

## Ecto- and endoparasites of introduced gemsbok in the Orange Free State

L.J. Fourie \*, S. Vrahimis, I.G. Horak, H.J. Terblanche and O.B. Kok

L.J. Fourie & O.B. Kok, Department of Zoology & Entomology, University of the Orange Free State,  
P.O. Box 339, Bloemfontein, 9300 Republic of South Africa

S. Vrahimis & H.J. Terblanche, Directorate of Nature and Environmental Conservation,  
P.O. Box 517, Bloemfontein, 9300

I.G. Horak, Faculty of Veterinary Science, University of Pretoria, Onderstepoort, 0110

Received 7 March 1991; accepted 20 June 1991

The gemsbok, *Oryx gazella*, is an introduced species in the Orange Free State. Two antelope were shot each month in the Willem Pretorius Nature Reserve from February 1987 to January 1988 in order to determine their parasitic burdens. Although none of the gemsbok harboured large burdens, nine ixodid tick species, two louse species, 17 nematode species and a cestode species were recovered. *Margaropus winthemi*, which was mainly present from July to September, was the most abundant tick, followed by *Rhipicephalus evertsi evertsi*, which showed no clear pattern of seasonal abundance. Young antelope harboured significantly greater numbers of the sucking louse *Linognathus oryx* than did older animals. *Trichostrongylus falculatus* was the most numerous nematode, followed by *Cooperia fuelleborni*. No pattern of seasonal abundance was evident for any of the helminths.

Die gemsbok *Oryx gazella* is 'n uitheemse spesie in die Oranje-Vrystaat. Twee gemsbokke is op 'n maandelikse basis in die Willem Pretoriuswildtuin vanaf Februarie 1987 tot Januarie 1988 versamel ten einde hul parasietladings te bepaal. Alhoewel geen individu besondere hoë ladings gehad het nie is nege verskillende skildbosluisspesies, twee luisspesies, 17 rondewurmspesies en 'n lintwurmspesie herwin. *Margaropus winthemi*, wat hoofsaaklik vanaf Julie tot September op die bokke voorgekom het, was die volopste, gevolg deur *Rhipicephalus evertsi evertsi*, wat geen duidelike seisoenale voorkoms getoon het nie. Jong bokke het betekenisvol meer bloedsuiende luise *Linognathus oryx* vergeleke met ouer bokke gehuisves. *Trichostrongylus falculatus* was die volopste rondewurms. Geen patroon van seisoenale voorkoms is deur enige van die helminte getoon nie.

**Keywords:** Ecto- and endoparasites, *Oryx gazella*, antelope, introduced species

\* To whom correspondence should be addressed

### Introduction

The natural distribution of gemsbok, *Oryx gazella* was confined to the more arid regions of southern Africa, principally in the central north-western and northern Cape, as well as in Botswana and Namibia (Du Plessis 1969). This antelope has, however, been introduced into many regions of southern Africa and it is now widely distributed (Terblanché 1988; Fourie & Vrahimis 1989). It failed to thrive in several regions into which it had been introduced and parasites may play a role in this (Horak, Potgieter, Walker, De Vos & Boomker 1983a; Fourie & Vrahimis 1989).

According to available empirical evidence on parasite-induced mortality, the probability of a host dying within a given time can be related to its parasitic burden (Anderson 1979). Where it is suspected that parasites may be the cause of host mortality, quantification of parasitic burdens should be a basic prerequisite. This paper describes the quantitative and qualitative aspects of the parasite populations associated with introduced gemsbok in the Willem Pretorius Nature Reserve. An attempt was made to elucidate the reasons for the slow population growth of gemsbok within this reserve. No previous work on the parasite loads of any of the mammal species within this reserve has been published.

### Materials and Methods

#### Study area

The Willem Pretorius Nature Reserve (28° 16' – 28° 21'S;

27° 07' – 27° 23'E, altitude 1 375–1 510 m) is located approximately 30 km north-east of the town Winburg in the Orange Free State, Republic of South Africa. In area the reserve comprises 12 091 ha, of which the Allemanskraal Dam, when full, covers 2 742 ha.

