Diversity, seasonality and sites of attachment of adult ixodid ticks on dogs in the central region of the Free State Province, South Africa

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ABSTRACT

JACOBS, P.A.H., FOURIE, L.J., KOK, D.J. & HORAK, I.G. 2001. Diversity, seasonality and sites of attachment of adult ixodid ticks on dogs in the central region of the Free State Province, South Africa. *Onderstepoort Journal of Veterinary Research*, 68:281–290

Several surveys of ticks infesting dogs belonging to owners in resource-limited and more affluent communities have been conducted in South Africa, but no such investigation has been carried out in the Free State Province of this country. The present study was initiated to meet this shortcoming. Ticks were collected from dogs at six localities in, and to the east of the city of Bloemfontein in the central region of the province. Three of these localities could be classed as resource-limited and two as affluent, while the sixth locality was an animal shelter serving all members of the public.

Adult ticks belonging to nine ixodid tick species were collected, of which *Rhipicephalus sanguineus* was the most numerous. Significantly more *R. sanguineus* was collected from dogs at resource-limited than at more affluent localities. The greatest proportions of these ticks attached to the backs and necks of the dogs, with the proportions being larger in long-haired than in short-haired dogs. Most *R. sanguineus* were collected during the warmer months particularly from January to April.

The greatest proportions of *Haemaphysalis leachi*, the next most numerous species, were also collected from the backs and the necks of the dogs. Most of these were present during the period September to November.

Keywords: Central Free State, dogs, *Haemaphysalis leachi*, ixodid ticks, *Rhipicephalus sanguineus*, seasonality, sites of attachment, South Africa

INTRODUCTION

Surveys of ixodid ticks on domestic dogs at several localities in South Africa have shown that these animals are infested by at least 18 species (Theiler 1962; Horak, Jacot Guillarmod, Moolman & De Vos 1987c; Horak 1995; Bryson, Horak, Höhn & Louw 2000; Horak, Emslie & Spickett 2001). In these surveys three species were frequently collected, namely *Haemaphysalis leachi*, *Rhipicephalus sanguineus* and *Rhipicephalus simus*. The seasonal occurrences of *H. leachi* and *R. simus* on dogs have both been determined in two surveys in South Africa, one conducted in the Eastern Cape Province and the other in north-eastern KwaZulu-Natal (Horak *et al.* 1987c; 2001), while the seasonal occurrence of *R. sanguineus* has been determined on kennelled dogs in Pretoria North, Gauteng Province (Horak 1982). However, little is known concerning the tick species that infest dogs in the Free State Province of South Africa. In order to address this shortcoming the present study to determine the species diversity, prevalence, relative density, sites of attachment and seasonal occurrence of ticks infesting dogs was conducted at localities in, and to the east of the city of Bloemfontein in the central

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Accepted for publication 31 October 2001—Editor

region of the province. Not only would this information have important implications for zoonoses and diseases of dogs transmitted by the ticks but also for the planning of control strategies.

An understanding of a particular tick's bionomics is essential for integrated pest management to be effective in that it serves to identify those parts of the life cycle that may be susceptible to control (Fourie & Kok 1992). Ascertaining the preferred attachment sites of ticks also has important implications for control, especially when "spot on" acaricide treatment is considered.

MATERIALS AND METHODS

Study area

The various sampling localities were chosen so as to include dogs belonging to owners of different socio-economic backgrounds and demographic profiles representative of the population of the central Free State region surrounding the provincial capital city of Bloemfontein (29°07'S 26°12'E). Commencing during February 1995, sampling took place in two suburbs of Bloemfontein, namely Brandwag and Batho and also at the kennels of the Society for the Prevention of Cruelty to Animals (SPCA), situated in East End. From November 1995 onwards dogs at three additional localities were sampled, namely Heidedal (also a suburb of Bloemfontein), and at Botshabelo (29°14'S 26°42'E) and Thaba Nchu (29°12'S 26° 50'E) located 55 and 65 km east of Bloemfontein respectively. Both Botshabelo and Thaba Nchu can be classified as resource-limited urban and peri-urban settlements. Sampling was terminated at all localities during October 1996.

When considering the level of urban development of an area in which a sampling locality was situated, factors such as tarred roads, veterinary clinics, shopping centres, number of vacant stands and availability of transport were taken into account. Thus Bloemfontein can be regarded as being the most developed, followed by Thaba Nchu and then Botshabelo. In Botshabelo and Thaba Nchu there is evidence of poor town planning and housing consists mainly of shacks and huts. There are very few brick homes. The inhabitants also have a very different culture to that of those of the city of Bloemfontein. Hunting is part of their lifestyle, and the use of spears, bows and arrows, traps, pitfalls and dogs for this purpose are not uncommon (De Wet 1986). Cattle are allowed to roam freely because there are no fences and a communal grazing system is practised. Stock-theft is commonplace and consequently the cattle are accompanied at all times while grazing by a member of their owner's family (Jeppe 1980). Dogs usually accompany this person and may thus spend a lot of time in the veld.

The SPCA at East End is situated close to the suburb of Heidedal, but cannot be grouped with any of the other localities because it essentially is a holding facility for dogs. It should be noted, however, that it is surrounded by veld and that there are other animal species resident on the property besides dogs. These include stray cats, horses and pigs.

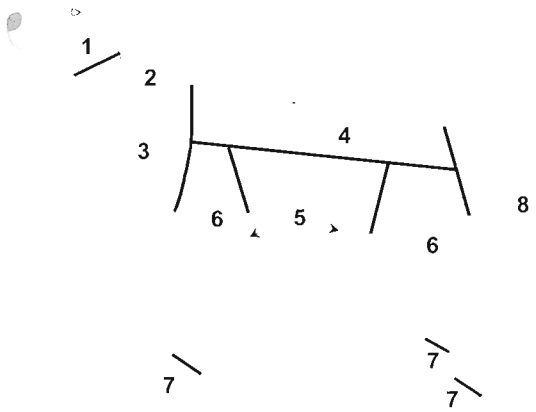
Survey animals

At each locality three long-haired (hair length > 4 cm) and three short-haired dogs were sampled. With the exception of those at the SPCA, the same dogs were sampled each month. This was easily accomplished because the dogs selected belonged to individuals at fixed addresses. They were not treated with an acaricide during the study. At the SPCA new arrivals were immediately treated with an acaricide and were not sampled until ticks that were acquired on the premises of the SPCA started attaching. Although different sets of dogs were examined at the SPCA, sampling was always done in the same set of kennels.

