The relative host status of rock elephant shrews *Elephantulus myurus* and Namaqua rock mice *Aethomys namaquensis* for economically important ticks

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Received 18 October 1991; accepted 25 March 1992

Several tick species of medical and veterinary importance occur in the southern Orange Free State. The purpose of the present study was to determine the host status of rock elephant shrews (*Elephantulus myurus*) and Namaqua rock mice (*Aethomys namaquensis*) for these ticks. Infestation levels were used as a criterion. The seasonal abundances of the ticks as well as the effects of landscape topography and sex of the host on infestation levels were also investigated. Incidental observations were made on the pouched mouse (*Saccostomys campestris*). No adult ticks were recovered from any of these small mammals. Seven tick species were found on the elephant shrews of which only *Ixodes rubicundus* and *Rhipicephalus punctatus* occurred in high numbers on a large proportion of the animals. Both these ticks cause paralysis in domestic stock. The Namaqua rock mice harboured eight tick species. Only *Haemaphysalis leachi/spinulosa* and *R. punctatus* had a relative abundance exceeding 15%. Three of the 10 pouched mice examined were infested with small numbers of ticks. The 132 rock elephant shrews examined harboured a mean total burden of 121 immature ticks compared to four on each of the 321 Namaqua rock mice. The larvae and nymphs of *I. rubicundus* occurred mainly in the colder months (April to September), while those of *H. leachi/spinulosa* preferred the warmer months (October to March). Large numbers of larvae of *R. punctatus* were present from December to July and nymphs from August to October. Infestation levels of *I. rubicundus* were consistently higher on animals trapped on southern slopes than on those trapped on northern slopes. The sex of the hosts seemed to have little effect on infestation levels.

Verskeie bosluissoorte wat van mediese en veeartsenykundige belang is, kom in die suidelike Oranje Vrystaat voor. Die doel van hierdie studie was om die status van klipklaasneuse (*Elephantulus myurus*) en Namakwa klipmuise (*Aethomys namaquensis*) as gashere van hierdie bosluise te bepaal. Besmettingsvlakke is as maatstaf geneem. Ondersoek is voorts ingestel na die seisoensvoorkoms van die bosluise en die effek van landskaptopografie en gasheergeslag op besmettingsvlakke. Terloopse waarnemings is ook op die wangsakmuis (*Saccostomys campestris*) gemaak. Geen volwasse bosluise is op enige van die diertjies gevind nie. Sewe bosluissoorte is op die klipklaasneuse gevind, maar die resultate dui daarop dat klipklaasneuse goeie gashere vir slegs twee van hierdie bosluise, nl. *Ixodes rubicundus* en *Rhipicephalus punctatus*, is. Beide bosluise kan verlamming onder vee veroorsaak. Agt verskillende bosluise is op Namakwa klipmuise gevind. Slegs twee van hierdie bosluissoorte, nl. *Haemaphysalis leachi/spinulosa* en *R. punctatus* het 'n relatiewe volopheid van meer as 15% getoon. Drie van die 10 wangsakmuise wat ondersoek is, was besmet met enkele bosluise. Klipklaasneuse (n = 132) was oor die studietydperk met 'n gemiddeld van 121 bosluise besmet vergeleke met die vier van Namakwa klipmuise (n = 321). In teenstelling met *H. leachi/spinulosa* was die seisoensvoorkoms van *I. rubicundus* larwes en nimfe hoofsaaklik tot die kouer maande van die jaar (April tot September), beperk. Hoë besmettingsvlakke van *R. punctatus* larwes is op gashere gevind vanaf Desember tot Julie. Nimfgetalle het gepiek vanaf Augustus tot Oktober. In teenstelling met *R. punctatus* en *H. leachi/spinulosa* is daar deurgaans hoër besmettingsvlakke van *I. rubicundus* aangeteken op diere versamel op suidelike hellings, vergeleke met dié versamel op noordelike hellings. Weinig verskille in besmettingsvlakke tussen die gasheergeslagte is gevind.

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Ticks are considered to be the most important biological vectors of micro-organisms which cause disease in man and animals (Balashov 1972). Small mammals may act as reservoir hosts for many of these tick-transmitted diseases (Balashov 1972). In addition, it has been suggested that rodents possibly serve as hosts of more ixodid tick species than any other mammal taxa (Oliver 1989). As ticks are obligate parasites, a major factor influencing population dynamics is the suitability and abundance of hosts (Randolph 1975).

