

## PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. XXVI. THE MOSAIC OF IXODID TICK INFESTATIONS ON BIRDS AND MAMMALS IN THE MOUNTAIN ZEBRA NATIONAL PARK

I. G. HORAK<sup>(1)</sup>, L. J. FOURIE<sup>(2)</sup>, P. A. NOVELLIE<sup>(3)</sup> and E. J. WILLIAMS<sup>(4)</sup>

### ABSTRACT

HORAK, I. G., FOURIE, L. J., NOVELLIE, P. A. & WILLIAMS, E. J., 1991. Parasites of domestic and wild animals in South Africa. XXVI. The mosaic of ixodid tick infestations on birds and mammals in the Mountain Zebra National Park. *Onderstepoort Journal of Veterinary Research*, 58, 125–136 (1991).

Sixteen species of ixodid ticks were collected over varying periods of time from 6 species of ground-frequenting birds and 15 species of small and large mammals in the Mountain Zebra National Park, Karoo, Cape Province. *Margaropus winthemi* followed by *Rhipicephalus glabroscutatum* and *Rhipicephalus evertsi evertsi* were the most abundant species. The host preferences of 14 tick species and the seasonal abundances of 13 species were determined.

Small numbers of immature stages of only a few tick species were generally recovered from ground-frequenting birds, mice and rats. Amongst the slightly larger animals the smallest number of ticks and species were recovered from springhares and the largest numbers from scrub hares. Amongst the larger mammals, very few ticks were harboured by springbuck and black wildebeest, while heavy infestations of several species were encountered on Cape mountain zebras and eland.

### INTRODUCTION

Studies on the ecology of ixodid ticks may involve a single tick species on a single host species (Sutherst, Wharton, Cook, Sutherland & Bourne, 1979), or on a variety of hosts (Randolph, 1975a, b; Doube, 1974). These studies could also encompass several tick species on a single host species (Baker & Ducasse, 1967; Londt, Horak & De Villiers, 1979; Knight & Rechav, 1978; Horak, De Vos & Brown, 1983), or on a number of host species in the same habitat (Rechav, 1982; Horak, Sheppey, Knight & Beuthin, 1986; Rechav, Zeederberg & Zeller, 1987). The latter approach makes it possible to determine the preferred hosts of the ticks as well as the contribution made by each host species towards the total tick population.

Numerous tick species are found within the Mountain Zebra National Park (Young, Zumpt, Boomker, Penzhorn & Erasmus, 1973; Horak, Potgieter, Walker, De Vos & Boomker, 1983). This park also contains large numbers of bird and mammal species (Fourie, 1983). Several studies on the abundance and seasonality of a number of these tick species have already been published (Horak & Williams, 1986; Horak & Fourie, 1986; Horak, Knight & De Vos, 1986; Horak, Moolman & Fourie, 1987; Horak & MacIvor, 1987; MacIvor & Horak, 1987).

Some of the results presented in the latter publications will be repeated to give a more complete picture of the pattern of tick infestation in the park. This paper describes the abundance of 16 ixodid tick species on 6 species of ground-frequenting birds and 15 mammal species in the park.

### MATERIALS AND METHODS

#### Study locality

The Mountain Zebra National Park (32° 15' S; 25° 27' E; alt. 1 200–1 957 m) comprises an area of 6 536 ha in extent situated 20 km south-west of Cradock in the Cape Province, Republic of South

Africa. The physiography and climate of this park have been described in detail by Fourie (1983). It contains approximately 190 bird species (Skead, 1965; Penzhorn & Bronkhorst, 1976; Penzhorn, 1977; Grobler & Bronkhorst, 1981) and 33 small mammal species (De Graaf & Nel, 1970; Nel & Pretorius, 1971). Of these the rock dassie (*Procavia capensis*), estimated to number 12 700 in 1983, is one of the numerically dominant species. The numbers of large animals, counted in February 1983 during a National Parks Board ground count census, have been summarized by Horak & Fourie (1986).

#### Survey period

The main survey ran from February 1983 to December 1985 with Smith's red hares (referred to in previous publications as red rock rabbits), scrub hares, rock dassies, mountain reedbuck, springbuck, black wildebeest and eland being shot and examined at approximately 3-monthly intervals during this period. The other animals were generally killed within this period but 2 red hares had already been examined during November 1982.

#### Survey animals

The bird and mammal species examined, their numbers and the periods over which they were collected are summarized in Table 1.

A total of 6 species of ground-frequenting birds and 15 mammal species were examined. The birds and larger mammals were shot, while the rats and mice were trapped and killed.

#### Tick recovery

The helmeted guineafowls were processed as described by Horak & Williams (1986), while whole body searches were made under the stereoscopic microscope for ticks on the smaller birds. The ticks on the lagomorphs, rodents and dassies were recovered and counted as described by Horak, Sheppey, Knight & Beuthin (1986), and those on the larger mammals as described by Horak, Meltzer & De Vos (1982) and Horak, Potgieter, Walker, De Vos & Boomker (1983). The length of the idiosoma of maturing female ticks of all species was measured to the nearest 0.5 mm under a stereoscopic microscope to determine the number of ticks engorging successfully on each host species.

<sup>(1)</sup> Faculty of Veterinary Science, University of Pretoria, Onderstepoort 0110

<sup>(2)</sup> Department of Zoology and Entomology, University of the Orange Free State, Bloemfontein 9301

<sup>(3)</sup> National Parks Board, P.O. Box 2696, Kimberley 8300

<sup>(4)</sup> Tick Research Unit, Rhodes University, Grahamstown 6140

Received 13 March 1991—Editor

TABLE 1 Birds and mammals examined for ixodid ticks in the Mountain Zebra National Park

Species	Common name	No. Examined	Dates collected
<b>Birds</b>			
<i>Numida meleagris</i>	Helmeted guineafowl	16	Feb. 84-Dec. 85
<i>Galerida magnirostris</i>	Thick-billed lark	4	Feb.-May 1985
<i>Chersomanes albofasciata</i>	Spike-heeled lark	3	Feb. 85
<i>Certhilauda curvirostris</i>	Long-billed lark	10	Mar. 84-Feb. 85
<i>Cercomela familiaris</i>	Familiar chat	5	June and July 84
<i>Anthus similis</i>	Nicholson's pipit	5	June 84-May 85
<b>Mammals</b>			
<i>Lepus saxatilis</i>	Scrub hare	26	Feb. 83-Dec. 85
<i>Pronolagus rupestris</i>	Smith's red hare	28	Nov. 82-Dec. 85
<i>Pedetes capensis</i>	Springhare	17	Feb. 83-Dec. 85
<i>Otomys irroratus</i>	Vlei rat	2	May and June 84
<i>Otomys unisulcatus</i>	Bush Karroo rat	38	Mar. 84-Dec. 85
<i>Rhabdomys pumilio</i>	Striped mouse	30	Mar. 84-Dec. 85
<i>Aethomys namaquensis</i>	Namaqua rock mouse	6	Mar.-Dec. 84
<i>Saccostomys campestris</i>	Pouched mouse	3	May and June 84
<i>Felis caracal</i>	Caracal	3	May 84-Mar. 85
<i>Procavia capensis</i>	Rock dassie	25	May 83-Dec. 85
<i>Equus zebra zebra</i>	Cape mountain zebra	14	Feb. 83-Dec. 84
<i>Connochaetes gnou</i>	Black wildebeest	9	May 83-Dec. 85
<i>Antidorcas marsupialis</i>	Springbuck	18	Nov. 83-Dec. 85
<i>Taurotragus oryx</i>	Eland	11	May 83-Dec. 85
<i>Redunca fulvorufula</i>	Mountain reedbuck	18	Nov. 83-Dec. 85

RESULTS AND DISCUSSION

Sixteen ixodid tick species were recovered during the course of this survey (Table 2). The minimum estimated length of the idiosoma of maturing female ticks of each species approximately 24 h before detaching is also supplied in the table.

Two species of *Rhipicephalus*, both of which have been described previously as *Rhipicephalus oculatus*, were recovered. According to C. M. Clifford & J. E.

