODUCTION

Seventeen species of ixodid ticks have been reported from cattle in Mozambique (Dias 1993). Amongst these *Amblyomma theileri* has been synonymized with *Amblyomma hebraeum* (Camicas, Hervy, Adam & Morel 1998), and in our opinion the tick identified by Dias (1993) as *Rhipicephalus sanguineus*, is more likely to be *Rhipicephalus turanicus*. Dias (1993) also lists five tick species that parasitize goats in Mozambique. These five ticks, namely *A. hebraeum*, *Rhipicephalus (Boophilus) microplus*, *Rhipicephalus appendiculatus*, *Rhipicephalus evertsi evertsi* and *Rhipicephalus simus* also infest cattle (Dias 1993). Although no surveys have been carried out on the tick species that infest sympatric cattle and goats in Mozambique, several such studies have been done in South Africa (Baker & Ducasse 1967, 1968; Rechav 1982; Nyangiwe & Horak 2007).

In KwaZulu-Natal Province, South Africa, Baker & Ducasse (1968) examined cattle at five localities at which goats were also present, and in the Eastern Cape Province Nyangiwe & Horak (2007) examined sets of five cattle and five goats at 72 communal cattle dip-tanks. The latter authors stated that there are no tick species that infest either of these hosts to the exclusion of the other in that region of the country. However, whereas cattle may harbour large numbers of both adult and immature ticks (Baker & Ducasse 1967), goats are often hosts of large numbers of immature ticks and fewer adults (Baker & Ducasse 1968; MacIvor & Horak 2003). Baker & Ducasse (1968) and Nyangiwe & Horak (2007) concluded that goats played an important role in maintaining infestations of ticks that normally infest cattle, and recommended that they should be included in tick control programmes designed for cattle on the same properties.

The objective of the present study was to compare the prevalence of infestation of the major ixodid tick species that infest sympatric cattle and goats in Maputo Province, Mozambique.

MATERIALS AND METHODS

Localities and animals

Ticks were collected from cattle at 30 localities spread throughout Maputo Province, and from goats at 25 of these localities. However, the required numbers of five animals of both species were realised at only 21 of these sites, and consequently only the tick burdens of animals examined at the latter localities were compared for the purpose of this communication.

Tick collections

Ticks were collected from the ears, bodies, bellies, feet, tails and peri-anal regions of the cattle and goats on the single occasion that each locality was visited. The collections of ticks from each bovine or goat were not intended to be exhaustive, and focused mainly on adult ticks, but several nymphs of *A. hebraeum* and *R. appendiculatus* were also collected. The ticks were placed in 70% ethyl alcohol in internally labelled vials and transported to a laboratory in Maputo or in Pretoria where they were identified and counted under a stereoscopic microscope.

Presentation of data

Only the five major tick species collected from both cattle and goats were considered for comparison. These were *A. hebraeum*, *R. (B.) microplus*, *R. appendiculatus*, *R. e. evertsi* and *R. simus*. Because the collections of ticks from each animal were not complete, the actual numbers of ticks recovered from the cattle and goats cannot be compared. However, the presence or absence of a particular tick species on the two host species, as well as at the various sampling localities, can be compared. These data are presented in tabular format together with similar data collected from cattle and goats in the Eastern Cape Province, South Africa.

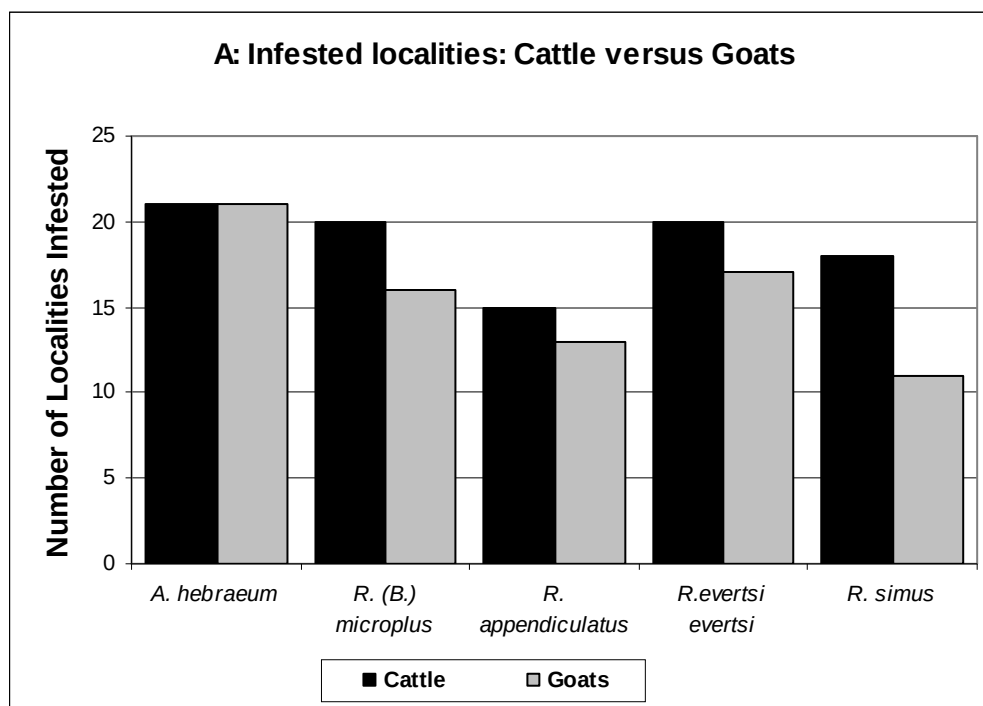
The statistical analyses were performed by Prof J.O. Nöthling of the Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria. The proportion of infested cattle was compared to the proportion of infested goats by means of a Chi-square test, while the proportion of dip-tanks at which infested cattle were present was compared to the proportion at which there were infested goats by means of Fischer's exact test. A paired t-test was used to compare the differences between the average numbers of infested cattle and infested goats at each dip-tank. If the differences were not normally distributed Willcoxon's signed rank test was used. The NCSS 2004 software package (www.NCSS.com) was used for all statistical analyses.

The data are also presented graphically.