All dogs are treated on arrival at the SPCA because many of them are heavily infested with ticks which could lead to severe infestation of the premises and, in addition, it would have given, as far as this survey is concerned, an incorrect indication of the tick burdens acquired by the dogs while residing at the SPCA.

Tick collection

At each sampling occasion all visible ticks were removed from the dogs by means of straight, blunt-



1 – Head	5 – Abdomen
2 – Ears	6 – Legs
3 – Neck	7 – Feet
4 – Back	8 – Tail

FIG. 1 Body regions from which ticks were collected

tipped forceps. Those hidden in the dog's pelage were detected by thorough palpation and were then collected as above. The ticks were placed in labelled vials containing 70% ethanol and the information on the labels included date, locality, size of dog, dog or kennel number and any other pertinent information. The vials were transported to the laboratory where the ticks were identified to species level with the aid of a stereoscopic microscope and quantified. These data were used to determine species diversity, relative density, prevalence and the seasonal occurrence of the most abundant species. Relative density was calculated by dividing the total number of ticks of a particular species by the total number of dogs sampled (Kassai 1999). Prevalence was determined by dividing the number of dogs infested with a particular species by the number of dogs sampled and expressing the result as a percentage (Kassai 1999).

Attachment sites and hair length

The proportion of ticks attached to various body regions was determined only at the SPCA and a distinction was made between dogs with long and short hair. Twelve dogs, six with long hair and six with short hair, were examined fortnightly. These 12 dogs included the six animals that were used to determine the seasonal occurrence of ticks. Sampling took place from April 1995 to December 1995, thus including summer and winter months. The body of the dog was divided into eight regions, namely head, ears, neck, back, abdomen, legs, feet and tail (Fig. 1). The ticks collected from each of the eight body regions were placed in separately labelled bottles for later identification and counting. Although all stages of development were collected, only adult ticks were used in the final analysis.

TABLE 1 Diversity, relative density and prevalence of adult ixodid ticks on domestic dogs in the central Free State region, South Africa

Tick species	Number collected			Relative density	% dogs infested (prevalence)
	♂♂	♀♀	Total		
Boophilus decoloratus	19	46	65	4.6	1.4
Haemaphysalis leachi	785	505	1 290	5.8	22.4
Hyalomma truncatum	0	2	2	2.0	0.1
Ixodes rubicundus	7	0	7	7.0	0.1
Rhipicephalus evertsi everstsi	0	2	2	2.0	0.1
Rhipicephalus follis	1	1	2	1.0	0.2
Rhipicephalus gertrudae	60	52	112	9.3	1.2
Rhipicephalus sanguineus	12 233	7 917	20 150	27.4	73.5
Rhipicephalus warburtoni	5	1	6	2.0	0.3

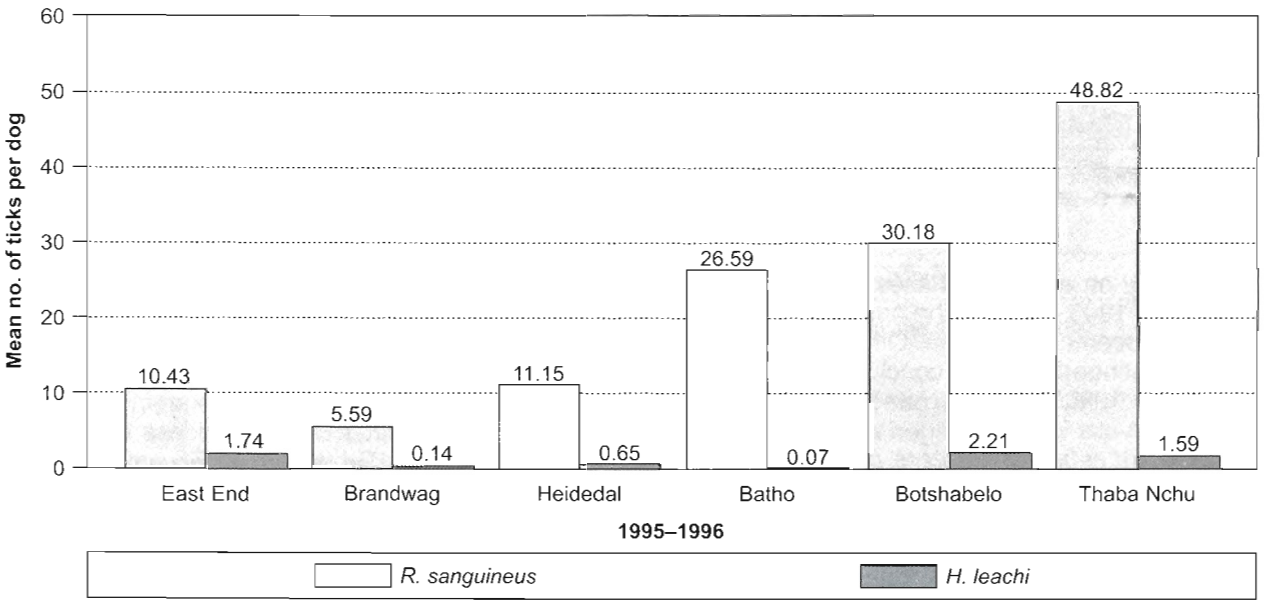


FIG. 2 Mean numbers of *Rhipicephalus sanguineus* and *Haemaphysalis leachi* collected per dog at six localities in the central Free State region, South Africa

TABLE 2 Adult ixodid ticks collected from domestic dogs at various localities in the central Free State region, South Africa

