

PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. XXIX. IXODID TICKS ON HARES IN THE CAPE PROVINCE AND ON HARES AND RED ROCK RABBITS IN THE ORANGE FREE STATE

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ABSTRACT

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One hundred and seventeen scrub hares, *Lepus saxatilis*, were examined for ixodid ticks in various regions of the Cape Province. They were infested with 18 tick species and the seasonal abundances of the immature stages of *Amblyomma hebraeum*, *Amblyomma marmoreum*, *Hyalomma marginatum rufipes*, *Rhipicephalus appendiculatus* and *Rhipicephalus glabroscutatum* and all stages of *Rhipicephalus oculatus* and the adults of a *Rhipicephalus* sp. (near *R. oculatus*) were determined.

Seventy-two scrub hares on 3 farms in the Orange Free State harboured 10 ixodid tick species and the seasonal abundances of the immature stages of *H. marginatum rufipes* and *Hyalomma truncatum* and all stages of *Rhipicephalus punctatus* were determined.

Thirty Cape hares, *Lepus capensis*, examined in the northern Cape Province harboured 5 tick species and the seasonal abundances of the immature stages of *H. marginatum rufipes* and *H. truncatum* were determined. Thirty-four Cape hares examined in the south-western Orange Free State carried 6 tick species and the seasonal abundance of immature *H. marginatum rufipes* was determined on these animals.

Twenty-eight Smith's red rock rabbits examined on 2 farms in the south-western Orange Free State were infested with 7 tick species.

INTRODUCTION

The scrub hare, *Lepus saxatilis*, the Cape hare, *Lepus capensis*, and Smith's red rock rabbit, *Pronolagus rupestris*, are indigenous to Africa. According to Smithers (1983) the scrub hare is widely distributed in South Africa except in forested areas and in the arid country bordering the Orange River in the north-western Cape Province. The Cape hare occurs in south-western Transvaal, throughout most of the Orange Free State and the Cape Province excluding the south-eastern sector. Smith's red rock rabbit is present in the extreme southern Transvaal, central and southern Orange Free State, central and southern Natal and is widely distributed in the Cape Province excluding the northern parts and the coastal forested areas (Smithers, 1983). Although their distributions overlap in large parts of the country, their habitat preferences keep them fairly separate within specific localities. Scrub hares prefer savanna woodland and scrub, where there is grass cover. Cape hares prefer arid open habitat, while Smith's red rock rabbit is closely confined to rocky hillsides, boulder-strewn koppies and rocky ravines with some grass or shrub cover (Smithers, 1983).

All 3 are nocturnal, although scrub and Cape hares may forage during the day in overcast weather (Smithers, 1983). None of them burrow, and the scrub and Cape hare inhabit temporary forms where their precocial young are born. Smith's red rock rabbits utilize rocky shelters and the females make nests where their young, which are probably altricial, are born (Smithers, 1983).

According to Theiler (1962) hares and rock rabbits in South Africa may be infested with 23 ixodid tick species. In recent years a number of surveys of the ticks infesting these animals have been conducted in this country (Horak, Sheppey, Knight & Beuthin, 1986; Horak & Knight, 1986; Horak & MacIvor, 1987; Rechav, Zeederberg & Zeller, 1987; Petney & Horak, 1987; Horak, Fourie, Novellie &

Williams, 1991). Similar surveys have also been conducted in Kenya (Clifford, Flux & Hoogstraal, 1976) and New Zealand (Heath, Tenquist & Bishop, 1987). From these it would appear that hares and rabbits are good hosts of the immature stages of a large number of tick species. In South Africa scrub hares are also good hosts of the adults of *Ixodes pilosus*, *Rhipicephalus nitens*, *Rhipicephalus oculatus* and a *Rhipicephalus* sp. (near *R. oculatus*) (Horak *et al.*, 1986; Horak & Knight, 1986), while Smith's red rock rabbit is the preferred host of adult *Rhipicephalus arnoldi* (Horak, Fourie, Novellie & Williams, 1991).

Because of their importance as hosts of ixodid ticks it was decided to examine hares and red rock rabbits from a number of localities in South Africa for these parasites. The results of the surveys done in the Cape Province and the Orange Free State are presented here, while those in the Transvaal will appear later. The surveys conducted north-east of Grahamstown in the eastern Cape Province and described here are an extension of those of Horak & Knight (1986) and include the tick burdens of an additional 47 hares. The results for the south-western Cape Province were obtained from 5 scrub hares examined at the same locality as that reported in an earlier survey by Horak *et al.* (1986).

MATERIALS AND METHODS

Survey animals

A total of 189 scrub hares, 64 Cape hares and 28 Smith's red rock rabbits were examined. They were shot at night using a single-shot rifle or a shotgun.

Tick recovery

The hares and rabbits were processed for tick recovery as described by Horak *et al.* (1986). The hair and scrapings collected by their method were poured on to a sieve with 20 mm apertures held over a sieve with 150 µm apertures and thoroughly washed. The hair retained on the upper sieve was squeezed and the fluid expressed from it was poured through the finer sieve. The contents of the latter sieve were examined *in toto* under a stereoscopic microscope and the ticks collected, identified and counted. The partially dry hair was mass-measured and a representative sample taken for microscopic examination.