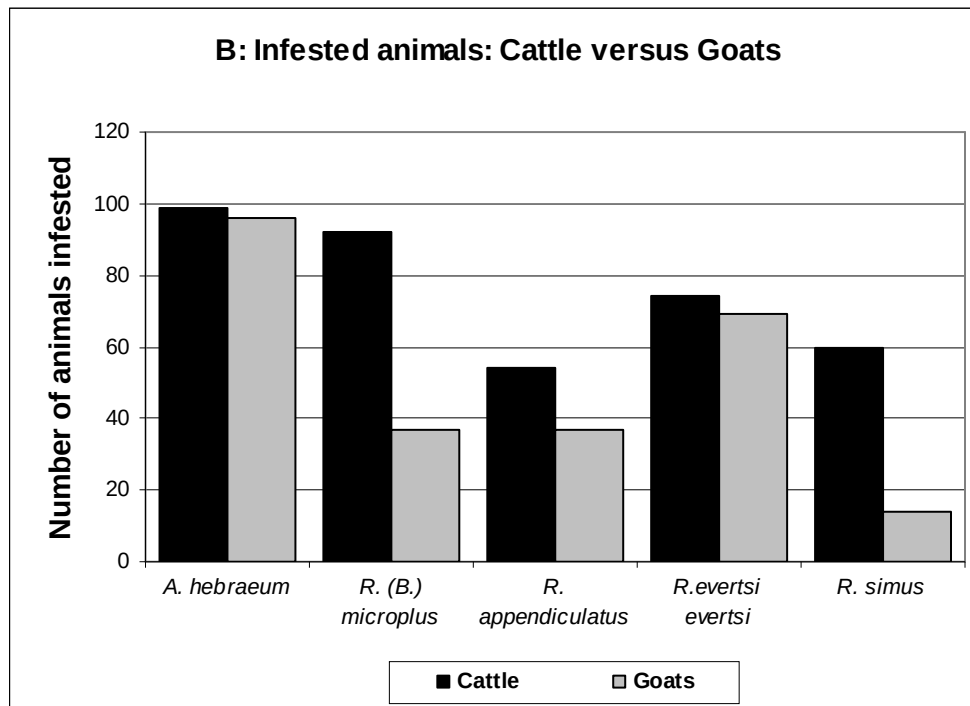
RESULTS

Amblyomma hebraeum was present on cattle and goats at all 21 sampling localities, and similar total numbers (99 vs. 96), and proportions (Chi-square, $P = 0.26$), and average numbers were infested (Willcoxon's signed rank test, $P=0.6$) (Table 3.1, Fig. 3.1). The total number of nymphs collected from the

goats (677) was slightly greater than that from the cattle (558), but a significantly greater proportion of goats than cattle were infested with nymphs (Chi-square, $P < 0.01$). There was, however, no significant difference between the average numbers of cattle (3.5 ± 1.69) and goats (4.3 ± 0.96) infested with nymphs at each dip tank ($P = 0.08$, paired t -test). Many more adult ticks were collected from the cattle (584) than from the goats (71), and a significantly greater proportion (Chi-square, $P < 0.001$) and average number ($P < 0.001$, paired t -test) of cattle than goats were infested with adult ticks (Table 3.1).



a) Localities at which *Amblyomma hebraeum*, *Rhipicephalus (Boophilus) microplus*, *Rhipicephalus appendiculatus*, *Rhipicephalus evertsi evertsi* and *Rhipicephalus simus* were present on cattle and goats



b) Cattle and goats from which these ticks were collected at 21 localities in Maputo Province, Mozambique

FIG. 3.1 The number of a) localities at which *Amblyomma hebraeum*, *Rhipicephalus (Boophilus) microplus*, *Rhipicephalus appendiculatus*, *Rhipicephalus evertsi evertsi* and *Rhipicephalus simus* were present on cattle and goats, and the total numbers of b) cattle and goats from which these ticks were collected at 21 localities in Maputo Province, Mozambique

Table 3.1. Relative prevalence of ixodid ticks on 105 cattle and 105 goats examined in sets of five at 21 localities in Maputo Province

Tick and host species	Number (proportion) of animals infested			Number (proportion) of localities positive	Average number ($\pm$ SD) of animals infested at each locality		
	Nymphs	Adults	Nymphs and adults		Nymphs	Adults	Nymphs and adults
<i>Amblyomma hebraeum</i>							
Cattle	74 (70.5%) ^a	90 (85.7%) ^a	99 (94.3%)	21 (100%)	3.5 ($\pm$ 1.69)	4.3 ($\pm$ 1.00) ^a	4.7 ($\pm$ 0.56)
Goats	90 (85.7%) ^a	22 (21.0%) ^a	96 (91.4%)	21 (100%)	4.3 ($\pm$ 0.96)	1.0 ($\pm$ 1.24) ^a	4.6 ($\pm$ 0.68)
<i>Rhipicephalus (Boophilus) microplus</i>							
Cattle			92 (87.6%) ^a	20 (95.2%)			4.4 ($\pm$ 1.43) ^a
Goats			37 (35.2%) ^a	16 (76.2%)			1.8 ($\pm$ 1.51) ^a
<i>Rhipicephalus appendiculatus</i>							
Cattle	46 (43.8%)	28 (26.7%) ^a	54 (51.4%) ^a	15 (71.4%)	2.2 ($\pm$ 2.11)	1.3 ($\pm$ 1.85) ^a	2.6 ($\pm$ 2.10)
Goats	36 (34.3%)	1 (0.9%) ^a	37 (35.2%) ^a	13 (61.9%)	1.7 ($\pm$ 1.90)	0.05 ($\pm$ 0.25) ^a	1.8 ($\pm$ 1.95)
<i>Rhipicephalus evertsi evertsi</i>							
Cattle		74 (70.5%)		20 (95.2%)		3.5 ($\pm$ 1.32)	
Goats		69 (65.7%)		17 (81.0%)		3.3 ($\pm$ 2.02)	
<i>Rhipicephalus simus</i>							
Cattle		60 (57.1%) ^a		18 (85.7%) ^a		2.9 ($\pm$ 1.82) ^a	
Goats		14 (13.3%) ^a		11 (52.4%) ^a		0.62 ($\pm$ 0.67) ^a	

Pairs of figures in the same column, under the same species name and bearing the same superscript are significantly different ($P \leq 0.05$)

The proportion and average numbers of cattle infested with *R. (Boophilus) microplus* were significantly greater than the proportion and average numbers of infested goats (Chi-square, $P < 0.001$, and paired *t*-test, $P < 0.001$ respectively). There was, however, no difference in the proportion of localities at which infested cattle and goats were present (Fisher's exact test, $P = 0.18$).

A total of 4 932 *R. (B.) microplus* was collected from the cattle compared to a total of 357 ticks from the goats, and 151 out of a total of 445 female *R. (B.) microplus* collected from some of the cattle exceeded 5 mm in length, while 15 of a total of 74 females collected from some of the goats also exceeded this length.

The average numbers of cattle and goats that were infested with *R. appendiculatus* nymphs and adults at each locality, and the proportion of localities at which infested cattle and goats were present did not differ significantly (paired *t*-test, $P = 0.07$, and Fischer's exact test, $P = 0.74$ respectively). Compared to goats, the proportion of cattle and the average numbers infested with adult *R. appendiculatus* at each locality were significantly greater (Chi-square, $P < 0.001$, and Willcoxon's signed rank test, $P < 0.01$ respectively). The proportion of cattle infested with nymphs and adults was also significantly greater than the proportion of goats similarly infested (Chi-square, $P = 0.02$).

Few *R. evertsi evertsi* nymphs, but several hundred adults were collected from both cattle and goats. The proportions and average numbers of cattle and goats that were infested, and the proportion of localities at which infested cattle and goats were present were similar (Chi-square, $P = 0.46$, paired *t*-test, $P = 0.5$, and Fischer's exact test, $P = 0.34$ respectively) (Table 3.1, Fig. 3.1).