Keirans (personal communication to J. B. Walker) their examination of the syntype and of *R. oculatus* described by Neumann (1901) from "Damaraland, D.S.W. Afrika" revealed that these ticks do not belong to the same species as the series described under this name by Theiler & Robinson (1953). We accept the ticks described by Neumann (1901) as *R. oculatus sensu stricto*, and have listed those described by Theiler & Robinson (1953) as *Rhipicephalus* sp. (near *R. oculatus*).

TABLE 2 The ixodid tick species recovered from animals in the Mountain Zebra National Park and the minimum lengths of the idiosoma of maturing female ticks\*

Tick species	Minimum length in mm of idiosoma of maturing females
<i>Amblyomma marmoreum</i>	9,0
<i>Haemaphysalis hyracophila</i>	4,0
<i>Haemaphysalis spinulosa</i>	4,0
<i>Hyalomma marginatum turanicum</i>	7,5
<i>Hyalomma truncatum</i>	7,5
<i>Ixodes rubicundus</i>	5,0
<i>Ixodes</i> sp.	5,0
<i>Magaropus winthemi</i>	4,5
<i>Rhipicephalus arnoldi</i>	4,0
<i>Rhipicephalus distinctus</i>	4,0
<i>Rhipicephalus evertsi evertsi</i>	6,0
<i>Rhipicephalus follis</i>	6,0
<i>Rhipicephalus glabroscutatum</i>	4,5
<i>Rhipicephalus lounsburyi</i>	5,0
<i>Rhipicephalus oculatus</i>	5,0
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i> )	5,0

\* These ticks could detach within the next 24 h

The host records for each of the tick species within the park, and the seasonal abundances of those species of which sufficient numbers were recovered, are summarized in Tables 3-13 and Fig. 1-11. The seasonal abundances are based on accumulated monthly mean numbers of ticks recovered from the various host species irrespective of the year in which the hosts were examined.

Considering the semi-arid climate, cold winters and hot summers of the region in which the survey was conducted (Fourie, 1983), a surprisingly large number of tick species were recovered. Some of these ticks, notably *A. marmoreum*, *H. spinulosa*, *R. follis* and *R. evertsi evertsi*, have widespread distributions and can also be found in moister regions (Theiler, 1962; Howell, Walker & Nevill, 1978; Walker & Olwage, 1987; Horak, Jacot-Guilarmod, Moolman & De Vos, 1987; Horak, Keep, Spickett & Boomker, 1989). Others, such as *H. hyracophila*, *R. arnoldi*, *R. distinctus* and *R. oculatus*, are host specific and are only found where their hosts are present and the climate is suitable (Theiler, 1962).

TABLE 3 Host records of *Amblyomma marmoreum* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Birds</b>							
Helmeted guineafowl	16	13	884	14	0	0	898
<b>Mammals</b>							
Scrub hare	26	13	78	9	0	0	87
Smith's red hare	28	6	12	2	0	0	14
Bush Karroo rat	38	2	2	0	0	0	2
Caracal	3	2	108	0	0	0	108
Rock dassie	25	4	3	1	0	0	4
Cape mountain zebra	14	4	180	1	0	0	181
Eland	11	8	167	0	0	0	167
Mountain reedbuck	18	3	10	2	0	0	12

TABLE 4 Host records of various ixodid tick species in the Mountain Zebra National Park

Tick and host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<i>Haemaphysalis hyracophila</i>							
Smith's red hare	28	2	1	1	0	0	2
Rock dassie	25	15	18	3	20	7(2)	48
<i>Ixodes</i> sp.							
Cape mountain zebra	14	1	32	0	0	0	32
Black wildebeest	9	1	2	0	0	0	2
Springbuck	18	1	4	2	0	0	6
Eland	11	1	0	0	1	1	2
<i>Rhipicephalus arnoldi</i>							
Scrub hare	26	3	1	0	2	2(2)	5
Smith's red hare	28	24	77	10	78	41	206
Rock dassie	25	18	186	148	0	0	334
Cape mountain zebra	14	1	0	0	2	0	2
<i>Rhipicephalus lounsburyi</i>							
Caracal	3	1	0	0	0	1	1
Black wildebeest	9	1	0	0	2	0	2
Eland	11	2	0	0	3	0	3
Mountain reedbuck	18	4	0	0	19	10(1)	29
<i>Rhipicephalus oculatus</i>							
Scrub hare	26	19	957	306	21	23(4)	1 307
Smith's red hare	28	1	0	0	2	1	3
Springhare	17	2	2	0	0	0	2
Mountain reedbuck	18	1	4	0	0	0	4
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i> )							
Eland	11	1	0	0	0	2	2
<i>Rhipicephalus</i> spp.							
Scrub hare	26	2	2	0	0	0	2
Smith's red hare	28	1	1	0	0	0	1
Vlei rat	2	2	111	7	0	0	118
Bush Karroo rat	38	10	40	3	0	0	43
Striped rouse	30	11	95	7	0	0	102
Namaqua rock mouse	6	6	188	16	0	0	204
Pouched mouse	3	2	48	3	0	0	51
Rock dassie	25	2	4	0	0	0	4

( ) = Number of maturing females

Generally the ground-frequenting birds and the rodents were each infested with only 1 or a few tick species, and then only the immature stages. The lagomorphs, caracals and rock dassies harboured fairly similar mean total burdens of approximately 50–100 ticks, comprising several species. Although immature ticks predominated, each of these animals harboured some adult ticks, particularly of those species of which they are considered the preferred hosts.

Of the small to medium-sized antelope the springbuck harboured the smallest numbers of ticks and the black wildebeest the fewest species. With the exception of *R. glabroscutatum* on the mountain reedbuck, none of these hosts harboured large numbers of adult ticks. In contrast the mountain zebras and eland were infested with large numbers of the immatures and adults of many tick species.

These findings confirm the observations of Horak, Potgieter, Walker, De Vos & Boomker (1983) and Horak (1987), who suggest that the larger the host species the more likely it is to carry large numbers of adult ticks, while the really small hosts are likely to carry only immature ticks. There may be several reasons for this, such as the greater surface area exposed, larger volumes of CO<sub>2</sub> exhaled or less efficient grooming by the larger animals.

#### *Amblyomma marmoreum* (Table 3; Fig. 1)

No adult ticks were recovered, but of the animals examined guineafowls were the preferred hosts of larvae and nymphs. Tortoises are the preferred hosts of all developmental stages of this tick, but the immature stages have also been recovered from a

variety of other hosts (Theiler & Salisbury, 1959; Norval, 1975; Horak, MacIvor, Petney & De Vos, 1987). Tortoises are plentiful in the park, consequently the presence of immature ticks on a number of host species is not surprising. Considerably more larvae than nymphs were recovered from the various hosts (1 444 larvae, 29 nymphs), confirming similar observations by Horak, MacIvor, Petney & De Vos (1987). It must therefore be assumed that the nymphs also prefer tortoises to other host species.

In this study only 2 bush Karroo rats were infested out of a total of 96 rodents (including 17 springhares) examined. In the Bontebok National Park no larvae of *A. marmoreum* were recovered from the 28 rodents examined, whereas more than 35 % of the

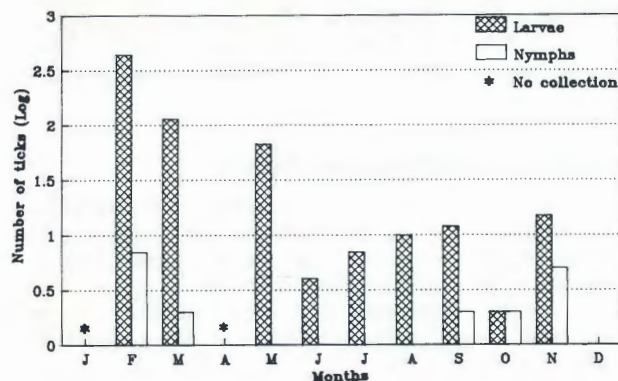


FIG. 1 The seasonal abundance of *Amblyomma marmoreum* on guineafowls, scrub hares, mountain zebras and eland in the Mountain Zebra National Park

