



Parasites of domestic and wild animals in South Africa. XLIII. Ixodid ticks of domestic dogs and cats in the Western Cape Province

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ABSTRACT

HORAK, I.G. & MATTHEE, SONJA. 2003. Parasites of domestic and wild animals in South Africa. XLIII. Ixodid ticks of domestic dogs and cats in the Western Cape Province. *Onderstepoort Journal of Veterinary Research*, 70:187–195

Ticks were collected at monthly intervals for 16 consecutive months from individual dogs by their owners in or close to the town of Stellenbosch, Western Cape Province. They were also collected for 27 consecutive months from dogs presented for a variety of reasons at three veterinary clinics in Stellenbosch, and from dogs upon admission to an animal welfare shelter. At one of the veterinary clinics ticks were also collected from cats.

Dog owners collected six ixodid species from their pets and the most numerous of these were *Haemaphysalis leachi* and *Rhipicephalus gertrudae*. Twelve ixodid tick species and the argasid tick, *Otobius megnini* were collected from dogs at veterinary clinics and the animal shelter, and *H. leachi*, *R. gertrudae* and *Rhipicephalus sanguineus* were the most numerous. A total of nine dogs were infested with the Karoo paralysis tick, *Ixodes rubicundus*. No clear pattern of seasonality was evident for *H. leachi*, which was present throughout the year. The largest numbers of adult *R. gertrudae* were generally present from August to October, while adult *R. sanguineus* were collected during October 2000, February and March 2001, from January to April 2002 and during October 2002. Five ixodid tick species, of which *H. leachi* was the most numerous and prevalent, were collected from cats.

Keywords: Cats, dogs, *Haemaphysalis leachi*, ixodid ticks, *Rhipicephalus gertrudae*, *Rhipicephalus sanguineus*, seasonality, Stellenbosch, Western Cape Province

INTRODUCTION

During the past 20 years 50 943 ixodid ticks, belonging to 22 species in six genera have been counted on domestic dogs in five surveys conducted in South Africa (Horak, Jacot Guillarmod, Moolman & De Vos 1987b; Horak 1995; Bryson, Horak, Höhn & Louw 2000; Horak, Emslie & Spickett 2001; Jacobs,

Fourie, Kok & Horak 2001). Three tick species were predominant in these surveys, namely *Haemaphysalis leachi*, *Rhipicephalus sanguineus* and *Rhipicephalus simus*, and 10 662, 35 460 and 1 989 individuals of the three species, respectively, were counted.

Haemaphysalis leachi is widely distributed in Africa and its adults infest both domestic and wild carnivores and felids (Walker 1991; Horak, Braack, Fourie & Walker 2000). *Rhipicephalus sanguineus* has probably the most widespread global distribution of any ixodid tick and nearly exclusively uses domestic dogs as hosts for both its immature and adult stages of development (Walker, Keirans & Horak 2000). Although it is widespread in South Africa, its

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distribution is patchy in that it is confined to localities within urban, suburban, peri-urban and rural areas where there are both domestic dogs and human dwellings and associated man-made structures, to which its free-living stages are adapted. *Rhipicephalus simus* is widely distributed in southern Africa and its adults prefer domestic and wild carnivores, felids, suids and equids and also domestic cattle as hosts (Walker *et al.* 2000). However, in the western regions of the Western Cape, Northern Cape and Free State Provinces of South Africa it appears to be partially or wholly replaced by *Rhipicephalus gertrudae* (Walker *et al.* 2000), of which the adults prefer cattle, sheep, equids, wild carnivores and primates, including humans, as hosts (Brain & Bohrmann 1992; Walker *et al.* 2000; Horak, Fourie, Heyne, Walker & Needham 2002).

Infestation with any tick has a nuisance value, but *H. leachi* also transmits *Babesia canis* to dogs (Lewis, Penzhorn, Lopez-Rebollar & De Waal 1996), *R. sanguineus* transmits *Ehrlichia canis* (Groves, Dennis, Amyx & Huxsoll 1975) and, in countries other than South Africa, also *Babesia canis* (Liebisch & Gillani 1979). It can also transmit *Rickettsia conorii*, the causative organism of tick-bite fever in humans (Neitz, Alexander & Mason 1941), and hence its control from both veterinary and medical perspectives is important. Heavy infestations with *R. gertrudae* have been recorded as a major contributing factor towards the deaths of young baboons, *Papio ursinus* in an arid environment in Namibia (Brain & Bohrmann 1992).