Only adult *R. simus* were collected from the cattle and goats. A significantly greater proportion of cattle than goats was infested (Chi-square, $P < 0.001$), and infested cattle were present at a significantly greater proportion of localities than

infested goats (Fischer's exact test, $P = 0.04$) (Fig. 3.1). The average number of infested cattle at each locality was also significantly greater than the average number of infested goats (Wilcoxon's signed rank test, $P < 0.001$).

DISCUSSION

Although it was not our intention to collect immature ticks, the fairly large numbers of nymphs of both *A. hebraeum* and *R. appendiculatus* that were collected contributed significantly towards the results obtained for both tick species. Had only adult ticks been collected, fewer goats would have been recorded as being infested with either species.

Table. 3. 2: Ticks collected from cattle and goats in the Eastern Cape Province, South Africa and in Maputo Province, Mozambique

Province and tick species	Cattle			Goats		
	Total No. of ticks		No. of collections	Total No. of ticks		No. of collections
	Nymphs	Adults		Nymphs	Adults	
Eastern Cape, RSA¹	Treated ca. 14 days previously			Untreated		
<i>Amblyomma hebraeum</i>	4	588	138	19	49	61
<i>R. (Boophilus) microplus</i>	960 (all stages)		242	236 (all stages)		113
<i>Rhip. appendiculatus</i>	5	2 154	271	59	1 865	296
<i>Rhip. evertsi evertsi</i>	31	1 926	316	41	2 210	334
Maputo, Mozambique²	Untreated			Untreated		
<i>Amblyomma hebraeum</i>	558	584	99	677	71	96
<i>R. (Boophilus) microplus</i>	4 932 (all stages)		92	357 (all stages)		37
<i>Rhip. appendiculatus</i>	501	269	54	423	3	37
<i>Rhip. evertsi evertsi</i>	12	368	74	78	346	69
<i>Rhip. simus</i>	NA	250	60	NA	23	14

¹ Nyangiwe & Horak (2007); ² Present study

RSA= Republic of South Africa; NA= Not applicable, nymphs feed on rodents

Nyangiwe & Horak (2007) collected adult *A. hebraeum* from 138 of 360 cattle examined in the Eastern Cape Province, South Africa, and from 61 of 360 goats examined at the same localities as the cattle (Table 3.2). Although the proportion of goats infested with adult ticks in the current survey was reasonably similar to that conducted by Nyangiwe & Horak (2007), 20.9% compared to 16.9%, the proportion of infested cattle differed considerably,

85.7% compared to 38.3% (Table 3.2). Horak, MacIvor, Petney & De Vos (1987) concluded that the larger the host species the greater the likelihood that it would harbour adult *A. hebraeum*, and this was confirmed by the present findings.

Amblyomma hebraeum was present at every locality sampled in Maputo Province compared to only 54.2% of 72 localities in the Eastern Cape Province (Nyangiwe & Horak 2007). This difference can probably be ascribed to the prevailing climate of Maputo Province as being more suitable for *A. hebraeum* than that of the eastern regions of the Eastern Cape Province.

Rhipicephalus (Boophilus) microplus is a cattle tick, and is usually only found on other animals provided infested cattle are present at the same locality. Its ability to infest goats was reported 40 years ago by Baker & Ducasse (1968), who recovered a total of 266 ticks in all stages of development in nine consecutive collections from a goat, while the total yield of nine collections each from two calves at the same locality in KwaZulu-Natal Province, South Africa, was 32 692 ticks. However, as far back as 1943, Theiler, in her monograph on the ticks of domestic livestock in Mozambique, mentioned that the tick that she then referred to as *Boophilus (Uroboophilus) fallax*, and that is now accepted as *R. (B.) microplus* (Camicas *et al.* 1998), was found mostly on cattle, but that it could also occur on equines, ovines and caprines (Theiler 1943). Furthermore Dias (1993) listed both *Rhipicephalus (Boophilus) decoloratus* and *R. (B.) microplus* from cattle in Mozambique, but listed only *R. (B.) microplus* from goats. Nyangiwe & Horak (2007) recorded 242 collections of *R. (B.) microplus* from cattle and 113 collections from goats examined at the same localities in the Eastern Cape Province, South Africa (Table 3.2). They also noted that a large proportion of maturing female ticks collected from the goats were 5 mm or more in length (standard females), indicating that they should complete their engorgement and detach within the following 24 h.

The recovery of *R. (B.) microplus* from goats at so many localities in the present study can partly be ascribed to the high prevalence of infestation on cattle at the same localities (Fig. 3.1). The presence of standard female ticks on many of the goats in this survey as well as that of Nyangiwe & Horak (2007) is a fair indication that in at least two regions of southern Africa *R. (B.) microplus* has adapted to feeding on goats, and may even be able to survive on these animals in the complete absence of cattle. Nyangiwe & Horak (2007) speculated that if *R. (B.) microplus* had indeed adapted to goats, a further adaptation to various wildlife species, particularly those that share much of their habitat with goats in the Eastern Cape Province, may be imminent. A similar risk does not seem to exist in Maputo Province, where most of the larger wildlife species were annihilated during the civil war of the 1980s. Subsequent human settlement and agricultural activities in the province, which is the most populous in Mozambique, have now decimated much of the remaining wildlife's natural habitat. With the possible exception of a few isolated localities it would seem as if the introduced *R. (B.) microplus* has completely displaced the indigenous *R. (B.) decoloratus* in Maputo Province.

Domestic cattle and large wild herbivores such as greater kudu, *Tragelaphus strepsiceros*, eland, *Taurotragus oryx*, and African buffaloes, *Syncerus caffer*, are the hosts favoured by adult *R. appendiculatus* (Baker & Ducasse 1967; Horak, Boomker, Spickett & De Vos 1992; Horak, Golezardy & Uys 2007). These animals as well as many smaller domestic and wild herbivores can also all be heavily infested with the immature stages of this tick (Baker & Ducasse, 1967, 1968; Horak, Gallivan, Braack, Boomker & De Vos 2003; Horak *et al.* 2007). Contrary to the study of Baker & Ducasse (1968) in KwaZulu-Natal, in which slightly more adult *R. appendiculatus* were collected from cattle than from goats, and that of Nyangiwe & Horak (2007) in the Eastern Cape Province, in which slightly more goats than cattle were infested with adult ticks, only three adult ticks were recovered from a single goat in the present survey compared to 269 adult ticks from 28 cattle (Table 3.2). One of the reasons for this anomaly can be that the collections by Nyangiwe & Horak (2007) were all made during

the months January to May (mid-summer to autumn), the period of peak abundance of adult *R. appendiculatus* in the Eastern Cape Province (Rechav 1982), as well as in the Kruger National Park, which lies immediately to the west of Maputo Province (Horak *et al.* 1992). In the Mozambican survey 12 of the 21 localities were sampled during June or July, months during which few adults are present, but in which large numbers of larvae and nymphs occur (Horak *et al.* 1992), as in the present case.

