Onderstepoort J. vet. Res., 53, 187–197 (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

I. G. HORAK[1], K. SHEPPEY[2], M. M. KNIGHT[1], and C. L. BEUTHIN[3]

ABSTRACT

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 (1986)

Vaal ribbok (*Pelea capreolus*), bontebok (*Damaliscus dorcas dorcas*) and scrub hares (*Lepus saxatilis*) were slaughtered in the Bontebok National Park at regular intervals and examined for arthropod parasites. Twelve species of ixodid ticks were recovered; the antelope each harboured 9 species and the hares 11.

Rhipicephalus nitens was the most prevalent and most abundant tick. The vaal ribbok also harboured large numbers of *Ixodes pilosus* and the bontebok fairly large numbers of *Rhipicephalus glabroscutatum*.

The vaal ribbok were infested with 2 lice species and the larvae of 3 oestrid fly species. The bontebok harboured 2 lice species and the larvae of 2 oestrid flies, and the scrub hares were infested with a louse species and a flea species.

The host preference and seasonal abundance of some of the parasites were determined.

INTRODUCTION

The parasites of 3 antelope species found in the Bontebok National Park (34° 02′ S, 20° 25′ E, Alt. 90–200 m) situated in the south-western Cape Province, have been the subjects of considerable study in the past few years (Verster, Imes & Smit, 1975; Boomker, Horak & De Vos, 1981; Horak, Meltzer & De Vos, 1982; Horak, Brown, Boomker, De Vos & Van Zyl, 1982; Horak, De Vos & De Klerk, 1982; Boomker, Horak, Gibbons & De Vos, 1983). This research was aimed at determining the species composition and abundance of the arthropod and helminth fauna of the bontebok, *Damaliscus dorcas dorcas;* the vaal ribbok, *Pelea capreolus,* and the springbok, *Antidorcas marsupialis,* in the park. However, it did not give an indication of the seasonal abundance of the various parasites recovered.

A year-long study of the biology of the vaal ribbok within the park necessitated the regular slaughter of some animals. So as not to waste valuable research material, these animals were processed for the recovery of arthropod and helminth parasites. At the same time bontebok, scrub hares (*Lepus saxatilis*), striped mice (*Rhabdomys pumilio*), and vlei rats (*Otomys irroratus*) were killed and examined for parasites.

MATERIALS AND METHODS

The physiography of the Bontebok National Park has been described by Boomker *et al.* (1981), but since that date the springbok population, which then numbered 83, has been reduced to 5 animals.

Four vaal ribbok and 2 bontebok were shot at 2-monthly intervals from February 1983 until February 1984. On each occasion an attempt was made to shoot a juvenile, a sub-adult and an adult male and female vaal ribbok and a juvenile and adult bontebok. One vaal ribbok killed by a car just outside the park and 2 additional vaal ribbok and 2 bontebok from within the park were also examined. Parasites from these animals were recovered, counted and identified as described by Malan, Reinecke & Scialdo (1981); Horak, Brown, Boomker, De Vos & Van Zyl (1982) and Horak, Potgieter, Walker, De Vos & Boomker (1983)! One eye of each animal was placed in formalin and later examined under a stereoscopic microscope for 1st stage *Gedoelstia* sp. larvae, and the subscutaneous side of the skin of each animal was examined for the presence of *Strobiloestrus* sp. larvae. The immature stages of the ixodid ticks *Hyalomma truncatum, Ixodes pilosus* and *Rhipicephalus nitens* were identified by comparison with laboratory-reared specimens.

Except for April 1983, when only 1 scrub hare was obtained, 2 scrub hares were shot at night at 2-monthly intervals from April 1983 until February 1984. Ectoparasites were recovered from these animals by placing the whole hare, with the skin intact, in a sturdy plastic bag immediately after it had been shot and adding sufficient tick-detaching agent* to immerse the animal. The hare was left in the bag until the following morning, then thoroughly scrubbed with a brush with 20 mm long steel bristles and washed, particular attention being paid to the external ear canals, neck and the feet. The scrubbings and washings plus the contents of the plastic bag were poured onto a sieve with 150 μm apertures. The material that was retained was then collected, preserved with formalin and stored. A total of 19 striped mice collected in the park from April–October 1983, and 9 vlei rats collected in the park from April–December 1983, were examined in a similar fashion to the scrub hares.

Rainfall and minimum and maximum atmospheric temperatures were recorded daily in the park.

RESULTS

The total numbers of arthropod parasites recovered from the vaal ribbok, bontebok and scrub hares, their relative abundance and the percentage of animals infested are summarized in Tables 1–3.

A total of 12 tick species was recovered, of which each antelope species harboured 9 and the hares 11. The larvae of 3 oestrid fly species were recovered, the vaal ribbok being infested with all 3 and the bontebok with 2 of these. The vaal ribbok and the bontebok were each infested with 2 louse species and the scrub hares with 1 species. The scrub hares also harboured 1 flea species. The vaal ribbok killed outside the park harboured small

[1] Tick Research Unit, Rhodes University, Grahamstown 6140

[2] Department of Zoology and Entomology, Rhodes University, Grahamstown 6140

[3] Computer Centre, Rhodes University, Grahamstown 6140

Received 2 July 1986—Editor

* Triatix: Coopers SA (Pty) Ltd

TABLE 1 The arthropod parasites recovered from 30 vaal ribbok in the Bontebok National Park

Arthropod species	Total numbers of arthropods recovered						Percentage of vaal ribbok infested
Ixodid ticks	Larvae	Nymphae	Adults		Total	Relative abundance %	
			Males	Females			
Amblyomma marmoreum	96	4	0	0	100	0,75	36,7
Boophilus sp.	0	2	0	0	2	0,02	3,3
Haemaphysalis aciculifer	0	0	0	5(1)	5	0,04	10,0
Ixodes pilosus	3 084	780	62	186(22)	4 112	30,79	100,0
Rhipicephalus evertsi evertsi	0	2	2	0	4	0,03	6,7
Rhipicephalus gertrudae	0	0	4	2	6	0,04	6,7
Rhipicephalus glabroscutatum	506	102	14	10	632	4,73	63,3
Rhipicephalus nitens	7 101	872	212	249(60)	8 434	63,16	100,0
Rhipicephalus sp.	0	0	39	20	59	0,44	30,0
Total	10 787	1 762	333	472	13 354	100,00	

Lice	Nymphae	Adults	Total	Relative abundance %	
Damalinia pelea	5 350	11 090	16 440	99,59	100,0
Linognathus peleus	16	52	68	0,41	3,3
Total	5 366	11 142	16 508	100,00	

Oestrid fly larvae	1st stage	2nd stage	3rd stage	Total	Relative abundance %	
Gedoelstia sp.*	53	0	0	53	24,20	10,7
*Oestrus ovis***	14	6[1]	[5]	20[6]	9,13	26,9
Strobiloestrus sp.	3	111	32	146	66,67	60,0
Total	70	117[1]	32[5]	219[6]	100,00	

( ) = Number of maturing female ticks, i.e. idiosoma of *H. aciculifer* > 4,5 mm and of *I. pilosus* and *R. nitens* > 5,0 mm in length
[ ] = Dead larvae
* = Eyes of 28 animals examined
** = 26 animals examined

TABLE 2 The arthropod parasites recovered from 16 bontebok in the Bontebok National Park