TABLE 5 Host records of *Haemaphysalis leachi/spinulosa* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Birds</b>							
Long-billed lark	10	2	2	0	0	0	2
<b>Mammals</b>							
Springhare	17	2	1	4	0	0	5
Bush Karroo rat	38	2	40	9	0	0	49
Namaqua rock mouse	6	3	1	8	0	0	9
Caracal	3	1	0	0	0	1* (1)	1

\* *H. spinulosa* ( ) = Number of maturing females

TABLE 6 Host records of *Hyalomma marginatum turanicum* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Birds</b>							
Helmeted guineafowl	16	5	19	3	0	0	22
Thick-billed lark	4	3	20	6	0	0	26
Long-billed lark	10	7	67	17	0	0	84
Familiar chat	5	3	5	12	0	0	17
Nicholson's pipit	5	3	6	4	0	0	10
<b>Mammals</b>							
Scrub hare	26	16	996	1 672	0	0	2 668
Smith's red hare	28	6	325	0	0	0	325
Springhare	17	4	13	1	0	0	14
Rock dassie	25	1	0	1	0	0	1
Cape mountain zebra	14	14	0	0	201	44 (10)	245
Springbuck	18	1	0	0	2	0	2
Eland	11	11	0	0	955	191 (57)	1 146

( ) = Number of maturing females

scrub hares, grey rhebuck and bontebok were infested (Horak, Sheppey, Knight & Beuthin, 1986). Howell, Petney & Horak (1989) recovered a total of only 5 larvae and 1 nymph of *Amblyomma hebraeum* from 159 collections from striped mice in a region abounding with this tick. It is thus apparent that the larvae of *A. marmoreum* and also of *A. hebraeum* do not readily infest rodents, but prefer some larger animal.

Larvae of *A. marmoreum* feeding on naturally infested tortoises take approximately 35 days or more to engorge and detach (Dower, Petney & Horak, 1988). It seemed reasonable to assume that larvae feeding on warm-blooded animals would engorge more rapidly. In this case the length of the life cycle and the seasonal abundance of this tick could be affected by the hosts on which it feeds during its immature stages of development. However, the seasonal abundance does not seem to be influenced by this possibility as most larvae are recovered in autumn and most nymphs in spring (Norval, 1975; Horak & Williams, 1986; Horak, Sheppey, Knight & Beuthin, 1986; Rechav *et al.*, 1987). This pattern also applies to the larvae in the present study.

***Haemaphysalis hyracophila* (Table 4)**

We have assumed that the immature *Haemaphysalis* ticks recovered from the rock dassies and Smith's red hares are *H. hyracophila*, particularly as they differ morphologically from those of *H. leachi/spinulosa*. Although only small numbers were recovered, rock dassies are the preferred hosts of all stages of development.

Horak & Fourie (1986) commented on the small number of immature ticks compared to the total

numbers of adults they recovered from 77 dassies in the park. A similar situation exists in the present study. Although a large variety of hosts were examined only 2 of 28 Smith's red hares in addition to the dassies were infested with immature ticks of this species, and these 2 carried only 1 tick each. Possibly the collection technique is not sensitive enough to collect all the immature stages.

In their earlier study, Horak & Fourie (1986) recovered adult ticks from April–December. In this survey no animals were examined during April, and adult ticks were present from May–December.

***Haemaphysalis leachi/spinulosa* (Table 5)**

Because we have difficulty in differentiating the immature stages of these ticks we are discussing the 2 species together. Rodents are the preferred hosts of the immature stages of both, while adult *H. leachi* prefer the larger carnivores and wild cats, and *H. spinulosa* the smaller carnivores (Norval, 1984; Hussein & Mustafa, 1985; Horak, Jacot Guillarmod, Moolman & De Vos, 1987). Although we recovered only small numbers of ticks these host preferences were still apparent. Unless more collections are made from long-billed larks in future, the presence of a larva on 2 of these birds must be viewed as accidental infestations.

***Hyalomma* spp. (Tables 6, 7; Fig. 2, 3)**

The findings relating to *H. marginatum turanicum* and *H. truncatum* have previously been discussed by Horak & MacIvor (1987). It is now clear that scrub hares are the preferred hosts of the immature stages and mountain zebras and eland the preferred hosts of the adults of both species of *Hyalomma* occurring in the park.

TABLE 7 Host records of *Hyalomma truncatum* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Mammals</b>							
Scrub hare	26	15	273	604	0	0	877
Smith's red hare	28	5	35	8	0	0	43
Bush Karroo rat	38	2	4	0	0	0	4
Striped mouse	30	2	20	4	0	0	24
Namaqua rock mouse	6	2	6	0	0	0	6
Cape mountain zebra	14	13	0	0	174	31 (1)	205
Springbuck	18	1	0	0	2	0	2
Eland	11	11	0	0	350	51 (15)	401
Mountain reedbuck	18	1	0	0	2	0	2

( ) = Number of maturing females

TABLE 8 Host records of *Ixodes rubicundus* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Mammals</b>							
Scrub hare	26	11	8	27	0	0	35
Smith's red hare	28	20	105	585	0	0	690
Vlei rat	2	1	2	0	0	0	2
Bush Karroo rat	38	1	1	0	0	0	1
Namaqua rock mouse	6	2	5	0	0	0	5
Pouched mouse	3	1	4	0	0	0	4
Caracal	3	3	26	1	43	44 (16)	114
Eland	11	7	0	0	34	81 (7)	115
Mountain reedbuck	18	7	16	0	20	29 (6)	65

( ) = Number of maturing females

With the possible exception of the springhare, which is a very large rodent, the immature stages of *H. marginatum turanicum* preferred ground-frequenting birds to rodents as hosts. Although the Smith's red hares carried a fairly large number of larvae of *H. marginatum turanicum* no nymphs were recovered. Possibly the immature stages of the latter tick cannot complete their life cycle on this host species.

The absence of any seasonal overlap between the immature and adult stages of *H. marginatum turanicum* indicates that only a single life cycle can be completed annually in the Mountain Zebra Park. Rechav *et al.* (1987) found that the seasonal activity pattern for *Hyalomma marginatum rufipes* at Bloemhof in the south-western Transvaal is similar

to that determined for *H. marginatum turanicum* in the present survey.

In addition to scrub hares the immature stage of *H. truncatum* preferred rodents to ground-frequenting birds as hosts. As some overlap in the seasonal abundance of immature and adult *H. truncatum* does occur, the possibility of more than 1 annual life cycle exists. Rechav *et al.* (1987) also recorded 2 peaks of activity for the immature stages of *H. truncatum*, 1 in winter and the other in early, rather than late, summer.

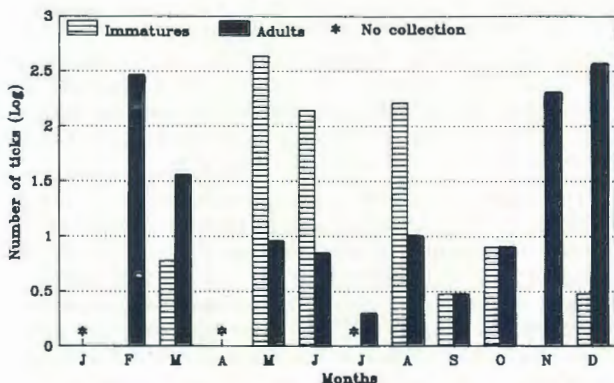


FIG. 2 The seasonal abundance of immature *Hyalomma marginatum turanicum* on guineafowls and scrub hares and adults on mountain zebras and eland in the Mountain Zebra National Park

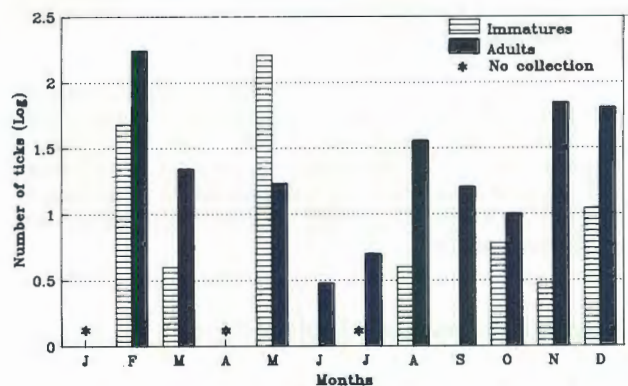


FIG. 3 The seasonal abundance of immature *Hyalomma truncatum* on scrub hares and adults on mountain zebras and eland in the Mountain Zebra National Park