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TABLE 1 Ixodid ticks recovered from 47 scrub hares on the farm "Bucklands", eastern Cape Province

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	10	3	0	0	13	9
<i>Amblyomma marmoreum</i>	123	3	0	0	126	12
<i>Boophilus</i> sp.	7	0	0	0	7	2
<i>Haemaphysalis leachi</i>	1	2	0	0	3	3
<i>Haemaphysalis silacea</i>	26	22	2	0	50	16
<i>Hyalomma marginatum rufipes</i>	168	90	0	0	258	12
<i>Hyalomma truncatum</i>	1	2	0	0	3	1
<i>Ixodes pilosus</i>	1	0	0	0	1	1
<i>Rhipicephalus appendiculatus</i>	507	281	0	0	788	28
<i>Rhipicephalus evertsi evertsi</i>	237	171	0	0	408	24
<i>Rhipicephalus glabroscutatum</i>	2 175	769	0	0	2 944	28
<i>Rhipicephalus oculatus</i>	6 010	1 397	97	80 (28)	7 584	41
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i>)	11	8	21	6	46	15

() = Number of maturing female ticks i.e. idiosoma of *R. oculatus* > 5,0 mm in length

TABLE 2 Ixodid ticks recovered from 42 scrub hares in the Andries Vosloo Kudu Reserve, eastern Cape Province

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	1 948	638	0	0	2 586	42
<i>Amblyomma marmoreum</i>	65	6	0	0	71	11
<i>Haemaphysalis silacea</i>	45	33	0	0	78	18
<i>Hyalomma marginatum rufipes</i>	370	324	0	0	694	28
<i>Ixodes pilosus</i>	3	1	0	0	4	3
<i>Rhipicephalus appendiculatus</i>	348	438	0	0	786	31
<i>Rhipicephalus evertsi evertsi</i>	299	405	0	0	704	36
<i>Rhipicephalus glabroscutatum</i>	930	303	0	0	1 233	21
<i>Rhipicephalus oculatus</i>	1 196	839	118	70 (29)	2 223	37
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i>)	28	4	18	12 (3)	62	14
<i>Rhipicephalus simus</i>	14	2	0	0	16	6

() = Number of maturing female ticks, i.e. idiosoma of *R. oculatus* and *Rhipicephalus* sp. (near *R. oculatus*) > 5,0 mm in length

The remainder of the hair was examined macroscopically in a white plastic tray and all the adult ticks collected, identified and counted. The length of the idiosoma of maturing females of each species was measured under a stereoscopic microscope. The minimum length assigned to each species was that length which we estimated the maturing female tick would reach 24 h before detaching.

Comment: We are unable to distinguish between the immature stages of *Hyalomma marginatum rufipes* and *Hyalomma marginatum turanicum*. Where the distributions of these ticks overlap (Howell, Walker & Nevill, 1978) we have identified the immatures only to specific level. Where in other surveys we have recovered the adults of only one subspecies we have assigned the immatures recovered now to that subspecies.

DESCRIPTIONS OF SURVEY LOCALITIES AND RESULTS

Scrub hares

Eastern Cape Province

The farm "Bucklands" and the adjacent Andries Vosloo Kudu Reserve are situated around 33° 07' S and 26° 42' E, approximately 25 km north-east of Grahamstown in a vegetation zone classified as Valley Bushveld (Acocks, 1988). The vegetation has been described in greater detail by Rechav (1982), while Horak & Knight (1986) have listed some of the fauna on both properties.

An attempt was made to shoot 2 scrub hares on each property at monthly intervals from February 1985 to January 1987. This was not always possible

and only 1 hare was obtained on the farm during December 1985 and none during October 1986. In the reserve only 1 hare was obtained during April and 1 during July 1985 and none during December 1985 and May 1986.

The Thomas Baines Nature Reserve (33° 23' S, 26° 30' E) lies approximately 12 km south-west of Grahamstown within a vegetation zone categorized as False Macchia, Eastern Province Thornveld and Valley Bushveld (Acocks, 1988). Five scrub hares were examined in this reserve.

The numbers of ticks recovered from hares on the farm "Bucklands" and the Andries Vosloo Kudu Reserve are summarized in Tables 1 and 2.

The hares on the farm "Bucklands" were infested with 13 ixodid tick species of which *R. oculatus* was the most abundant and prevalent. Eleven species were recovered from the hares in the Andries Vos-

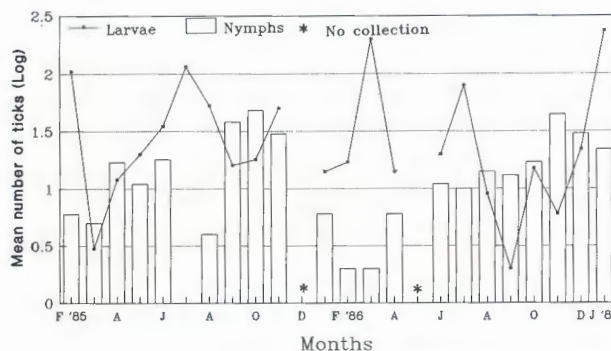


FIG. 1 The seasonal abundance of *Amblyomma hebraeum* on scrub hares in the Andries Vosloo Kudu Reserve, eastern Cape Province.

TABLE 3 Ixodid ticks recovered from 5 scrub hares in the Thomas Baines Nature Reserve, eastern Cape Province

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	460	46	0	0	506	5
<i>Haemaphysalis silacea</i>	0	62	0	0	62	4
<i>Ixodes pilosus</i>	12	18	1	1	32	4
<i>Rhipicephalus appendiculatus</i>	2 189	133	0	0	2 322	5
<i>Rhipicephalus evertsi evertsi</i>	46	47	0	0	93	5
<i>Rhipicephalus follis/R. simus</i>	26	0	0	0	26	4

TABLE 4 Ixodid ticks recovered from 3 scrub hares on the farm "Henham" in the Colesberg district, Karoo

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Hyalomma marginatum</i>	9	33	0	0	42	3
<i>Ixodes rubicundus</i>	0	0	0	2	2	1
<i>Rhipicephalus oculatus</i>	19	5	0	0	24	1
<i>Rhipicephalus punctatus</i>	8	1	1	0	10	1

TABLE 5 Ixodid ticks recovered from 5 scrub hares in the Bontebok National Park, south-western Cape Province

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoratum</i>	5	2	0	0	7	2
<i>Boophilus</i> sp.	9	0	0	0	9	2
<i>Hyalomma truncatum</i>	5	9	0	0	14	2
<i>Ixodes pilosus</i>	10	1	1	7	19	4
<i>Rhipicephalus evertsi evertsi</i>	6	19	0	0	25	2
<i>Rhipicephalus glabroscuratum</i>	4	1	0	0	5	2
<i>Rhipicephalus nitens</i>	93	113	57	33 (10)	296	5

() = Number of maturing female ticks, i.e. idiosoma of *R. nitens* > 5,0 mm in length

loo Kudu Reserve. Of these *Amblyomma hebraeum* was the most abundant and prevalent, closely followed by *R. oculatus*.