Arthropod species	Total numbers of arthropods recovered						Percentage of bontebok infested
Ixodid ticks	Larvae	Nymphae	Adults		Total	Relative abundance %	
			Males	Females			
Amblyomma marmoreum	30	4	0	0	34	0,25	37,5
Haemaphysalis aciculifer	0	0	4	4(1)	8	0,06	25,0
Hyalomma truncatum	0	0	1	0	1	0,01	6,3
Ixodes pilosus	207	146	0	10	363	2,66	93,8
Rhipicephalus evertsi evertsi	0	16	0	0	16	0,11	6,3
Rhipicephalus gertrudae	0	0	2	2	4	0,03	6,3
Rhipicephalus glabroscutatum	1 208	425	68	32(4)	1 733	12,69	93,8
Rhipicephalus nitens	8 156	2 978	164	169(12)	11 467	83,96	100,0
Rhipicephalus sp.	0	0	26	6	32	0,23	37,5
Total	9 601	3 569	265	223	13 658	100,00	

Lice	Nymphae	Adults	Total	Relative abundance %	
Damalinia sp.	1 453	696	2 149	63,90	93,8
Linognathus sp.	642	572	1 214	36,10	56,3
Total	2 095	1 268	3 363	100,00	

Oestrid fly larvae	1st stage	2nd stage	3rd stage	Total	Relative abundance %	
Gedoelstia sp.	845	240	540	1 625	99,94	100,0
Strobiloestrus sp.	0	1	0	1	0,06	6,3
Total	845	241	540	1 626	100,00	

( ) = Number of maturing female ticks, i.e. idiosoma of *H. aciculifer* and of *R. glabroscutatum* > 4,5 mm and of *R. nitens* > 5,0 mm in length

TABLE 3 The arthropod parasites recovered from 11 scrub hares in the Bontebok National Park

Arthropod species	Total numbers of arthropods recovered						Percentage of hares infested
Ixodid ticks	Larvae	Nymphae	Adults		Total	Relative abundance %	
			Males	Females			
Amblyomma marmoreum	30	4	0	0	34	2,63	45,5
Boophilus sp.	0	5	0	0	5	0,39	9,1
Haemaphysalis aciculifer	0	2	0	0	2	0,16	9,1
Haemaphysalis leachi	7	1	0	0	8	0,62	9,1
Hyalomma truncatum	10	5	0	0	15	1,16	27,3
Ixodes pilosus	84	128	1	9(1)	222	17,22	72,7
Ixodes sp.	0	0	0	1	1	0,08	9,1
Rhipicephalus evertsi evertsi	1	1	0	0	2	0,16	18,2
Rhipicephalus glabroscutatum	7	1	0	0	8	0,62	36,4
Rhipicephalus nitens	556	277	81	73(5)	987	76,57	100,0
Rhipicephalus sp.	0	5	0	0	5	0,39	18,2
Total	695	429	82	83	1 289	100,00	
Lice	Nymphae		Adults		Total	Relative abundance %	
Haemodipsus sp.	17		63		80	100,00	54,5
Fleas	Adults				Total	Relative abundance %	
Ctenocephalides felis damarensis	32				32	100,00	72,7

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

TABLE 4 The ixodid ticks recovered from 19 striped mice in the Bontebok National Park

Tick species	Total numbers of ticks recovered					Percentage of mice infested
	Larvae	Nymphae	Males	Females	Total	
Haemaphysalis leachi	3	2	1	0	6	15,8
Rhipicephalus glabroscutatum	1	0	0	0	1	5,3
Rhipicephalus sp.	28	2	0	0	30	15,8
Total	32	4	1	0	37	31,6

TABLE 5 The ixodid ticks recovered from 9 vlei rats in the Bontebok National Park

Tick species	Total numbers of ticks recovered					Percentage of rats infested
	Larvae	Nymphae	Males	Females	Total	
Boophilus sp.	1	0	0	0	1	11,1
Haemaphysalis leachi	5	3	0	0	8	33,3
Ixodes pilosus	1	0	0	0	1	11,1
Rhipicephalus sp.	57	21	0	0	78	33,3
Total	64	24	0	0	88	55,6

numbers of *Boophilus decoloratus, Boophilus microplus, I. pilosus, Rhipicephalus evertsi evertsi, R. nitens, Damalinia pelea* and 26 2nd stage *Strobiloestrus* sp. larvae.

The total numbers of ixodid ticks recovered from the striped mice and vlei rats are summarized in Tables 4 and 5.

The mice were infested with 3 tick species and the rats with 4.

Ixodid ticks

Because vaal ribbok, bontebok and scrub hares were shot on each occasion during April, June, August and December 1983 and during February 1984, the mean tick burdens of these 3 host species during an 11-month period are comparable. Table 6 is a summary of the mean burdens and the overall ratios of larvae to nymphae to adults of the 3 major tick species recovered from the 3 host species from April 1983–February 1984.

Ixodes pilosus

All the vaal ribbok were infested with *I. pilosus* and they harboured more larvae, nymphae and adults of this tick than did the other 2 hosts, on which the mean tick burdens were similar in most respects. More than 11 % of female *I. pilosus* on all vaal ribbok were maturing (Table 1). More female than male *I. pilosus* were recovered from each of the host species. The ratio of parasitic larvae to nymphae to adults was 14,7:5,6:1,0 (Table 6).

The seasonal abundance of *I. pilosus* on the 3 hosts separately as well as the combined mean burdens are graphically presented in Fig. 1.

No clear pattern of seasonal abundance can be discerned on the individual host species. The combined mean burdens reveal that larvae peaked during June, nymphae during August and adults during October and December.

TABLE 6 The mean numbers of ticks recovered from vaal ribbok, bontebok and scrub hares in the Bontebok National Park during the period April 1983–February 1984

Tick and host species	Mean numbers of ticks recovered					Percentage of hosts infested
	Larvae	Nymphae	Males	Females	Total	
Ixodes pilosus						
Vaal ribbok	112,4	29,2	2,1	5,4(0,8)	149,1	100,0
Bontebok	13,4	10,2	0,0	0,7	24,3	91,7
Scrub hares	7,6	11,6	0,1	0,8	20,1	72,7
Total	133,4	51,0	2,2	6,9	193,5	
Ratios	14,7	:5,6		:1,0		
Rhipicephalus glabroscutatum						
Vaal ribbok	20,9	4,3	0,3	0,4	25,9	66,7
Bontebok	79,7	32,8	5,3	2,5(0,3)	120,3	91,7
Scrub hares	0,6	0,1	0,0	0,0	0,7	36,4
Total	101,2	37,2	5,6	2,9	146,9	
Ratios	11,9	:4,4		:1,0		
Rhipicephalus nitens						
Vaal ribbok	270,0	35,5	5,9	6,7(1,5)	318,1	100,0
Bontebok	548,7	237,3	13,2	13,5(1,0)	812,7	100,0
Scrub hares	50,5	25,2	7,4	6,6(0,4)	89,7	100,0
Total	869,2	298,0	26,5	26,8	1 220,5	
Ratios	16,3	:5,6		:1,0		

( ) = Number of maturing female ticks, i.e. idiosoma of *R. glabroscutatum* > 4,5 mm and of *I. pilosus* and *R. nitens* > 5,0 mm in length

Most of the bontebok were infested with *R. glabroscutatum*, and they also harboured more ticks in each stage of development than did the other 2 hosts. Only the bontebok harboured maturing female *R. glabroscutatum* (Table 2), while the scrub hares carried no adults of this tick. Approximately twice as many males as females were recovered. The ratio of parasitic larvae to nymphae to adults was 11,9:4,4:1,0 (Table 6). Peak numbers of immature *R. glabroscutatum* were present on the vaal ribbok and bontebok from April–August. Too few adults were recovered from the vaal ribbok to accurately determine seasonal abundance on this host, while on the bontebok they reached a peak from August–December (Fig. 2). The combined mean burdens of the vaal ribbok and bontebok revealed the same pattern of seasonal abundance as that observed on the bontebok.