The climate is characterized by dry, cold winters and generally warm to hot summers. Frost occurs from mid-May to mid-October with 100–150 frost days per year (Bourquin 1973). The mean annual rainfall is 520,8 mm of which 75% occurs between October and April (Bourquin 1973).

The reserve lies in Transitional *Cymbopogon-Themedra* veld (Acocks 1975), and can be divided into four basic vegetation types (Müller 1986). These are:

- (i) Tree and shrub community of the hilly areas (10,0% of area);
- (ii) Grassland community of the hilly areas (11,3% of area);
- (iii) Grassland community of the plains (67,1% of area);
- (iv) Thornveld (11,6%).

Information on the variety of game species, abundance, as well as whether introduced or naturally occurring, is summarized in Table 1.

#### Survey animals

Two gemsbok were shot monthly from February 1987 to January 1988 for the collection of external and internal parasites. An attempt was made on each occasion to shoot at

**Table 1** Large animals present in the Willem Pretorius Nature Reserve during 1988

Species	Number	Status
Black wildebeest ( <i>Connochaetes gnou</i> )	474	Reintroduced
Eland ( <i>Taurotragus oryx</i> )	104	Reintroduced
White rhinoceros ( <i>Ceratotherium simum</i> )	16	Reintroduced?
Blesbok ( <i>Damaliscus dorcas</i> <i>phillipsi</i> )	762	Reintroduced
Red hartebeest ( <i>Alcelaphus</i> <i>buselaphus caama</i> )	161	Reintroduced
Springbok ( <i>Antidorcas</i> <i>marsupialis</i> )	943	Reintroduced
Burchell's zebra ( <i>Equus</i> <i>burchelli</i> )	118	Reintroduced
Gemsbok ( <i>Oryx gazella</i> )	135	Introduced
Mountain reedbuck ( <i>Redunca fulvorufa</i> )	200	Present at all times
Ostrich ( <i>Struthio camelus</i> )	210	Reintroduced
Impala ( <i>Aepyceros melampus</i> )	152	Introduced
Buffalo ( <i>Syncerus caffer</i> )	160	Reintroduced?
Kudu ( <i>Tragelaphus</i> <i>strepsiceros</i> )	28	Reintroduced
Giraffe ( <i>Giraffa</i> <i>camelopardalis</i> )	45	Introduced

Reintroduced? = Status uncertain

random one juvenile (horns < 300 mm and coat colour brown or with adult colouring) or sub-adult (adult colouring with horn length and body size approximately three quarters of that of adults), as well as one adult. Twenty-four gemsbok (11 calves, 2 sub-adults and 11 adults) were examined. All were shot in the neck to prevent damage to the brain or to the heart and lungs, which were required for parasite recovery.

The carcasses were transported to a laboratory as soon as possible after death to prevent the loss of external parasites. On arrival the carcasses were weighed to the nearest kilogram.

#### Parasite recovery

At the laboratory the animals were skinned and eviscerated. The skins were processed for ectoparasite recovery as described by Horak, Meltzer & De Vos (1982) and the nasal passages and sinus cavities for the recovery of oestrid larvae as described by Malan, Reinecke & Krecek (1981).

The ticks, lice and oestrid larvae recovered were counted and identified under a stereoscopic microscope. The lungs and gastro-intestinal tracts were processed for helminth recovery and the worms were counted as described by Horak, De Vos & Brown (1983b).

Parasite densities (n/kg) were determined by dividing the total number of ecto- and endoparasites recovered from each animal by the live mass of the animal.

#### Kidney fat index

The physiological condition of the animals was determined by using the kidney fat index (Smith 1970):

$$\text{Kidney fat index} = \frac{\text{Weight of perinephric fat}}{\text{Kidney weight}} \times 100$$

Correlations between kidney fat index and parasite densities were performed.

#### Data analysis

The comparisons of means and variances were conducted using *t*-tests on transformed data (Petney, Van Ark & Spickett 1990).