Four of the five above-mentioned surveys were done in the provinces of Gauteng, North West, north-eastern KwaZulu-Natal and central Free State, all summer rainfall regions (Horak 1995; Bryson *et al.* 2000; Horak *et al.* 2001; Jacobs *et al.* 2001), while the fifth was conducted in a non-seasonal rainfall region in the Eastern Cape Province (Horak *et al.* 1987b). No survey of the ticks infesting dogs in the Western Cape Province, a winter rainfall region, has been conducted and the present study was undertaken to fill this gap in our knowledge.

The checklist of the ticks of Africa, south of the Sahara, compiled by Theiler (1962), does not indicate from which countries records for cats originate. Besides this list there appears to be only one published report of ticks infesting domestic cats in South Africa, and it pertains to ticks on cats in the Kruger National Park that have become feral (Horak *et al.* 2000). The current survey adds to our knowledge in this field.

MATERIALS AND METHODS

The survey region comprised the town of Stellenbosch (33°55' S, 18°50' E) and its immediate environs in the Western Cape Province, and two groups of dogs were examined. In one ticks were collected from individual dogs by their owners, and in the other they were collected from dogs presented at three veterinary clinics, or upon admission to an animal welfare shelter.

Once a month from September 2000 to December 2001 the dog owners manually de-ticked their dogs and placed the ticks from each dog in separate labelled vials containing 70% alcohol. Two of these dogs were de-ticked by one of us (S.M.), and the sites of attachment recorded. The veterinarians, or their assistants, manually de-ticked dogs presented at their practices from October 2000 to December 2002, and the ticks for each month were pooled for each practice. Two of the veterinarians had collected ticks prior to the commencement of the survey, and these ticks have been included in the total counts, but not in the monthly seasonal occurrence counts. One of the veterinarians also collected ticks from cats. Ticks were collected from dogs upon their admission to the animal welfare shelter from October 2000 to December 2002, and the ticks for each month were pooled. Ticks were also collected each month from December 2001 to June 2002 and from October to December 2002 from dogs upon admission to an animal welfare shelter in the nearby town of Franschhoek (33°50' S, 19°07' E), Western Cape Province.

RESULTS

The species and numbers of ticks collected from individual dogs by their owners are summarized in Table 1. Ticks belonging to six ixodid species were collected. The most numerous of these were *H. leachi* and *R. gertrudae*, and their sites of attachment are summarized in Table 2 and their seasonality is graphically illustrated in Fig. 1. More than 50% of adult *H. leachi* and *R. gertrudae* attached to the head, ears, neck and shoulders of the dogs. *Haemaphysalis leachi* was present throughout the year with the largest numbers collected during September 2000 and June 2001 and the smallest numbers during November 2000 and March 2001. Most *R. gertrudae* were collected during September and October 2000 and August and September 2001. With the exception of April when only one was collected, none were present from February to June 2001.

The total numbers of ticks collected from dogs at veterinary clinics and the animal shelter at Stellenbosch are summarized in Table 3. Twelve ixodid

tick species and the argasid tick, *Otobius megnini* were collected from these dogs, and the seasonal occurrence of *H. leachi*, *R. gertrudae* and *R. san-*

TABLE 1 Ticks collected from dogs belonging to individual owners at Stellenbosch, Western Cape Province

Tick species	Number of ticks					No. of collections (98)
	Larvae	Nymphs	Males	Females	Total	
<i>Haemaphysalis aciculifer</i>	0	0	0	1	1	1
<i>Haemaphysalis leachi</i>	0	3	410	826	1 239	96
<i>Haemaphysalis zumpti</i>	0	0	1	0	1	1
<i>Ixodes pilosus</i> group	0	0	0	3	3	3
<i>Ixodes rubicundus</i>	0	0	4	29	33	3
<i>Rhipicephalus gertrudae</i>	0	0	115	127	242	26

TABLE 2 Attachment sites of adult *Haemaphysalis leachi* and *Rhipicephalus gertrudae* on dogs at Stellenbosch, Western Cape Province

Tick species (No. collected)	Body region					Rump and perineum
	Head	Ears	Neck and shoulders	Lower legs, feet	Abdomen	
<i>Haemaphysalis leachi</i> (112)	12.5	9.8	37.5	6.2	30.4	3.6
<i>Rhipicephalus gertrudae</i> (19)	10.6	10.5	31.6	10.5	36.8	0