Tick species	Numbers of ticks collected											
	SPCA (East End)		Brandwag		Heidedal		Batho		Botshabelo		Thaba Nchu	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Boophilus decoloratus	1	2	0	0	0	0	1	0	10	21	7	23
Haemaphysalis leachi	318	239	2	12	50	17	0	6	236	105	179	126
Hyalomma truncatum	0	2	0	0	0	0	0	0	0	0	0	0
Ixodes rubicundus	0	0	0	0	0	0	7	0	0	0	0	0
Rhipicephalus evertsi evertsi	0	2	0	0	0	0	0	0	0	0	0	0
Rhipicephalus follis	0	0	0	0	0	0	0	0	1	1	0	0
Rhipicephalus gertrudae	0	0	0	0	0	0	0	0	60	52	0	0
Rhipicephalus sanguineus	2 243	1 222	219	123	657	491	1 260	1 090	2 842	1 805	5 012	3 186
Rhipicephalus warburtoni	0	0	0	0	0	0	5	1	0	0	0	0

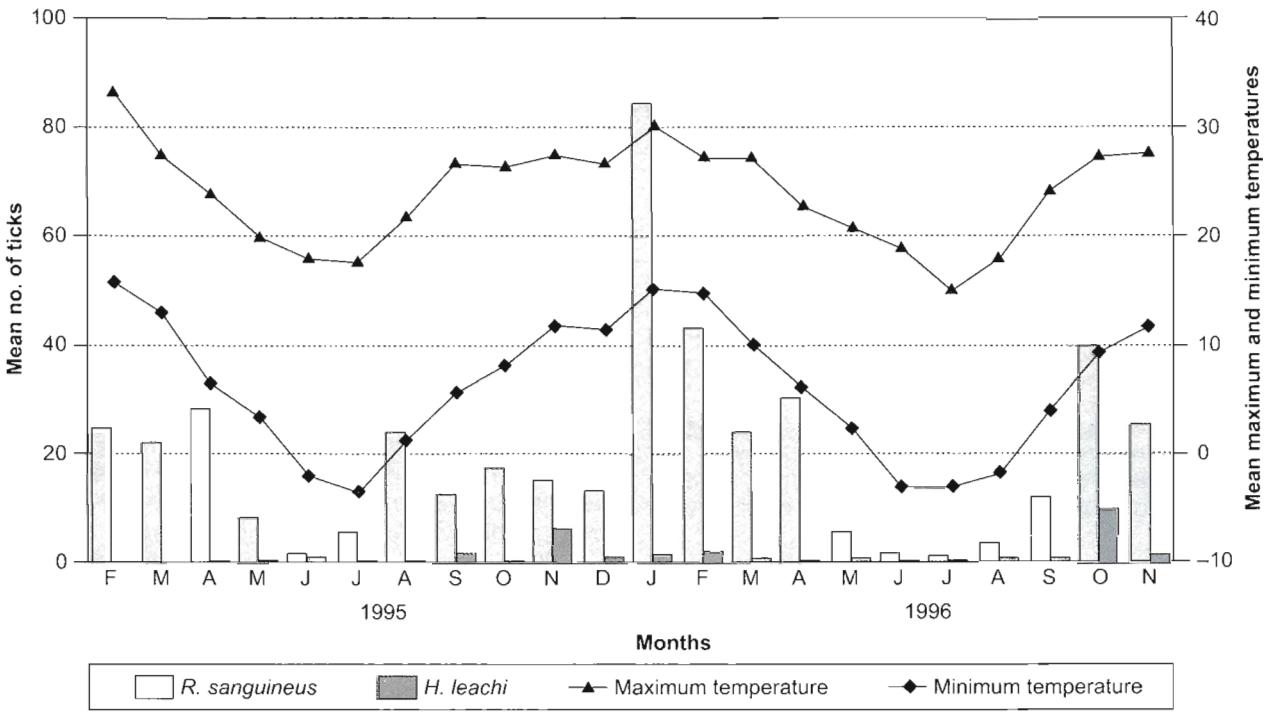


FIG. 3 Seasonal occurrence of *Rhipicephalus sanguineus* and *Haemaphysalis leachi* on dogs (pooled data) in the central Free State region, South Africa

The survey on attachment sites was terminated at the end of 1995 because the number of dogs sampled was deemed adequate. Other sampling at the SPCA continued until the conclusion of the survey in October 1996.

RESULTS

Tick diversity, prevalence and relative density

A total of 21 636 adult ticks representing nine species were collected during the study. Two species dominated at all localities, namely *R. sanguineus* and to a lesser extent *H. leachi*. Of all the dogs sampled 73.5 % were infested with *R. sanguineus* and 22.4 % with *H. leachi* (Table 1), and the relative densities of infestation were 27.4 and 5.8 ticks respectively. The proportion of dogs infested by other ticks constituted less than 4 % of the total number examined and the other species collected constituted less than 1.0 % of the total sample (Table 1). *Boophilus decoloratus* and *Rhipicephalus gertrudae* were the dominant species in the latter group. In addition 31 nymphs of *Amblyomma marmoreum* and seven nymphs of *Otobius megnini* were collected from the dogs.

The tick species collected at the various study sites are summarized in Table 2.