Of all tick species that belong to the genus *Rhipicephalus* in Africa, *R. e. evertsi* has the most widespread distribution and also has one of the largest host ranges (Walker *et al.* 2000). The preferred hosts of its adult and immature stages are domestic and wild equids and eland (Norval 1981; Horak *et al.* 2007), but cattle, goats and sheep are also suitable hosts (Walker *et al.* 2000). Baker & Ducasse (1968) collected more adult ticks from untreated cattle than from goats at five localities in KwaZulu-Natal Province, whereas Nyangiwe & Horak (2007) collected adult ticks from slightly more goats than from cattle at their 72 sampling localities (Table 3.2).

Only adult *R. simus* were collected from both cattle and goats in the present study. This is not surprising as the immature stages infest rodents (Norval & Mason 1981; Rechav 1982). In the study conducted in the Eastern Cape Province by Nyangiwe & Horak (2007), no *R. simus* were collected from cattle or from goats, even though it was present on dogs sampled at the same localities (Nyangiwe, Horak & Bryson 2006). In the present study the majority of dogs examined concurrently with the cattle and goats were infested (De Matos, Siteo, Neves, Bryson & Horak 2008). Judging by the number and the variety of hosts infested and the widespread occurrence of *R. simus* in Maputo Province, the prevailing climate and other environmental conditions are obviously favourable for its survival.

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CHAPTER 4

Ixodid Ticks Infesting Dogs in Maputo Province

INTRODUCTION

Dias (1993) recorded 12 species of ixodid ticks infesting dogs in Mozambique, namely *Amblyomma hebraeum*, *Amblyomma tholloni*, *Haemaphysalis humerosoides* (considered a synonym of *Haemaphysalis leachi* by Camicas, Hervy, Adam & Morel (1998), *Haemaphysalis leachi*, *Ixodes pilosus*, *Rhipicephalus appendiculatus*, *Rhipicephalus kochi*, *Rhipicephalus muehlensi*, *Rhipicephalus reichenowi* (considered a synonym of *Rhipicephalus planus* by Walker, Keirans & Horak (2000), *Rhipicephalus sanguineus*, *Rhipicephalus simus* and *Rhipicephalus tricuspis*. However, he supplied no accurate information on the geographic distribution of these tick species within Mozambique. The first study taking the geographic distribution of ticks infesting domestic dogs in this country into account was done by Neves, Afonso & Horak (2004) in southern Mozambique. They recovered ten species of ticks and recorded the geographic coordinates of the localities at which the ticks were collected.

In South Africa a total of 23 ixodid and one argasid tick species have been recovered from dogs (Horak, Jacot Guillarmod, Moolman & De Vos 1987b; Horak 1995; Bryson, Horak, Höhn & Louw 2000; Horak, Emslie & Spickett 2001; Jacobs, Fourie, Kok & Horak 2001; Horak & Matthee 2003; Nyangiwe, Horak & Bryson 2006). The geographic distributions of some of the most important ticks that infest dogs, namely *H. leachi* (*Haemaphysalis elliptica*), ticks of the *Ixodes pilosus* group, *Rhipicephalus gertrudae* and *R. simus* have already been mapped by other workers (Howell, Walker & Nevill 1978; Walker *et al.* 2000). Subsequently one of

the most commonly occurring ticks on dogs, namely *H. leachi*, has been reinstated as *Haemaphysalis elliptica*, an old taxon originally described from the Cape of Good Hope (Apanaskevich, Horak & Camicas 2007). With the exception of the ticks in the survey conducted by Jacobs *et al.* (2001), most of the ticks identified as *H. leachi* in the above-mentioned surveys, have been re-examined and confirmed as actually being *H. elliptica* (Apanaskevich *et al.* 2007).

In north-eastern KwaZulu-Natal Province, South Africa, Horak *et al.* (2001) recorded seven species of ixodid ticks from dogs belonging to persons in rural communities. Adult *H. elliptica* (then referred to as *H. leachi*) followed by immature *A. hebraeum* and adult *R. simus* were the most numerous of these. Jacobs *et al.* (2001) collected ticks from dogs in households in affluent and in resource-limited communities in and around the city of Bloemfontein, Free State Province, South Africa, and recorded significantly more *R. sanguineus* on dogs in the latter than in the former localities. The other South African surveys indicated that dogs owned by urban householders are more likely to be infested with *R. sanguineus* than those on larger properties, whereas dogs kept under more extensive conditions, on small-holdings or farms, are liable to be infested with *H. elliptica* (then referred to as *H. leachi*) and *R. simus*.

The purpose of this study was to determine the species composition of ticks that infest domestic dogs in Maputo Province and their geographic distributions.

MATERIALS AND METHODS

Survey localities and animals

Thirty rural communal cattle dip-tanks or villages, evenly spread throughout Maputo Province were selected for the survey. Ticks were to be collected,

whenever possible, from five dogs at each of these localities. In addition 24 dogs at two villages in southern Maputo Province were examined for ticks during a rabies inoculation campaign, as well as two dogs at two villages in the south-east of the province.

Tick collections

All visible ticks were collected from each dog and placed in separate labelled vials containing 70 % ethyl alcohol. Thereafter the body surface of the dog was palpated and all ticks detected in this manner were collected and placed in the same vials as the visual collections. The ticks were initially sorted, identified and counted under a stereoscopic microscope at a central Veterinary laboratory in Maputo and their identities confirmed by Prof I. Horak at the Faculty of Veterinary Science, University of Pretoria, South Africa.

RESULTS AND DISCUSSION

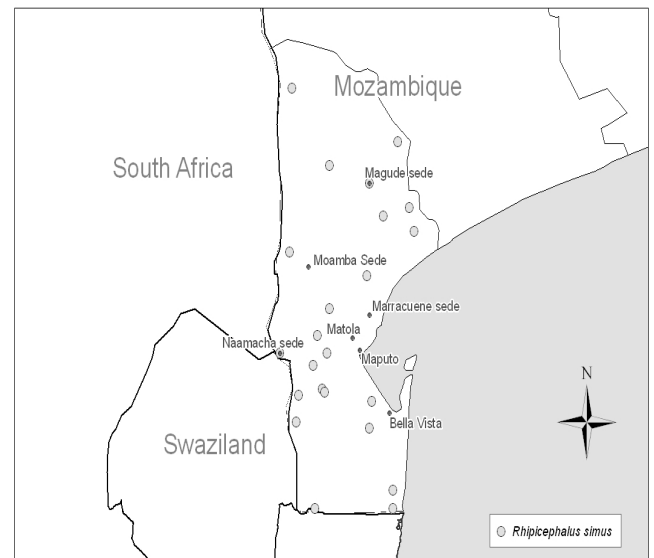
Table. 4.1 Ticks collected from 132 dogs at 27 rural localities in Maputo Province, Mozambique