TABLE 3 Ticks collected from dogs at veterinary clinics and at an animal shelter at Stellenbosch, Western Cape Province

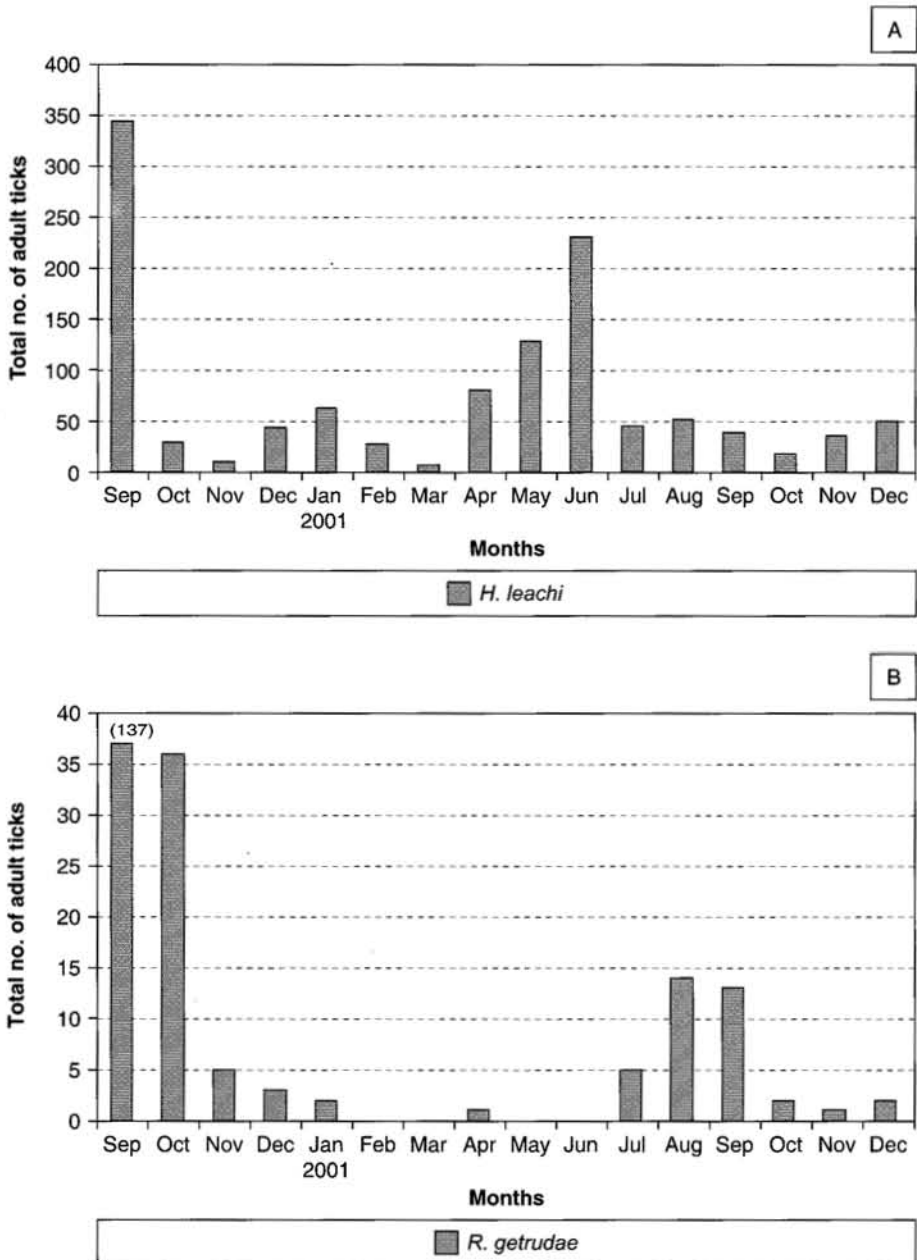
Tick species	Number of ticks					No. of collections (108)
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoratum</i>	0	9	0	0	9	2
<i>Boophilus decoloratus</i>	0	0	0	1	1	1
<i>Haemaphysalis aciculifer</i>	0	0	1	2	3	3
<i>Haemaphysalis leachi</i>	23	25	1 560	4 566	6 174	107
<i>Haemaphysalis spinulosa</i>	0	0	1	1	2	1
<i>Hyalomma truncatum</i>	0	0	0	1	1	1
<i>Ixodes pilosus</i> group	0	9	7	41	57	29
<i>Ixodes rubicundus</i>	0	0	0	7	7	6
<i>Rhipicephalus gertrudae</i>	0	0	188	249	437	54
<i>Rhipicephalus lounsburyi</i>	0	0	0	3	3	2
<i>Rhipicephalus nitens</i>	8	0	0	0	8	2
<i>Rhipicephalus sanguineus</i>	1	5	98	115	219	12
<i>Otobius megnini</i>	0	3	0	0	3	3