Rhipicephalus nitens

All the vaal ribbok, bontebok and scrub hares were infested with *R. nitens*. The bontebok harboured the greatest mean numbers of larvae, nymphae and adults. The vaal ribbok harboured considerably more larvae than did the scrub hares, but the nymphal and adult burdens of these 2 hosts were similar. More than 24 % of female *R. nitens* on the vaal ribbok were maturing compared with 7,1 % on the bontebok and 6,8 % on the scrub hares (Tables 1–3). The mean total burdens consisted of slightly more female than male ticks. The ratio of parasitic larvae to nymphae to adults was 16,3:5,6:1,0 (Table 6).

Larval numbers of *R. nitens* peaked during April and nymphae during August or October on each of the 3 hosts (Fig. 3). The largest numbers of adults were present on the vaal ribbok and bontebok during February and December 1983 and February 1984. Small numbers of adults were recovered from the scrub hares on each occasion, peak numbers occurring during December 1983 and February 1984.

Lice

Amongst the vaal ribbok examined there were 6 juveniles and an adult female with bilateral pneumonia. Some of the juveniles and the sick female harboured considerably more *D. pelea* than the other vaal ribbok. Table 7 is a summary of the mean lice burdens of these 3 groups of vaal ribbok.

The juveniles and the sick female excluded, the seasonal abundance of *D. pelea* on the other animals is graphically illustrated in Fig. 4.

Peak burdens of *D. pelea* were recovered during June.

The mean *Damalinia* sp. burdens of the 7 juvenile bontebok consisted of 124 nymphae and 70 adults compared with 65 nymphae and 22 adults on the 9 adult animals. With the exception of 1 adult female which harboured a large number of *Linognathus* sp., the juvenile bontebok always carried more lice of this genus than did the adult animals. No pattern of seasonal prevalence could be determined for the *Damalinia* sp. or *Linognathus* sp. on the bontebok.

Few lice were recovered from the scrub hares (Table 3).

Oestrid fly larvae

Gedoelstia sp.

The corneas of the eyes of 3 of the 28 vaal ribbok examined for *Gedoelstia* larvae were infested. Only 1st stage larvae were recovered from these animals.

All the bontebok were infested with *Gedoelstia* larvae, whose mature 3rd stage was larger than those of either *Gedoelstia cristata* or *Gedoelstia hassleri* and differed from the latter species in certain aspects of its ventral spinulation. Of the 845 1st stage larvae recovered 19 were present on the corneas, 237 in the heart chambers, 589 in the nasal passages and none on the dura of the cranial cavity. First stage larvae were recovered from the eyes during April, June, August and December 1983 and

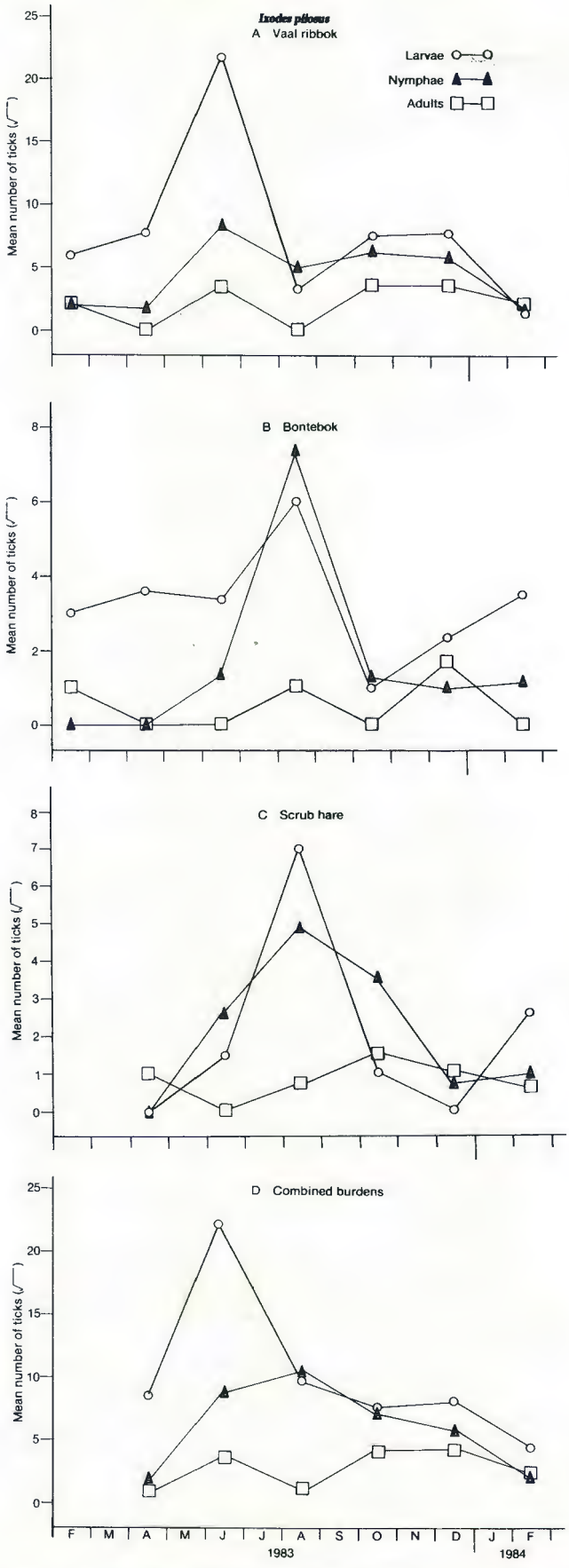

FIG. 1 The seasonal abundance of *Ixodes pilosus* on
A. Vaal ribbok
B. Bontebok
C. Scrub hares, and
D. The combined burdens of the 3 hosts in the Bontebok National Park

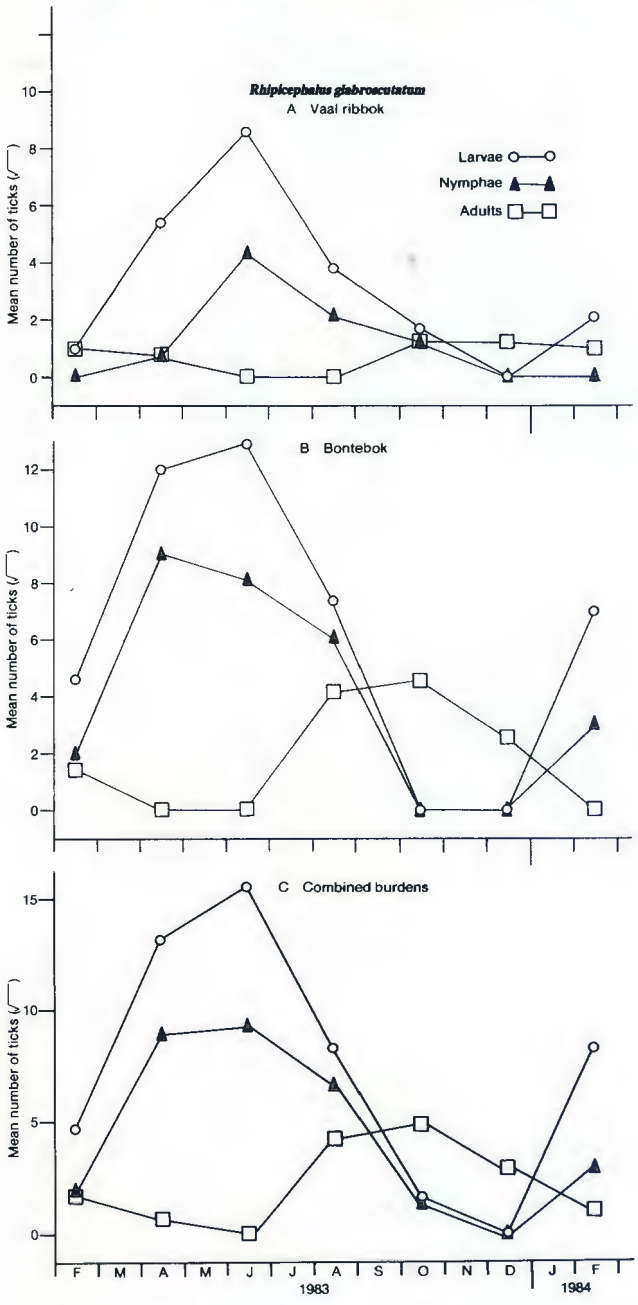

FIG. 2 The seasonal abundance of *Rhipicephalus glabroscutatum* on
A. Vaal ribbok
B. Bontebok, and
C. The combined burdens of the 2 hosts in the Bontebok National Park

during February 1984, but no clear pattern of seasonal abundance was evident.