In the south-western region of the Orange Free State, the rock elephant shrew *Elephantulus myurus* occurs sympatrically with the Namaqua rock mouse *Aethomys namaquensis* (Smithers 1983). The latter, followed by the former, are the most abundant of the small mammals confined to rocky terrain (their natural habitat) in the southern parts of the Orange Free State. The elephant shrew has been implicated as an important host of the immature stages of two paralysis-inducing tick species (Stampa 1959; Fourie, Horak & Marais 1988a). Sound quantitative data substantiating this claim are lacking. Furthermore, the relative status of the rock elephant shrew and Namaqua rock mouse as hosts of economically important ticks has not as yet been evaluated.

The objectives of this study were to identify and quantify tick burdens on these small mammals in the south-western Orange Free State, to determine seasonal patterns of abundance of their ticks and to ascertain the effects of topography on tick burdens.

Methods

Study area

Rock elephant shrews and Namaqua rock mice were collected on the farms 'Preezfontein' (29°50'S / 25°23'E) and 'Slangfontein' (30°08'S / 25°24'E) situated approximately 8 km and 40 km respectively from the town of Fauresmith in the south-western Orange Free State. The vegetation in the area has been classified as False Upper Karoo (Acocks 1975) and the climate described as semi-arid with approximately 69% of the annual rainfall occurring during the summer months. Because of the irregular rainfall, mild to severe droughts occur periodically. Air temperatures exhibit major circadian and seasonal fluctuations. The mean maximum temperatures for 1980–1986 range between 32,2°C in January and 17,2°C in June. The mean minimum temperatures varied between 16,4°C in January and 1,3°C in July. Absolute temperatures varied between 39,4 and –6,3°C (Fourie, Petney, Horak & De Jager 1989).

Survey animals

From January to December 1985 an attempt was made to capture at least two specimens of each mammal species on a monthly basis at both sampling localities. From January 1986 to December 1987 animals were captured only at 'Preezfontein'. Box traps similar to Sherman traps were used and baited with a mixture of peanut butter and oatmeal (3:2). The traps were placed on rocky outcrops and checked in the early morning and late afternoon. Trapped specimens were euthanased after which they were preserved in 10% formalin in 250 ml plastic bottles.

In order to determine the relative abundance of the various small mammals, as well as to eliminate experimental topographical trapping preference, two traplines consisting of 50 traps each, were set on northern and on southern slopes from January to December 1987 excluding February. The traps were spaced 7–10 m apart and baited as previously described. Trapping periods varied from 2–4 days during each month. Several of the trapped specimens were killed and processed for tick recovery. However, because of the poor trapping success of elephant shrews, trap lines were abandoned, and traps were placed where the likelihood of catching the shrews seemed greater on northern and southern slopes from January 1988 to December 1988. Because of this bias the latter data were not considered for the determination of relative abundance of the various small mammal species.

Tick recovery

Ticks were recovered by sieving the liquid in each bottle through a 150-μm aperture sieve. This was followed by scrubbing the animals with a tooth brush, washing them in a water-filled container and again pouring the contents of the container through the sieve. The contents of the sieve and the whole animal were then examined under a stereoscopic microscope and the ticks collected and placed in labelled bottles containing 70% ethanol for later identification and counting.

We were unable to differentiate between the immature stages of *Haemaphysalis leachi* and *Haemaphysalis spinulosa* and have designated these as *H. leachi/spinulosa.*

Treatment of data

Seasonal abundance was determined by pooling the numbers of ticks collected from elephant shrews and rock mice in a particular month irrespective of the year during which the hosts were examined. The data were expressed as mean tick burden per animal for the various months. A non-parametric Mann Whitney test was used to test for significant differences in the tick burdens between hosts collected from northern and from southern slopes. To determine whether host sex-related differences occurred in tick burdens, data were transformed to ln (tick count + 1) and an unpaired two-tailed *t* test was performed to compare the means.

Results

A total of 256 *Aethomys namaquensis*, 102 *Elephantulus myurus* and 65 *Saccostomys campestris* were captured on northern and southern slopes during 1987.