### Results

#### Ectoparasites

Nine ixodid tick species and two louse species were recovered (Table 2). *Margaropus winthemi* was the most abundant tick and the only one for which a clear pattern of seasonal abundance could be determined. The largest numbers were present from July to September. *Rhipicephalus evertsi evertsi* was the second most abundant and although it occurred throughout the year, the largest numbers of immatures were present from February to May and from Decem-

**Table 2** The total numbers of ectoparasites recovered from 24 gemsbok in the Willem Pretorius Nature Reserve

Ectoparasite	Number recovered					Number of animals infested
	Larvae	Nymphs	Males	Females	Total	
<b>Ticks</b>						
<i>Amblyomma marmoreum</i>	457	11	0	0	468	14
<i>Hyalomma marginatum rufipes</i>	0	0	50	20	70	11
<i>Hyalomma truncatum</i>	0	0	23	3	26	6
<i>Ixodes rubicundus</i>	0	0	1	2	3	3
<i>Margaropus winthemi</i>	2128	3912	7249	2797	16086	16
<i>Rhipicephalus evertsi evertsi</i>	3737	806	283	161	4987	24
<i>Rhipicephalus foliis</i>	0	0	12	27	39	4
<i>Rhipicephalus gertrudae</i>	0	0	50	13	63	7
<i>Rhipicephalus punctatus</i>	0	0	35	5	40	6
<b>Lice</b>						
		Nymphs	Adults	Total		
<i>Damalinia</i> sp.		0	9	9		7
<i>Linognathus oryx</i>		382	3499	3881		22

ber to January while adults were present during March, September and November.

The larvae of *Amblyomma marmoreum* were most abundant from February to April. *Hyalomma marginatum rufipes* was erratically present throughout the year whereas *Hyalomma truncatum* was recovered only from July to January 1988. Adults of *Rhipicephalus foliis* and *Rhipicephalus gertrudae* were erratically present in small numbers from September to December.

Significantly more sucking lice *Linognathus oryx* were recovered from the calves and sub-adults than from adult gemsbok ( $t = 2,97$ ;  $df = 22$ ;  $p < 0,05$ ).

### Helminths

The numbers and species of helminths recovered are presented in Table 3. Although the numbers of helminths recovered were not particularly large, 17 nematode species, one cestode and the larvae of another cestode were recovered. *Trichostrongylus falculatus* was the most abundant followed by *Cooperia fuelleborni*. No clear pattern of seasonal abundance was evident for any of the helminth species.

### Parasite densities and condition

The parasite densities of the gemsbok belonging to the various age categories are presented in Table 4. No seasonal trends in these densities were discernible. A comparison between the parasite densities of calves and sub-adults

**Table 3** The total numbers of helminths recovered from 24 gemsbok in the Willem Pretorius Nature Reserve

Helminths	Number recovered			Number of animals infected
	4th stage	Adults	Total	
<b>Nematodes</b>				
<i>Agriostomum equidentatum</i>	0	2	2	1
<i>Cooperia/Paracooperia</i> spp.	30	—	30	1
<i>Cooperia fuelleborni</i>	—	8914	8914	13
<i>Cooperia hungi</i>	—	60	60	1
<i>Cooperia neitzi</i>	—	150	150	2
<i>Cooperia yoshidae</i>	—	3864	3864	14
<i>Dictyocaulus</i> sp.	0	3	3	2
<i>Haemonchus</i> spp.	125	—	125	4
<i>Haemonchus bedfordi</i>	—	23	23	2
<i>Haemonchus contortus</i>	—	943	943	15
<i>Haemonchus mitchelli</i>	—	25	25	1
<i>Impalaia tuberculata</i>	60	2502	2562	9
<i>Longistronchylus sabie</i>	0	221	221	7
<i>Oesophagostomum</i> sp.	30	31	61	3
<i>Paracooperia serrata</i>	—	91	91	3
<i>Strongyloides</i> sp.	0	145	145	4
<i>Trichostrongylus axei</i>	0	255	255	7
<i>Trichostrongylus falculatus</i>	0	18485	18485	16
<i>Trichuris</i> sp.	0	187	187	12
<b>Cestodes</b>				
	Larvae	Scolices	Total	
<i>Moniezia</i> sp.	*	25	25	5
<i>Taenia hydatigena</i>	4	*	4	2