Oestrus ovis

Seven of the 26 vaal ribbok examined for the larvae of *O. ovis* were infested. Although these larvae developed to mature 3rd stage larvae in the vaal ribbok, all the 3rd stage larvae recovered were dead.

Strobiloestrus sp.

The seasonal abundance of the 3 larval stages is graphically presented in Fig. 5.

First stage larvae were recovered from the subcutaneous tissue of the vaal ribbok during December 1983, 2nd stage larvae from the subcutaneous tissue and hides from February–June 1983 and during December 1983 and February 1984. Third stage larvae, of which several

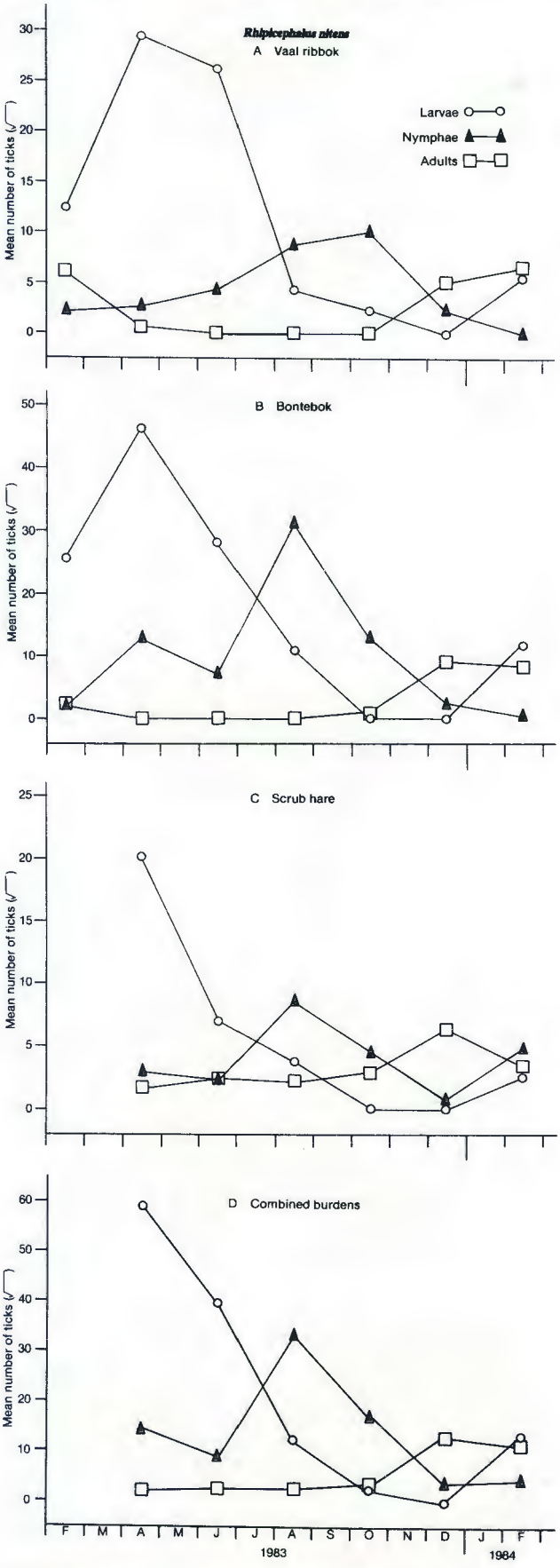

FIG. 3 The seasonal abundance of *Rhipicephalus nitens* on
A. Vaal ribbok
B. Bontebok
C. Scrub hares, and
D. The combined burdens of the 3 hosts in the Bontebok National Park

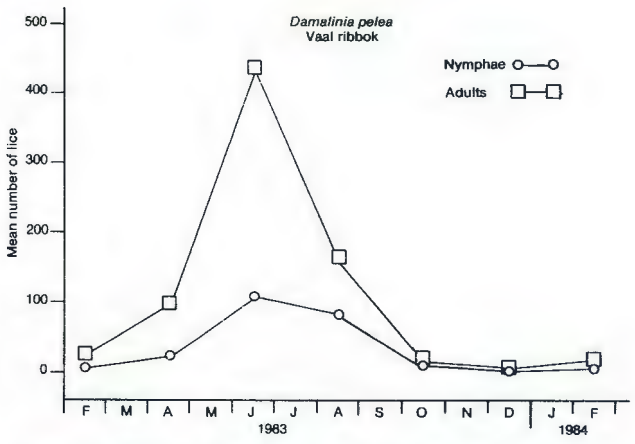

FIG. 4 The seasonal abundance of *Damalinia pelea* on sub-adult and adult vaal ribbok in the Bontebok National Park

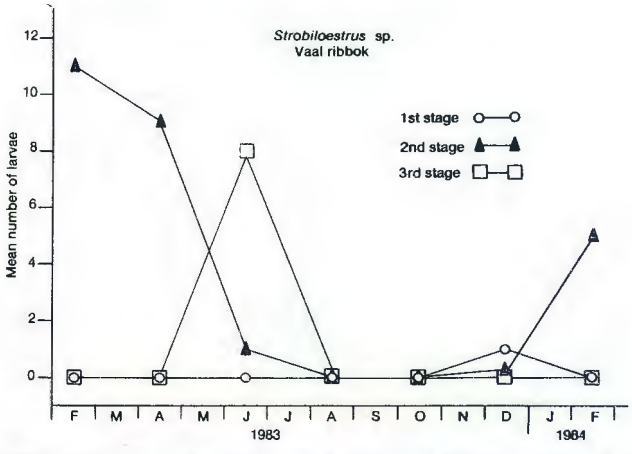

FIG. 5 The seasonal abundance of the larvae of *Strobiloestrus* sp. in the subcutaneous tissue and hides of vaal ribbok in the Bontebok National Park

appeared to be nearly mature, were recovered from warble-like lesions in the hides during June 1983. No larvae were recovered during August and October 1983.

The larvae were recovered mainly from the subcutaneous tissue and hides of the upper half of the thorax and loin region. Fewer were present on the shoulders and rump. Larvae were not found in the vicinity of the spine.

Only 1 bontebok was infested, and that with a single 2nd stage larva.

Climate

The mean monthly minimum and maximum atmospheric temperatures and total monthly rainfall in the park from February 1983–February 1984 are graphically represented in Fig. 6.

The lowest minimum temperatures were recorded during July and August 1983, and the highest maxima during February and March 1983 and from December 1983–February 1984.