Both the abundance and prevalence of the immature stages of *A. hebraeum* were markedly reduced on the hares on the farm compared with those on the reserve. For this reason the seasonal abundance of this tick was determined only on the hares in the reserve (Fig. 1). The seasonal abundances of the immature stages of *H. marginatum rufipes*, *Rhipicephalus appendiculatus* and *Rhipicephalus glabroscuratum* and all stages of development of *R. oculatus* on the hares on the farm and reserve have been combined for each species and are illustrated in Fig. 2-5.

The larvae of *A. hebraeum* reached the largest numbers during February and July of 1985 and during March and July of 1986 and January of 1987. The nymphs peaked during September and October of

1985 and during November and December of 1986. The immature stages of *H. marginatum rufipes* were most commonly present from February to August,

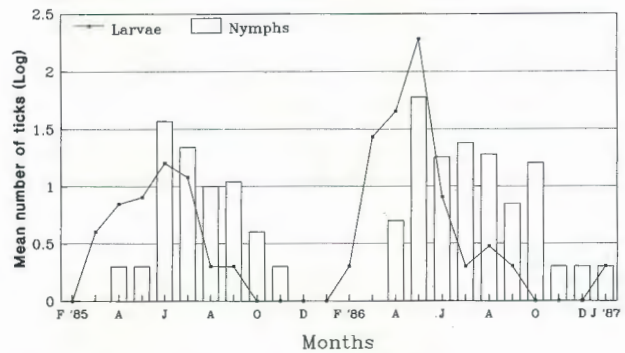


FIG. 3 The seasonal abundance of *Rhipicephalus appendiculatus* on scrub hares on the farm "Bucklands", and in the Andries Vosloo Kudu Reserve, eastern Cape Province.

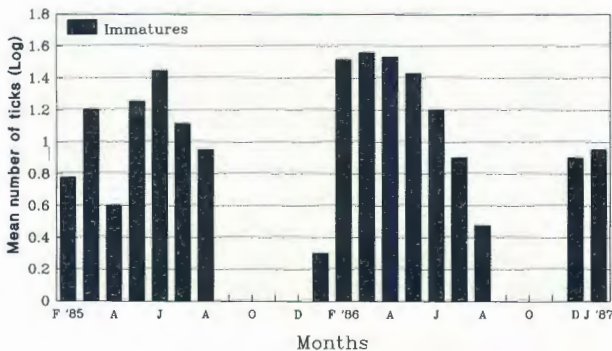


FIG. 2 The seasonal abundance of *Hyalomma marginatum rufipes* on scrub hares on the farm "Bucklands" and in the Andries Vosloo Kudu Reserve, eastern Cape Province.

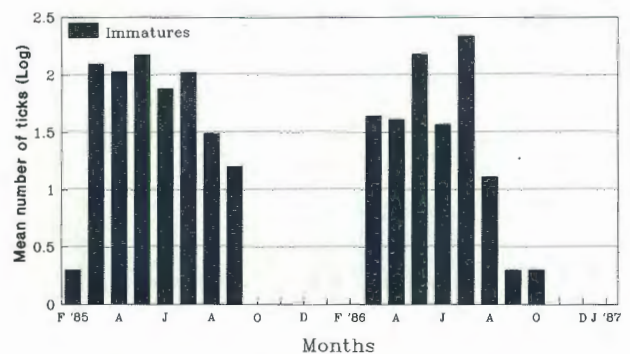


FIG. 4 The seasonal abundance of *Rhipicephalus glabroscuratum* on scrub hares on the farm "Bucklands" and in the Andries Vosloo Kudu Reserve, eastern Cape Province.

TABLE 6 Ixodid ticks recovered from 11 scrub hares on the farm "Taaiboskraal", north-western Cape Province

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Hyalomma truncatum</i>	177	174	0	0	351	11
<i>Ixodes rubicundus</i>	0	0	3	2	5	1
<i>Rhipicephalus evertsi evertsi</i>	2	3	0	0	5	3
<i>Rhipicephalus gertrudae</i>	0	20	0	0	20	3
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i>)	0	0	0	1	1	1

TABLE 7 Ixodid ticks recovered from 5 scrub hares on the farm "Sandfontein", northern Cape Province

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Hyalomma marginatum rufipes</i>	24	26	0	0	50	1
<i>Hyalomma truncatum</i>	232	270	1	0	503	5
<i>Rhipicephalus evertsi evertsi</i>	0	3	0	1	4	2
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i>)	2	0	0	1	3	2

TABLE 8 Ixodid ticks recovered from 50 scrub hares on the farms "Preezfontein" and "Slangfontein", south-western Orange Free State

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoreum</i>	1	3	0	0	4	3
<i>Haemaphysalis leachi/spinulosa</i>	1	0	0	0	1	1
<i>Hyalomma marginatum rufipes</i>	47	347	0	0	394	26
<i>Hyalomma truncatum</i>	39	44	0	0	83	5
<i>Ixodes rubicundus</i>	4	0	0	1 (1)	5	4
<i>Rhipicephalus arnoldi</i>	5	0	2	2	9	3
<i>Rhipicephalus oculatus</i>	0	0	0	1 (1)	1	1
<i>Rhipicephalus punctatus</i>	422	238	349	176 (18)	1 185	46

() = Number of maturing female ticks, i.e. idiosoma of *I. rubicundus* > 5,0 mm; *R. arnoldi* > 4,0 mm; *R. oculatus* > 5,0 mm and *R. punctatus* > 5,0 mm in length

although some were recovered during December 1986 and January 1987. The largest numbers of *R. appendiculatus* larvae were recovered from March to June or July and of nymphs from May or June to September or October. The greatest numbers of immatures of the 2-host *R. glabroscutatum* were recovered from March to July. The larvae of *R. oculatus* reached the highest numbers from March to July or August, the nymphs from May to September and the adults from August to December.