The numbers of ticks collected from the three host species are summarized in Tables 1–3. No adult ticks were present on any of the animals. Despite seven tick species being collected from the rock elephant shrews (n = 132), the results suggest that these animals are preferred by only two of these, namely *Ixodes rubicundus* and *Rhipicephalus punctatus*. Eight ixodid tick species parasitized the Namaqua rock mouse (n = 321). Only two of these, *H. leachi/spinulosa* and *R. punctatus*, had a relative abundance in excess of 15%. The mean total tick burden (all species) recorded on elephant shrews during the study period was

Table 1 Ixodid ticks recovered from 132 rock elephant shrews *Elephantulus myurus* on the farms 'Preezfontein' and 'Slangfontein' in the south-western Orange Free State

Tick species	Numbers recovered			Relative abundance	Percentage of animals
	Larvae	Nymphs	Total	%	infested
Amblyomma marmoreum	5	0	5	0,03	2,27
Haemaphysalis leachi/spinulosa	26	20	46	0,29	5,30
Hyalomma marginatum rufipes	0	1	1	0,01	0,76
Ixodes rubicundus	2365	1966	4331	27,08	78,79
Rhipicephalus arnoldi	1	3	4	0,02	3,03
Rhipicephalus distinctus	0	3	3	0,02	2,27
Rhipicephalus punctatus	8999	2602	11601	72,55	100,00
Total	11396	4595	15991	100	100

Table 2 Ixodid ticks recovered from 321 Namaqua rock mice *Aethomys namaquensis* on the farms 'Preezfontein' and 'Slangfontein' in the south-western Orange Free State

Tick species	Numbers recovered			Relative abundance %	Percentage of animals infested
	Larvae	Nymphs	Total		
Haemaphysalis leachi / spinulosa	676	360	1036	76,63	49,53
Hyalomma marginatum rufipes	1	0	1	0,07	0,31
Hyalomma truncatum	10	0	10	0,74	0,31
Ixodes rubicundus	17	0	17	1,26	3,74
Rhipicephalus distinctus	8	10	18	1,33	2,80
Rhipicephalus evertsi evertsi	1	0	1	0,07	0,31
Rhipicephalus gertrudae	4	12	16	1,18	1,56
Rhipicephalus punctatus	157	96	253	18,72	19,63
Total	874	478	1352	100	72

Table 3 Ixodid ticks recovered from 10 pouched mice *Saccostomys campestris* on the farms 'Preezfontein' and 'Slangfontein' in the south-western Orange Free State

Tick species	Numbers recovered			Relative abundance %	Percentage of animals infested
	Larvae	Nymphs	Total		
Haemaphysalis leachi / spinulosa	12	6	18	90	20
Ixodes rubicundus	0	1	1	5	10
Rhipicephalus evertsi evertsi	1	0	1	5	10
Total	13	7	20	100	30

121 compared to four on Namaqua rock mice. Only three of the 10 pouched mice examined were infested with ixodid ticks.

No difference in the species composition of ticks collected from animals from the two farms was discernible. In view of the close proximity of these two localities and in order to enlarge the monthly sample sizes for the determination of seasonal activity, results for the two farms and the various years were combined. The immature stages of *I. rubicundus* were active mainly during autumn and winter with discrete peaks during April and August for the larvae and nymphs respectively (Figure 1). Larvae of *R. punctatus* reached high numbers in December and maintained this level until July. Nymphs reached peak levels from August to October (Figure 2). Larval numbers of *H. leachi/spinulosa* increased rapidly in spring (October) followed by an increase in nymphal numbers, both remaining at fairly high levels during summer whereafter larval numbers decreased in May and nymphs in June (Figure 3).

Because of the small monthly sample sizes, comparisons of tick burdens on hosts collected on northern and southern slopes were done for two or four-monthly periods for the three major tick species. Consistently more *I. rubicundus* larvae and nymphs were recorded on elephant shrews collected on southern slopes than on northern slopes (Table 4). These differences were, however, only significant ($p < 0,05$) for the nymphs recovered during the period July to August. Results obtained for *R. punctatus* and *H. leachi/spinulosa* were variable with no conspicuous trends discernible (Tables 5 & 6).