Although the numbers of days on which rain fell during the 1st and 2nd halves of 1983 were similar (38 as opposed to 39), the total rainfall for the 1st half of the year totalled only 169,9 mm compared with 290,5 mm during the latter half.

DISCUSSION

Host preference

During December 1979, 5 vaal ribbok and 8 bontebok were examined for parasites in the Bontebok National

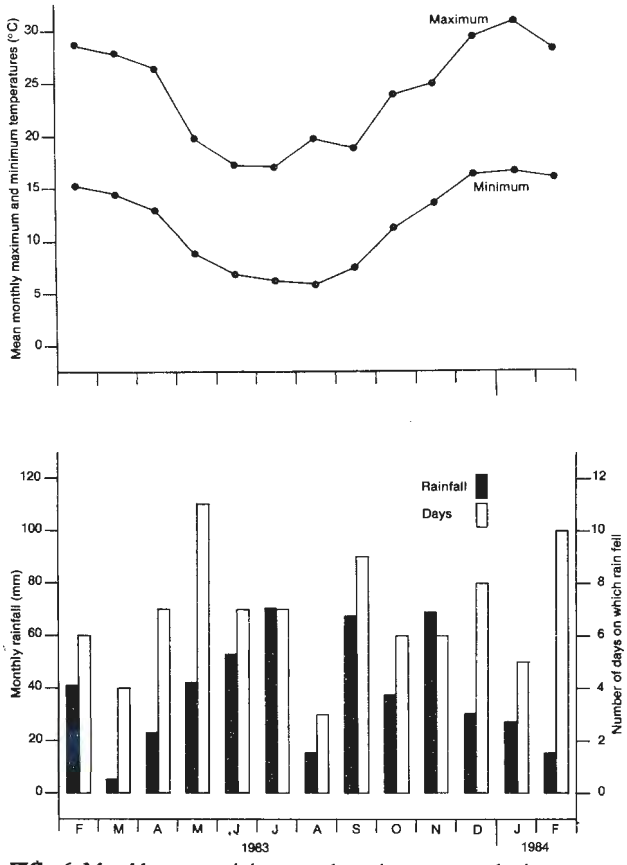

FIG. 6 Monthly mean minimum and maximum atmospheric temperatures and monthly rainfall in the Bontebok National Park from February 1983–February 1984

TABLE 7 The mean burdens of *Damalinia pelea* on 3 groups of vaal ribbok

Group	Number of animals	Mean number of lice recovered		
		Nymphae	Adults	Total
Juveniles	6	608	1 308	1 916
Sick female	1	962	656	1 618
Sub-adults and adults	23	32	113	145

TABLE 8 The definitive arthropod parasites of vaal ribbok, bontebok and scrub hares in the bontebok National Park

Arthropod species	Host species		
	Vaal ribbok	Bontebok	Scrub hare
Ixodid ticks			
Ixodes pilosus	X		
Rhipicephalus glabroscutatum		X	
Rhipicephalus nitens	X	X	X
Lice			
Damalinia pelea	X		
Fleas			
Ctenocephalides felis damarensis			X

Park (Horak, Brown, Boomker, De Vos & Van Zyl, 1982; Horak, De Vos & De Klerk, 1982). The vaal ribbok slaughtered then harboured only 2 ixodid tick species and 1 louse species. No fly larvae were recovered, although lesions suggesting earlier *Gedoelstia* sp. and *Strobiloestrus* sp. infestation were present. The bontebok harboured 3 ixodid tick species, a lice species and *Gedoelstia* sp. larvae. The larger variety of arthropods recovered in the present survey is not indicative of either an increase in infestation or an improvement in recovery methods, which were basically similar in both investigations, but is partly due to the larger number of animals processed, and more particularly to the examination of animals at regular intervals during a period of 13 months. This demonstrates the necessity of regular examinations in order to obtain accurate host-parasite records for a host species in a particular environment. It also eliminates the possibility of parasites that may have been accidentally acquired by a host species being regarded as definitive parasites of that species. Table 8 is a summary of the arthropods which we consider to be definitive parasites of vaal ribbok, bontebok and scrub hares in the Bontebok National Park. Only those parasites which have been specifically identified are included in the table.

A great advantage of examining several host species within a particular environment at regular intervals is that, where certain parasites utilize more than 1 of these hosts, the contribution made by each to the total parasite population can be assessed. This has been demonstrated by Randolph (1975a, b) in her studies on *Ixodes trianguliceps* on small mammals in Sussex, England and by MacLeod (1970) and Minshull (1981), who studied the ticks of several large mammals in Zambia and Zimbabwe respectively. In addition, the effect that each host species, its sex or its habits may have on the abundance of a parasite can also be determined (Randolph, 1975b).

Ixodid ticks

Since the reduction in springbok numbers, vaal ribbok, bontebok and scrub hares comprise more than 90 % of the total population of larger mammals recorded in the park by Boomker *et al.* (1981). They are also the major hosts of the 3 most prevalent tick species, namely *I. pilosus, R. glabroscutatum* and *R. nitens*. The 28 mice and rats examined harboured only 1 larva of each of the former 2 ticks (Tables 4, 5). Consequently, the antelope and hares' combined tick burdens will account for the bulk of ticks parasitic on animals in the park, and the ratios of the parasitic life stages of the 3 major tick species summarized in Table 6 will be reasonably accurate. However, it must be borne in mind that the various life stages probably feed for different lengths of time and that the 2 month intervals between examinations could have led to major peaks of activity of any of the life stages being missed. Both these factors could have a marked effect on the life stage ratios.

The ratios of parasitic larvae to nymphae to adults for the 3 tick species were fairly similar. In all cases they indicated that a greater loss occurred between the nymphal and adult stages than between the larval and nymphal stages. Randolph (1975a), after careful examination of a number of host species, concluded that in the case of *I. trianguliceps* there was better survival from nymphs to adults than from larvae to nymphs. We are inclined to agree with her findings and feel that, despite the thorough methods of tick recovery employed in the present survey, it is likely that more larvae than other stages were not collected. Despite this shortcoming it is worth noting that at least 12–17 parasitic larvae of the 3 species under discussion are required to ensure the later attachment of 1 adult (Table 6).

Amblyomma marmoreum

The adults of this tick prefer tortoises, while the immature stages have been recovered from a variety of hosts (Theiler & Salisbury 1959; Norval, 1975). More than 35 % of all vaal ribbok, bontebok and scrub hares examined in the present survey were infested with the immature stages of this tick.

By combining the burdens of the 3 hosts and then calculating the mean burden for each month of examination a fairly clear pattern of seasonal abundance emerges

despite the small numbers. The greatest number of larvae were recovered from February–June 1983 and during February 1984, and the greatest number of nymphae during October and December 1983 (spring to early summer). This pattern of seasonal abundance seems to indicate that the greatest numbers of adults would be present on tortoises from December–March (summer), provided that the life cycle is completed in 1 year. No tortoises were examined, but Norval (1975) states that tortoises in the eastern Cape Province harboured the greatest numbers of *A. marmoreum* larvae during April (autumn), nymphae during spring and adults during mid-summer.

***Boophilus* spp.**

Cattle are the preferred hosts of both *B. decoloratus* and *B. microplus* (Hoogstraal, 1956; Howell, Walker & Neville, 1978), a fact verified by the tick burden of the vaal ribbok which was killed outside the park after it had been grazing in close proximity to cattle. This animal harboured ticks of both these species in greater numbers than the combined burdens of all the animals examined from within the park. Horak, Potgieter, Walker, De Vos & Boomker (1983) and Horak, De Vos & Brown (1983) have found that *B. decoloratus* prefers the larger antelope species while most animals below blue wildebeest size (bontebok and vaal ribbok fall within the category) do not become heavily infested. This could be one of the reasons for the small *Boophilus* burdens of the park animals.