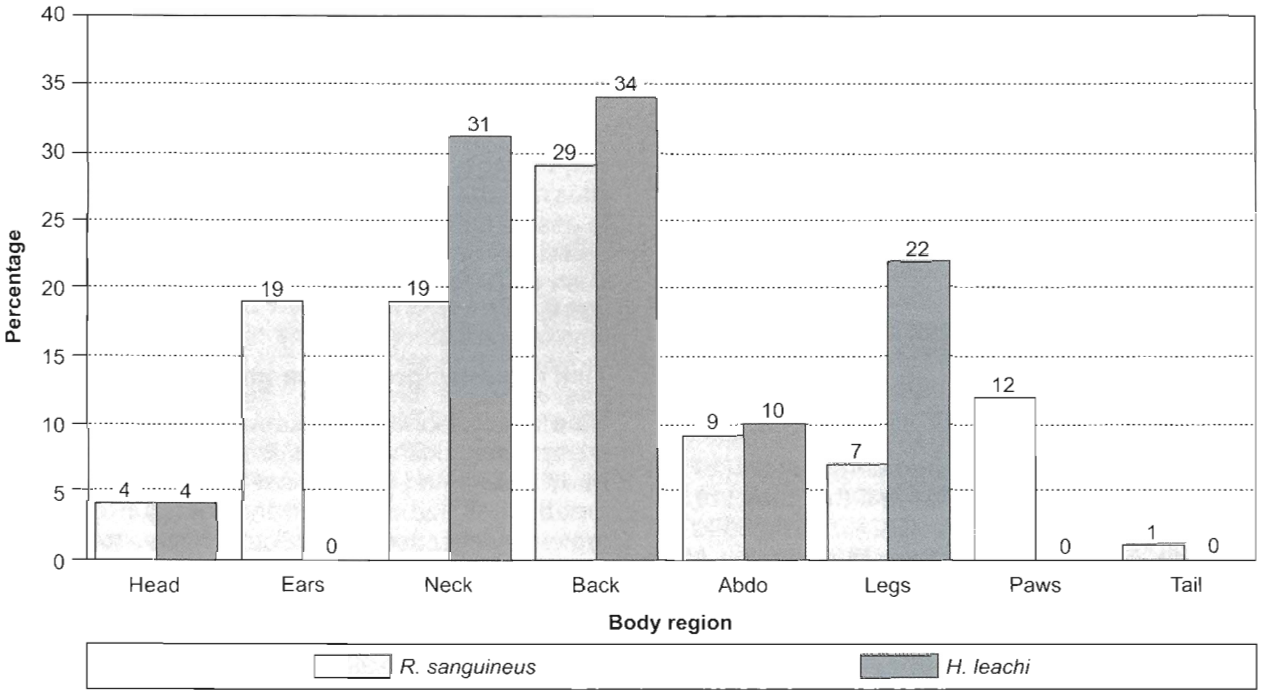


FIG. 4 Percentages of *Rhipicephalus sanguineus* and *Haemaphysalis leachi* attached to various body regions

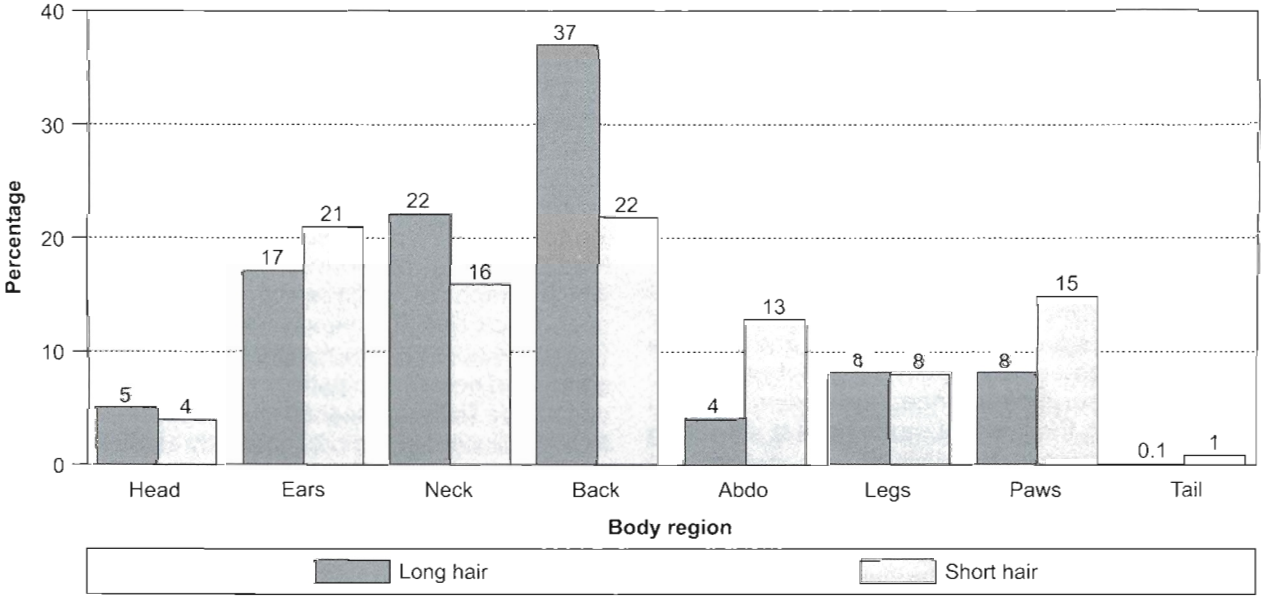


FIG. 5 Percentage of *Rhipicephalus sanguineus* attached to various body regions on long and short-haired dogs

Haemaphysalis leachi and *R. sanguineus* were present at all localities and *B. decoloratus* was collected at the SPCA, Batho, Botshabelo and Thaba Nchu.

The mean numbers of *R. sanguineus* and *H. leachi* collected per dog at each locality for the duration of the study are graphically illustrated in Fig. 2.

Most *R. sanguineus* (mean = 48.82) were collected from dogs at Thaba Nchu followed by Botshabelo (mean = 30.18). The smallest number (mean = 5.59) was collected from dogs at Brandwag. Although *H. leachi* was present at all six localities the numbers were low, varying from a mean of 0.07 ticks in Batho to 2.21 in Botshabelo.

Seasonal dynamics

With the exception of *R. sanguineus* and *H. leachi*, the numbers of ticks of other species collected were

too small to determine their seasonal occurrence. The monthly mean numbers of *R. sanguineus* and *H. leachi* based on pooled data from all localities are graphically illustrated in Fig. 3. Mean minimum and maximum temperatures, obtained from the weather bureau in Bloemfontein, are superimposed in the figure.

Dogs were infested with *R. sanguineus* throughout the year, with the largest number of ticks collected during the warm months of January to April. *Haemaphysalis leachi* was most abundant during spring and early summer (September to November).

Attachment sites and hair length

Most *R. sanguineus* attached on the back (29 %), followed by the ears (19 %) and the neck (19 %), while a significant proportion (12 %) attached to the feet (Fig. 4). Few were found on the tail (1 %). Most *H. leachi* attached on the back (34 %), followed by the neck (31 %) and the legs (22 %). None was found on the ears, the feet or tails of the dogs.

The distribution of *R. sanguineus* on the bodies of dogs with long or with short hair is graphically illustrated in Fig. 5. Attachment on the two groups of dogs was generally relatively similar, the conspicuous differences being that 37 % attached to the back, 4 % to the abdomen and 8 % to the paws of long-haired dogs compared to 22 %, 13 % and 15 % respectively on short-haired dogs.