Although not illustrated, the larvae of *A. marmoreum* were generally present from February to May and the nymphs from October to December. The adults of the *Rhipicephalus* sp. (near *R. oculatus*) were usually most abundant during August and from November to April.

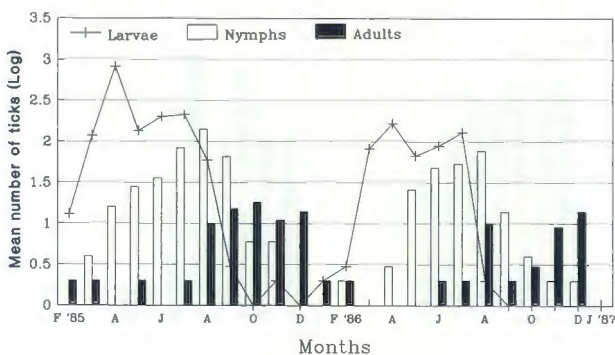


FIG. 5 The seasonal abundance of *Rhipicephalus oculatus* on scrub hares on the farm "Bucklands" and in the Andries Vosloo Kudu Reserve, eastern Cape Province.

The 5 hares examined in the Thomas Baines Nature Reserve were all infested with the immature stages of *A. hebraeum*, *R. appendiculatus* and *Rhipicephalus evertsi evertsi* (Table 3).

Karoo

The farm "Henham" is located approximately 2 km west of Colesberg (30° 44' S, 25° 06' E), in a vegetation zone classified as False Upper Karoo (Acocks, 1988). Three scrub hares were shot on this farm during July 1989.

The hares were all infested with the immature stages of *H. marginatum* (no subspecific identification could be made) (Table 4). One also harboured *Ixodes rubicundus*, *R. oculatus* and *Rhipicephalus punctatus*.

South-western Cape Province

The physiography of the Bontebok National Park (34° 02' S, 20° 25' E), approximately 5 km south of Swellendam, and situated in a vegetation zone described as Coastal Renosterbosveld (Acocks, 1988), has been described by Boomker, Horak & De Vos (1981). One scrub hare was shot in this park during February 1985 and 2 during February 1988 as well as 2 during February 1990.

The 5 hares examined in the park were infested with 7 ixodid tick species of which *R. nitens* was the most abundant and prevalent (Table 5).

North-western Cape Province

The farm "Taaiboskraal" (31° 42' S, 18° 53' E) is located approximately 15 km east of Vanrhynsdorp. The vegetation of this region is classified as

TABLE 9 Ixodid ticks recovered from 22 scrub hares on the farm "Bishops Glen", central Orange Free State

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoreum</i>	4	4	0	0	8	3
<i>Boophilus</i> sp.	9	0	0	0	9	2
<i>Haemaphysalis spinulosa</i>	0	1	0	1	2	2
<i>Hyalomma marginatum rufipes</i>	34	31	0	0	65	5
<i>Hyalomma truncatum</i>	637	166	0	0	803	9
<i>Ixodes rubicundus</i>	4	0	1	0	5	2
<i>Rhipicephalus arnoldi</i>	0	1	1	3 (2)	5	2
<i>Rhipicephalus evertsi evertsi</i>	5	6	0	0	11	3
<i>Rhipicephalus punctatus</i>	476	189	125	68 (13)	858	17

() = Number of maturing female ticks, i.e. idiosoma of *R. arnoldi* > 4,0 mm and *R. punctatus* > 5,0 mm in length

TABLE 10 Ixodid ticks recovered from 30 Cape hares on the farm "Sandfontein", northern Cape Province

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoreum</i>	15	4	0	0	19	8
<i>Hyalomma marginatum rufipes</i>	115	135	0	0	250	19
<i>Hyalomma truncatum</i>	1 636	1 490	0	0	3 126	24
<i>Rhipicephalus gertrudae</i>	0	1	0	0	1	1
<i>Rhipicephalus oculatus</i>	8	74	20	25 (3)	127	4

() = Number of maturing female ticks, i.e. idiosoma of *R. oculatus* > 5,0 mm in length

Succulent Karoo (Acocks, 1988). Eight scrub hares were examined on the farm during November 1988 and 3 during June 1989.

All the hares were infested with the immature stages of *Hyalomma truncatum* (Table 6).

Northern Cape Province

The farm "Sandfontein" (29° 56' S, 24° 21' E), lies approximately 43 km south-east of Hopetown. The vegetation of this area is classified as False Arid Karoo (Acocks, 1988). Four scrub hares were shot on the farm during November 1988 and 1 during June 1989.

The 5 hares examined on the farm were all infested with the immature stages of *H. truncatum* (Table 7).

South-western Orange Free State

The farms "Preezfontein" (29° 50' S, 25° 23' E) and "Slangfontein" (30° 08' S, 25° 24' E) lie approximately 8 and 40 km south-west of Jagersfontein respectively, in a vegetation zone classified as false Upper Karoo (Acocks, 1988). Scrub hares were shot at irregular intervals on both farms during 1985, but 1 to 4 hares were shot each month from December 1985 to December 1986 on "Preezfontein".

The total number of ticks recovered from the 50 hares examined are summarized in Table 8. The seasonal abundances of *H. marginatum rufipes* (combined with that on the Cape hares shot at the same time) and *R. punctatus* are graphically illustrated in Fig. 6 and 7.

The scrub hares were infested with 8 tick species of which *R. punctatus* was the most abundant and prevalent. The largest numbers of immature *H. marginatum rufipes* tended to be present on the hares from about March or April to July or August. No clear pattern of seasonal abundance was evident for *R. punctatus*.