\* = Not recovered in ruminants

**Table 4** The parasite densities and kidney fat indices of 24 gemsbok in the Willem Pretorius Nature Reserve

Date	Age category	Sex	Parasite density *	Kidney fat index
February 1987	Calf	M	13,69	26,2
	Adult	M	20,73	36,5
March	Calf	F	7,44	26,5
	Adult	F	13,54	85,6
April	Calf	M	10,68	12,1
	Adult	M	14,39	20,2
May	Calf	M	21,69	47,9
	Adult	M	16,44	39,1
June	Calf	F	4,04	23,0
	Adult	M	51,44	44,7
July	Sub-adult	M	35,35	15,2
	Adult	M	35,30	7,6
August	Calf	M	18,72	12,0
	Adult	F	22,88	25,9
September	Calf	F	3,95	15,4
	Adult	M	34,88	16,8
October	Calf	F	32,05	18,8
	Calf	M	5,52	26,9
November	Sub-adult	M	31,98	16,6
	Adult	M	12,52	9,9
December	Calf	F	8,26	19,7
	Adult	F	2,32	25,4
January 1988	Calf	F	7,35	24,6
	Adult	M	36,05	24,3

\* Parasite density = Total number of ecto- and endoparasites recovered/kg host live mass

(grouped together) and those of adults showed no significant differences ( $t = 1,40$ ;  $df = 22$  and  $p > 0,1$ ).

Only one kidney fat index rating in excess of 50 was recorded (Table 4). The lowest kidney fat index ratings were recorded during July to November when most values were below 25.

There was no significant correlation between parasite density and kidney fat index.

### Climate

Total monthly rainfall exceeded 50 mm during February, September, November and December. The lowest mean minimum temperatures were recorded from June to August and the highest maxima from February to April and October to January.

### Discussion

Although no individual gemsbok was particularly heavily infested with large numbers of parasites, a wide variety of species was recovered.

### Ixodid ticks

#### *Amblyomma marmoreum*

Tortoises are the preferred hosts of the adults of this tick but the immature stages can be found on reptiles, birds and

mammals (Petney, Horak & Rechav 1987). Their presence on the gemsbok is thus not unexpected. The period of maximum larval and nymphal abundance on the antelope corresponds to that observed by Norval (1975) in the eastern Cape Province.

#### *Hyalomma* spp.

As was the case with sheep and cattle on the farm 'Preezfontein' in the south-western Orange Free State (Fourie, Horak & Marais 1988b; Fourie & Horak 1990), *H. marginatum rufipes* was more abundant than *H. truncatum* on the gemsbok. Peak abundance on the domestic stock on the farm occurred between November and February or April but ticks were erratically present in small numbers on the gemsbok almost throughout the year.

Although only small numbers of *H. truncatum* were present, it was recovered from at least one gemsbok during each month from October to January. The largest numbers of this tick were present on the cattle on 'Preezfontein' during September and from November to January (Fourie & Horak 1990).

#### *Margaropus winthemi*

This is a one-host tick reaching peak numbers during the winter months (Howell, Walker & Nevill 1983; Horak, Knight & De Vos 1986). One of its original hosts was probably the Cape mountain zebra *Equus zebra zebra* but it has adapted to various large wild hosts as well as horses and cattle (Howell *et al.* 1978).

Burdens exceeding 30 000 ticks per animal have been recovered from Cape mountain zebras in the Mountain Zebra National Park during July (Horak *et al.* 1986). In the present survey the largest individual burdens were recorded on gemsbok during July, August and September, but these never exceeded 5 000 ticks.

#### *Ixodes rubicundus*

This tick can cause paralysis and subsequent mortality amongst domestic stock and wild ruminants, including gemsbok (Howell *et al.* 1983; Fourie & Vrahimis 1989). Burdens of between 0.26 and 2.12 female ticks/kg host mass have been recorded on paralysed gemsbok (Fourie & Vrahimis 1989). The recovery of only three ticks from the gemsbok examined during the present investigation probably indicates that the study region represents a marginal distribution area for the tick.