***Ixodes rubicundus* (Table 8; Fig. 4)**

These findings have previously been discussed by Horak, Moolman & Fourie (1987). In summary the immature stages prefer Smith's red hares and the

TABLE 9 Host records of *Margaropus winthemi* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Birds</b>							
Helmeted guineafowl	16	2	2	0	0	0	2
<b>Mammals</b>							
Scrub hare	26	2	4	0	0	0	4
Smith's red hare	28	3	3	0	0	0	3
Springhare	17	2	6	2	0	0	8
Striped mouse	30	1	1	0	0	0	1
Caracal	3	1	11	2	0	0	13
Rock dassie	25	4	6	0	0	0	6
Cape mountain zebra	14	14	56 816	27 737	13 353	4 353 (640)	102 259
Black wildebeest	9	1	892	8	4	4	908
Springbuck	18	1	2	0	0	0	2
Eland	11	9	12 792	6 874	1 915	893 (109)	22 474
Mountain reedbuck	18	3	6	2	0	0	8

( ) = Number of maturing females

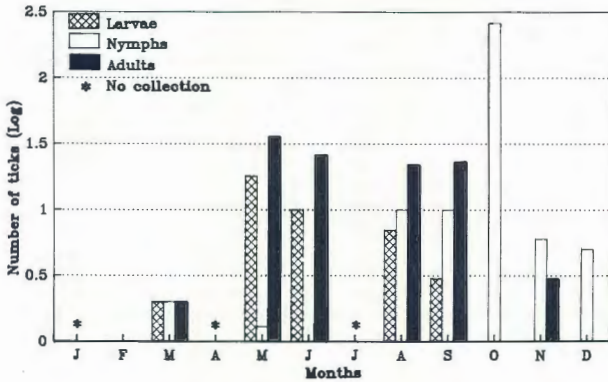


FIG. 4 The seasonal abundance of immature *Ixodes rubicundus* on Smith's red hares and adults on eland and mountain reedbuck in the Mountain Zebra National Park

adults eland and mountain reedbuck, while caracal harbour all stages of development. The rock elephant shrew, *Elephantulus myurus*, is, however, probably the prime host of the immature stages (Stampa, 1959). Unfortunately we did not examine any shrews and our data for the park are thus incomplete in this respect. With the exception of eland, which roam on the plateaux and hills, all the aforementioned hosts prefer mountainous terrain, which is also the preferred habitat of the tick (Theiler, 1950; Stampa, 1959).

Although the periods of seasonal abundance of the immature and adult ticks appear to overlap (Fig. 4), it must be remembered that the life cycle takes 2 years to complete (Howell *et al.*, 1978). The larvae and nymphs are present from autumn to spring of the first year and the adults during the same period of the second year.

***Margaropus winthemi* (Table 9; Fig. 5)**

This is by far the most numerous tick recovered from Cape mountain zebras (Horak, Knight & De Vos, 1986). Theiler & Salisbury (1958) and Howell *et al.* (1978) state that it is most commonly found on horses, but that it also attacks cattle. Young *et al.* (1973) have recorded large infestations on zebras in the park and Horak, Potgieter, Walker, De Vos & Boomker (1983) have recovered small numbers from gemsbok in the park in early summer. The gemsbok have subsequently all been removed from the park.

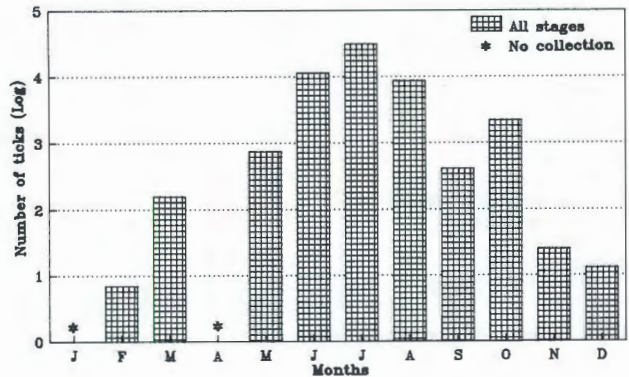


FIG. 5 The seasonal abundance of *Margaropus winthemi* on mountain zebras and eland in the Mountain Zebra National Park

The large numbers recovered from eland in the present survey and the high proportion of engorging females indicate that these large antelope must also be considered preferred hosts. With the exception of black wildebeest, which may harbour moderate numbers of *M. winthemi* (Table 9), the presence of small numbers on other animals in the present survey must be regarded as evidence of the superabundance of free-living larvae during the winter months. The absence of adults indicates that the parasitic life cycle can probably not be completed on these accidental hosts.

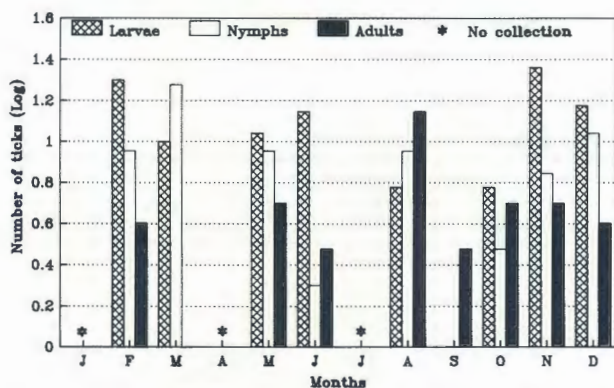
The ratio of larvae to nymphs to adults (3.4:1.7:1.0) based on the combined burdens of the zebras, wildebeest and eland is not unlike that of the 1-host tick *Boophilus decoloratus* (3.0:1.1:1.0) on Burchell's zebras, *Equus burchelli*, in the Kruger National Park (Horak, De Vos & De Klerk, 1984). The major losses between the larval and nymphal, and nymphal and adult stages probably occur just prior to, during, and just after moulting.

The addition of the monthly burdens of the eland to those of the mountain zebras further confirms the winter abundance of this tick noted by Theiler & Salisbury (1958), Howell *et al.* (1978) and Horak, Knight & De Vos (1986). It has been suggested by Penzhorn & Horak, (1989) that pale-winged starlings, *Onychognathus naboroupp*, exploit the large numbers of *M. winthemi* present on zebras in the park as a food source during winter. The virtual absence of ticks from November–March suggests that overwintering must occur as detached engorged females or more probably as eggs.

TABLE 10 Host records of *Rhipicephalus distinctus* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Mammals</b>							
Scrub hare	26	9	41	3	1	0	45
Smith's red hare	28	4	10	0	0	0	10
Springhare	17	1	1	0	0	0	1
Vlei rat	2	1	1	0	0	0	1
Bush Karroo rat	38	1	1	0	0	0	1
Namaqua rock mouse	6	1	1	0	0	0	1
Caracal	3	1	2	0	0	0	2
Rock dassie	25	23	747	132	208	73 (4)	1 160

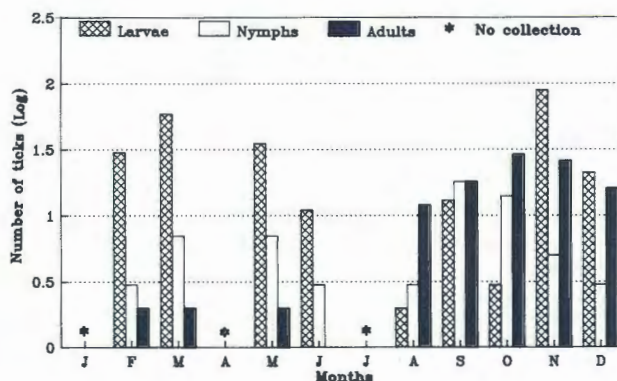
( ) = Number of maturing females

FIG. 6 The seasonal abundance of immature *Rhipicephalus arnoldi* on Smith's red hares and rock dassies and adults on Smith's red hares in the Mountain Zebra National Park***Rhipicephalus arnoldi* (Table 4; Fig. 6)**

The adults of this tick prefer Smith's red hares (Norval, 1985), but as evidenced by the present and a previous survey (Horak & Fourie, 1986), the immature stages prefer rock dassies. The habitats of the latter animals and those of Smith's red hares largely overlap. The hares are, however, nocturnal, while the dassies are strictly diurnal (Smithers, 1983; Fourie, 1983). The 2 adult ticks recovered from a mountain zebra must be regarded as an accidental infestation. The ratio of larvae to nymphs and nymphs to adults (2,1:1,3:1,0) based on the combined burdens of scrub hares, Smith's red hares and rock dassies in the present survey are exceptionally close. This suggests that some other animals, not examined in the present survey, may have harboured large numbers of immature ticks. It is, however, also possible that the rocky shelters and refuges occupied by the hares and dassies respectively afford excellent protection for the free-living ticks. This would ensure their efficient translation through the various life cycle stages with minimal loss. The lack of a clear pattern of seasonal abundance for any of the life stages further supports the latter theory. The heat and moisture originating from the host while in its form or refuge provides an ideal microhabitat for the year-round development of the ticks.