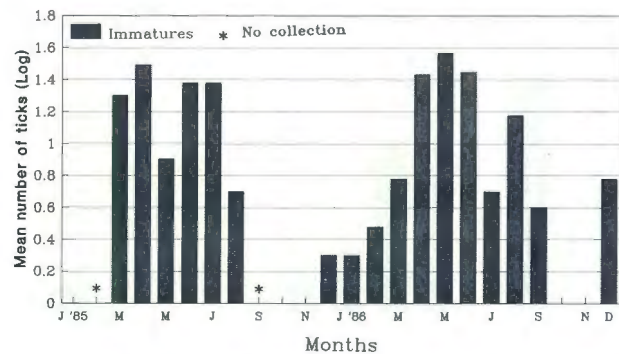


FIG. 6 The seasonal abundance of *Hyalomma marginatum rufipes* on scrub and Cape hares on the farms "Preezfontein" and "Slangfontein", south-western Orange Free State.

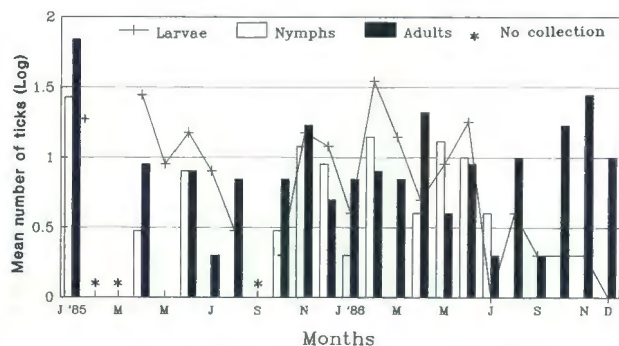


FIG. 7 The seasonal abundance of *Rhipicephalus punctatus* on scrub hares on the farms "Preezfontein" and "Slangfontein", south-western Orange Free State.

Central Orange Free State

The farm "Bishops Glen" (29° 00' S 26° 21' E) is situated approximately 17 km north-east of Bloemfontein within a vegetation zone described as Dry Cymbopogon-Themeda Veld (Acocks, 1988). With the exception of April and December 1989 when no hares were obtained and January 1990

TABLE 11 Ixodid ticks recovered from 34 Cape hares on the farms "Preezfontein" and "Slangfontein", south-western Orange Free State

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Hyalomma marginatum rufipes</i>	63	376	0	0	439	20
<i>Hyalomma truncatum</i>	0	1	0	0	1	1
<i>Ixodes rubicundus</i>	0	0	0	4 (3)	4	2
<i>Rhipicephalus evertsi evertsi</i>	11	0	0	0	11	1
<i>Rhipicephalus oculatus</i>	9	0	16	17	42	8
<i>Rhipicephalus punctatus</i>	27	10	9	6	52	12

() = Number of maturing female ticks, i.e. idiosoma of *I. rubicundus* > 5,0 mm in length

TABLE 12 Ixodid ticks recovered from 28 Smith's red rock rabbits on the farms "Preezfontein" and "Slangfontein", south-western Orange Free State

Tick species	Total numbers recovered					No. of hares infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma marmoratum</i>	24	1	0	0	25	11
<i>Hyalomma marginatum rufipes</i>	1	1	0	0	2	2
<i>Hyalomma truncatum</i>	3	1	0	0	4	3
<i>Ixodes rubicundus</i>	6	0	0	0	6	5
<i>Rhipicephalus arnoldi</i>	15	25	14	12 (1)	66	13
<i>Rhipicephalus evertsi evertsi</i>	1	0	0	0	1	1
<i>Rhipicephalus punctatus</i>	9	2	0	0	11	7

() = Number of maturing female ticks, i.e. idiosoma of *R. arnoldi* > 4,0 mm in length

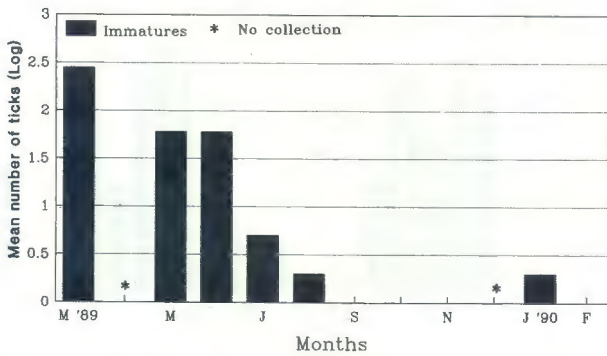


FIG. 8 The seasonal abundance of *Hyalomma truncatum* on scrub hares on the farm "Bishops Glen", central Orange Free State.

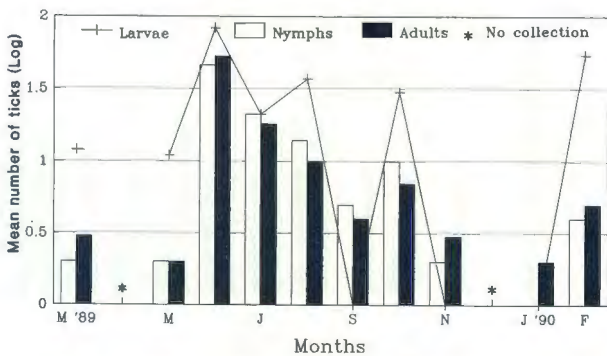


FIG. 9 The seasonal abundance of *Rhipicephalus punctatus* on scrub hares on the farm "Bishops Glen", central Orange Free State.

when 4 were shot, 2 scrub hares were shot on the farm at monthly intervals from March 1989 to February 1990.

The numbers of ticks recovered from the 22 scrub hares examined on this farm are summarized in Table 9, and the seasonal abundances of *H. truncatum* and *R. punctatus* are illustrated in Fig. 8 and 9.

The hares were infested with 9 tick species of which *H. truncatum* and *R. punctatus* were the most abundant and *R. punctatus* the most prevalent. The largest numbers of immature *H. truncatum* were recovered from March to June. The largest numbers of all stages of development of *R. punctatus* were present during June.