TABLE 4 Ticks collected from dogs at an animal shelter at Franschhoek, Western Cape Province

Tick species	No. of ticks					No. of collections (10)
	Larvae	Nymphs	Males	Females	Total	
<i>Haemaphysalis leachi</i>	0	1	506	449	956	10
<i>Rhipicephalus gertrudae</i>	0	0	9	17	26	3
<i>Rhipicephalus nitens</i>	0	0	0	1	1	1
<i>Rhipicephalus sanguineus</i>	1	4	83	56	144	2

TABLE 5 Ticks collected from cats at a veterinary clinic at Stellenbosch, Western Cape Province

Tick species	Number of ticks					No. of collections (20)
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoratum</i>	0	2	0	0	2	1
<i>Haemaphysalis leachi</i>	0	1	70	65	136	20
<i>Haemaphysalis spinulosa</i>	0	0	0	1	1	1
<i>Ixodes pilosus</i> group	0	17	2	4	23	7
<i>Rhipicephalus gertrudae</i>	0	0	3	2	5	2

FIG. 1 The seasonal occurrence of adult (A) *Haemaphysalis leachi* and (B) *Rhipicephalus gertrudae* on dogs belonging to individual owners at Stellenbosch, Western Cape Province

guineus are graphically illustrated in Fig. 2. Most *H. leachi* were collected during August 2001 and from May to September 2002. *Rhipicephalus gertrudae* was most numerous in October 2000, September, October and December 2001, and August to October 2002. No ticks of this species were collected during March to May and July 2001 and during June and July 2002. *Rhipicephalus sanguineus* was present during October 2000, February and March 2001, and from January to April and during October 2002.

Four ixodid tick species were recovered from dogs at the animal shelter at Franschoek, the most numerous of these being *H. leachi* and *R. sanguineus*, while a single female *R. nitens* was also collected (Table 4). *Haemaphysalis leachi* was collected during every month that collections were made, whereas *R. sanguineus* was present only during March and April 2002.

Five ixodid tick species were collected from cats at a veterinary clinic in Stellenbosch, and of these *H.*