Tick burdens on male and female hosts were significantly

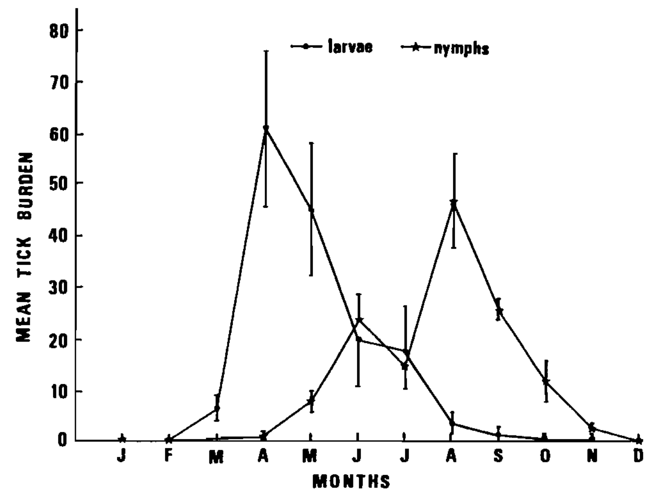

Figure 1 Seasonal abundance of *Ixodes rubicundus* larvae and nymphs on rock elephant shrews (n = 132). Data are expressed as means ± *S.E.*

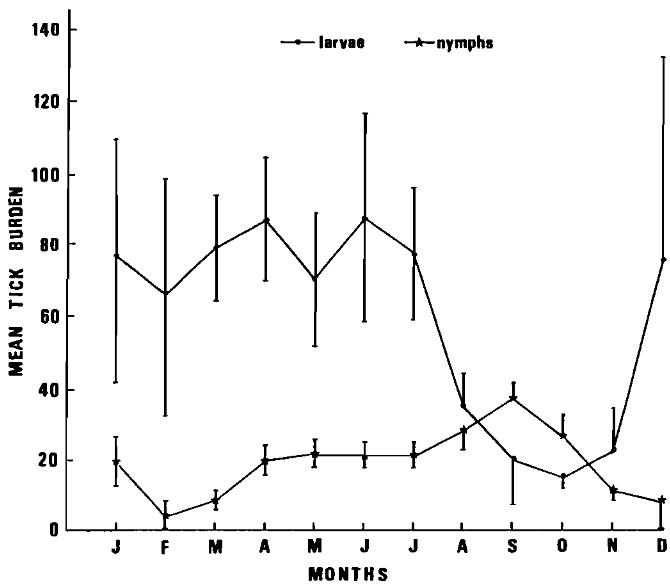

Figure 2 Seasonal abundance of *Rhipicephalus punctatus* larvae and nymphs on rock elephant shrews (n = 132). Data are expressed as means ± *S.E.*

different on only two occasions. Elephant shrew males carried significantly ($p < 0{,}05$) higher burdens of *I. rubicundus* nymphs during July–August and Namaqua rock mouse males carried significantly higher burdens of *H. leachi/spinulosa* nymphs during the March–April period than females of the two species.

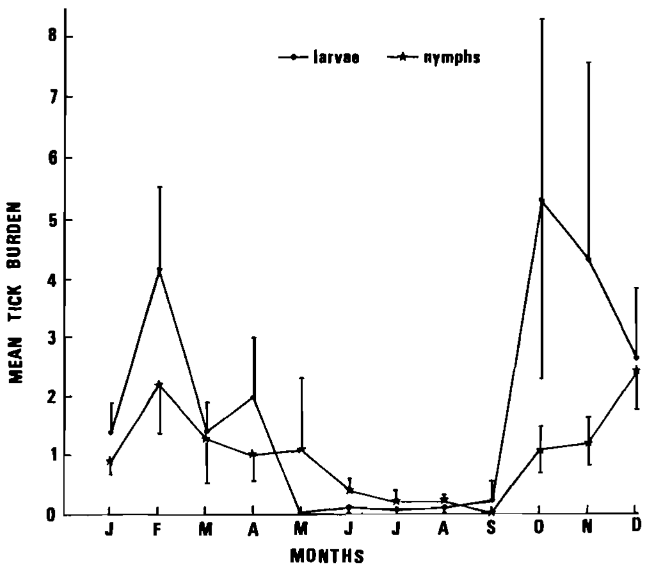

Figure 3 Seasonal abundance of *Haemaphysalis leachi / spinulosa* larvae and nymphs on Namaqua rock mice (n = 321). Data are expressed as means ± *S.E.*

Discussion

The three species of ticks with the highest relative abundance on the rock elephant shrews and Namaqua rock mice are all of economic importance. *I. rubicundus* and *R. punctatus* cause paralysis in domestic stock (Fourie *et al.* 1988a, b; Fourie *et al.* 1989). *H. leachi* is an important vector of *Babesia canis*, the cause of biliary fever in dogs. This tick is also a vector for the organisms causing tick bite fever in humans and Q-fever in humans and animals (Howell, Walker & Nevill 1978).