Cape hares

Northern Cape Province

With the exception of February and June 1989 when no hares were obtained, 2 to 6 Cape hares were shot on the farm "Sandfontein" each month from December 1988 to December 1989.

The 30 hares examined were infested with 5 tick species (Table 10) and the seasonal abundance of the immature stages of *H. truncatum* is graphically illustrated in Fig. 10.

The largest numbers of *H. truncatum* were recovered from January to May and during November and December 1989. Peak burdens of *H. marginatum rufipes* were present during March and May.

South-western Orange Free State

With the exception of February, July and September when no hares were obtained, 1 or 2 Cape hares

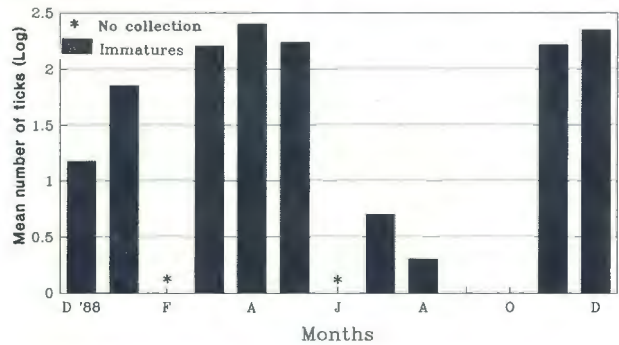


FIG. 10 The seasonal abundance of *Hyalomma truncatum* on Cape hares on the farm "Sandfontein", northern Cape Province.

were shot on the farm "Slangfontein" at monthly intervals during 1985. Except for May, when no hares were collected, 1 or 2 Cape hares were shot each month during 1986 on the farm "Preezfontein".

The total numbers of ticks recovered from the 34 hares shot on the 2 farms are summarized in Table 11.

The hares were infested with 6 tick species of which the immature stages of *H. marginatum rufipes* were the most abundant and prevalent. The seasonal abundance of this tick has been combined with that on the scrub hares shot at the same time (Fig. 6).

Smith's red rock rabbits

South-western Orange Free State

Six red rock rabbits were shot on the farm "Slangfontein" during 1985 and 7 on the farm "Preezfontein". Except for March, August and November when no rabbits were collected, 1 or 2 rabbits were shot on "Preezfontein" each month during 1986. The total numbers of ticks recovered from the 28 red rock rabbits examined are summarized in Table 12.

The red rock rabbits were infested with 7 tick species of which *R. arnoldi* was the most abundant and prevalent.

DISCUSSION

The differences in the ixodid tick fauna of the 2 hare and 1 rabbit species are probably due to 3 chief factors. The first being the habitat preferences of the hosts and the second and third the host and habitat preferences of the ticks. Nevertheless it is still possible to define the host status of the various hare species for some of the tick species recovered. This has been done in Table 13.

TABLE 13 The host status of scrub hares, Cape hares and Smith's red rock rabbits for various tick species that are not just incidental parasites

Host and tick species	Host status	
	Immature stages	Adult ticks
Scrub hares		
<i>Amblyomma hebraeum</i>	Good	N/A
<i>Amblyomma marmoreum</i>	Good	N/A
<i>Hyalomma marginatum rufipes</i>	Preferred	N/A
<i>Hyalomma truncatum</i>	Preferred	N/A
<i>Ixodes pilosus</i>	Good	Good
<i>Rhipicephalus appendiculatus</i>	Good	N/A
<i>Rhipicephalus evertsi evertsi</i>	Good	N/A
<i>Rhipicephalus glabroscutatum</i>	Good	N/A
<i>Rhipicephalus nitens</i>	Good	Preferred
<i>Rhipicephalus oculatus</i>	Definitive	Definitive
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i>)	N/A	Good
<i>Rhipicephalus punctatus</i>	Good	Preferred
<i>Rhipicephalus simus</i>	Good	N/A
Cape hares		
<i>Amblyomma marmoreum</i>	Good	N/A
<i>Hyalomma marginatum rufipes</i>	Preferred	N/A
<i>Hyalomma truncatum</i>	Preferred	N/A
<i>Rhipicephalus oculatus</i>	Definitive	Definitive
<i>Rhipicephalus punctatus</i>	Good	Good
Smith's red rock rabbits		
<i>Amblyomma marmoreum</i>	Good	N/A
<i>Ixodes rubicundus</i> *	Preferred	N/A
<i>Rhipicephalus arnoldi</i> *	Good	Definitive

N/A = Not applicable

* Horak, Fourie, Novellie & Williams (1991)

With the exception of *R. arnoldi*, for which Smith's red rock rabbit is the definitive host of the adults, the scrub hare is a good or preferred host of all the ticks occurring on the other 2 lagomorph species, as well as of a number of additional tick species.

Of all the tick species recovered from the hares and rabbits only 2 can be considered definitive parasites of these hosts. These are *R. oculatus* on the scrub and Cape hare and adult *R. arnoldi* on Smith's red rock rabbit. Although the scrub hare is a good or preferred host of all stages of development of 3 other tick species (Table 13), it shares this status with other animals within a particular tick's distribution range as will be discussed later.

Combining the findings of the present survey with those of earlier studies (Horak *et al.*, 1986; Horak, Fourie, Novellie & Williams, 1991) a total of 25 ixodid tick species have recently been recovered from scrub hares. While several of these must be considered accidental infestations, the scrub hare is nevertheless an important host of ixodid ticks in South Africa in which country at least 83 species are known to occur (Walker, 1991).

Amblyomma hebraeum

The geographic distribution of this tick is limited to the northern and eastern parts of South Africa (Howell *et al.*, 1978). Consequently only the scrub hares examined in the Grahamstown area of the eastern Cape Province, a region which falls within the distribution range of the tick, were infested.

Adults of this tick prefer large herbivores, while the immature stages can be found on a variety of bird and mammal species (Theiler, 1962; Horak, MacIvor, Petney & De Vos, 1987; Walker 1991).