Tick species	No. of positive localities	No. of dogs infested	Number of ticks collected				
			Larvae	Nymphs	Males	Females	Total
<i>Amblyomma hebraeum</i>	16	57	48	195	24	4	271
<i>Haemaphysalis elliptica</i>	25	100	0	9	252	331	592
<i>Haemaphysalis</i> spp.	4	6	0	0	3	4	7
<i>Ixodes cavipalpus</i>	1	2	0	0	1	2	3
<i>Rhipicephalus appendiculatus</i>	7	13	0	37	2	0	39
<i>Rhipicephalus evertsi evertsi</i>	2	2	0	0	2	1	3
<i>Rhipicephalus pravus</i> group	1	1	0	0	0	2	2
<i>Rhipicephalus sanguineus</i>	8	21	1	8	120	67	196
<i>Rhipicephalus simus</i>	24	79	0	0	334	259	593
<i>Rhipicephalus turanicus</i>	9	22	0	0	39	23	62

A total of nine ixodid tick species that could be identified to species level were recovered from the dogs in Maputo Province. Of these *H. elliptica*, *R. simus*, *A. hebraeum*, and *R. sanguineus* followed by *R. turanicus* were the most abundant. With the exception of *I. pilosus*, *R. kochi*, *Rhipicephalus muelhensi*, and *Rhipicephalus planus*, the tick species recorded from dogs by Dias (1993) were also recovered in this study. However, it must be emphasised that Dias' list consists of tick species collected from dogs from the whole of Mozambique, and that both his and our collections were not exhaustive.



a) *Haemaphysalis elliptica*



b) *Rhipicephalus simus*

Fig.4. 1: Localities at which a) *Haemaphysalis elliptica* and b) *Rhipicephalus simus* were present on dogs in Maputo Province

All the species collected from dogs by Neves et al. (2004) were recovered in the present study and in addition the following species, *R. appendiculatus*, *Rhipicephalus evertsi evertsi* and *Ixodes cavipalpus* were collected. Neves et al. (2004) recovered more *R. sanguineus* in their study than were collected in this survey, but that was probably because most of their collections were done in the city. In this survey more *H. elliptica* than *R. sanguineus* were recovered, and this is probably because most of the collections were done in rural areas. *H. elliptica* was present in all districts of Maputo Province, while *R. sanguineus* was present in only three of the eight districts of the province.

Amblyomma hebraeum

In the present study this tick was collected in all districts of Maputo Province and all stages of development were recovered. Similar results were obtained by Horak *et al.* (1987b) in the Eastern Cape Province, South Africa, while Neves *et al.* (2004) in their study conducted in Mozambique only recovered immature stages.

Adult *A. hebraeum* prefer large herbivorous animals as hosts (Norval 1983; Horak, MacIvor, Petney & De Vos 1987a; Horak, Golezardy & Uys 2007). These large adult ticks are, however, found on dogs and other smaller animals, particularly when the former are in poor health, as some of the dogs in the present survey were. The larvae infest a variety of hosts, including large and small herbivores, carnivores, ground-frequenting birds and even tortoises, and some of these hosts are also infested by nymphs (Norval 1983; Horak *et al.* 1987a; Horak, Braack, Fourie & Walker 2000; Horak, McKay, Henen, Hofmeyr, Heyne & De Villiers 2006). The immature stages are almost invariably present on free-running domestic dogs, and more especially those in rural areas within the tick's distribution range in southern Africa (Horak *et al.* 1987b, 2001; Neves *et al.* 2004; Nyangwiwe *et al.* 2006). Although the present survey was designed to collect adult ticks, some larvae and a fairly large number of *A. hebraeum* nymphs were collected, undoubtedly because of the latter's large size, particularly when they are engorged.

Haemaphysalis elliptica

This is the second most abundant tick species recovered in the present survey, and it was collected in all districts of Maputo Province. More female ticks were collected from the dogs than males. *H. elliptica* has been collected from dogs in all the surveys conducted in South Africa as well as the previous one conducted in Mozambique. It was not only present on dogs at all but two of the 27 localities at which ticks were collected from dogs in the present survey, but was recovered from 100 of the 132 dogs examined (Table 4.1). Free-ranging domestic dogs and the larger wild felids are particularly susceptible to infestation with *H. elliptica* (Horak *et al.* 1987b, 2000, 2001; Neves *et al.* 2004). Its immature stages infest murid rodents, and have been collected from these animals in many regions of South Africa and in Zimbabwe (Norval 1984; Fourie, Horak & Van Den Heever 1992; Braack, Horak, Jordaan, Segerman & Louw 1996; Petney, Horak, Howell & Meyer 2004; Horak, Fourie & Braack 2005; Matthee, Horak, Beaucournu, Durden, Ueckermann & McGeogh 2007). However, no systematic collections of ticks from these small mammals appear to have been done in Mozambique.

Haemaphysalis elliptica is widely distributed in South Africa (Howell *et al.* 1978, as *H. leachi*) and its distribution extends into southern Mozambique and Zimbabwe (Apanaskevich *et al.* 2007). In central and northern Mozambique its spread overlaps that of the southern distribution of *H. leachi sensu stricto* (Apanaskevich *et al.* 2007). The present survey confirms its distribution in the southern part of the country (Fig. 4.1a).

In the past it was presumed that it was *H. leachi* that was responsible for the transmission of *Babesia canis rossi*, the cause of virulent babesiosis in domestic dogs in South Africa (Lewis, Penzhorn, Lopez-Rebollar & De Waal 1996). It is now apparent that Lewis *et al.* (1996) actually conducted their experiments with *H.*

elliptica and that it is this tick that is the vector of this *Babesia* species (Apanaskevich *et al.* 2007). At this time *H. leachi sensu stricto* has as yet not been confirmed as the vector of pathogenic organisms that affect domestic dogs.

Ixodes cavipalpus

According to Walker (1991) *I. cavipalpus* is probably the most widely distributed *Ixodes* sp. in the Afrotropical region. Amongst a variety of other hosts, it has been collected from both small and large wild carnivores (Theiler 1962), and two males and six females have been collected from domestic dogs in Harare, Zimbabwe (Goldsmid 1963). In the present survey a single male and two females were collected from dogs only at the Mahubo dip-tank between Boane and Bela Vista in the south of the province. However, not only dogs but also cattle and goats examined at the same locality were infested, confirming the tick's wide host range. Ticks of this genus frequently mate off the host animal, thus accounting for the preponderance of females over males as recorded in the present survey and that in Zimbabwe even though very few ticks were collected.

Rhipicephalus appendiculatus

Adult *R. appendiculatus* infest cattle, goats and large wild bovids (Walker *et al.* 2000; Nyangiwe & Horak 2007), and its immature stages are found on the same hosts as the adults as well as on smaller bovids and scrub hares (Horak & Fourie 1991, Walker *et al.* 2000). All stages of development may, however, infest domestic dogs and wild carnivores (Goldsmid 1963; Horak *et al.* 2000, 2001; Nyangiwe *et al.* 2006). In the present study nymphs and males were collected from 13 dogs at seven localities.