Haemaphysalis aciculifer

This tick has a wider distribution than that given by Theiler (1962), who stated that it had been found in the warmer, more humid areas of the northern and eastern Transvaal and in the Umfolozi and Pietermaritzburg regions of Natal. It had apparently been introduced into South Africa from East Africa at the turn of the century (Theiler, 1962) and consequently it may still be spreading. We did not recover it in large numbers and it is thus difficult to determine its preferred hosts. Despite the small number of adults recovered in the present survey, they did exhibit a pattern of seasonal abundance, being present during February 1983 and from August 1983–February 1984. Rodents and hares have been recorded as hosts of the immature stages of this tick (Hoogstraal & El Kammah, 1972) and 1 of the scrub hares in this survey was infested with 2 nymphae (Table 3).

Haemaphysalis leachi

Some of the scrub hares, mice and rats were infested with immature ticks and one of the mice also carried an adult tick. Hoogstraal (1956) lists domestic dogs and the larger wild carnivores as hosts of adult ticks and field rodents as hosts of the immature stages. The source of infestation in the park was probably caracal, and domestic dogs and cats which occasionally get into the park

Hyalomma truncatum

A single male tick was recovered from 1 of the bontebok, but no other antelope were infested. Hares are frequently infested by the immature stages of *Hyalomma* spp. (Clifford, Flux & Hoogstraal, 1976), and 3 of the scrub hares examined were infested with the larvae and nymphae of *H. truncatum*. These hares had probably acquired their infestation outside the park, where they had used pasture previously utilized by cattle, as these animals and large antelope are the preferred hosts of the adult *Hyalomma* spp. occurring in South Africa (Howell *et al.*, 1978).

Ixodes pilosus

Adult ticks were recovered from the heads of the antelope, particularly around the face, and from the underside of the body. The immature stages were present on the legs, bodies and heads of the antelope.

The total numbers of male and female *I. pilosus* recovered from the 3 major host species were 63 and 205 respectively (Tables 1–3), a ratio of 1:3,3. Norval (1974) collected 29 males and 102 females (a ratio of 1:3,5) from bushbuck and duiker in the eastern Cape Province. He found that slightly more than half the males were attached to the host, while equal proportions of the remainder were in copula or attached to females. We do not know how many of the males we collected were attached to the host but a large number were in copula. None, however, were attached to the integument of females. On the evidence of the male to female ratio, Norval (1974) suggests that mating may occur on the host or on the ground.

Although we have listed the vaal ribbok as a definitive host of this tick, it could be argued that the bontebok and scrub hares also qualify, as they too harboured both adult and immature ticks. Furthermore, consideration should be given to the fact that the habitat preferences of the animals and of the tick could determine the level of infestation on a particular host species. This tick is found in sourveld areas all along the coast from Port Shepstone to Cape Town (Howell *et al.*, 1978), and sourveld is usually associated with the cooler southern slopes within a region. In the park, the vaal ribbok are frequently encountered on the gravel slopes, while the bontebok and hares prefer the plain and other level areas. Thus, the habitat preferences of the animals and not necessarily the host preference of *I. pilosus* could dictate their levels of infestation.

The seasonal abundance, as revealed by the combined mean burdens of the vaal ribbok, bontebok and scrub hares, indicates that a single life cycle is completed annually. Peak burdens of larvae during June give rise to peak nymphal burdens in August which in turn are responsible for the peak in adult numbers during October and December. However, it is possible that a separate winter cohort of adult ticks, as evidenced by the increase in adult burdens during June, could be responsible for the slight rise in larval numbers during December (Fig. 1). No corresponding rise in nymphal burdens is evident, however.

Rhipicephalus evertsi evertsi

This tick prefers cattle and equids as hosts (Hoogstraal, 1956; Norval, 1981; Horak, 1982; Horak, De Vos & De Klerk, 1984). The progenitors of the small numbers recovered in the present survey had probably been brought into the park originally by hares which had acquired their infestations on the surrounding farms, or by the Cape buffalo and eland that had been introduced and subsequently removed from the park (Boomker *et al.*, 1981).

Rhipicephalus gertrudae

Very few adult ticks were recovered and then only from the vaal ribbok and bontebok.

Rhipicephalus glabroscutatum

All stages of development of this 2-host tick were recovered mainly from around the feet and on the lower legs of the antelope. The fact that more males than females were recovered is in our experience normal for many members of the genus *Rhipicephalus* in South Africa.

It is possible that host habitat preference influenced the levels of infestation on the 2 antelope species, but nevertheless we have not accorded the vaal ribbok the status of preferred host. The reason for this is that on the bontebok more than 1/3 of the larvae successfully

moulted into nymphae, while on the vaal ribbok only about 1/5 did so (Tables 1, 2). The vaal ribbok is manifestly not a good host of the immature stages.

The seasonal prevalence indicates that one life cycle a year can be completed, with the immature stages that are present in autumn and winter giving rise to adults during spring and early summer (Fig. 2). This pattern of seasonal abundance is virtually identical with that described for this tick on kudu and domestic goats in Valley Bushveld in the eastern Cape Province (Knight & Rechav, 1978; MacIvor & Horak, 1984) and mountain zebra in the Karoo (Horak, Knight & De Vos, 1986). In both regions, this tick has to cope with hot and usually comparatively dry summers.

Rhipicephalus nitens

Adult ticks were recovered mainly from the heads of the antelope, and particularly from the outer ear and the lower edge of the mandible. On the hares they occurred on the ears.

The immature stages were recovered mainly from around the feet and on the lower legs of the antelope. Fair numbers of nymphae were also present on the heads of the bontebok.

The fact that more female than male ticks were recovered from the antelope, and that male ticks only slightly exceeded the number of female ticks on the hares is unusual for a tick of the genus *Rhipicephalus* in which, in our experience, males usually considerably outnumber females (Horak, 1982; Horak, Potgieter, Walker, De Vos & Boomker, 1983; Horak *et al.*, 1984; Horak & Fourie, 1986; Horak *et al.*, 1986). However, the 5 vaal ribbok and 8 bontebok examined in the park in December 1979 harboured more male than female *R. nitens* (864 and 620 respectively) (Horak, Brown, Boomker, De Vos & Van Zyl, 1982), while the 6 vaal ribbok and 2 bontebok examined during December 1983 in the present survey also harboured more males than females (171 and 128 respectively). In contrast, the 4 vaal ribbok and 2 bontebok examined during February 1983 and during February 1984 harboured a total of 69 male:94 female and 136 male:191 female *R. nitens* respectively. Apparently, therefore, males outnumber females on the host animals early in the season of adult activity, while the converse is true later in the season. If this is not just a fortuitous observation, additional long term studies planned for the park might elucidate this phenomenon. Three vaal ribbok and 3 bontebok that were examined during February 1985 harboured total burdens of 75 male:111 female *R. nitens*.

We have listed both antelope species and the scrub hare as preferred hosts on the basis of the number of immature and adult ticks recovered on each as well as the fact that female ticks matured on all of them. We are unaware of other *Rhipicephalus* species in South Africa that utilize both ruminants and lagomorphs as preferred hosts for all stages of development. *R. nitens* has a geographical distribution limited to the south-western Cape Province (Morel, 1969), and by making use of a wide range of hosts within its confined distribution its chances of survival are enhanced.