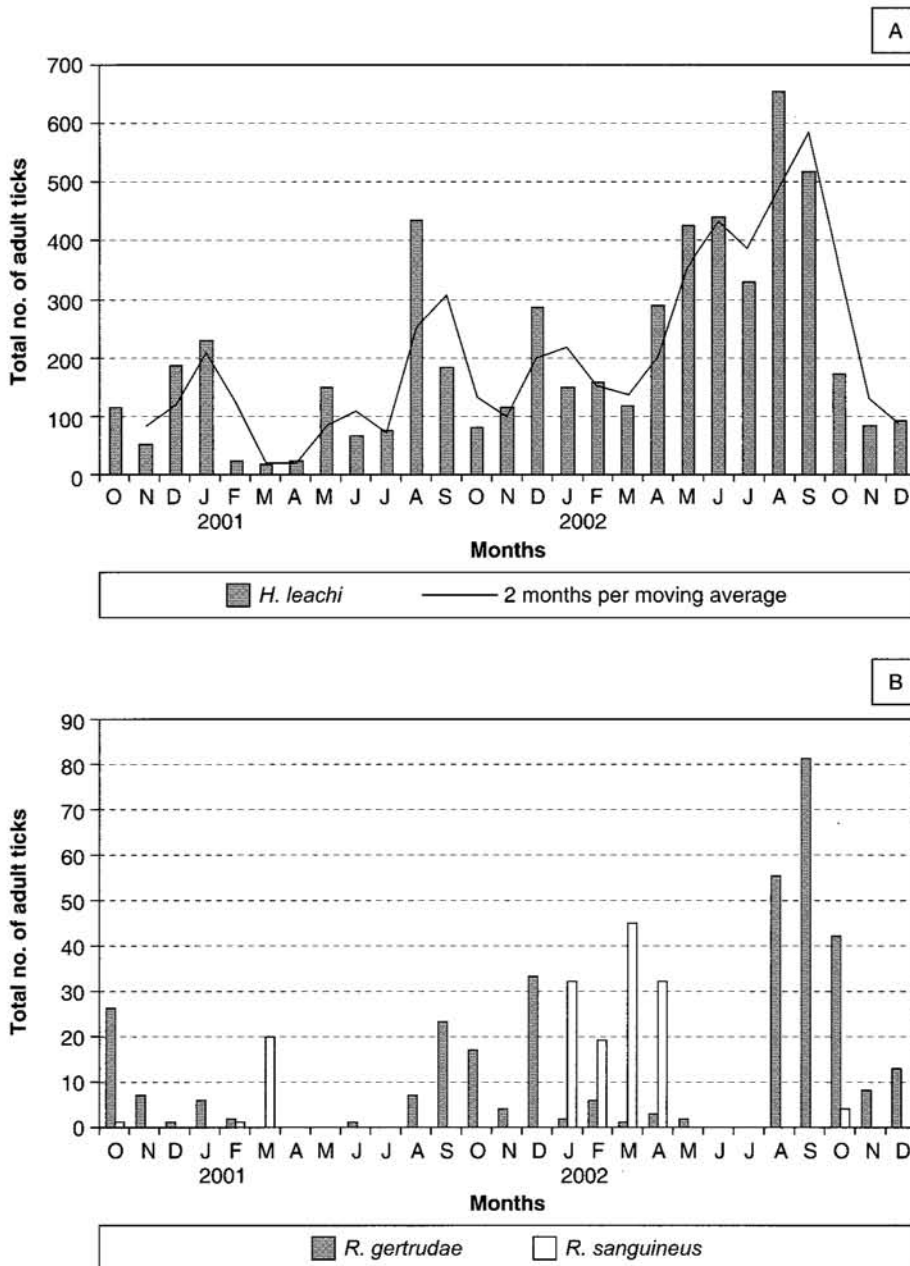


FIG. 2 The seasonal occurrence of (A) adult *Haemaphysalis leachi* (including 2-month moving average), and (B) adult *Rhipicephalus gertrudae* and *Rhipicephalus sanguineus* on dogs at veterinary clinics and an animal welfare shelter at Stellenbosch, Western Cape Province

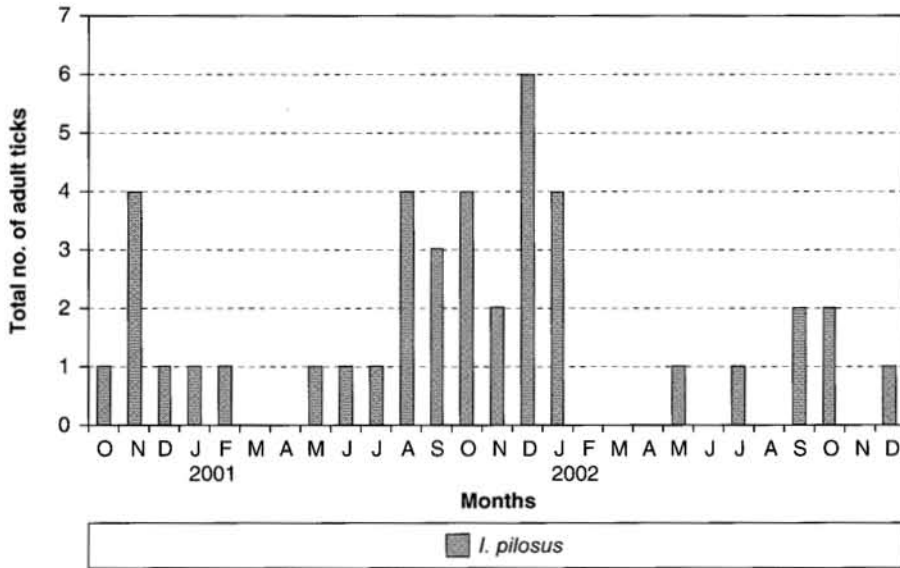


FIG. 3 The seasonal occurrence of adult *Ixodes pilosus* group ticks on dogs belonging to individual owners and at an animal welfare shelter, and on dogs and cats at veterinary clinics at Stellenbosch, Western Cape Province

leachi and ticks of the *Ixodes pilosus* group were the most numerous (Table 5).

The combined seasonal occurrence of adult ticks of the *I. pilosus* group on both dogs and cats at the various survey localities in Stellenbosch is graphically illustrated in Fig. 3. With the exception of March and April 2001 and 2002, when none were recovered, adult ticks of this group were present in every month of the year either during 2001 or 2002.