Rhipicephalus evertsi evertsi

According to Walker (1991) this is one the most widely distributed species in the Afrotropical region, and although its preferred hosts are horses, sheep, goats and cattle it is not surprising that small numbers of this tick were recovered from dogs in the present survey.

***Rhipicephalus pravus* group**

Ticks, considered as *Rhipicephalus* sp. near *pravus* by Walker *et al.* (2000), have been collected from a variety of hosts in southern Mozambique and the north-eastern regions of the adjacent Mpumalanga and Limpopo Provinces of South Africa. Two females of this species were collected from a dog in the present survey and single female from a dog in the survey conducted by Neves *et al.* (2004).

Rhipicephalus sanguineus

This tick was collected only in three districts of Maputo Province, namely Boane, Namaacha and Manhiça where the collections were done at the owners' homes. This result confirms those of other surveys that indicate that caged or chained dogs, or dogs owned by urban householders are more likely to be infested with *R. sanguineus* than those on larger properties, whereas those kept under more extensive conditions on small-holdings or farms, are liable to be infested with *H. elliptica* (Horak *et al.* 2001).

All stages of development of *R. sanguineus* infest domestic dogs (Horak 1982), which Walker *et al.* (2000) believes are its only true hosts. Although our collections focused on adult ticks, one larva and eight nymphs were collected, confirming their

host preference. The tick's life cycle is adapted to the resting places of dogs in man-made structures such as sheds, dog kennels and human dwellings (Howell *et al.* 1978; Horak 1982). Its prevalence and intensity of infestation are significantly higher on city or urban dogs, which are usually confined to the properties of their owners, than on rural dogs (Neves *et al.* 2004). Its presence on 21 dogs at eight of the rural sampling localities in the present survey suggests that these animals were at least for some part of the day, chained, or caged at the dwellings of their owners.

Rhipicephalus simus

This is one of the most abundant tick species found in the present study. No immature stages of this tick were recovered. This is not surprising because the immature stages parasitize various species of rats and mice (Walker 1991). Adult *R. simus* have a preference for domestic and wild carnivores, zebras, *Equus* spp., warthogs *Phacochoerus africanus*, and domestic cattle (Walker *et al.* 2000). Its preference for dogs and for cattle is evident in the present study, in that it was collected from 79 dogs of the 132 examined compared to 103 cattle of the 145 examined. Its immature stages infest murid rodents (Norval & Mason 1981; Braack *et al.* 1996; Horak *et al.* 2005), and it is thus more common on dogs in rural environments, where rodents are likely to be plentiful, than on city or urban dogs (Horak *et al.* 1987b, 2001; Neves *et al.* 2004).

With the exception of the Sabié dip-tank in the central western region of Maputo Province, and the Chiango dip-tank and one of the villages in the south-east, *R. simus* was present on dogs throughout the province (Fig. 4.1b). This geographic spread lies within the overall distribution mapped for this tick in southern Africa by Walker *et al.* (2000).

Rhipicephalus turanicus

This tick species was collected in four districts of Maputo Province, namely Boane, Namaacha, Matutuine and Magude. No larvae or nymphs were recovered, and more males than females were collected. *R. turanicus* has been collected from dogs and scrub hares in north-eastern KwaZulu-Natal Province, South Africa, a region adjoining the southern border of Mozambique and from wild carnivores and from the vegetation in the Kruger National Park, to the west (Horak, Spickett, Braack, Penzhorn, Bagnall & Uys 1995; Horak *et al.* 2000, 2001). According to Walker (1991) dogs are somewhat less favoured as hosts than sheep and goats. In the present survey, however, many more dogs than goats were infested.

Like *R. sanguineus*, *R. turanicus* has a very widespread distribution outside Africa, and the two ticks are often mistaken for each other, particularly as the adults of both infest domestic dogs (Walker *et al.* 2000). Unlike *R. sanguineus*, however, *R. turanicus* does not make use of man-made structures as an integral part of its life cycle. Furthermore, whereas *R. sanguineus* infests virtually only domestic dogs during all its stages of development, adult *R. turanicus*, besides domestic dogs, infest a variety of hosts, amongst these are cats, sheep, goats, horses, wild carnivores, hares and birds, and its immature stages probably infest rodents and other small mammals (Horak *et al.* 1995, 2000; Walker *et al.* 2000). Because *R. turanicus* is a parasite of wildlife as well as domestic animals it is encountered on animals in urban, rural and wildlife environments (Walker *et al.* 2000). In addition, it would seem from the restricted late summer abundance of adult *R. turanicus* (Horak *et al.* 2001), that it is only likely to complete one life cycle annually in South Africa, whereas *R. sanguineus* often completes more than one (Horak 1982; Horak & Matthee 2003).

CONCLUSIONS AND FINDINGS

A total of nine ixodid tick species that could be identified to species level were recovered from the dogs in Maputo Province. Of these *A. hebraeum*, *H. elliptica*, *R. sanguineus* and *R. simus* followed by *R. turanicus* were the most abundant. In addition to their own tick species, dogs are also parasitized by tick species that infest other domestic animals such as cattle and goats. Although dogs in this survey were infested by two of the most important tick species of cattle, namely *A. hebraeum* and *R. appendiculatus*, they should not be considered as significant maintenance hosts of these ticks.

Ixodes cavipalpus and *R. evertsi evertsi* can now be added to the list of ixodid tick species previously published for dogs in Mozambique.

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CHAPTER 5

General discussion, conclusions and recommendations

Early researchers

Most of our knowledge concerning the ticks of Mozambique comes from the works of three people, namely Gertrud Theiler (1943, 1962), João Tendeiro (1954) and J.A. Travassos Santos Dias. Of these three Travassos Dias without doubt made the greatest contribution. He described new species and listed the existing species present in Mozambique. He constructed host-tick lists for both domestic and wild animals in Mozambique as well as giving general descriptions of the regions in which the various tick species occurred. Furthermore, he also described seven tick species not indigenous to Mozambique.

Dias (1993) listed 59 ixodid tick species for Mozambique, nine of which were new species described by him. Of these nine new species, six have now been synonymized with other species (Camicas, Hervy, Adam & Morel 1998; Walker, Keirans & Horak 2000), leaving 53 species. Two of these remaining 53 species have also been synonymized (Camicas *et al.* 1998; Walker *et al.* 2000), and we now also know that a further two, namely *Ixodes pilosus* and *Rhipicephalus capensis* do not occur in Mozambique. This leaves a total of 49 valid ixodid tick species that Dias (1993) recorded in Mozambique. However, despite the many collections that he made throughout Mozambique, few localities at which particular tick species were collected were accurately identified. Consequently the precise geographic distributions of many species are largely unknown.

Nomenclature

Just prior to the commencement of this study as well as during its conduct and write up, changes to the specific names of three of the tick species recovered were and have been made. Two of these are important parasites of cattle, and were previously known as *Boophilus microplus* and *Hyalomma marginatum rufipes*, and the third possibly the most important tick infesting domestic dogs in southern Africa, *Haemaphysalis leachi*. A fourth species, belonging to the *Rhipicephalus pravus* group, probably still needs to be described. It was collected from cattle, goats and dogs in the present study.