The marked differences between the tick burdens of the hares examined on the farm "Bucklands" and those in the adjacent Andries Vosloo Kudu Reserve can be ascribed to the regular acaricidal treatment of domestic stock on the farm (Horak & Knight, 1986; Petney & Horak, 1987). The ratio of larvae to nymphs of 3,1:1 on the hares in the reserve is considerably lower than that on a number of other host species (Horak, MacIvor, Petney & De Vos, 1987). This indicates that scrub hares are better hosts of the nymphs than of the larvae.

No clear pattern of seasonal abundance was obvious but the larvae tended to reach the largest numbers during late summer or autumn and during winter and the nymphs during spring or early summer. Petney & Horak (1987) recovered the largest numbers of larvae from the vegetation of the Andries Vosloo Kudu Reserve during March to June and August or September. Knight & Rechav (1978) recovered the largest numbers of larvae from kudu in the same area during April and of nymphs during April and during November and December.

The scrub hare has been shown by Bezuidenhout (1988) to be a potential reservoir of *Cowdria ruminantium*, the cause of heartwater in cattle, sheep and goats. The presence of large numbers of *A. hebraeum*, the vector of this organism, on scrub hares may thus be significant in the epidemiology of the disease.

Amblyomma marmoreum

This tick is widely distributed in South Africa (Walker, 1991), hence its recovery from hares at nearly every locality. Its absence on the animals

examined at Vanrhynsdorp could be because these animals were not examined during periods of peak seasonal abundance of the tick.

Adult ticks prefer tortoises and the immature stages are present on these animals as well as on various mammals and ground-frequenting birds (Norval, 1975; Horak, MacIvor, Petney & De Vos, 1987; Walker, 1991).

On those properties on which it was possible to determine seasonal abundance the larvae were generally most abundant from late summer to early winter and the nymphs from spring to early summer. This pattern of abundance confirms earlier findings (Norval, 1975; Horak & Williams, 1986; Horak *et al.*, 1986; Rechav *et al.*, 1987).

***Hyalomma* spp.**

The adults are found on large hosts such as eland, zebras and cattle, while the immature stages prefer hares (Horak & MacIvor, 1987; Rechav *et al.*, 1987; Walker, 1991; Horak, Fourie, Novellie & Williams, 1991). The immature stages of *H. marginatum rufipes* may also be found on ground-frequenting birds and those of *H. truncatum* on rodents (Rechav *et al.*, 1987; Horak, Fourie, Novellie & Williams, 1991). The scrub hare and the Cape hare appear to be equally good hosts of these ticks confirming the findings of Rechav *et al.* (1987). In those studies in which it has been possible to make comparisons, birds and rodents appear to harbour only small numbers of ticks (Rechav *et al.*, 1987; Horak, Fourie, Novellie & Williams, 1991). However, because of their own large number their contribution to the total tick population may be significant.

The larvae and nymphs of *H. marginatum rufipes* were generally present in the largest numbers on the hares at some time during the period February to August. This corresponds with the findings of Horak & MacIvor (1987) on scrub hares and Rechav *et al.* (1987) on helmeted guineafowls.

In the northern Cape Province *H. truncatum* was present on Cape hares in the greatest numbers during the period November to May. The summer (November to March) abundance on these animals resembles that observed by Rechav *et al.* (1987). In the central Orange Free State the largest numbers were recovered from scrub hares from March to June.

Ixodes rubicundus

Although only very small numbers were recovered in the present survey, previous studies have indicated that Smith's red rock rabbit is one of the preferred hosts of the immature stages (Stampa, 1959; Horak, Fourie, Novellie & Williams, 1991). The adults prefer mountain reedbeek, eland, caracal and sheep (Stampa, 1959; Fourie, Horak & Marais, 1988b; Horak, Fourie, Novellie & Williams, 1991). Some of the scrub and Cape hares examined in the present study were also infested by adults.

Ixodes pilosus

This tick is found in sourveld regions along the coast from Port Shepstone in the east to Cape Town in the west (Howell *et al.*, 1978). Within this region all stages of development may be found on scrub hares, grey rhebeek, bontebok, caracal and domestic dogs (Horak *et al.*, 1986; Horak, Jacot Guillarmod, Moolman & De Vos, 1987). In the Bontebok National Park the scrub hare is as good a host as the bontebok, but not as good as the grey rhebeek (Horak *et al.*, 1986).

Rhipicephalus appendiculatus

The distribution of this tick in South Africa is similar to that of *A. hebraeum* (Howell *et al.*, 1978). Its recovery from the hares examined in the eastern Cape Province and not from other localities confirms this fact. Clifford *et al.* (1976) recovered the immature stages of *R. appendiculatus* from *Lepus crawshayi* examined in regions with a high rainfall in Kenya and Uganda, but none from *L. capensis* examined in localities in Kenya with a low rainfall. They ascribe these differences as almost certainly being due to tick distribution and habitat requirements rather than host preference.

Contrary to the findings for *A. hebraeum* on "Bucklands" and the Kudu Reserve, acaricidal treatment of livestock on the farm appeared to have no effect on the number of immature *R. appendiculatus* harboured by the 2 groups of hares. The seasonal abundance of the immature stages is similar to that described on kudu examined at the same locality (Knight & Rechav, 1978) and Angora goats on "Bucklands" (Rechav, 1982).

Rhipicephalus arnoldi

Although it appears from the present study that all stages of development prefer Smith's red rock rabbits as hosts, a comparative survey conducted in the Mountain Zebra National Park indicated that rock dassies were the preferred hosts of the immature stages (Horak, Fourie, Novellie & Williams, 1991). The habitats of the red rock rabbits and rock dassies overlap, but the former are nocturnal and the latter diurnal (Smithers, 1983; Fourie, 1983) and this may account for the differences in their burdens of immature ticks.