***Rhipicephalus distinctus* (Table 10; Fig. 7)**

Theiler (1947) recorded this tick as preferring rock dassies as hosts, and the present study confirms that fact. In an earlier survey of the ectoparasites of rock dassies in the Mountain Zebra Park, Horak & Fourie (1986) commented on the apparent paucity of nymphs in comparison with the number of adults recovered. The current study supports that observa-

FIG. 7 The seasonal abundance of *Rhipicephalus distinctus* on rock dassies in the Mountain Zebra National Park

tion and, although several larvae and only a few nymphs were recovered from scrub hares and some larvae from Smith's red hares, it is still possible that these animals do play a role as hosts of the immature stages.

In the previous survey the largest numbers of larvae were present from December–May and adults from August–January. The activity periods recorded now correspond almost exactly with those previously observed. In that survey nymphal burdens peaked during January and March compared with September and October currently. These fluctuations possibly reflect variations in the small nymphal burdens rather than shifts in nymphal activity.

***Rhipicephalus evertsi evertsi* (Table 11; Fig. 8)**

Equids, and possibly more particularly zebras, are the preferred hosts of this tick (Norval, 1981; Horak, De Vos & De Klerk, 1984). The large numbers of immature ticks recovered from the external ear canals of zebras and eland certainly indicates that they are excellent hosts of these developmental stages. The scrub hares in this study and in surveys at other localities, also proved to be efficient hosts of the immature stages (Horak & Knight, 1986; Rechav *et al.*, 1987). The large numbers of adults recovered from the eland in the present survey implies that they may be more efficient hosts of this stage of development than the mountain zebras.

Although all stages of development were present in variable numbers throughout the year, suggesting that the life cycle can be continuous, some seasonality was apparent, with the largest numbers of immatures present from February–May and of adults from December–February.

TABLE 11 Host records of *Rhipicephalus evertsi evertsi* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Number of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Birds</b>							
Helmeted guineafowl	16	2	3	0	0	0	3
<b>Mammals</b>							
Scrub hare	26	22	268	272	0	0	540
Smith's red hare	28	8	16	6	0	0	22
Springhare	17	4	6	1	0	0	7
Caracal	3	3	34	1	0	0	35
Rock dassie	25	1	4	0	0	0	4
Cape mountain zebra	14	14	6 384	4 797	619	201 (35)	12 001
Black wildebeest	9	9	180	24	18	8	230
Springbuck	18	15	400	10	0	0	410
Eland	11	11	2 196	1 161	1 123	267 (38)	4 747
Mountain reedbuck	18	12	116	14	0	1	131

( ) = Number of maturing females

TABLE 12 Host records of *Rhipicephalus follis* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Number of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Mammals</b>							
Cape mountain zebra	14	7	0	0	19	7	26
Black wildebeest	9	1	0	0	2	0	2
Springbuck	18	1	0	0	2	0	2
Eland	11	10	0	0	971	446 (50)	1 417

( ) = Number of maturing females

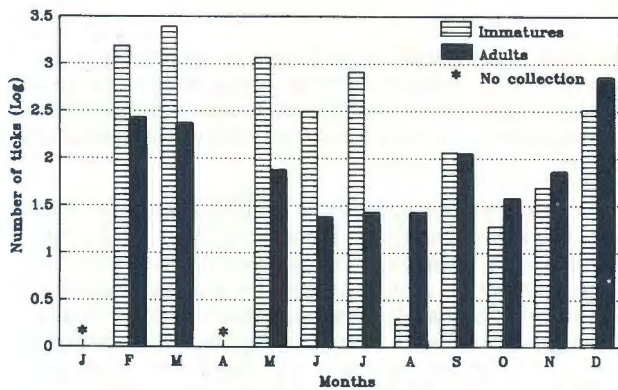


FIG. 8 The seasonal abundance of *Rhipicephalus evertsi evertsi* on mountain zebras and eland in the Mountain Zebra National Park

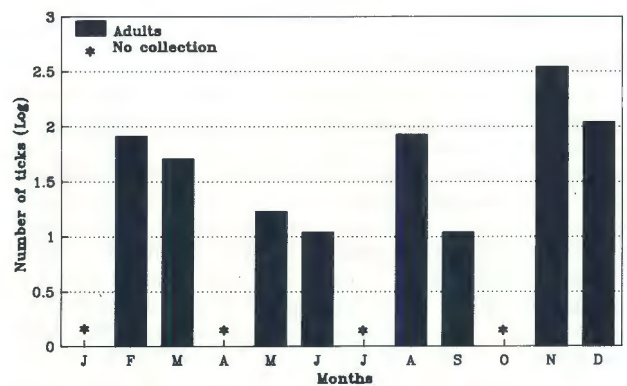


FIG. 9 The seasonal abundance of adult *Rhipicephalus follis* on eland in the Mountain Zebra National Park

***Rhipicephalus follis* (Table 12; Fig. 9)**

The problems encountered in establishing the correct identity of this tick have been mentioned by Walker (1989) cited by Horak *et al.* (1989). There are no published descriptions of the immature stages, but we have reared larvae and nymphs and these were used as aids in identifying these stages in the present survey. Unfortunately the immature stages of other ticks are similar in appearance to those of *R. follis* and this has complicated specific identification. The immature stages of all these ticks have been combined as *Rhipicephalus* spp. in Table 4 and all apparently prefer rodents as hosts. Eland are the preferred hosts of the adults.

Horak *et al.* (1989) recovered adult *R. follis* from bushbuck in the Weza State Forest, Natal, from December to April. Most adults were recovered from eland in the present survey during November and December.

***Rhipicephalus glabroscutatum* (Table 13; Fig. 10)**

The geographic distribution of this 2-host tick in the Valley Bushveld regions of the eastern Cape Province and in the eastern Karoo has been described by MacIvor (1985). In the Valley Bushveld, kudu, common duikers, cattle and goats are the preferred hosts (Knight & Rechav, 1978; Horak & Knight, 1986; MacIvor & Horak, 1987). In the present survey in the eastern Karoo, eland and mountain reedbuck were preferred hosts, while in the Bontebok National Park in the south-western Cape Province, bontebok fill this niche (Horak, Sheppey, Knight & Beuthin, 1986).