Working independently Murrell, Campbell & Barker (2000) and Beati & Keirans (2001) made use of molecular analyses supported by an analysis of morphological characters and came to the conclusion that the genus *Rhipicephalus* is paraphyletic in respect of the genus *Boophilus*. Consequently Murrell & Barker (2003) proposed the use of the nomenclature *Rhipicephalus (Boophilus)* spp. for ticks belonging to this grouping. This name change was included in the world list of valid tick names published by Horak, Camicas & Keirans (2002), and I have decided to accept this change, although many people prefer to retain *Boophilus* as a generic name.

After an extensive study of adult specimens collected from Egypt in the north of Africa to South Africa in the south of this continent, and of reared series of their immature stages Apanaskevich, Horak & Camicas (2007) decided that the entity hitherto referred to as *Haemaphysalis leachi* consisted of two species. These are *H. leachi sensu stricto* for the northern species and *Haemaphysalis elliptica*, an old taxon originally described in 1844 from the Cape of Good Hope by Koch. The distributions of these two ticks overlap in northern Zimbabwe, Zambia and northern Mozambique (Apanaskevich *et al.* 2007). All the ticks belonging to this group

collected from dogs in Maputo Province by Neves, Afonso & Horak (2004) have been re-examined as well as those collected in the present survey and have been identified as *H. elliptica*.

Apanaskevich & Horak (2006, 2008) made a thorough study of all stages of development of the *Hyalomma marginatum* group of ticks throughout their distribution range and decided that the various subspecies within this grouping deserved specific status. They consequently proposed the species names *Hyalomma glabrum*, *Hyalomma isaaci*, *Hyalomma marginatum*, *Hyalomma rufipes* and *Hyalomma turanicum* for the five entities in this group. Although only a single *Hyalomma* tick was collected in the present survey; it has been identified as *H. rufipes*.

The *Rhipicephalus pravus* group of ticks comprises some species of which all stages of development have been illustrated and described (Walker *et al.* 2000), as well as of some closely related, but as yet undescribed species. One of these ticks has been designated as *Rhipicephalus* sp. near *pravus* and its distribution stretches across southern Africa from northern Namibia in the west, through Botswana and northern South Africa to southern Mozambique in the east (Walker *et al.* 2000). While the distribution of another, designated as *Rhipicephalus* sp. near *punctatus* extends from southwest Angola in the west through Zambia and Zimbabwe to northern Mozambique in the east (Walker *et al.* 2000). The tick collected in the present study resembles the entity designated as *R.* sp. near *pravus*, and its distribution in Maputo Province also falls within the distribution range of the latter tick as illustrated by Walker *et al.* (2000). Adult ticks of this species infest a variety of domestic and wild hosts, including hares, and the immature stages infest elephant shrews and hares (Walker *et al.* 2000). In the present survey three cattle, two goats and two dogs were infested with adult ticks.

Methodology

The survey protocol used was that described by Horak & Potgieter (2007) for the conduct of surveys to determine the species composition and geographic distribution of ticks within a region or country. If all entities suggested by them, namely five cattle, five goats, five dogs and three vegetation sites are sampled at a particular locality, this adds up to a total of 18 opportunities of collecting a particular tick species at a particular locality. Although this sampling intensity does not necessarily mean that all tick species will be collected at each sampling site, the 14 identified species that we collected from cattle, goats and dogs in Maputo Province during the 3-year survey period, compared to the 19 valid tick species reported from these animals by Dias (1993) over a collection period of approximately 40 years, is excellent. Furthermore four tick species, not mentioned before by Dias (1993) as infesting domestic animals, were collected, namely *Ixodes cavipalpus*, *Rhipicephalus longus*, ticks of the *R. pravus* group and *Rhipicephalus turanicus*.

The same six species of ticks recovered from the drag-samples of the vegetation were also recovered from cattle or dogs, and thus drag-sampling the vegetation yielded no additional species. Drag-sampling should, however, in my opinion, not be omitted from the protocol as it is an efficient means of collecting immature ticks of several species (Horak, Gallivan, Spickett & Potgieter 2006). This is especially true during the cooler months of the year when few adult ticks are present on hosts, but their questing immature stages are plentiful on the vegetation. It would thus appear that the protocol employed in the current survey was efficient in attaining its objectives.

Hosts and tick species

Amongst the 59 species of ixodid ticks originally recorded by Dias (1993) from Mozambique, he listed 24 species as parasitizing domestic cattle, goats and dogs.

Of these 24 species he reported 17 from cattle, five from goats and 12 from dogs. However, if we take the synonymies that have subsequently occurred into account and also exclude the species that do not occur in Mozambique, Dias (1993) actually recorded a total of 19 valid ixodid tick species that infest cattle, goats and dogs in Mozambique.

Of the 19 valid tick species listed from cattle goats and dogs by Dias (1993), he reported 15 from cattle, five from goats and nine from dogs. In the present study 12 ixodid tick species were collected from cattle, 11 from goats and nine from dogs (Table 5.1). The distribution ranges of three of the tick species reported from cattle by Dias (1993), namely *Amblyomma pomposum*, *Amblyomma variegatum* and *Rhipicephalus compositus* do not include southern Mozambique, hence it is not surprising that these ticks were not collected in the present survey.

**Table. 5.1. Ticks species and their domestic hosts reported by Dias (1993)
compared with the tick species collected in the present survey**

Tick species	Listed by Dias (1993)		Collected in this study	
	Presence	Host	Presence	Host
<i>A. hebraeum</i>	Yes	C, G, D	Yes	C, G, D
<i>A. pomposum</i>	Yes	C		
<i>A. variegatum</i>	Yes	C		
<i>H. elliptica</i>			Yes	D
<i>H. leachi</i>	Yes	C, D		
<i>H. rufipes</i>	Yes	C	Yes	C
<i>H. truncatum</i>	Yes	C		
<i>Ix. cavipalpus</i>			Yes	C, G, D
<i>R. (B.) decoloratus</i>	Yes	C		
<i>R. (B.) microplus</i>	Yes	C, G	Yes	C, G
<i>R. appendiculatus</i>	Yes	C, G, D	Yes	C, G, D
<i>R. compositus</i>	Yes	C		
<i>R. evertsi evertsi</i>	Yes	C, G	Yes	C, G, D
<i>R. kochi</i>	Yes	D	Yes	C, G
<i>R. longus</i>			Yes	C, G
<i>R. lunulatus</i>	Yes	C		
<i>R. maculatus</i>	Yes	C		
<i>R. muehlensi</i>	Yes	D		
<i>R. pravus group</i>			Yes	C, G, D
<i>R. sanguineus</i>	Yes	C, D	Yes	D
<i>R. simus</i>	Yes	C, G, D	Yes	C, G, D
<i>R. tricuspis</i>	Yes	D	Yes	G
<i>R. turanicus</i>			Yes	C, G, D

C = cattle; G = goats; D = dogs

Judging by the number of tick species collected from goats in the present study, namely 11, and the fact that 10 of these were also collected from cattle; it would appear that goats are important hosts of a larger number of tick species that also infest cattle than the five species recorded by Dias (1993). The importance of goats as alternative hosts for four of the most important tick species that infest cattle, namely *A. hebraeum*, *R. (B.) microplus*, *R. appeniculatus* and *R. evertsi evertsi* has been demonstrated by Baker & Ducasse (1968) and Nyangiwe & Horak (2007) in KwaZulu-Natal and the Eastern Cape Province of South Africa, and in Maputo Province in Chapter 3 of this dissertation.