DISCUSSION

The major differences between this survey and those conducted on dogs elsewhere in South Africa were the frequency with which *Ixodes rubicundus* and *R. gertrudae* were recovered, and the apparently restricted seasonal occurrence of *R. sanguineus*.

All the parasitic stages of development of *Amblyomma marmoreum*, the South African tortoise tick, prefer the latter animals as hosts (Norval 1975). However, the frequency with which the immature stages, and particularly larvae, are recovered from domestic and wild carnivores implies that they are both widespread and catholic in their host preference (Horak *et al.* 1987b; 2000). The presence of nymphs on a dog at a veterinary clinic and another at the animal shelter at Stellenbosch during November 2000 not only confirms the presence of questing immature stages at this time of year but also

their rather non-selective host preference. The collection of *Boophilus decoloratus* from dogs is not unusual (Goldsmid 1963; Horak 1995; Jacobs *et al.* 2001), and indicates that the infested animals had been in localities in which domestic cattle or horses, the preferred hosts of this tick, were kept (Mason & Norval 1980).

Although *Haemaphysalis aciculifer* is fairly widespread in South Africa, it is seldom present in large numbers (Walker 1991). It infests a variety of hosts and has been collected from wild carnivores (Norval 1985). One of the largest infestations recorded on the latter animals consisted of 15 adults collected from a honey badger, *Mellivora capensis* in the Kruger National Park (Horak *et al.* 2000). Its immature stages have been collected from ground-nesting birds in the Western Cape Province (Horak & Boomker 1998), thus establishing its presence here and accounting for the adults in four collections from dogs.

Adult *H. leachi* prefer the larger wild canids and felids as well as domestic dogs as hosts (Norval 1984; Horak *et al.* 1987b; 2000), but have also been collected from feral domestic cats (Horak *et al.* 2000). In the central Free State most adult *H. leachi* were collected from the neck, back and legs of dogs (Jacobs *et al.* 2001). Although the attachment sites of only 112 adult ticks of this species were determined in the present survey, most of these were collected from the head, neck and shoulders of the dogs. This tick is widespread throughout the

warmer eastern regions of the country (Howell, Walker & Nevill 1978), and it would appear that Stellenbosch and its environs in the Western Cape Province is an imminently suitable habitat. Adult *H. leachi* is most numerous on dogs in the Eastern Cape Province from May or June to February (Horak *et al.* 1987b), in the central Free State from September to November (Jacobs *et al.* 2001), and in north-eastern KwaZulu-Natal from January or February to March or April (Horak *et al.* 2001), but no clear pattern of seasonality emerged in the present survey. However, most ticks appeared to be present during the cooler months of the year from May to September. The year-round presence of *H. leachi* on dogs at Stellenbosch implies that canine babesiosis can be expected during any season.

The southern regions of the Western Cape Province do not seem to be an ideal habitat for *Hyalomma truncatum* (Howell *et al.* 1978), and few ticks of this species are encountered here (Horak & Boomker 1998). Although adult *H. truncatum* feed on a variety of domestic ungulates (Norval 1982), they sometimes also infest dogs (Norval 1982; Horak 1995; Jacobs *et al.* 2001), on which penetrating necrotic lesions may occur at their sites of attachment (Burr 1983). The single tick collected in the current survey is probably a rare accidental infestation of a dog in this region.

Ticks of the *Ixodes pilosus* group have been collected from domestic dogs and several wild carnivore species and appear to have a preference for felids (Horak *et al.* 1987b; 2000). Consequently the recovery of ticks of this group from both dogs and cats in the present survey is to be expected, particularly as the Stellenbosch region lies within the distribution range of these ticks (Howell *et al.* 1978). Most of the ticks collected from cats were nymphs, and the greater proportional density of ticks of this species on these animals than on dogs confirms its preference for felids. Although few ticks were collected from animals at any of the survey sites, and hence an accurate evaluation cannot be made, peaks in activity from late winter and spring to mid-summer are evident. In the coastal region of the Eastern Cape Province most *I. pilosus* group adults were present on caracals, *Caracal caracal* from November to May (Horak *et al.* 1987b), whereas most adults were present on antelopes and scrub hares, *Lepus saxatilis* in the Bontebok National Park outside Swellendam in the Western Cape Province from October to December (Horak, Sheppey, Knight & Beuthin 1986), somewhat similar to the present findings.