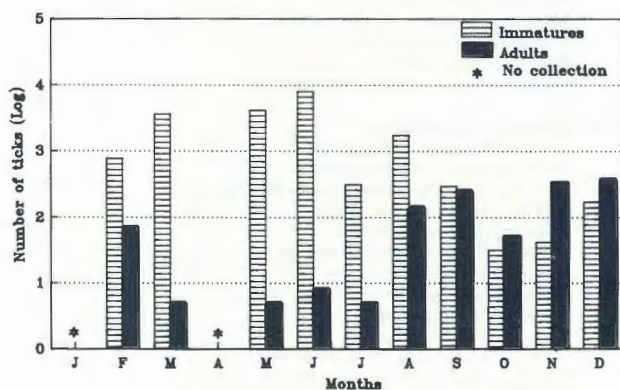
With the exception of scrub hares, on which the sites of attachment are unknown, both immature and adult ticks occur on the lower legs and around the feet of their preferred hosts (Horak & Knight, 1986). The translation of larvae to nymphs is good



TABLE 13 Host records of *Rhipicephalus glabroscutatum* in the Mountain Zebra National Park

Host species	No. examined	No. infested	Numbers of ticks recovered				
			Larvae	Nymphs	Males	Females	Total
<b>Birds</b>							
Helmeted guineafowl	16	1	3	0	0	0	3
<b>Mammals</b>							
Scrub hare	26	13	329	212	1	0	542
Smith's red hare	28	6	7	1	0	0	8
Springhare	17	2	1	1	0	0	2
Caracal	3	1	23	1	0	0	24
Rock dassie	25	2	2	0	1	0	3
Cape mountain zebra	14	14	1 419	271	133	103 (8)	1 926
Black wildebeest	9	7	222	10	18	16 (4)	266
Springbuck	18	13	30	4	94	60	188
Eland	11	11	5 628	2 683	668	331 (34)	9 310
Mountain reedbuck	18	18	19 544	4 249	548	247 (16)	24 588

( ) = Number of maturing females

FIG. 10 The seasonal abundance of *Rhipicephalus glabroscutatum* on scrub hares, mountain zebras, black wildebeest, springbuck, eland and mountain reedbuck in the Mountain Zebra National Park

on scrub hares and eland, while it is poor on mountain zebras and black wildebeest. On mountain reedbuck, which harbour the largest numbers of larvae, less than 1 in 4 of these will develop to the nymphal stage (Table 13).

The presence of the immature stages from March–June and the adults from August–February is similar to that described on kudu, common duikers goats and cattle in the eastern Cape Province (Knight & Rechav, 1978; MacIvor & Horak, 1984, 1987) and bontebok in the south-western Cape Province (Horak, Sheppey, Knight & Beuthin, 1986). Although this tick is associated with foot abscess in goats in the eastern Cape Province (MacIvor & Horak, 1987) no evidence of abscessation was seen in any of the wild hosts.

#### *Rhipicephalus lounsburyi* (Table 4)

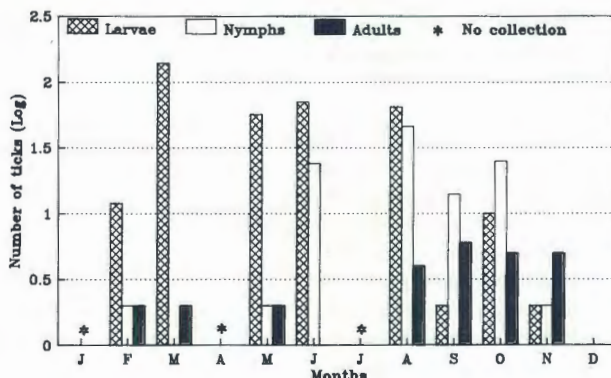
This recently-named tick has been collected in the north-eastern, south-western and west coast regions of the Cape Province (Walker, 1990). The adults have been recovered from sheep, grey rhebuck and bontebok (Walker, 1990) and black wildebeest, eland and particularly mountain reedbuck in the present survey. The single tick recovered from the caracal must be considered an accidental infestation. The hosts of the immature stages are unknown (Walker, 1990).

In the Mountain Zebra Park it was most abundant during August when it was recovered from black wildebeest, eland and mountain reedbuck.

#### *Rhipicephalus oculatus* (Table 4; Fig. 11)

All stages of development of this tick prefer hares as hosts (Horak & Knight, 1986). Most of the scrub hares in the present survey, but only 1 of the Smith's red hares were infested. The larvae recovered from 2 springhares and a mountain reedbuck are probably accidental infestations.

The ticks exhibited a clear pattern of seasonal abundance on the scrub hares with larvae reaching the highest numbers from March–August, nymphs from June–October and the adults from August–November. It would thus appear that all stages avoided the really hot summer months from December–February.

FIG. 11 The seasonal abundance of *Rhipicephalus oculatus* on scrub hares in the Mountain Zebra National Park

#### *Rhipicephalus* sp. (near *R. oculatus*) (Table 4)

Two ticks only were recovered, both from 1 eland. It seems therefore that the Cradock district lies at the edge of one of the distributional boundaries of this tick. On a farm and nature reserve near Grahamstown, eastern Cape Province, scrub hares, kudu, cattle, sheep and goats were infested with small numbers of adult ticks, suggesting a fairly wide host range (Horak & Knight, 1986).

#### HOST/PARASITE LIST

The ticks recorded below were recovered from animals in the Mountain Zebra National Park only during this survey (Table 14). The host preferences of the ticks are also indicated. Preferred hosts are those animals which, within the distribution range of a particular tick, will nearly always be infested with the largest numbers of that tick. Where adult ticks

TABLE 14 Host/parasite list for ixodid ticks collected from birds and mammals in the Mountain Zebra National Park from November 1982–December 1985. The ticks whose names are given in bold type prefer the host(s) under which they are listed. (Im=immature, Ad=adult ticks)

PART 1: BIRDS

- Numida meleagris* Helmeted guineafowl  
**Amblyomma marmoreum** (Im)  
*Hyalomma marginatum turanicum* (Im)  
*Margaropus winthemi* (Im)  
*Rhipicephalus evertsi evertsi* (Im)  
*Rhipicephalus glabroscutatum* (Im)  
*Galerida magnirostris* Thick-billed lark  
*Hyalomma marginatum turanicum* (Im)  
*Certhilauda curvirostris* Long-billed lark  
*Haemaphysalis leachi/spinulosa* (Im)  
*Hyalomma marginatum turanicum* (Im)  
*Cercomela familiaris* Familiar chat  
*Hyalomma marginatum turanicum* (Im)  
*Anthus similis* Nicholson's pipit  
*Hyalomma marginatum turanicum* (Im)

PART 2: MAMMALS

- Lepus saxatilis* Scrub hare  
*Amblyomma marmoreum* (Im)  
***Hyalomma marginatum turanicum*** (Im)  
***Hyalomma truncatum*** (Im)  
*Ixodes rubicundus* (Im)  
*Margaropus winthemi* (Im)  
*Rhipicephalus arnoldi* (Im, Ad)  
*Rhipicephalus distinctus* (Im, Ad)  
*Rhipicephalus evertsi evertsi* (Im)  
*Rhipicephalus glabroscutatum* (Im, Ad)  
***Rhipicephalus oculatus*** (Im, Ad)  
*Rhipicephalus* sp. (Im)  
*Pronolagus rupestris* Smith's red hare  
*Amblyomma marmoreum* (Im)  
*Haemaphysalis hyracophila* (Im)  
*Hyalomma marginatum turanicum* (Im)  
*Hyalomma truncatum* (Im)  
***Ixodes rubicundus*** (Im)  
*Margaropus winthemi* (Im)  
***Rhipicephalus arnoldi*** (Im, Ad)  
*Rhipicephalus distinctus* (Im)  
*Rhipicephalus evertsi evertsi* (Im)  
*Rhipicephalus glabroscutatum* (Im)  
*Rhipicephalus oculatus* (Ad)  
*Rhipicephalus* sp. (Im)  
*Pedetes capensis* Springhare  
*Haemaphysalis leachi/spinulosa* (Im)  
*Hyalomma marginatum turanicum* (Im)  
*Margaropus winthemi* (Im)  
*Rhipicephalus distinctus* (Im)  
*Rhipicephalus evertsi evertsi* (Im)  
*Rhipicephalus glabroscutatum* (Im)  
*Rhipicephalus oculatus* (Im)  
*Otomys irroratus* Vlei rat  
*Ixodes rubicundus* (Im)  
*Rhipicephalus distinctus* (Im)  
*Rhipicephalus* sp. (Im)  
*Otomys unisulcatus* Bush Karroo rat  
*Amblyomma marmoreum* (Im)  
***Haemaphysalis leachi/spinulosa*** (Im)  
*Hyalomma truncatum* (Im)