DISCUSSION

Two phenomena influence the interactions between ticks and hosts (Sonenshine 1975). The first is tick-dependent and includes host predilection and opportunism. The second is host-dependent and includes factors such as activity patterns, habitat utilisation, social behaviour, home range, and body-size (Barnard 1989). In the present study habitat utilisation was an important factor. This, however, does not mean that any tick, found in the same area as dogs, will automatically infest these animals because specific appetence responses may prevent this (Barnard 1989). Infestation of dogs by ticks that have other preferred hosts depends largely on sympatry. This is particularly true in places such as Botshabelo and Thaba Nchu where dogs and cattle often share the same localities around the home or in the veld. In Brandwag the dogs surveyed were restricted to a single property, thus reducing the possibility of contact with tick species other than those present on the premises.

Attachment sites

There are several factors that influence the choice of attachment sites of ixodid ticks to their hosts. Amongst these are tick density (Andrews & Petney 1981), interspecific interaction between ticks (Andrews, Petney & Bull 1982), habitat (Balashov 1972; Wilkinson 1972), season of the year (Evans 1952) and, in the case of *R. simus* also host species (Walker, Keirans & Horak 2000). Preferred attachment sites must be taken into account when sampling ticks to ensure unbiased results. Furthermore, they are of particular importance for the application of acaricides such as "spot-on" formulations (Fourie & Van Zyl 1991).

Tick diversity, prevalence and relative density

Nine species of adult ticks were collected in the present study. *Rhipicephalus sanguineus* followed by *H. leachi* had the highest prevalence and the greatest relative density in the central Free State region. In other surveys in South Africa a total of 18 species, belonging to six genera, have been found on dogs. In the Grahamstown region, Eastern Cape Province, Horak *et al.* (1987c) collected 14 species from dogs, with *H. leachi* the most prevalent followed by *R. simus*. At the Veterinary Academic Hospital, Onderstepoort, ten species were collected from dogs diagnosed with *Babesia canis* infection, and the most prevalent species was *H. leachi* followed by *R. sanguineus* (Horak 1995). Six species were collected from dogs belonging to clients of the Animal Hospital of the Faculty of Veterinary Science, Medical University of Southern Africa or of the Outreach Clinic of this Faculty at Maboloka, North West Province (Bryson *et al.* 2000). The most prevalent species was *R. sanguineus* followed by *H. leachi*. Dogs belonging to people in rural communities in north-eastern KwaZulu-Natal harboured seven tick species of which nymphs of *Amblyomma hebraeum* and adults of *H. leachi* and *R. simus* were the most numerous (Horak *et al.* 2001). In the latter survey and in that conducted near Grahamstown no *R. sanguineus* was collected. Ticks other than *R. sanguineus* and *H. leachi* collected in the present study can be considered incidental infestations.

The various species encountered on the dogs surveyed in the central Free State region in the present study are discussed below.

Amblyomma marmoreum

This tick is endemic to southern Africa and is widely distributed in South Africa (Theiler & Salisbury 1959; Walker & Olwage 1987). It is a three-host species (Norval 1975) and the adults are specific parasites of reptiles, particularly tortoises and some of the larger snakes and lizards (Walker 1991). Its immature stages have been found on domestic and wild herbivores and carnivores and on scrub hares (*Lepus saxatilis*) and helmeted guineafowls (*Numida meleagris*) (Horak, MacIvor, Petney & De Vos 1987b;

Horak *et al.* 1987c; Horak, Braack, Fourie & Walker 2000). In the present study only nymphs were collected and these were probably acquired when the dogs were hunting or minding cattle with their owners.

Boophilus decoloratus

This is a one-host tick that prefers domestic cattle, large wild ruminants and domestic and wild equids as hosts (Mason & Norval 1980; Walker 1991). It has also been collected in small numbers from domestic dogs (Goldsmid 1963; Horak 1995). Its distribution is generally limited to areas with an annual rainfall exceeding 380 mm and it is widespread in the north and east as well as in the southern coastal regions of South Africa (Howell, Walker & Nevill 1983). The sympatry of dogs and cattle in Batho, Botshabelo and Thaba Nchu probably enhances the likelihood of infestation.

Boophilus decoloratus was also collected from dogs at the SPCA. This was unexpected because of the brick and mortar structure of the facility as opposed to the natural grassland and savanna habitat preferred by the tick (Howell *et al.* 1983). However, the buildings are surrounded by veld and, besides dogs, there are other resident animals on site, including horses, which could serve as a source of infestation. In addition many of the dogs at the SPCA come from resource-limited environments such as Batho, where infestation may be acquired from cattle. Although dogs are dipped upon arrival at the SPCA it is possible that the acaricide was ineffective or that some of the dogs were inadvertently not dipped.

Haemaphysalis leachi

Adult *H. leachi* is a common parasite of domestic dogs, but is equally prevalent on jackals and the larger wild felids (Norval 1984; Horak *et al.* 2000). Its immature stages infest rodents (Norval 1984), but have also been collected from dogs (Horak 1995). In the present study fairly heavy burdens of larvae, nymphs and adults were found on a dog in one of the more affluent localities, confirming the latter observation. The majority of *H. leachi* collected at the SPCA attached to the back and neck of the dogs. According to Howell *et al.* (1983) they feed chiefly on the head and shoulders, but can be found on other parts of the body in heavy infestations.

Haemaphysalis leachi prefers higher rainfall and does not occur in desert or semi-desert (Theiler 1962; Howell *et al.* 1983). However, it has been suggested that the distribution of *H. leachi* is affected more by the availability of rodent and carnivore hosts than by climate (Norval 1984). A paucity of rodents at a locality can result in low numbers of adult ticks, as was probably the case in the present study and in the study conducted by Bryson *et al.* (2000) on dogs owned by members of the densely populated urban community of Garankuwa, North West Province. The tick's distribution in many parts of South Africa is still unknown.

Most *H. leachi* recovered during the current study were collected at the SPCA. The kennels are situated next to open veld and it is possible that nymphs were brought in on rodents that had been attracted to the dog food in the kennels and that some immatures also developed on the dogs themselves. At Botshabelo and Thaba Nchu dogs may wander or accompany their owners into the veld, and are hence likely to become infested.