Recently we have also recovered the immature stages of *Rhipicentor nuttalli* from rock elephant shrews in the central Orange Free State. The hosts of the immature stages were previously unknown (Walker 1991). In its adult stage this tick excretes a toxin which causes paralysis in dogs (Theiler 1962; Norval & Colborne 1985). Three of the paralysis-inducing ticks thus utilize rock elephant shrews as hosts during their immature stages of development and it is tempting to speculate whether this host association has anything to do with toxin production.

Ixodes rubicundus

Three elephant shrew species, which are mainly confined to rocky terrain, occur in South Africa (Smithers 1983) and the distribution of these species to a large extent encompasses that of *I. rubicundus* (Howell *et al.* 1978). The distribution range of this tick appears to be extending (Spickett & Heyne 1988) and it is possible that, provided the bioclimatic requirements of the tick are satisfied, its distribution limits

Table 4 The mean (± *S.E.*) number of *Ixodes rubicundus* recovered from rock elephant shrews on northern and on southern slopes on the farm 'Preezfontein' in the south-western Orange Free State

	Northern slopes					Southern slopes				
	Larvae		Nymphs			Larvae		Nymphs		
Months	$\bar{x}$	*S.E.*	$\bar{x}$	*S.E*	*n*	$\bar{x}$	*S.E.*	$\bar{x}$	*S.E.*	*n*
January–February	–	–	–	–	–	–	–	–	–	3
March–April	14,7	4,6	–	–	11	36,4	14,0	–	–	16
May–June	27,0	7,1	8,9	3,6	6	81,6	25,6	26,6	11,9	5
July–August	2,1	0,7	8,5	2,8	8	12,8	8,9	17,7	4,1	9
September–October	–	–	11,0	6,4	3	–	–	13,3	5,4	6
November–December	–	–	2,0	–	1	–	–	4,2	1,7	6

Table 5 The mean (± *S.E*) number of *Rhipicephalus punctatus* recovered from rock elephant shrews on northern and on southern slopes on the farm 'Preezfontein' in the south-western Orange Free State

	Northern slopes					Southern slopes				
	Larvae		Nymphs			Larvae		Nymphs		
Months	$\bar{x}$	*S.E.*	$\bar{x}$	*S.E.*	*n*	$\bar{x}$	*S.E.*	$\bar{x}$	*S.E.*	*n*
January–February	–	–	–	–	–	89,0	44,5	12	9,8	3
March–April	65,4	15,4	12,9	5,3	11	106,6	21,8	9,6	1,5	16
May–June	98,3	22,9	35,5	4,3	6	73,6	23,7	14,6	3,9	5
July–August	52,3	21,9	19,0	4,1	8	73,1	16	29,0	4,3	9
September–October	16,7	4,8	19,0	11,1	3	17,5	4,0	30,3	7,2	6
November–December	18	–	7	–	1	7,3	4,4	10,2	3,0	6

Table 6 The mean (± *S.E.*) number of *Haemaphysalis leachi/spinulosa* recovered from Namaqua rock mice on northern and on southern slopes on the farm 'Preezfontein' in the south-western Orange Free State