- Ixodes rubicundus* (Im)  
*Rhipicephalus distinctus* (Im)  
*Rhipicephalus* sp. (Im)  
*Rhabdomys pumilio* Striped mouse  
*Hyalomma truncatum* (Im)  
*Margaropus winthemi* (Im)  
*Rhipicephalus* sp. (Im)  
*Aethomys namaquensis* Namaqua rock mouse  
*Haemaphysalis leachi/spinulosa* (Im)  
*Hyalomma truncatum* (Im)  
*Ixodes rubicundus* (Im)  
*Rhipicephalus distinctus* (Im)  
*Rhipicephalus* sp. (Im)  
*Saccostomys campestris* Pouched mouse  
*Ixodes rubicundus* (Im)  
*Rhipicephalus* sp. (Im)  
*Felis caracal* Caracal  
*Amblyomma marmoreum* (Im)  
***Haemaphysalis spinulosa*** (Ad)  
***Ixodes rubicundus*** (Im, Ad)  
*Margaropus winthemi* (Im)  
*Rhipicephalus distinctus* (Im)  
*Rhipicephalus evertsi evertsi* (Im)  
*Rhipicephalus glabroscutatum* (Im)  
*Rhipicephalus lounsburyi* (Ad)  
*Procavia capensis* Rock dassie  
*Amblyomma marmoreum* (Im)  
***Haemaphysalis hyracophila*** (Im, Ad)  
*Hyalomma marginatum turanicum* (Im)  
*Margaropus winthemi* (Im)  
***Rhipicephalus arnoldi*** (Im)  
***Rhipicephalus distinctus*** (Im, Ad)  
*Rhipicephalus evertsi evertsi* (Im)  
*Rhipicephalus glabroscutatum* (Im)  
*Rhipicephalus* sp. (Im)  
*Equus zebra zebra* Cape mountain zebra  
*Amblyomma marmoreum* (Im)  
***Hyalomma marginatum turanicum*** (Ad)  
***Hyalomma truncatum*** (Ad)  
*Ixodes* sp. (Im)  
***Margaropus winthemi*** (Im, Ad)  
*Rhipicephalus arnoldi* (Ad)  
*Rhipicephalus follis* (Ad)  
***Rhipicephalus evertsi evertsi*** (Im, Ad)  
*Rhipicephalus glabroscutatum* (Im, Ad)  
*Connochaetes gnou* Black wildebeest  
*Ixodes* sp. (Im)  
*Margaropus winthemi* (Im, Ad)  
*Rhipicephalus evertsi evertsi* (Im, Ad)  
*Rhipicephalus follis* (Ad)  
*Rhipicephalus glabroscutatum* (Im, Ad)  
*Rhipicephalus lounsburyi* (Ad)  
*Antidorcas marsupialis* Springbuck  
*Hyalomma marginatum turanicum* (Ad)  
*Hyalomma truncatum* (Ad)  
*Ixodes* sp. (Im)  
*Margaropus winthemi* (Im)  
*Rhipicephalus evertsi evertsi* (Im)  
*Rhipicephalus follis* (Ad)  
*Rhipicephalus glabroscutatum* (Im, Ad)  
*Taurotragus oryx* Eland  
*Amblyomma marmoreum* (Im)  
***Hyalomma marginatum turanicum*** (Ad)  
***Hyalomma truncatum*** (Ad)  
***Ixodes rubicundus*** (Ad)  
*Ixodes* sp. (Ad)  
***Margaropus winthemi*** (Im, Ad)  
***Rhipicephalus evertsi evertsi*** (Im, Ad)  
***Rhipicephalus follis*** (Ad)  
***Rhipicephalus glabroscutatum*** (Im, Ad)  
*Rhipicephalus lounsburyi* (Ad)  
*Rhipicephalus* sp. (near *R. oculatus*) (Ad)  
*Redunca fulvorufula* Mountain reedbuck  
*Amblyomma marmoreum* (Im)  
*Hyalomma truncatum* (Ad)  
*Ixodes rubicundus* (Im, Ad)  
*Margaropus winthemi* (Im)  
*Rhipicephalus evertsi evertsi* (Im, Ad)  
***Rhipicephalus glabroscutatum*** (Im, Ad)  
*Rhipicephalus oculatus* (Im)  
***Rhipicephalus lounsburyi*** (Ad)

are involved, they will permit these to engorge successfully. Several host species can act as preferred hosts of a single tick species.

#### ACKNOWLEDGEMENTS

We wish to thank the National Parks Board of Trustees for placing the animals in the Mountain Zebra National Park at our disposal. We are most grateful to Mr P. C. Pieterse, Park Warden, and his staff, and Messrs M. M. Knight and J. Willemse of the Tick Research Unit, Rhodes University for processing the carcasses for tick recovery.

We much appreciate the assistance of Dr Jane B. Walker with the identification of *Rhipicephalus follis* and *Rhipicephalus lounsburyi* and for supplying the references necessary for the identification of *Rhipicephalus oculatus* and the *Rhipicephalus* sp. (near *R. oculatus*). Miss Andrea van Niekerk plotted the graphs.

This research was funded by the Council for Scientific and Industrial Research, the Department of Agricultural Development, Rhodes University, the Meat Board and the Mohair Board.

#### REFERENCES

- BAKER, MAUREEN K. & DUCASSE, F. B. W., 1967. Tick infestation of livestock in Natal. I. The predilection sites and seasonal variations of cattle ticks. *Journal of the South African Veterinary Medical Association*, 38, 447-453.
- DE GRAAF, G. & NEL, J. A. J., 1970. Notes on the smaller mammals of the eastern Cape National Parks. *Koedoe*, 13, 147-149.
- DOUBE, B. M., 1974. Seasonal patterns of abundance and host relationships of the Australian paralysis tick, *Ixodes holocyclus* Neumann (Acarina: Ixodidae), in south-eastern Queensland. *Australian Journal of Ecology*, 4, 345-360.
- DOWER, KATHY M., PETNEY, T. N. & HORAK, I. G., 1988. The developmental success of *Amblyomma hebraeum* and *Amblyomma marmoreum* on the leopard tortoise, *Geochelone pardalis*. *Onderstepoort Journal of Veterinary Research*, 55, 11-13.
- FOURIE, L. J., 1983. The population dynamics of the rock hyrax *Procavia capensis* (Pallas, 1766) in the Mountain Zebra National Park. Ph.D. thesis, Rhodes University, Grahamstown.
- GROBLER, J. H. & BRONKHORST, P. J., 1981. Additions and amendments to the bird and mammal lists of the Mountain Zebra National Park. *Koedoe*, 24, 199-203.
- HORAK, I. G., MELTZER, D. G. & DE VOS, V., 1982. Helminth and arthropod parasites of springbok, *Antidorcas marsupialis* in the Transvaal and western Cape Province. *Onderstepoort Journal of Veterinary Research*, 49, 7-10.
- HORAK, I. G., POTGIETER, F. T., WALKER, JANE B., DE VOS, V. & BOOMKER, J., 1983. The ixodid tick burdens of various large ruminant species in South African nature reserves. *Onderstepoort Journal of Veterinary Research*, 50, 221-228.
- HORAK, I. G., DE VOS, V. & BROWN, MOIRA R., 1983. Parasites of domestic and wild animals in South Africa. XVI. Helminth and arthropod parasites of blue and black wildebeest (*Connochaetes taurinus* and *Connochaetes gnou*). *Onderstepoort Journal of Veterinary Research*, 50, 243-255.
- HORAK, I. G., DE VOS, V. & DE KLERK, B. D., 1984. Parasites of domestic and wild animals in South Africa. XVII. Arthropod parasites of Burchell's zebra, *Equus burchelli*, in the eastern Transvaal Lowveld. *Onderstepoort Journal of Veterinary Research*, 51, 145-154.
- HORAK, I. G. & WILLIAMS, E. J., 1986. Parasites of domestic and wild animals in South Africa. XVIII. The crowned guinea fowl (*Numida meleagris*), an important host of immature ixodid ticks. *Onderstepoort Journal of Veterinary Research*, 53, 119-122.
- HORAK, I. G. & FOURIE, L. J., 1986. Parasites of domestic and wild animals in South Africa. XIX. Ticks and fleas on rock dassies (*Procavia capensis*) in the Mountain Zebra National Park. *Onderstepoort Journal of Veterinary Research*, 53, 123-126.
- HORAK, I. G., KNIGHT, M. M. & DE VOS, V., 1986. Parasites of domestic and wild animals in South Africa. XX. Arthropod parasites of the Cape mountain zebra (*Equus zebra zebra*). *Onderstepoort Journal of Veterinary Research*, 53, 127-132.