Because few ticks were collected from the dogs during this study, and then at a variety of localities, it was not possible to accurately determine the seasonal occurrence of *H. leachi* in the central Free State region. The results obtained do, however, suggest that these ticks are most abundant during spring and early summer (September to November). In Nigeria, in the northern hemisphere, most *H. leachi* were collected from dogs during February and March (Dipeolu 1975). On smallholdings in the Eastern Cape Province, South Africa, the largest numbers of adult *H. leachi* were present on dogs from June to February (Horak *et al.* 1987c). In contrast, the greatest numbers were collected from dogs belonging to people in rural communities in north-eastern KwaZulu-Natal during the period January to April (Horak *et al.* 2001). This suggests that considerable variation in the seasonality of *H. leachi* occurs in the different geographic regions of South Africa.

Hyalomma truncatum

Adults of this tick feed on a variety of large domestic and wild ungulates (Norval 1982). They also sometimes infest dogs (Norval 1982; Horak 1995) and large necrotic lesions may develop at the attachment sites on these animals (Burr 1983). The immature stages prefer scrub hares as hosts, and will also infest rodents (Horak & MacIvor 1987). Although it is widely distributed in South Africa, particularly in the drier western regions (Howell *et al.* 1983), only two ticks were collected during the present study. Dogs on farms and smallholdings are, however, frequently infested by *Hyalomma* spp. (Fourie 2000, unpublished data).

Ixodes rubicundus

This tick is colloquially known as the Karoo paralysis tick because of the toxicosis it can cause which results in generalised paralysis in a variety of domestic and wild ungulates (Howell *et al.* 1983). Its hosts include sheep, goats and cattle, and wild animals such as caracals (*Caracal caracal*), mountain reedbuck (*Redunca fulvorufula*) and eland (*Taurotragus oryx*) (Stampa 1959; Howell *et al.* 1983; Horak,

Moolman & Fourie 1987a; Fourie & Horak 1991). It is a three-host tick and rock elephant shrews (*Elephantulus myurus*) and Smith's red rock rabbits (*Pronolagus rupestris*) are the preferred hosts of the immature stages (Stampa 1959; Horak *et al.* 1987a; Fourie, Horak & Van den Heever 1992). The tick's distribution is largely confined to hilly or mountainous terrain in the west and south of the country in regions with Karoo or Karoo-like vegetation (Howell *et al.* 1983; Spickett & Heyne 1988). Only seven ticks were collected during the present survey and then only at Batho where the terrain is hilly.

Otbious megnini

This argasid tick was originally introduced into South Africa from Mexico (Theiler 1962). The larvae and nymphs parasitize the ear canals of cattle, sheep, goats and horses, while pigs, cats, rabbits and humans can also be infested (Jagannath & Lokesh 1989). It prefers semi-arid, high-lying regions and is apparently always associated with man-made stone or brick structures (Theiler & Salisbury 1958; Howell *et al.* 1983).

Rhipicephalus evertsi evertsi

A variety of animals including cattle, sheep, goats and horses serve as hosts for this tick (Walker 1991; Walker *et al.* 2000). It is a two-host species and all parasitic stages frequently feed on the same host. With the exception of the arid western regions it is present throughout South Africa (Walker *et al.* 2000). Only two ticks were collected in the present study.

Rhipicephalus follis and *Rhipicephalus gertrudae*

Both these ticks have previously been referred to as *R. capensis* and the adults prefer large herbivores as hosts, but have been collected from domestic dogs and from wild carnivores (Walker *et al.* 2000). *Rhipicephalus follis* is present in the east and south and *R. gertrudae* in the central and south-western regions of South Africa (Walker *et al.* 2000). Only two *R. follis* and 112 *R. gertrudae* were collected during the present study, and then only in Botshabelo. Both species have also been recorded on cattle in Botshabelo (Dreyer, Fourie & Kok 1998).

Rhipicephalus sanguineus

Rhipicephalus sanguineus has probably the most widespread distribution of all ticks that infest dogs (Hoogstraal 1956; Walker *et al.* 2000). It inhabits both wet and arid, tropical and sub-tropical regions worldwide, but has a predilection for warm habitats. According to Heath (1974) an environmental temperature below 7 °C is probably unsuitable for *R. sanguineus*. This, however, is contrary to the findings of the present study where, during July 1995, a mean minimum temperature of –3.6 °C was recorded and yet ticks were still present on the dogs. The exact distribution of *R. sanguineus* in South Africa has, however, never been determined, but it is apparently less common in the drier areas (Theiler 1962). However, this could be due to the sparseness of humans and their habitations as well as dogs in these regions.

It is a three-host tick and all stages of development prefer domestic dogs (Walker *et al.* 2000). In the present study *R. sanguineus* was found mostly on the back (29 %), on the ears (19 %), and the neck (19 %) with few ticks in the tail region. Horak (1982) recorded most adult ticks on the neck (29.7 %), ears (19.3 %) and the shoulders (17.2 %) of kennelled dogs in Pretoria North, Gauteng Province, South Africa. However, the definition of back, shoulders and abdomen between the present and Horak's study differ considerably. Howell *et al.* (1983), on the other hand, state that adults are usually found on the ears, neck and between the toes, but that in heavy infestations ticks may attach almost anywhere. Mumcuoglu, Burgan, Ioffe-Uspensky & Manor (1993) reported that most *R. sanguineus* are found on the ears and abdomen of dogs in the Negev Desert, Israel, findings that are in agreement with those of Koch (1982) in the United States of America. These differences suggest that there are other factors involved which have an influence on the tick's preferred sites of attachment, as can be seen from the observations on long and short-haired dogs in the present study. Mumcuoglu *et al.* (1993) speculate that the reason for the head being a predilection site is that self-grooming of this region is difficult. The smaller number of ticks found on the tail is possibly due to the fact that dogs can effectively groom this region.

In the Northern Hemisphere *R. sanguineus* favours the warmer months from March to September. Adult ticks do, however, occur throughout the year although numbers are generally lower during the colder winter months (Amin & Madbouly 1973; Dipeolu 1975; Mumcuoglu *et al.* 1993). In the present study and that conducted in Pretoria North, South Africa (Horak 1982), adult *R. sanguineus* was also most abundant during the summer months with small numbers present on dogs during winter. Burdens of *R. sanguineus* were particularly large on dogs in Botshabelo during January, February and April 1996 and in Thaba Nchu during January and February. The lack of tick control on dogs in these localities probably contributed to these high burdens. Dog owners in the more affluent communities tend to control ticks on a regular basis, resulting in lower burdens.