#### *Rhipicephalus* spp.

*Rhipicephalus evertsi evertsi* was the second most abundant tick collected. It prefers equids as hosts (Norval 1981; Horak *et al.* 1986), but has also been recovered from a large variety of other ungulates (Theiler 1962).

Adult female ticks of this species can cause paralysis, particularly amongst sheep lambs (Gothe & Bezuidenhout 1986). Odd cases of paralysis in adult sheep and calves have also been reported (Stampa 1959).

*Rhipicephalus follis*, although never present in very large numbers, has a fairly widespread distribution in South Africa. It occurred from December to April on bushbuck *Tragelaphus scriptus* in the Weza State Forest, Natal (Horak,

Keep, Spickett & Boomker 1989).

In Namibia, Biggs & Langenhoven (1984) found that adult ticks of the *Rhipicephalus capensis* group, in which *R. gertrudae* predominated, were present on cattle in substantial numbers from November to March. This is two months later than in the present survey.

*Rhipicephalus punctatus*, then referred to as *Rhipicephalus* sp. (near *Rhipicephalus pravus*), has recently been incriminated as a cause of paralysis in Angora goats (Fourie, Horak & Marais 1988a). This tick exhibited a major peak of abundance on sheep on the farm 'Preezfontein' during February and a minor peak during August (Fourie *et al.* 1988b). On cattle on the same farm it was present during January and April, and from September to November (Fourie & Horak 1990). With the exception of the two females recovered during May, the seasonal abundance of this tick on the gemsbok was reasonably similar to that found on the cattle on 'Preezfontein'. We do not know whether larger numbers of this tick than presently recovered could cause paralysis of gemsbok or not.

#### Lice

Few gemsbok were infested with *Damalinia* sp., and those that were, harboured only one or two lice. Since these lice feed mainly on skin debris (Nelson, Keirans, Bell & Clifford 1975) it is unlikely that they would have a detrimental effect, unless they occurred in very large numbers.

The significantly larger burdens of the blood-sucking louse *L. oryx* on the young gemsbok, when compared with those of the adult animals, are similar to results obtained for sucking lice on rock dassies *Procavia capensis* (Fourie, Horak & Visser 1987). A possible reason for this disparity in burdens may be that the physical nature of the juvenile skin favours the feeding of these lice.

#### Helminths

##### *Nematodes*

With a single exception, namely the sub-adult animal examined during November, young gemsbok harboured fewer nematodes than did adult animals (Table 2). These differences were significant. The reasons for these differences could be two-fold. First, several of the calves examined were still suckling and were therefore not exposed to the same extent to infective nematode larvae as were the older animals. Second, except for four months, rainfall was low and hence veld contamination was probably also low. This is confirmed by the small numbers of fourth stage larvae recovered from the antelope, indicating that little infection had been acquired from the grazing. The higher burdens in the adult animals were probably the result of the survival of earlier infections and the gradual acquisition of new infections. Infections in all age groups were very low and would probably not have any deleterious effects.

Most of the nematodes recovered probably originally emanated from other host species, both from within and outside the reserve but may also be parasites of gemsbok. Thus *Haemonchus contortus* and *Trichostrongylus axei* are primarily parasites of sheep; *Cooperia hungi*, *Longistongylus sabie* and *Impalaia tuberculata* parasites of impala; *Cooperia yoshidai* of blesbok (Horak 1981); *Agriostomum*

*equidentatum* and *Paracooperia serrata* of springbok (Horak *et al.* 1982); *Haemonchus bedfordi* of blue wildebeest and black wildebeest (Horak *et al.* 1983b) and *Cooperia neitzi* of kudu (Boomker, Horak & De Vos 1989). *Trichostrongylus falculatus* prefers a fairly dry habitat (Horak 1981) and this would overlap the habitat preferences of gemsbok resulting in a stable host-parasite relationship. The same possibly also applies to *Cooperia fuelleborni*.

### Cestodes

Two gemsbok harboured *Cysticercus tenuicollis*, the larval stage of *Taenia hydatigena*. These cysts had probably been acquired from jackals, which are one of the host species of the adult worms (Reinecke 1983), from within the reserve.