Judging from the number of ticks recovered, the bontebok is apparently a better host of *R. nitens* than the vaal ribbok. However, an important factor in the determination of host suitability is the number of female ticks that are able to engorge and mature on the host. Thus, although the bontebok may be the preferred host of *R. nitens*, the vaal ribbok appears to be the effective host, as it allows more females to mature. The latter fact may be entirely due to the physical attributes of the 2 antelope species. The bontebok has short, fairly coarse hair which would probably facilitate the dislodging of engorging female ticks during grooming. In contrast, the vaal ribbok has fairly long, fine, dense hair.

The seasonal occurrence and morphology of *R. nitens* is similar to that of *Rhipicephalus appendiculatus*. Howell *et al.* (1978) making use of Theiler's (1962) distribution data, show *R. appendiculatus* as occurring in the south-western Cape Province and thus overlapping the distribution of *R. nitens*. In our experience, *R. appendiculatus* does not occur in this region, and its southern distribution probably does not extend west much past 25° East.

***Rhipicephalus* sp.**

Adult ticks of this species were recovered mainly from around the feet and on the lower legs of vaal ribbok and bontebok and were present from April–August 1983.

Lice

The lice on the bontebok and scrub hares have been identified only to generic level. According to Ledger (1980), there is still doubt as to the identity of the *Damalinia* and *Linognathus* species infesting bontebok, and he has listed no lice from the scrub hare.

In both antelope species, the juveniles generally harboured more lice than the older animals. Chalmers & Charleston (1980) recorded the same phenomenon for *Damalinia bovis* and *Linognathus vituli* on cattle in New Zealand, and Horak, De Vos & Brown (1983) made similar observations on young blue wildebeest calves and those a year older. Only *Damalinia pelea* on the older vaal ribbok exhibited a clear pattern of seasonal abundance being more numerous from April–August with a peak in June. Horak, De Vos & Brown (1983) found that *Damalinia theileri* and *Linognathus* species peaked on blue wildebeest in the Kruger National Park during autumn and during spring. This preference for the cooler months of the year confirms Murray & Gordon's (1969) observations for *Damalinia ovis* on sheep in Australia and those of Chalmers & Charleston (1980) for cattle lice in New Zealand.

Oestrid fly larvae

***Gedoelstia* sp.**

Flies of this genus normally deposit their larvae on the eyes of their hosts, whence they migrate by various routes to the nasal passages and sinuses (Basson, 1966; Horak & Butt, 1977).

Accidental infestations of domestic stock with larvae of this genus may result in severe ocular lesions (Basson, 1962). The 1st stage larvae recovered from the vaal ribbok must be regarded as accidental infestations of an abnormal host and, although ocular lesions were present in several of these animals, larvae were recovered from the corneas of only 3. It is the experience of one of us (I.G.H.) that *Gedoelstia* sp. larvae are seldom recovered from severely affected eyes.

Some of the young bontebok exhibited ocular lesions, but none of the older ones did. The recovery of 1st stage *Gedoelstia* sp. larvae from the eyes, the heart chambers and the nasal passages of the bontebok, while none were found on the dura mater, indicates that the infestation followed an oculo-vascular route to the nasal cavity rather than an oculo-cranial route (Basson, 1966; Horak & Butt, 1977). The small number of larvae recovered from the eyes compared with the fairly large number in the heart suggests that the larvae may spend some time in the heart. A similar phenomenon has been noticed with *Gedoelstia* species infesting blue wildebeest, where the 1st stage larvae seemed to accumulate on the dura mater before migrating to the nasal cavity (Horak, De Vos & Brown, 1983).

The recovery of 1st stage larvae from the eyes of bontebok during most months of the survey indicates that in

the Bontebok National Park the life cycle continues throughout the year and thus no clear pattern of seasonal abundance can be determined. It is our experience, and that of the park warden, however, that most eye problems occur in vaal ribbok during December each year, an indication of a peak of fly activity at this time.

Oestrus ovis

Bedford (1926) lists sheep and goats as hosts of *O. ovis*, and he also mentions that he had recently received some larvae of this fly collected from vaal ribbok. Zumpt (1965) states that only domestic sheep and goats and certain of their close wild relatives are hosts of this parasite. We agree with Zumpt: although one of us (I.G.H.) has examined hundreds of antelope of several species for oestrid larvae, the vaal ribbok is the only animal he has found to be infested with *O. ovis*. We feel that the vaal ribbok is only an accidental host of these larvae because, although the larvae are able to mature they all seem to die before leaving the nasal passages. This is possibly due to the cranial anatomy of the vaal ribbok which has very small frontal sinuses, not extending into the horns, and comparatively large maxillary and palatine sinuses. The 3rd stage larvae, which normally mature in the frontal sinuses of sheep (Cobbett & Mitchell, 1941), crawl into the maxillary and palatine sinuses of the vaal ribbok probably because of the lack of space in the frontal sinuses. Here they mature, but being then unable to escape, subsequently die. All the dead larvae were recovered from these sinuses.

The infestation in the vaal ribbok originates from sheep which often graze in large numbers right up to the perimeter of the park.

***Strobiloestrus* sp.**

According to Zumpt's (1965) host list, the larvae recovered from the vaal ribbok are likely to be *Strobiloestrus clarkii*. Only 2 adult flies of this species are known, both of which were caught in the Cape Province during the last century. No specific identification of the larvae recovered from the hides of the vaal ribbok could be made, as we were unable to rear flies from the 3rd stage larvae we had collected.

The vaal ribbok are natural hosts of larvae of this fly, as not only were most of them infested, but the larvae were able to mature and leave their hides to pupate. We assume this process took place between June and August because of the large number of nearly mature 3rd stage larvae recovered in June. The animals examined in August harboured no larvae but had lesions where the larvae had previously been located. The bontebok is an accidental host of this parasite and becomes infested only because of its close association with vaal ribbok in the park. Accidental infestations have been recorded in cattle (Horak & Boomker, 1981) and Merino sheep (Brain, Van der Merwe & Horak, 1983) running with klipspringers and mountain reedbuck respectively, both of which are hosts of *Strobiloestrus clarkii* (Zumpt, 1965).

The life cycle and seasonal occurrence of *Strobiloestrus* sp. infesting the vaal ribbok in the Bontebok National Park is similar to that of *Hypoderma lineatum* infesting cattle in the Northern Hemisphere. *H. lineatum* adults lay eggs attached to the hair of cattle during the northern spring and summer. The 1st stage larvae, which hatch from these eggs, migrate by various routes to the subcutaneous tissue of the backs of the cattle, which they reach about 4 weeks after hatching. Here they moult to the 2nd and 3rd stages before leaving the skins during spring to pupate in the soil (Zumpt, 1965).

Strobiloestrus sp. flies probably attach their eggs to the hair of the vaal ribbok during September and October (spring) and 1st stage larvae are found in the subcutaneous tissue of the back during December. We were unable to determine whether these larvae had migrated there from other sites or had penetrated the skin directly above them, after hatching from the egg. These larvae moult to the 2nd stage during December and by February all are in this stage of development. The 2nd stage larvae moult to the 3rd stage during May and June (autumn and winter), and the latter larvae leave the skin to pupate during June and July (winter), so that the animals are free of infestation in August. One of us (I.G.H.) has found that in regions with relatively cold winters the 1st oestrid flies to hatch after winter (*O. ovis*, *Oestrus variolosus* and *G. hassleri*) do so towards the end of September and at the beginning of October (Horak, 1977; Horak & Butt, 1977). We suggest that the same occurs with *Strobiloestrus* sp. in the park. Only 1 life cycle a year is possible.

ACKNOWLEDGEMENTS

We wish to thank the National Parks Board for placing the animals and facilities in the Bontebok National Park at our disposal.

The research was funded by the Meat Board, Rhodes University, the Council for Scientific and Industrial Research and the National Parks Board.