I. G. HORAK, L. J. FOURIE, P. A. NOVELLIE & E. J. WILLIAMS

- 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. & KNIGHT, M. M., 1986. A comparison of the tick burdens of wild animals in a nature reserve and on an adjacent farm where tick control is practised. *Journal of the South African Veterinary Association*, 57, 199-203.
- HORAK, I. G., MOOLMAN, L. C. & FOURIE, L. J., 1987. 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., 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., MACIVOR, K. M. DE F., PETNEY, T. N. & DE VOS, V., 1987. 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., 1987. 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., 1987. Arthropod parasites of some wild animals in South Africa and Namibia. *Journal of the South African Veterinary Association*, 58, 207-211.
- HORAK, I. G., KEEP, M. E., SPICKETT, A. M. & BOOMKER, J., 1989. Parasites of domestic and wild animals in South Africa. XXIV. Arthropod parasites of bushbuck and common duiker in the Weza State Forest, Natal. *Onderstepoort Journal of Veterinary Research*, 56, 63-66.
- HOWELL, C. J., WALKER, JANE B. & NEVILL, E. M., 1978. Ticks, mites and insects infesting domestic animals in South Africa. Part I. Descriptions and biology. Department of Agricultural Technical Services, Republic of South Africa, Science Bulletin No. 393, v + 69 pp.
- HOWELL, D. J., PETNEY, T. N. & HORAK, I. G., 1989. The host status of the striped mouse, *Rhabdomys pumilio*, in relation to the tick vectors of heartwater in South Africa. *Onderstepoort Journal of Veterinary Research*, 56, 289-291.
- HUSSEIN, S. H. & MUSTAFA, B. E., 1985. *Haemaphysalis spinulosa* and *Rhipicephalus simus* (Acari: Ixodidae): Seasonal abundance of immature stages and host range in the Shambat area, Sudan. *Journal of Medical Entomology*, 22, 72-77.
- KNIGHT, M. M. & RECHAV, Y., 1978. Ticks associated with kudu in the eastern Cape: Preliminary report. *Journal of the South African Veterinary Association*, 49, 343-344.
- LONDT, J. G. H., HORAK, I. G. & DE VILLIERS, I. L., 1979. Parasites of domestic and wild animals in South Africa. XIII. The seasonal incidence of adult ticks (Acarina: Ixodidae) on cattle in the northern Transvaal. *Onderstepoort Journal of Veterinary Research*, 46, 31-39.
- MACIVOR, K. M. DE F. & HORAK, I. G., 1984. The internal and external parasites of Angora and Boer goats in Valley Bushveld near Uitenhage. *Angora Goat and Mohair Journal*, 26, 7-14.
- MACIVOR, K. M., 1985. The distribution and hosts of *Rhipicephalus glabroscutatum*. *Onderstepoort Journal of Veterinary Research*, 52, 43-46.
- MACIVOR, K. M. DE F. & HORAK, I. G., 1987. Foot abscess in goats in relation to the seasonal abundance of adult *Amblyomma hebraeum* and adult *Rhipicephalus glabroscutatum* (Acari: Ixodidae). *Journal of the South African Veterinary Association*, 58, 113-118.
- NEL, J. A. J. & PRETORIUS, J. J. L., 1971. A note on the smaller mammals of the Mountain Zebra National Park. *Koedoe*, 14, 99-110.
- NEUMANN, L. G., 1901. Revision de la famille de Ixodidés. (4<sup>e</sup> Mémoire). *Mémoires de la Société Zoologique de France*, 14, 249-372.
- NORVAL, R. A. I., 1975. Studies on the ecology of *Amblyomma marmoreum* Koch 1844 (Acarina: Ixodidae). *Journal of Parasitology*, 61, 737-742.
- NORVAL, R. A. I., 1981. The ticks of Zimbabwe. III. *Rhipicephalus evertsi evertsi*. *Zimbabwe Veterinary Journal*, 12, 31-35.
- 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. XII. The lesser known *Rhipicephalus* species. *Zimbabwe Veterinary Journal*, 16, 37-43.

PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. XXVI

- PENZHORN, B. L. & BRONKHORST, P. J. L., 1976. Additions to the check-list of birds of the Mountain Zebra National Park. *Koedoe*, 19, 171-174.
- PENZHORN, B. L., 1977. Further bird records from the Bontebok and Mountain Zebra National Parks. *Koedoe*, 20, 205-207.
- PENZHORN, B. L. & HORAK, I. G., 1989. Starlings, mountain zebras and ticks. *Koedoe*, 32, 133-134.
- RANDOLPH, SARAH E., 1975a. Seasonal dynamics of a host-parasite system. *Ixodes trianguliceps* (Acarina: Ixodidae) and its small mammal hosts. *Journal of Animal Ecology*, 44, 425-449.
- RANDOLPH, SARAH E., 1975b. Patterns of distribution of the tick *Ixodes trianguliceps* Birula on its hosts. *Journal of Animal Ecology*, 44, 451-474.
- RECHAV, Y., 1982. Dynamics of tick populations (Acari: Ixodidae) in the eastern Cape Province of South Africa. *Journal of Medical Entomology*, 19, 679-700.
- RECHAV, Y., ZEEDERBERG, M. E. & ZELLER, D. A., 1987. Dynamics of African tick (Acari: Ixodoidea) populations in a natural Crimean-Congo Hemorrhagic Fever focus. *Journal of Medical Entomology*, 24, 575-583.
- SKEAD, C. J., 1965. Report on the bird-life in the Mountain Zebra National Park, Cradock, C.P., in recent times. *Koedoe*, 1, 19-59.
- SMITHERS, R. H. N., 1983. The mammals of the southern African subregion. Pretoria: University of Pretoria.
- STAMPA, S., 1959. Tick paralysis in the Karoo areas of South Africa. *Onderstepoort Journal of Veterinary Research*, 28, 169-227.
- SUTHERST, R. W., WHARTON, R. H., COOK, I. M., SUTHERLAND, I. D. & BOURNE, A. S., 1979. Long-term population studies on the cattle tick (*Boophilus microplus*) on untreated cattle selected for different levels of tick resistance. *Australian Journal of Agricultural Research*, 30, 353-368.
- THEILER, GERTRUD, 1947. Ticks in the South African Zoological Survey collection. Part VI. Little known African Rhipicephalids. *Onderstepoort Journal of Veterinary Science and Animal Industry*, 21, 253-300.
- THEILER, GERTRUD, 1950. Zoological Survey of the Union of South Africa. Tick Survey—Part VI. Distribution of the Ixodids: *Ixodes pilosus* and *Ixodes rubicundus*. *Onderstepoort Journal of Veterinary Science and Animal Industry*, 24, 37-51.
- THEILER, GERTRUD & ROBINSON, BRITHA N., 1953. Ticks in the South African Zoological Survey collection. Part VII. Six lesser known African Rhipicephalids. *Onderstepoort Journal of Veterinary Research*, 26, 93-136.
- THEILER, GERTRUD & SALISBURY, LOIS E., 1958. Zoological Survey of the Union of South Africa. Tick Survey: Part X. Distribution of *Margaropus winthemi*, the winter horse tick. *Onderstepoort Journal of Veterinary Research*, 27, 599-604.
- 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 S9958. Report to the Director of Veterinary Services, Onderstepoort.
- 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., 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.
- YOUNG, E., ZUMPT, F., BOOMKER, J., PENZHORN, B. L. & ERASMUS, B., 1973. Parasites and diseases of Cape mountain zebra, black wildebeest, mountain reedbuck and blesbok in the Mountain Zebra National Park. *Koedoe*, 16, 77-81.