Although the numbers of adult ticks during winter were low in all localities, the fact that they never reached zero implies that diapause is not a dominant feature in the life cycle of this species. In Pretoria North Horak (1982) found that engorged nymphs that

detached during the late summer and the winter months only moulted to adults during the following spring resulting in a sudden rise in adult tick burdens. A similar phenomenon could have occurred in the present study accounting for the rapid rise in the number of adult ticks collected from the dogs during August or September.

Rhipicephalus sanguineus transmits *Ehrlichia canis*, the causative organism of canine ehrlichiosis (Howell *et al.* 1983). This disease is prevalent at localities in South Africa where *R. sanguineus* is the dominant tick species on dogs, whereas *Babesa canis*, the causative organism of canine babesiosis, is prevalent where its vector in South Africa, namely *H. leachi*, is the dominant species (Horak 1995; Bryson *et al.* 2000).

Rhipicephalus warburtoni

This tick, which has only recently been described, was previously referred to as a *Rhipicephalus pravus*-like tick or a *Rhipicephalus punctatus*-like tick, and as *R. punctatus* (Walker *et al.* 2000). The preferred hosts of the adults are cattle, sheep, goats and hares, while the immature stages prefer rock elephant shrews, which are found in areas with rocky outcrops and hills (Du Toit 1993; Walker *et al.* 2000). Only six ticks were recovered from the dogs in this study and then only in Batho, which is situated in hilly terrain, thus explaining the presence of the tick.

ACKNOWLEDGEMENTS

We are especially grateful to Ellie van Dalen, Eddie Williams and Errol Visagie for their assistance with the fieldwork involved in this study. The research was funded by the National Research Foundation and the University of the Free State.

REFERENCES

AMIN, O.M. & MADBOULY, M.H. 1973. Distribution and seasonal dynamics of a tick, a louse fly, and a louse infesting dogs in the Nile Valley and Delta of Egypt. *Journal of Medical Entomology*, 10:295–298.

ANDREWS, R.H. & PETNEY, T.N. 1981. Competition for sites of attachment to hosts in three parapatric species of reptile tick. *Oecologia* (Berlin), 51:227–232.

ANDREWS, R.H., PETNEY, T.N. & BULL, C.M. 1982. Niche changes between parasite populations: an example from ticks on reptiles. *Oecologia* (Berlin), 55:77–80.

BALASHOV, YU. S. 1972. Bloodsucking ticks (Ixodoidea)—Vectors of diseases of man and animals. *Miscellaneous Publications of the Entomological Society of America*, 8:161–376.

BARNARD, D.R. 1989. Habitat use by cattle affects host contact with Lone Star Ticks (Acari: Ixodidae). *Journal of Economic Entomology*, 82:854–859.

BRYSON, N.R., HORAK, I.G., HÖHN, E.W. & LOUW, J.P. 2000. Ectoparasites of dogs belonging to people in resource-poor communities in North West Province, South Africa. *Journal of the South African Veterinary Association*, 71:175–179.

BURR, E.W. 1983. Tick toxicosis in a crossbred terrier caused by *Hyalomma truncatum*. *Veterinary Record*, 113:260–261.

DE WET, D. 1986. Voedingspraktyke by die Suid-Sotho van Botshabelo—'n volkekundige perspektief. M.A. dissertation. University of the Orange Free State, Bloemfontein.

DIPEOLU, O.O. 1975. A survey of ectoparasitic infestations of dogs in Nigeria. *Journal of Small Animal Practice*, 16:123–129.

DREYER, KARIN, FOURIE, L.J. & KOK, D.J. 1998. Tick diversity, abundance and seasonal dynamics in a resource-poor urban environment in the Free State Province. *Onderstepoort Journal of Veterinary Research*, 65:305–316.

DU TOIT, J.S. 1993. Ecophysiology and host status of the rock elephant shrew *Elephantulus myurus* (Thomas & Schwann, 1906). M.Sc. thesis. University of the Orange Free State, Bloemfontein.

EVANS, G.O. 1952. The distribution of *Ixodes ricinus* (L.) on the body of cattle and sheep. *Bulletin of Entomological Research*, 41:709–723.

FOURIE, L.J. & HORAK, I.G. 1991. The seasonal activity of adult ixodid ticks on Angora goats in the south western Orange Free State. *Journal of the South African Veterinary Association*, 62: 104–106.

FOURIE, L.J. & VAN ZYL, J.M. 1991. Interspecific variations in attachment sites and density assessment in female *Ixodes rubicundus* (Acari: Ixodidae) on domestic and natural hosts. *Experimental and Applied Acarology*, 13:1–10.

FOURIE, L.J., HORAK, I.G. & VAN DEN HEEVER, J.J. 1992. The relative host status of rock elephant shrews *Elephantulus myurus* and Namaqua rock mice *Aethomys namaquensis* for economically important ticks. *South African Journal of Zoology*, 27:108–114.

FOURIE, L.J. & KOK, O.B. 1992. The role of host behaviour in tick-host interactions: a domestic host-paralysis tick model. *Experimental and Applied Acarology*, 13:213–225.

GOLDSMID, J.M. 1963. Ticks infesting dogs in the Salisbury area of Southern Rhodesia. *Journal of the South African Veterinary Medical Association*, 34:609–610.

HEATH, A.C.G. 1974. An investigation into the temperature and humidity preferenda of ixodid ticks, and their distribution in relation to bioclimatic zones in Australia. Ph.D. thesis. Department of Parasitology, University of Queensland, Australia.

HOOGSTRAAL, H. 1956. *African Ixodoidea. I. Ticks of the Sudan (with special reference to Equatoria Province and with preliminary reviews of the genera* Boophilus, Margaropus *and* Hyalomma*)*. Washington DC: Department of the Navy Bureau of Medicine and Surgery.

HORAK, I.G. 1982. Parasites of domestic and wild animals in South Africa. XIV. The seasonal prevalence of *Rhipicephalus sanguineus* and *Ctenocephalides* spp. on kennelled dogs in Pretoria North. *Onderstepoort Journal of Veterinary Research*, 49:63–68.