We gratefully acknowledge the assistance of the Park Warden, Mr E. Fourie and his staff and Mr P. Beukes of the University of Stellenbosch with the processing of the necropsies, also the technical assistance of Mrs Valerie A. Horak and Mr E. J. Williams.

Dr Jane B. Walker assisted with the identification of the ticks, particularly *R. gertrudae* and *R. nitens*, and drew our attention to the work of Morel on the distribution of the latter tick. She also very kindly supplied laboratory-reared specimens of the immature stages of *H. truncatum* and *I. pilosus*. Mr I. T. P. Pajor assisted with the identification of the fleas.

The graphs were drawn by Mrs Shelley Beuthin.

REFERENCES

BASSON, P. A., 1962. Studies on specific oculo-vascular myiasis (uitpeuloog). III. Symptomatology, pathology, aetiology and epizootiology. *Onderstepoort Journal of Veterinary Research*, 29, 211–240.

BASSON, P. A., 1966. Gedoelstial myiasis in antelopes of southern Africa. *Onderstepoort Journal of Veterinary Research*, 33, 77–91.

BEDFORD, G. A. H., 1926. Check-list of the Muscidae and Oestridae which cause myiasis in man and animals in South Africa. *Report of the Director of Veterinary Education and Research*, 11/12, 483–491.

BOOMKER, J., HORAK, I. G. & DE VOS, V., 1981. *Paracooperiodes peleae* gen. et sp. n. (Nematoda: Trichostrongylidae) from the vaal ribbok, *Pelea capreolus* (Forster, 1790). *Onderstepoort Journal of Veterinary Research*, 48, 169–174.

BOOMKER, J., HORAK, I. G., GIBBONS, LYNDA M. & DE, VOS, V., 1983. *Haemonchus contortus* from the vaal ribbok, *Pelea capreolus*, and the bontebok, *Damaliscus dorcas dorcas*, in the Bontebok National Park. *Onderstepoort Journal of Veterinary Research*, 50, 179–181.

BRAIN, VIRGINIA, VAN DER MERWE, H. ELIZE & HORAK, I. G., 1983. *Strobiloestrus* sp. larvae in Merino sheep. *Journal of the South African Veterinary Association*, 54, 185–186.

CHALMERS, KERRY & CHARLESTON, W. A. G., 1980. Cattle lice in New Zealand: Observations on the prevalence, distribution and seasonal patterns of infestation. *New Zealand Veterinary Journal*, 28, 198–200.

CLIFFORD, C. M., FLUX, J. E. C. & HOOGSTRAAL, H., 1976. Seasonal and regional abundance of ticks (Ixodidae) on hares (Leporidae) in Kenya. *Journal of Medical Entomology*, 13, 40–47.

COBBETT, N. G. & MITCHELL, W. C., 1941. Further observations on the life cycle and incidence of the sheep bot, *Oestris ovis* in New Mexico and Texas. *American Journal of Veterinary Research*, 2, 358–366.

HOOGSTRAAL, H., 1956. African Ixodoidea. I. Ticks of the Sudan (with special reference to Equatoria Province and with preliminary reviews of the genera *Boophilus*, *Margaropus* and *Hyalomma*).

Department of the Navy Bureau of Medicine and Surgery, Washington DC. 1101 pp.

HOOGSTRAAL, H. & EL KAMMAH, K. M., 1972. Notes on African *Haemaphysalis* ticks. X. *H.(Kaiseriana) aciculifer* Warburton and *H.(K.) rugosa* Santos Dias, the African representatives of the *spinigera* subgroup (Ixodoidea: Ixodidae). *Journal of Parasitology*, 58, 960–978.

HORAK, I. G., 1977. Parasites of domestic and wild animals in South Africa. I. *Oestrus ovis* in sheep. *Onderstepoort Journal of Veterinary Research*, 44, 55–64.

HORAK, I. G. & BUTT, M. J., 1977. Parasites of domestic and wild animals in South Africa. III. *Oestrus* spp. and *Gedoelstia hassleri* in the blesbok. *Onderstepoort Journal of Veterinary Research*, 44, 113–118.

HORAK, I. G. & BOOMKER, J., 1981. *Strobiloestrus* sp. larvae in cattle. *Journal of the South African Veterinary Association*, 52, 211–212.

HORAK, I. G., MELTZER, D. G. A. & 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., 1982. Parasites of domestic and wild animals in South Africa. XV. The seasonal prevalence of ectoparasites on impala and cattle in the northern Transvaal. *Onderstepoort Journal of Veterinary Research*, 49, 85–93.

HORAK, I. G., BROWN, MOIRA R., BOOMKER, J., DE VOS, V. & VAN ZYL,, ELSA A., 1982. Helminth and arthropod parasites of blesbok, *Damaliscus dorcas phillipsi*, and of bontebok *Damaliscus dorcas dorcas*. *Onderstepoort Journal of Veterinary Research*, 49, 139–146.

HORAK, I. G., DE VOS, V. & DE KLERK, B. D., 1982. Helminth and arthropod parasites of vaal ribbok, *Pelea capreolus* in the western Cape Province. *Onderstepoort Journal of Veterinary Research*, 49, 147–148.

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. & FOURIE, L. J., 1986. Parasites of domestic and wild animals in South Africa. XIX. Ixodid 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, 127–152.

HOWELL, C. J. WALKER, JANE B. & NEVILL, E. M., 1978. Ticks, mites and insects infesting domestic animals in South Africa. Part 1. Descriptions and biology. *Department of Agricultural Technical Services, Republic of South Africa, Science Bulletin* No. 393, v + 69 pp.

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.

LEDGER, J. A., 1980. The arthropod parasites of vertebrates in Africa south of the Sahara. Volume IV. Phthiraptera (Insecta). Publication No. 56 of the South African Institute for Medical Research, Johannesburg.

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.

MACLEOD, J., 1970. Tick infestation patterns in the southern province of Zambia. *Bulletin of Entomological Research*, 60, 253–274.

MALAN, F. S., REINECKE, R. K. & SCIALDO, ROSINA C., 1981. The recovery of helminths post-mortem from equines. II. Helminths and larvae of *Gasterophilus* from the gastro-intestinal tract and oestrids from the sinuses. *Onderstepoort Journal of Veterinary Research*, 48,145–147.

MINSHULL, JACQUELINE I., 1981. Seasonal occurrence, habitat distribution and host range of four ixodid tick species at Kyle Recreational Park in south eastern Zimbabwe. *Zimbabwe Veterinary Journal*, 12, 58–63.

MOREL, P. C., 1969. Contribution á la connaisance de la distribution des tiques (Acariens, Ixodidae et Amblyommidae) en Afrique ethiopienne continentale. Annexe cartographique, cartes 1–62. Institut d' Élevage et de Médecine Vétérinaire des Pays Tropicaux, Maisons-Alfort.

MURRAY, M. D. & GORDON, G., 1969. Ecology of lice on sheep. VII. Population dynamics of *Damalinia ovis* (Schrank). *Australian Journal of Zoology*, 17, 179–186.

NORVAL, R. A. I., 1974. Copulation and feeding in males of *Ixodes pilosus* Koch 1844 (Acarina: Ixodidae). *Journal of the Entomological Society of Southern Africa*, 37, 129–133.

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.

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.

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 + map.

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

VERSTER, ANNA, IMES, G. D. & SMIT, J. P. J., 1975. Helminths recovered from the bontbok, *Damaliscus dorcas dorcas* (Pallas, 1766). *Onderstepoort Journal of Veterinary Research*, 42, 29–31.

ZUMPT, F., 1965. Myiasis in man and animals in the Old World. London: Butterworths.