

ARTHROPOD PARASITES OF SPRINGBOK, GEMSBOK, KUDUS, GIRAFFES AND BURCHELL'S AND HARTMANN'S ZEBRAS IN THE ETOSHA AND HARDAP NATURE RESERVES, NAMIBIA

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ABSTRACT

HORAK, I. G., ANTHONISSEN, M., KRECEK, R. C. & BOOMKER, J., 1992. Arthropod parasites of springbok, gemsbok, kudus, giraffes and Burchell's and Hartmann's zebras in the Etosha and Hardap Nature Reserves, Namibia. *Onderstepoort Journal of Veterinary Research*, 59, 253–257 (1992)

A total of 48 springbok, 48 gemsbok, 23 kudus and 6 giraffes were examined for ticks and lice, while 9 Burchell's zebras and 6 Hartmann's mountain zebras were examined only for ticks. Springbok and gemsbok were shot in both the Etosha National Park in the north and the Hardap Nature Reserve in the south of Namibia. All the other animals were shot in the Etosha National Park.

A total of 7 ixodid tick species and 8 lice species were recovered. The springbok carried few ticks. The adults of a *Rhipicephalus* sp. (near *R. oculatus*) were most numerous on the gemsbok, especially during November. The kudus were the only animals harbouring *Rhipicephalus zambeziensis*. Adult *Hyalomma truncatum*, followed by adult *Hyalomma marginatum rufipes*, were most abundant on the giraffes and adult *Rhipicephalus evertsi mimeticus* were commonest on the zebras.

INTRODUCTION

The ixodid ticks found in Namibia have been listed by Theiler (1962). Her records were compiled after the identification of ticks that had generally been collected by stock inspectors, veterinarians, zoologists and other interested parties. These did not represent total collections of ticks from the animals examined.

In recent times more thorough collections of ticks have been made by examining animals of a particular species at regular intervals for periods of at least 1 year. Warthogs (*Phacochoerus aethiopicus*), Hartmann's mountain zebras (*Equus zebra hartmannae*) and cattle have been examined in Namibia in this way and 9 ixodid tick species recovered (Horak, Biggs, Hanssen & Hanssen, 1983; Horak, Biggs & Reinecke, 1984; Biggs & Langenhoven, 1984). In a recent review of ticks occurring in southern Africa, Walker (1991) lists 30 species from Namibia.

A number of animals of various species were to be shot in the Etosha National Park and the Hardap Nature Reserve, Namibia, for reproductive and biological studies, while others were to be killed for helminth recovery. This presented the opportunity to obtain ticks also from these animals and collections were made from springbok (*Antidorcas marsupialis*), gemsbok (*Oryx gazella*), kudus (*Tragelaphus strepsiceros*), giraffes (*Giraffa camelopardalis angolensis*), Burchell's zebras (*Equus burchelli antiqorum*) and Hartmann's mountain zebras. This paper records the ixodid tick burdens of these animals, and the lice burdens of the springbok, gemsbok and kudus. The helminths from the zebras, kudus and

giraffes have been reported elsewhere (Krecek, Reinecke & Malan, 1987; Boomker, Anthonissen & Horak, 1988; Krecek, Boomker, Penzhorn & Scheepers, 1990).

MATERIALS AND METHODS

Study sites

The localities at which the animals were shot are summarized in Table 1.

Survey animals

Springbok and gemsbok were shot in the Hardap Nature Reserve at approximately 2-monthly intervals from May 1983 to June 1984. Springbok were also shot near Okaukuejo and gemsbok from near Otjovasandu in the Etosha National Park from June 1983 until April 1984 and February 1984 respectively. In addition 4 gemsbok were shot near Okaukuejo towards the end of April and beginning of May 1984. Kudus were shot at 2-monthly intervals near Namutoni, Etosha National Park, from June 1983 until April 1984. Nine Burchell's zebras and 6 Hartmann's mountain zebras were shot near Okaukuejo and Otjovasandu respectively in the Etosha National Park.

Two giraffes were shot near Okaukuejo in November 1985, 2 in March 1986 and 2 in July 1986. These months fall within the 3 seasons described for Etosha by Berry (1980); these are hot and wet (January to April); cold and dry (May to August), and hot and dry (September to December).