It has been suggested that the caracal is a preferred host of adult *I. rubicundus* (Horak, Moolman & Fourie 1987a). The subsequent collection of this tick from a black-backed jackal, *Canis mesomelas*, an African wild cat, *Felis lybica*, and a caracal in the Northern Cape Province (Horak *et al.* 2000), as well as from a domestic dog in the central region of the Free State Province (Jacobs *et al.* 2001), denotes that several carnivore species may be suitable hosts for adult ticks of this species. The recovery in the present survey of ticks from nine dogs, of which one harboured ten and another 18, confirms this observation.

Prior to this study there were only 11 records of *R. gertrudae* infesting domestic dogs and none from cats (Walker *et al.* 2000; Jacobs *et al.* 2001), now there are at least 94 records for dogs and two for cats. Its immature stages, like those of *R. simus*, prefer murid rodents as hosts. Thus *R. gertrudae* not only occupies the potential geographic distribution of *R. simus* in the Western Cape Province, but also utilizes some of the latter tick's preferred hosts (Walker *et al.* 2000). However, whereas *R. simus* is a spring to late summer tick on dogs in the Eastern Cape Province and a summer to late summer tick on these animals in north-eastern South Africa (Horak *et al.* 1987b; 2001), *R. gertrudae* is primarily a spring tick on dogs in the Western Cape Province (Fig. 1 and 2), and an autumn to spring tick on sheep in this province and in the Northern Cape Province (Horak & Fourie 1992).

Rhipicephalus lounsburyi is a small tick that attaches around and between the hooves of sheep and wild antelopes in north-eastern Eastern Cape Province and southern and western Western Cape Province (Horak *et al.* 1986; Walker 1990), and its presence on dogs must be considered accidental. The distribution of *Rhipicephalus nitens* is confined to the fynbos regions of the Western and Eastern Cape Provinces (Walker *et al.* 2000), and all stages of development prefer sheep, wild antelopes and scrub hares as hosts (Horak, Williams & Van Schalkwyk 1991; Horak & Boomker 1998). The collection of an adult tick from a dog at Franschoek during December 2001, and larvae from a dog at Stellenbosch during June 2002 and from another during July reflect accidental infestations during months when adults or larvae are particularly numerous on antelopes and scrub hares in the Western Cape Province (Horak *et al.* 1986). Adults have previously been collected from dogs on small-holdings near Grahamstown in the Eastern Cape Province (Horak *et al.* 1987b).

In northern Gauteng Province adult *R. sanguineus* are most numerous on dogs from December to May with a secondary peak during September (Horak 1982), while in central Free State Province they are most numerous from January to April (Jacobs *et al.* 2001). Although adult ticks were present throughout the year at both localities, numbers were generally low during June and July (mid-winter). The adult ticks collected at Stellenbosch during October 2000 and 2002 possibly stem from recently-moulted over-wintered nymphs, while those collected during the period January to April at Stellenbosch and Franschoek probably represent the next generation adult progeny of spring-moulted ticks. This corresponds somewhat to the situation in northern Gauteng, but suggests that only two life cycles per year are completed at Stellenbosch, and not three as at the former locality (Horak 1982). Because of the chronic nature of canine ehrlichiosis, dogs suffering from it may present several months after detachment of the vector adult *R. sanguineus* ticks.

The larvae and various nymph stages of the argasid tick *O. megnini* may be found in the external ear canals of cattle that are kraaled at night, and of calves that are reared in stone or brick-walled pens (Howell *et al.* 1978; Fourie & Horak 1990). They have also been collected from the ear canals of sheep, goats, horses, dogs, cats and humans (Howell *et al.* 1978; Naude, Heyne, Van Der Merwe & Benic 2001; Huchzermeyer 2002). The source of the ticks on dogs in the present survey is likely to have been premises in which infested cattle or horses had been housed.

ACKNOWLEDGEMENTS

We greatly appreciate the time spent collecting ticks by Drs M.C. Franken, J.V. Jackson and M.E. Potgieter and the staff at their veterinary practices, by the staff of the Animal Welfare Society at Stellenbosch and the staff of the SPCA at Franschoek, and by the dog owners Mrs A. Huckfeldt, Mr B. Mostert and Prof J. Nel. This project was funded by financial assistance provided by Pfizer Animal Health.

REFERENCES

BRAIN, C. & BOHRMANN, R. 1992. Tick infestation of baboons (*Papio ursinus*) in the Namib Desert. *Journal of Wildlife Diseases*, 28:188–191.