*Moniezia* sp. was recovered only from the calves (Table 2). This is similar to the observations made on blue wildebeest *Connochaetes taurinus*, the adult animals becoming resistant to infection (Horak *et al.* 1983b).

### General

This study was initiated as part of an investigation to determine the reasons for the low population growth of gemsbok in the reserve, but no evidence that parasites are responsible could be found. As no data are available on the parasite burdens of other animals in the reserve, no comparisons on the relative levels of parasite infection can be made. Nevertheless, the gemsbok were infected with a large variety of tick and nematode species, many of which do not occur in the natural habitat of the antelope (Howell *et al.* 1983; Horak 1981). Although the parasite burdens were never very high, the potential always exists that under more favourable conditions, large burdens with concurrent detrimental effects could develop. In addition, because of the numerous parasite species harboured by the gemsbok, they could always serve as a source or reservoir of infection.

### Acknowledgements

We thank the Directorate of Nature and Environmental Conservation of the Orange Free State for permission to conduct this investigation, for the assistance of their staff, and for the use of facilities at the Willem Pretorius Nature Reserve. The assistance of D.P. Coetzee, H.F. Prinsloo, S.W. van Ee and C. Winterbach who shot and processed the antelope, and Santa Meyer, Hillary Stern and L. Barkhuizen who counted the parasites, is gratefully acknowledged. This research was funded by the Directorate of Nature and Environmental Conservation of the Orange Free State, the University of the Orange Free State, the University of Pretoria, the Foundation for Research Development, and Bayer Animal Health.

### References

- ACOCKS, J.P.H. 1975. Veld types of South Africa. *Mem. bot. Surv. S. Afr.* 2nd edn No. 40. 128pp.
- ANDERSON, R.M. 1979. The influence of parasitic infection on the dynamics of host population growth. In: *Population Dynamics*. (Eds) Anderson, R.M., Turner, B.D. & Taylor, L.R. Blackwell Scientific Publications, Oxford.
- BIGGS, H.C. & LANGENHOVEN, J.W. 1984. Seasonal prevalence of ixodid ticks on cattle in the Windhoek District of South West Africa/Namibia. *Onderstepoort J. vet. Res.* 51: 175-182.
- BOOMKER, J., HORAK, T.G. & DE VOS, V. 1989. Parasites of South African wildlife. IV. Helminths of kudu, *Tragelaphus strepsiceros*, in the Kruger National Park. *Onderstepoort J. vet. Res.* 56: 111-121.
- BOURQUIN, O. 1973. Utilization and aspects of management of the Willem Pretorius Game Reserve. *J. sth. Afr. Wildl. Mgmt Ass.* 3: 65-73.
- DU PLESSIS, S.F. 1969. The past and present geographical distribution of the Perissodactyla and Artiodactyla in southern Africa. M.Sc. thesis, University of Pretoria, Pretoria.
- FOURIE, L.J. & HORAK, I.G. 1990. Parasites of cattle in the south-western Orange Free State. *Jl S. Afr. vet. Ass.* 61: 27-28.
- FOURIE, L.J., HORAK, I.G. & MARAIS, L. 1988a. An undescribed *Rhipicephalus* species associated with field paralysis of Angora goats. *Jl S. Afr. vet. Ass.* 59: 47-49.
- FOURIE, L.J., HORAK, I.G. & MARAIS, L. 1988b. The seasonal abundance of adult ixodid ticks on Merino sheep in the south-western Orange Free State. *Jl S. Afr. vet. Ass.* 59: 191-194.
- FOURIE, L.J., HORAK, I.G. & VISSER, E.L. 1987. Quantitative and qualitative aspects of the parasite burdens of rock dassies (*Procavia capensis* Pallas, 1766) in the Mountain Zebra National Park. *S. Afr. J. Zool.* 22: 101-106.
- FOURIE, L.J. & VRAHIMIS, S. 1989. Tick-induced paralysis and mortality of gemsbok. *S. Afr. J. Wildl. Res.* 19: 118-121.
- GOTHE, R. & BEZUIDENHOUT, J.D. 1986. Studies on the ability of different strains or populations of female *Rhipicephalus evertsi evertsi* to produce paralysis in sheep. *Onderstepoort J. vet. Res.* 53: 19-24.
- HORAK, I.G. 1981. Host specificity and the distribution of the helminth parasites of sheep, cattle, impala and blesbok according to climate. *Jl S. Afr. vet. Ass.* 52: 201-206.
- HORAK, I.G., DE VOS, V. & BROWN, M.R. 1983b. 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 J. vet. Res.* 50: 243-255.
- HORAK, I.G., KEEP, M.E., SPICKETT, A.M. & BOOMKER, J. 1989. Parasites of domestic and wild animals in South Africa. XXIV. Arthropod parasites of bushbuck and common duiker in the Weza State Forest, Natal. *Onderstepoort J. vet. Res.* 56: 63-66.
- 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 J. vet. Res.* 53: 127-132.
- HORAK, I.G., MELZER, D.G.A. & DE VOS, V. 1982. Helminth and arthropod parasites of springbok, *Antidorcas marsupialis* in the Transvaal and western Cape Province. *Onderstepoort J. vet. Res.* 49: 7-10.
- HORAK, I.G., POTGIETER, F.T., WALKER, J.B., DE VOS, V. & BOOMKER, J. 1983a. The ixodid tick burdens of various large ruminant species in South African nature reserves. *Onderstepoort J. vet. Res.* 50: 221-228.
- HOWELL, C.J., WALKER, J.B. & NEVILL, E.M. 1983. Ticks, mites and insects infesting domestic animals in South Africa. Part 1. Descriptions and biology. *Sci. Bull. Dep. Agric. Wat. Supply Repub. S. Afr.* 393. 71 pp.