Too few ticks were recovered in the present study to determine patterns of seasonal abundance. However, Horak, Fourie, Novellie & Williams (1991), who recovered considerably more ticks, were also unable to determine the seasonal abundance of the various developmental stages. They ascribed this to the possible close association between the preferred hosts and the free-living ticks.

Rhipicephalus evertsi evertsi

This tick has a very wide distribution which includes some of the semi-arid areas of South Africa (Howell *et al.*, 1978). Although it also has a wide host range (Hoogstraal, 1956; Theiler, 1962), it hardly ever occurs in large numbers except on eland and zebras (Horak, Fourie, Novellie & Williams, 1991). Hares are good hosts of the immature stages as reported for *L. capensis* and *L. crawshayi* in Kenya by Clifford *et al.* (1976) and *L. saxatilis* in South Africa (Horak & Knight, 1986; Horak, Fourie, Novellie & Williams, 1991).

Rechav *et al.* (1987) observed a definite spring to autumn seasonality in the presence of the immature stages on scrub and Cape hares in the south-western Transvaal. This was not the case with the hares from the eastern Cape Province where the life cycle appeared to be continuous. It has been suggested by Matson & Norval (1977) that this tick may complete several life cycles annually.

Rhipicephalus glabroscutatum

The distribution of this tick in the eastern Cape Province, eastern Karoo and parts of the western Cape Province has been described by MacIvor (1985). The farm "Bucklands", the Andries Vosloo Kudu Reserve and the Bontebok National Park, all

lie within this distribution and ticks have been recovered from scrub hares at these localities and in the Karoo (Horak *et al.* 1986; Horak & Knight, 1986; Horak, Fourie, Novellie & Williams, 1991). The late summer to mid-winter occurrence of the immature stages of this 2-host tick on scrub hares in the eastern Cape Province corresponds to its seasonal abundance on other animals in this region and the Karoo (MacIvor & Horak, 1984; Horak, Fourie, Novellie & Williams, 1991).

Rhipicephalus nitens

According to Morel (1969), *R. nitens* has a geographic distribution limited to the south-western Cape Province. It has, however, been recovered in small numbers from dogs at Grahamstown and large numbers from sheep at Sidbury in the eastern Cape Province (Horak, Jacot Guillarmod, Moolman & De Vos, 1987; Horak, Williams & Van Schalkwyk, 1991). All stages of development feed on scrub hares, grey rhebuck, bontebok and sheep (Horak *et al.* 1986; Horak, Williams & Van Schalkwyk, 1991), hence it is difficult to identify a single preferred host species. Ruminants are, however, better hosts of the immature stages than are hares (Horak *et al.*, 1986).

Although it was not possible to determine seasonal abundance in the present survey, because of the spacing of the slaughter dates, this has been done in other studies. The larvae are present from late summer to winter, the nymphs during winter and spring and the adults during summer (Horak *et al.*, 1986; Horak, Williams & Van Schalkwyk, 1991).

Rhipicephalus oculatus

This tick was originally described from a hare, *Lepus timidus* (Neumann, 1901). This hare was probably *L. capensis*, but could possibly have been *L. saxatilis* (Smithers, R.H.N. in a personal communication to Walker, 1991). The taxonomic problems that exist between *R. oculatus* and the following species have been discussed by Walker (1991).

Judging by the findings of the present survey and an earlier survey in the eastern Karoo (Horak, Fourie, Novellie & Williams, 1991), *R. oculatus* occurs in the Valley Bushveld regions of the eastern Cape Province, in the Karoo, in the northern Cape Province and in the south-western Orange Free State. It is a definitive parasite of the scrub hare and the Cape hare. Greater numbers were recovered from Cape hares on the farms "Slangfontein" and "Preezfontein" in the south-western Orange Free State than on scrub hares examined on the same farms. This, however, may be due to habitat preferences of the ticks and the hares rather than host preference.

The seasonal abundance of this tick on scrub hares in the eastern Cape Province (Fig. 5) is similar to that on scrub hares in the Mountain Zebra National Park in the Karoo (Horak, Fourie, Novellie & Williams, 1991). It seems likely that only 1 life cycle is possible annually.

Rhipicephalus sp. (near R. oculatus)

This tick is fairly common in the Valley Bushveld regions of the eastern Cape Province, where adults may be found on scrub hares, kudu, cattle, sheep and goats (Horak & Knight, 1986). The adults are most abundant during the summer months.

Rhipicephalus punctatus

The taxonomic status of this tick in South Africa has recently been clarified by Walker (1991). It was

previously referred to as *Rhipicephalus pravus*-like on Angora goats, *Rhipicephalus sp. (near R. pravus)* on Merino sheep, and *Rhipicephalus sp. (near R. punctatus)* on cattle (Fourie, Horak & Marais, 1988a, b; Fourie & Horak, 1990). From the present and other published surveys it appears to occur in the northern and north-eastern Transvaal, the northern Karoo and south-western and central Orange Free State (Fourie *et al.*, 1988a, b; Fourie & Horak, 1990; Walker, 1991).

Within this distribution range the tick appears to favour rocky outcrops and hills. The preferred host for the immature stages is the rock elephant shrew which utilizes this terrain as habitat. This probably explains the difference in the tick burdens of the scrub hares and the Cape hares examined on the farms "Slangfontein" and "Preezfontein" in the south-western Orange Free State. Cape hares prefer open, level terrain (Smithers, 1983) and hence would not necessarily come into contact with the ticks.

Although scrub hares are the preferred hosts of adult ticks of this species, these may also attach to several other animals including goats, sheep and cattle (Fourie *et al.*, 1988a, b; Fourie & Horak, 1990). The ticks excrete a toxin while feeding and this can cause paralysis in Angora goat kids (Fourie *et al.*, 1988a).

No clear pattern of seasonal abundance is evident on the hares. This may be due to a close association between the tick and its host with the hare supplying warmth and moisture within its form, thus making continuous development of the free-living stages possible. On sheep and cattle adult ticks are most numerous from spring to summer (Fourie *et al.*, 1988b; Fourie & Horak, 1990).

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