All the species collected from dogs by Neves *et al.* (2004) in an earlier study conducted in southern Mozambique were recovered in the present study, and in addition *R. appendiculatus*, *R. evertsi evertsi* and *Ixodes cavipalpus* were collected from these animals. The dogs examined in the present survey were infested with four important tick species normally associated with cattle, namely *A. hebraeum*, *R. appendiculatus*, *R. evertsi evertsi* and *R. simus*. However, with the exception of *R. simus*, dogs should be viewed as accidental hosts of cattle ticks. The dogs did, however, harbour two important tick species of their own, namely *H. elliptica* and *Rhipicephalus sanguineus*, which were recovered neither from cattle or goats.

Judging by the numbers of ticks collected and the number of hosts infested, dogs would also appear to be the preferred hosts of adult *R. turanicus*, of which only a few were recovered from cattle and goats. This tick was not recorded as a separate entity by Dias (1993), but probably included by him with *R. sanguineus*. However, its validity as a separate species is underpinned by the fact that both it and *R. sanguineus* were collected from dogs and sometimes from the same dog, whereas only it and not *R. sanguineus* was collected from cattle and goats. Furthermore its geographic distribution in Maputo Province differs from that of *R. sanguineus*.

Haemaphysalis elliptica, *I. cavipalpus*, *R. longus* and *R. turanicus* can now be added to the lists of ixodid tick species previously published for Mozambique.

Displacement of *Rhipicephalus (Boophilus) decoloratus*

In the present study no *R. (B.) decoloratus* were recovered from cattle, goats, dogs, or from the vegetation. According to Dias (1993), *R. (B.) decoloratus* was at the time he compiled his list of the ticks of Mozambique, very common in all regions of the country, wherever there were cattle, and it was also a species collected from several wild mammals. This no longer seems to be the case in Maputo Province, where it appears to have disappeared completely and been replaced by *R. (B.) microplus*.

The reasons for this displacement are probably numerous. The total life cycle of *R. (B.) microplus* is slightly shorter than that of *R. (B.) decoloratus* (Arthur & Londt 1973; Londt & Arthur 1975), and females of *R. (B.) microplus* lay slightly more eggs than those of *R. (B.) decoloratus* (Spickett & Malan 1978). The spread of *R. (B.) microplus* in warm moist climates is thus assisted by its shorter life cycle and higher reproductive potential. Moreover cross-mating between the two species results in sterile eggs being produced (Spickett & Malan 1978). Although males of both species prefer to mate with conspecific females (Norval & Sutherst 1986), males of both species will nevertheless mate with females of the other species. As males of *R. (B.) microplus* are sexually mature a few days sooner than those of *R. (B.) decoloratus* (Londt & Arthur 1975), they have a greater chance of conspecific mating with females of their own species in mixed infestations, with excess males mating with a proportion of female *R. (B.) decoloratus*, than the converse occurring. The latter females will produce sterile eggs thus resulting in an ever-

increasing proportion of future mixed populations of these two ticks being *R. (B.) microplus*.

In southern Mozambique displacement has been augmented by the civil war and the hardships that accompanied it. One of these hardships was the lack of food with the resultant killing of both domestic and wild animals, and with the wild animals also their accompanying tick fauna, especially *R. (B.) decoloratus*. This probably led to the near extinction of *R. (B.) decoloratus* in this region. When restocking with cattle commenced after the war *R. (B.) microplus* was probably introduced or reintroduced on these animals, whereas the larger wildlife species, and hence *R. (B.) decoloratus*, have still not returned to Maputo Province.

Geographic distribution

The geographic distributions in Maputo Province of nine of the 14 ixodid tick species collected during the survey were plotted. This is the first time that this has been done in Mozambique based on the actual geographic coordinates of the localities at which the various tick species were collected. The distributions in Maputo Province of the major tick species collected, namely *A. hebraeum*, *H. elliptica*, *R. appendiculatus*, *R. evertsi evertsi* and *R. simus* all fit into the overall distribution patterns plotted for these ticks in Africa by Walker & Olwage (1987), Walker *et al.* (2000) and Walker, Bouattour, Camicas, Estrada-Pena, Horak, Latif, Pegram & Preston (2003), thus giving a better overall picture of the true distributions of these ticks. The absence of *R. (B.) decoloratus* in Maputo Province, despite its presence in immediately adjacent regions of South Africa (Howell, Walker & Nevill 1978), came as a surprise, as did the widespread distribution of the introduced tick *R. (B.) microplus* that has displaced it.

All the abovementioned species can be considered major species not only because of their prevalence and widespread distributions, but primarily because of the diseases that they transmit to cattle, goats and dogs (Lewis, Penzhorn, Lopez-Rebollar & De Waal 1996; Norval & Horak 2004).

The geographic coordinates of the localities at which minor or rarer tick species were collected should prove useful for future researchers who might wish to plot the distributions of these species for the whole country.

Conclusions

The examination of five cattle, five goats, five dogs and three drag-samples of the vegetation at a particular locality is an effective way of determining the species composition of ticks infesting domestic animals at such a locality. If sufficient localities are sampled in this way within a region, province or country, and the geographic coordinates of each locality recorded, this is also an effective way of plotting or mapping the distributions of the various tick species collected.

Goats are good hosts of most of the important ticks that infest cattle, and their inclusion in tick control programs designed for cattle should be considered.

It would appear as if the introduced tick *R. (B.) microplus* has completely displaced the indigenous tick *R. (B.) decoloratus* in Maputo Province, Mozambique.

RECOMMENDATIONS

Further surveys in the other provinces of Mozambique are recommended in order to accurately determine the geographic distribution of ixodid ticks that infest domestic livestock throughout this country. These surveys should pay particular attention to determining the northernmost boundaries of the distribution of *A. hebraeum* and *H. elliptica* in this country and the southernmost boundaries of *A. variegatum* and *H. leachi* as well as the regions in which these boundaries overlap. They should also focus on determining the extent to which *R. (B.) microplus* has displaced *R. (B.) decoloratus* in the country and where pockets of the latter tick still exist. It would of course be ideal if at the same time the prevalence and distribution of antibodies to the most important tick-borne diseases in Mozambique could be ascertained.

Because of the widespread distribution of *R. appendiculatus* in Maputo province and the absence of East Coast fever, no cattle from any region or district in which East Coast fever is present should be imported into Maputo Province.

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