- MALAN, F.S., REINECKE, R.K. & KRECEK, R.C. 1981. The recovery of helminths post-mortem from equines. II. Helminths and larvae of *Gasterophilus* from the gastrointestinal tract and oestrids from the sinuses. *Onderstepoort J. vet. Res.* 48: 145–147.
- MÜLLER, D.B. 1986. Plantekologie van die Willem Pretorius Wildtuin. Unpubl. Ph.D. thesis, University of the Orange Free State, Bloemfontein.
- NELSON, W.A., KEIRANS, J.E., BELL, J.F. & CLIFFORD, C.M. 1975. Review article: Host-ectoparasite relationships. *J. med. Entomol.* 12: 143–166.
- NORVAL, R.A.I. 1975. Studies on the ecology of *Amblyomma marmoreum* Koch 1844 (Acarina: Ixodidae). *J. Parasit.* 61: 737–742.
- NORVAL, R.A.I. 1981. The ticks of Zimbabwe. III. *Rhipicephalus evertsi evertsi*. *Zimb. vet. J.* 12: 31–35.
- PETNEY, T.N., HORAK, I.G. & RECHAV, Y. 1987. The ecology of the African vectors of heartwater, with particular reference to *Amblyomma hebraeum* and *Amblyomma variegatum*. *Onderstepoort J. vet. Res.* 54: 381–395.
- PETNEY, T.N., VAN ARK, H. & SPICKETT, A.M. 1990. On sampling tick populations: The problem of overdispersion. *Onderstepoort J. vet. Res.* 57: 123–127.
- REINECKE, R.K. 1983. Veterinary Helminthology. Butterworths, Pretoria. 392 pp.
- SMITH, N.S. 1970. Appraisal of condition estimation methods for East African ungulates. *E. Afr. Wildl. J.* 8: 123–129.
- STAMPA, S. 1959. Tick paralysis in the Karoo areas of South Africa. *Onderstepoort J. vet. Res.* 28: 169–225.
- TERBLANCHE, H.J. 1988. The status and distribution of large game species in the Orange Free State. Unpublished annual report (N7/5/5) OFS Provincial Administration, Directorate of Environmental and Nature Conservation, Bloemfontein. 119 pp.
- THEILER, G. The Ixodoidea parasites of vertebrates in Africa south of the Sahara (Ethiopian Region). Report to the Director of Veterinary Services, Onderstepoort. 260 pp.