Parasite recovery

The springbok, gemsbok, kudus and giraffes were processed for ectoparasite recovery as described by Horak, Boomker, Spickett & De Vos (1992). Ticks were recovered from the zebras by making whole body searches; this meant that few immature ticks and no lice were collected. The ectoparasites from all the animals were identified and counted under a stereoscopic microscope.

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TABLE 1 Localities at which various herbivores were shot in Namibia for the recovery of arthropod parasites

Locality	Co-ordinates	Vegetation type (Van der Merwe, 1983)
Otjovasandu, Etosha National Park	19° 15' S, 14° 30' E	Mopane savanna
Okaukuejo, Etosha National Park	19° 11' S, 15° 55' E	Mopane savanna
Namutoni, Etosha National Park	18° 49' S, 16° 56' E	Saline desert with dwarf shrub savanna fringe surrounded by Mopane savanna and Forest savanna and woodland
Hardap Nature Reserve	24° 30' S, 17° 45' E	Dwarf shrub savanna

TABLE 2 Ixodid ticks recovered from various wild herbivores in Namibia

Tick and host species	Locality	No. examined	No. infested	No. of ticks recovered				
				Larvae	Nymphs	Males	Females	Total
<i>Hyalomma marginatum rufipes</i>								
Gemsbok	Otjovasandu	18	1	0	0	1	0	1
	Okaukuejo	4	2	0	0	9	1	10
	Hardap	26	1	0	0	4	0	4
Giraffe	Okaukuejo	6	6	0	0	372	75	447
	Burchell's zebra	9	3	0	0	8	1	9
	Hartmann's mountain zebra	6	3	0	0	10	5	15
<i>Hyalomma truncatum</i>								
Gemsbok	Otjovasandu	18	5	0	0	6	1	7
	Okaukuejo	4	2	0	0	12	8	20
	Hardap	26	1	0	0	2	0	2
Giraffe	Okaukuejo	6	6	0	0	1550	584	2134
	Burchell's zebra	9	1	0	0	2	0	2
	Hartmann's mountain zebra	6	5	0	0	27	1	28
<i>Rhipicephalus evertsi mimeticus</i>								
Springbok	Okaukuejo	21	1	1	0	0	0	1
	Hardap	27	1	6	0	0	0	6
Gemsbok	Otjovasandu	18	2	0	3	2	0	5
	Namutoni	23	18	4835	1057	23	23	5938
Giraffe	Okaukuejo	6	5	0	0	14	5	19
	Burchell's zebra	9	6	5	4	34	9	52
	Hartmann's mountain zebra	6	5	13	9	46	13	81
<i>Rhipicephalus longiceps</i>								
Giraffe	Okaukuejo	6	1	0	0	1	0	1
<i>Rhipicephalus turanicus</i>								
Burchell's zebra	Okaukuejo	9	1	0	0	0	1	1
<i>Rhipicephalus sp. (near R. oculatus)</i>								
Springbok	Hardap	27	4	0	0	3	1	4
	Otjovasandu	18	1	0	0	1	0	1
Gemsbok	Hardap	26	17	0	0	220	130	350
	Namutoni	23	6	0	0	10	4	14
<i>Rhipicephalus zambeziensis</i>								
Kudu	Namutoni	23	7	2	0	10	8	20

RESULTS AND DISCUSSION

Ixodid ticks

The tick species recovered, the hosts from which they were collected and the localities at which the hosts were examined are summarized in Table 2.

A total of 7 ixodid tick species were recovered. With the exception of the *Rhipicephalus sp. (near R. oculatus)*, the Etosha National Park seemed to be a more favourable habitat for all species than the Hardap Nature Reserve. As noted in previous surveys, springbok had very low tick burdens (Horak, Meltzer & De Vos, 1982; De Villiers, Liveridge & Reinecke, 1985; Horak, Fourie, Novellie & Williams, 1991). Whether this was due to natural immunity, or host preference, or habitat preference, or behaviour of the antelope could not be determined in either this or the other surveys.

***Hyalomma* spp.**

Both *Hyalomma marginatum rufipes* and *Hyalomma truncatum* prefer the drier western regions of southern Africa (Theiler, 1962; Howell, Walker & Nevill, 1978; Walker, 1991). Judging by the present results the Okaukuejo region of the Etosha National Park is a better habitat for *H. truncatum* than for *H. marginatum rufipes*. The preferred hosts of the adults are large animals such as cattle (Horak, 1982; Biggs & Langenhoven, 1984), horses (Horak, Biggs & Reinecke, 1984; Horak, Knight & De Vos, 1986), zebras and eland (Rechav, Zeederberg & Zeller, 1987; Horak *et al.*, 1991). The present results indicate that giraffes probably rank above all the other animals mentioned above as the host of choice. Each of the 6 giraffes examined harboured more than 200 adult *Hyalomma* and 1 of them more than 850 ticks.