	Northern slopes					Southern slopes				
	Larvae		Nymphs			Larvae		Nymphs		
Months	$\bar{x}$	S.E.	$\bar{x}$	S.E	n	$\bar{x}$	S.E.	$\bar{x}$	S.E.	n
January–February	1,7	0,8	2,5	1,2	11	3,7	1,8	2,5	1,2	7
March–April	5,2	2,0	4,5	2,2	7	1,0	0,7	0,4	0,5	8
May–August	–	–	0,2	0,3	10	–	–	–	–	19
September–October	0,5	0,6	1,4	0,9	9	0,2	0,3	1,3	0,7	6
November–December	0,5	0,5	2,2	1,1	9	1,0	0,7	0,6	0,6	9

will eventually be similar to those of the elephant shrew species. The rock elephant shrew is a major host of the immature stages of this tick and large numbers have also been collected from *Elephantulus edwardii* (Stampa 1959). Other studies have indicated that Smith's red rock rabbits *Pronolagus rupestris* are also important hosts for immature *I. rubicundus* (Stampa 1959; Horak, Moolman & Fourie 1987). The numbers of ticks collected from red rock rabbits examined concurrently with this study in the same localities, indicate that in terms of tick abundance, these animals are secondary in importance to rock elephant shrews (Horak & Fourie 1991).

The seasonal abundance of immature *I. rubicundus* in this study is very similar to that observed by Stampa (1959) in the New Bethesda area of the Karoo and by Horak *et al.* (1987a) in the Cradock district of the Karoo.

The consistently higher burdens of *I. rubicundus* on rock elephant shrews captured on southern slopes as opposed to northern slopes is indicative of the sensitivity of the tick to adverse environmental conditions (De Jager 1988). Northern slopes are known to be warmer and less densely vegetated than southern slopes. Studies of the spatial distribution of free-living, adult *I. rubicundus* indicate that they are closely associated with trees and shrubs with a dense canopy (Stampa 1959; Fourie, Kok & Van Zyl 1991). Most of these adult ticks were also recovered on the southern more protected sides of the trees. In the northern hemisphere a similar situation pertains to *Rhipicephalus bursa* in Israel, where 66% of the tick population was found on the more densely vegetated northern slopes compared to 20% on the poorly vegetated southern slopes (Yeruham, Hadani, Galker, Rubina & Rosen 1987).

Rhipicephalus punctatus

This tick had previously been referred to as *Rhipicephalus pravus*-like on Angora goats (Fourie *et al.* 1988a), as *Rhipicephalus* sp. (near *R. pravus*) on Merino sheep (Fourie, Horak & Marais 1988b), and *Rhipicephalus* sp. (near *R. punctatus*) on cattle (Fourie & Horak 1990). Its taxonomic status in South Africa as *R. punctatus* has, however, recently been clarified by Walker (1991). It occurs in the northern and north-eastern Transvaal, the northern Karoo and south-western and central Orange Free State (Walker 1991; Horak & Fourie 1991). Within this distribution range it appears to prefer rocky outcrops and hills. All stages of development can be found on scrub hares *Lepus saxatilis* (Horak & Fourie 1991), but the immature stages seem to prefer rock elephant shrews as demonstrated in the present study. All the shrews were infested and their mean burden comprised 88 immature ticks. Small numbers can also be found on Namaqua rock mice. Adults may also be found on sheep, cattle, goats and gemsbok *Oryx gazella* (Fourie *et al.* 1988b; Fourie & Horak 1990, 1991; Fourie, Vrahimis, Horak, Terblanche & Kok 1991).

No clear pattern of seasonal abundance is evident on scrub hares (Horak & Fourie 1991). However, on ruminants the adults appear to prefer the warmer months from spring to summer (Fourie *et al.* 1988b; Fourie & Horak 1990, 1991). Adult *R. punctatus* excrete a toxin while feeding and this has caused paralysis in Angora goat kids (Fourie *et al.* 1988a).

The absence of any clear pattern of utilization by the immature stages of elephant shrews on northern or southern slopes seems to indicate a wider tolerance of climatic conditions than *I. rubicundus*. The larger number of shrews trapped on the northern slopes could, however, mean that a larger total number of immature *R. punctatus* is present on these slopes than on the southern slopes.

Haemaphysalis leachi/spinulosa

H. leachi is distributed throughout the eastern Cape, Natal, eastern and southern Transvaal and scattered in the rest of South Africa (Howell *et al.* 1978). *H. spinulosa* has also been recovered at several of the localities at which *H. leachi* occurs (Horak, Jacot Guillarmod, Moolman & De Vos 1987) and it would appear as if the distributions of these ticks overlap. Adult *H. leachi* prefer dogs, the large wild carnivores and cats, while adult *H. spinulosa* prefer the smaller carnivores (Norval 1984). The preferred hosts of the immature stages are rodents (Hoogstraal 1956; Norval 1984; Hussein & Mustafa 1985). Black-backed jackals *Canis mesomelas* and caracals *Felis caracal*, which occur in the present study region may harbour both adult *H. leachi* and adult *H. spinulosa* (Horak *et al.* 1987b). The immature stages recovered from the shrews and mice are thus also likely to belong to both species.