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.

FOURIE, L.J. & HORAK, I.G. 1990. Parasites of cattle in the south western Orange Free State. *Journal of the South African Veterinary Association*, 61:27–28.

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.

GROVES, M.G., DENNIS, G.L., AMYX, H.L. & HUXSOLL, D.L. 1975. Transmission of *Ehrlichia canis* to dogs by ticks (*Rhipicephalus sanguineus*). *American Journal of Veterinary Research*, 36:937–940.

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., SHEPPEY, K., KNIGHT, M.M. & BEUTHIN, C.L. 1986. Parasites of domestic and wild animals in South Africa. XXI. Arthropod parasites of vaal ribbok, bontebok and scrub hares in the western Cape Province. *Onderstepoort Journal of Veterinary Research*, 53:187–197.

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

HORAK, I.G., WILLIAMS, E.J. & VAN SCHALKWYK, P.C. 1991. Parasites of domestic and wild animals in South Africa. XXV. Ixodid ticks on sheep in the north-eastern Orange Free State and in the eastern Cape Province. *Onderstepoort Journal of Veterinary Research*, 58:115–123.

HORAK, I.G. & FOURIE, L.J. 1992. Parasites of domestic and wild animals in South Africa. XXXI. Adult ixodid ticks on sheep in the Cape Province and in the Orange Free State. *Onderstepoort Journal of Veterinary Research*, 59:275–283.

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

HORAK, I.G. & BOOMKER, J. 1998. Parasites of domestic and wild animals in South Africa. XXXV. Ixodid ticks and bot fly larvae in the Bontebok National Park. *Onderstepoort Journal of Veterinary Research*, 65:205–211.

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.

HORAK, I.G., FOURIE, L.J., HEYNE, HELOISE, WALKER, JANE B. & NEEDHAM, G.R. 2002. Ixodid ticks feeding on humans in South Africa: with notes on preferred hosts, geographic distribution, seasonal occurrence and transmission of pathogens. *Experimental and Applied Acarology*, 27:113–136.

HOWELL, C.J., WALKER, JANE B. & NEVILL, E.M. 1978. *Ticks, mites and insects infesting domestic animals in South*

- Africa. Part 1. Descriptions and biology.* Pretoria: Department of Agricultural Technical Services, Republic of South Africa (Science Bulletin, No. 393).
- HUCHZERMAYER, H.F. 2002. Another human ear tick case. *Journal of the South African Veterinary Medical Association*, 73:2.
- 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.
- LEWIS, B.D., PENZHORN, B.L., LOPEZ-REBOLLAR, L.M. & DE WAAL, D.T. 1996. Isolation of a South African vector-specific strain of *Babesia canis*. *Veterinary Parasitology*, 63:9–16.
- LIEBISCH, A. & GILLANI, S. 1979. Experimentelle Übertragung der Hundebabesiose (*Babesia canis*) durch einheimische deutsche Zeckenarten: I. Die braune Hundezecke (*Rhipicephalus sanguineus*). *Deutsche Tierärztliche Wochenschrift*, 86:149–153.
- MASON, C.A. & NORVAL, R.A.I. 1980. The ticks of Zimbabwe. I. The genus *Boophilus*. *Zimbabwe Veterinary Journal*, 11:36–43.
- NAUDÉ, T.W., HEYNE, H., VAN DER MERWE, I.R. & BENIC, M.J. 2001. Spinose ear tick, *Otobius megnini* (Dugès, 1884) as the cause of an incident of painful otitis externa in humans. *Journal of the South African Veterinary Association*, 72:118–119.
- NEITZ, W.O., ALEXANDER, R.A. & MASON, J.H. 1941. The transmission of tick-bite fever by the dog tick *Rhipicephalus sanguineus*, Latr. *Onderstepoort Journal of Veterinary Science and Animal Industry*, 16:9–17.
- 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.
- NORVAL, R.A.I. 1985. The ticks of Zimbabwe. XIV. The lesser known *Haemaphysalis* species. *Zimbabwe Veterinary Journal*, 16:54–59.
- 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. 260 pp. Mimeographed.
- WALKER, JANE B. 1990. Two new species of ticks from southern Africa whose adults parasitize the feet of ungulates: *Rhipicephalus lounsburyi* n. sp. and *Rhipicephalus neumanni* n. sp. (Ixodoidea, Ixodidae). *Onderstepoort Journal of Veterinary Research*, 57:57–75.
- 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 Academic Press: Cambridge.