HORAK, I.G. & MACIVOR, K.M. DE F. 1987. The scrub hare, a reliable indicator of the presence of *Hyalomma* ticks in the Cape Province. *Journal of the South African Veterinary Association*, 58: 15–19.

HORAK, I.G., MOOLMAN, L.C. & FOURIE, L.J. 1987a. Some wild hosts of the Karoo paralysis tick, *Ixodes rubicundus* Neumann, 1904 (Acari: Ixodidae). *Onderstepoort Journal of Veterinary Research*, 54:49–51.

HORAK, I.G., MACIVOR, K.M. DE F., PETNEY, T.N. & DE VOS, V. 1987b. Some avian and mammalian hosts of *Amblyomma hebraeum* and *Amblyomma marmoreum* (Acari: Ixodidae). *Onderstepoort Journal of Veterinary Research*, 54:397–403.

HORAK, I. G., JACOT GUILLARMOD, AMY, MOOLMAN, L.C. & DE VOS, V. 1987c. Parasites of domestic and wild animals in South Africa. XXII. Ixodid ticks on domestic dogs and wild carnivores. *Onderstepoort Journal of Veterinary Research*, 54: 573–580.

HORAK, I.G. 1995. Ixodid ticks collected at Onderstepoort from dogs diagnosed with *Babesia canis* infection. *Journal of the South African Veterinary Association*, 66:170–171

HORAK, I.G., BRAACK, L.E.O., FOURIE, L.J. & WALKER, JANE B. 2000. Parasites of domestic and wild animals in South Africa. XXXVIII. Ixodid ticks collected from 23 wild carnivore species. *Onderstepoort Journal of Veterinary Research*, 67: 239–250.

HORAK, I.G., EMSLIE, F.R. & SPICKETT, A.M. 2001. Parasites of domestic and wild animals in South Africa. XL. Ticks on dogs belonging to people in rural communities and carnivore ticks on the vegetation. *Onderstepoort Journal of Veterinary Research*, 68:135–141

HOWELL, C.J., WALKER, JANE B. & NEVILL, E.M. 1983. Ticks, mites and insects infesting domestic animals in South Africa. Part 1 Descriptions and biology. Department of Agricultural Technical Services, Republic of South Africa (Science Bulletin, no. 393).

JAGANNATH, M.S. & LOKESH, Y.V 1989. Life cycle of *Otobius megnini* (Acari: Argasidae), in *Progress in Acarology*, edited by G.P Channabasvanna & C.A. Viraktamath, Leiden: E.J. Brill.

JEPPE, W.J.O. 1980. *Bophuthatswana Land Tenure and Development*. Cape Town: Maskew Miller.

KASSAI, T 1999. *Veterinary Helminthology*. Butterworth-Heinemann: Reed Educational and Professional Publishing Ltd.

KOCH, H.G. 1982. Seasonal incidence and attachment sites of ticks (Acari: Ixodidae) on domestic dogs in southern Oklahoma and northwestern Arkansas, USA. *Journal of Medical Entomology*, 19:293–298.

MASON, C.A. & NORVAL, R.A.I. 1980. The ticks of Zimbabwe. I. The genus *Boophilus*. *Zimbabwe Veterinary Journal*, 11:36–43.

MUMCUOGLU, K.Y., BURGAN, I., IOFFE-USPENSKY, I. & MANOR, O. 1993. *Rhipicephalus sanguineus*: observations on the parasitic stage on dogs in the Negev Desert of Israel. *Experimental and Applied Acarology*, 17:793–798.

NORVAL, R.A.I. 1975. Studies on the ecology of *Amblyomma marmoreum* Koch 1844 (Acarina: Ixodidae). *Journal of Parasitology*, 63:737–742.

NORVAL, R.A.I. 1982. The ticks of Zimbabwe. IV. The genus *Hyalomma*. *Zimbabwe Veterinary Journal*, 13:2–10.

NORVAL, R.A.I. 1984. The ticks of Zimbabwe. IX. *Haemaphysalis leachi* and *Haemaphysalis spinulosa*. *Zimbabwe Veterinary Journal*, 15:9–17

SONENSHINE, D.E. 1975. Influence of host-parasite interactions on the population dynamics of ticks. *Miscellaneous Publications of the Entomological Society of America*, 9:243–249.

SPICKETT, A.M. & HEYNE, H. 1988. A survey of Karoo tick paralysis in South Africa. *Onderstepoort Journal of Veterinary Research*, 55:89–92.

STAMPA, S. 1959. Tick paralysis in the Karoo areas of South Africa. *Onderstepoort Journal of Veterinary Research*, 28:169–227

THEILER, GERTRUD & SALISBURY, LOIS E. 1958. Zoological survey of the Union of South Africa. Tick Survey: Part XI—Distribution of *Otobius megnini*, the spinose ear tick. *Onderstepoort Journal of Veterinary Research*, 27:605–610.

THEILER, GERTRUD & SALISBURY, LOIS E. 1959. Ticks in the South African Zoological Survey Collection. Part IX. "The *Amblyomma marmoreum* group" *Onderstepoort Journal of Veterinary Research*, 28:47–124.

THEILER, GERTRUD. 1962. The Ixodoidea parasites of vertebrates in Africa south of the Sahara (Ethiopian region). Project S 9958. Report to the Director of Veterinary Services, Onderstepoort [Mimeographed].

WALKER, JANE B. & OLWAGE, A. 1987 The tick vectors of *Cowdria ruminantium* (Ixodoidea, Ixodidae, genus *Amblyomma*) and their distribution. *Onderstepoort Journal of Veterinary Research*, 54:353–379.

WALKER, JANE B. 1991. A review of the ixodid ticks (Acari, Ixodidae) occurring in southern Africa. *Onderstepoort Journal of Veterinary Research*, 58:81–105.

WALKER, JANE B., KEIRANS, J.E. & HORAK, I.G. 2000. *The genus* Rhipicephalus *(Acari, Ixodidae): a guide to the brown ticks of the world*. Cambridge: Cambridge University Press.

WILKINSON, P.R. 1972. Sites of attachment of "Prairie" and "Montane" *Dermacentor andersoni* (Acarina: Ixodidae) on cattle. *Journal of Medical Entomology*, 9: 133–137