Although the rock shrews that were infested harboured virtually the same mean burdens of immature *H. leachi/spinulosa* (6,6 ticks) as did infested Namaqua rock mice (6,5 ticks), the greater percentage of the latter animals infested makes them the preferred of these two hosts. Too few pouched mice were examined to determine their host status.

The seasonal abundance of adult *H. leachi* on dogs near Grahamstown in the eastern Cape Province was determined by Horak *et al.* (1987b). Large numbers were generally present from May or June to February with the highest burdens being recorded during the period July to September and the lowest during March and April. If adults follow the same pattern of seasonal abundance in the south-western Orange Free State as recorded in the eastern Cape Province this would complement the present findings. Peak adult burdens would thus follow high nymphal burdens, which occur from mid- to late summer and would precede peak larval burdens present from spring to summer. The prolonged presence of adults would also account for the extended period during which immature ticks were present on the mice.

Amblyomma marmoreum

Tortoises are the preferred hosts of all developmental stages of this tick, but the immature stages have also been recovered from several other hosts (Theiler 1962; Norval 1975). The immature stages, however, seldom feed on rodents (Horak, Sheppey, Knight & Beuthin 1986; Horak, Fourie, Novellie & Williams 1991), and from the present findings the same would seem to apply to rock elephant shrews.

Hyalomma spp.

Scrub hares are the preferred hosts of both immature *H. marginatum rufipes* and *H. truncatum* and fairly large numbers of particularly the former were recovered from hares examined concurrently on the two farms (Horak & Fourie 1991). The adults are found on sheep, cattle and large antelope species (Fourie *et al.* 1988b, 1991b; Fourie & Horak 1990).

Rhipicephalus arnoldi and *R. distinctus*

The immature stages of both ticks prefer rock dassies *Procavia capensis* and Smith's red rock rabbits *Pronolagus rupestris* (Horak & Fourie 1986; 1991). The adults of *R. arnoldi* prefer red rock rabbits (Horak *et al.* 1991) and those of *R. distinctus*, rock dassies (Horak & Fourie 1986). Both these host species are present in the study area.

Rhipicephalus gertrudae

Adult ticks were recovered in small numbers from Angora goats on the farm (Fourie & Horak 1991). Although hosts of the immature stages have apparently not yet been recorded, Walker (1991) suggests that they are likely to be rodents.

Sex-related tick burdens

Several studies have indicated that male mammalian hosts may carry larger tick burdens than females (Seifert 1971; Sonenshine 1975; Keith & Cary 1990). These sex-related differences have been ascribed to differences in the size of home ranges and activity levels of male and female hosts (Sonenshine 1975). In cattle they have been attributed to lower and less stable levels of resistance in male animals (Seifert 1971). Possible reasons for the virtual absence of significant differences in tick burdens between male and female hosts in this study, could be due to small sample sizes or to the overdispersion of ticks within their host population which complicates analysis (Petney, Van Ark & Spickett 1990). The male and female home ranges of those elephant shrew species that have been studied are similar, but specific activity patterns such as foraging, trail cleaning and interspecific aggression may differ (Rathbun 1979). Observations on these aspects for *E. myurus* and *A. namaquensis* are lacking.

Many etho-ecological aspects of small mammal populations are still poorly understood and may prove to be the most important underlying source of variability in the analysis of host population parameters and tick burdens (Zimmerman, McWherter & Bloemer 1987). According to Randolph (1979) variability attributable to these factors may even prove to be greater than that owing to acquired resistance. It is evident that changes in home ranges and sex ratios in a population may influence the host support contribution of that species (Sonenshine 1975). Such changes may have significant implications particularly where ticks act as vectors for pathogens or exert other deleterious effects on their hosts.

Acknowledgements

We are grateful to D.C. Willemse of the Tick Research Unit, Rhodes University for processing the animals for tick recovery. J. van Niekerk of the farm 'Preezfontein' and G. Zwiegers of the farm 'Slangfontein' made their properties and the animals available to us.

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