Kudus are definitely not good hosts of adult *H. truncatum* (Horak *et al.*, 1992), while gemsbok should only be considered fair hosts of both species (Fourie, Vrahimis, Horak, Terblanche & Kok, 1991). Warthogs examined in the northern bushveld region of Namibia harboured more *H. truncatum* than *H. marginatum rufipes* (Horak *et al.*, 1983), while the converse was true for mountain zebras and horses examined in the central region west of Windhoek, and cattle examined east of Windhoek (Horak *et al.*, 1984; Biggs & Langenhoven, 1984). The preferred hosts of the immature stages of both species are scrub hares (Rechav *et al.*, 1987; Horak *et al.*, 1991; Horak & Fourie, 1991).

As only 2 giraffes were examined on each occasion, and then at 4-monthly intervals, it is virtually impossible to determine a pattern of seasonal abundance for these ticks. The total counts of *H. marginatum rufipes* were 206, 189 and 52, and those of *H. truncatum* 497, 602 and 1035, for both animals examined during November 1985 and March and July 1986 respectively.

Both these ticks have long mouthparts and these can cause considerable tissue damage, which may lead to secondary bacterial infection (Howell *et al.*, 1978). *H. marginatum rufipes* is a vector of *Anaplasma marginale*, the cause of gallsickness in cattle (Potgieter, 1981), and *H. truncatum* transmits a toxin causing sweating sickness in the latter animals (Howell *et al.*, 1978).

Rhipicephalus evertsi mimeticus

We are unable to differentiate the immature stages of this tick from those of *Rhipicephalus evertsi evertsi*. However, as the adults of only *R. evertsi mimeticus* were recovered we have assigned all the immatures to this subspecies. This tick prefers the arid regions of Namibia and western Botswana (Howell *et al.*, 1978).

In the case of *R. evertsi evertsi* equids are among the preferred hosts of all stages of development (Norval, 1981; Horak *et al.*, 1986). *R. evertsi mimeticus* appears also to favour these hosts (Horak *et al.*, 1984). The collection methods employed on the zebras in the present survey virtually precluded the recovery of immature ticks, which are found in the outer ear canals, and the numbers of adult ticks recovered were also small. Nevertheless their mean burdens of adult ticks were slightly higher than those of the other host species. The vast majority of the immature ticks recorded from the kudus at Namutoni were found on a single animal, which carried 4 172 larvae and 952 nymphs. Kudus are considered to be poor hosts of the closely related *R. evertsi evertsi* (Horak *et al.*, 1992).

No pattern of seasonal abundance was evident.

Rhipicephalus longiceps

Walker (1991) cites this as a rare tick found only in Namibia and Angola. It has been recovered from cattle, klipspringer and gemsbok (Walker, 1991), also from 3 of 37 warthogs examined in the northern bushveld of Namibia (Horak *et al.*, 1983). Its recovery from one of the giraffes appears to constitute a new host record.

Rhipicephalus turanicus

This tick has previously been recovered in the Etosha National Park and from Grootfontein in northern Namibia (Walker, 1991). Its adults have a very wide host range, and amongst the wild animals ostriches and zebras appear to carry the largest numbers (Pegram, Clifford, Walker & Keirans, 1987).

Rhipicephalus sp. (near R. oculatus)

The problems surrounding the species diagnosis of this tick and *Rhipicephalus oculatus sensu stricto* have been discussed by Walker (1991). She also records it as being widely distributed in Namibia, especially south of Windhoek, an observation confirmed by the present findings.

Walker (1991) lists the wild hosts as being mostly antelopes, particularly gemsbok and kudu. It has also been recorded (as *R. oculatus*) from 7 of 37 warthogs examined in the northern bushveld region of Namibia (Horak *et al.*, 1983). In the present survey gemsbok were more heavily infested than kudus, possibly owing to the more southerly locality at which they were examined. In a recent survey in South Africa, kudus just north of Grahamstown, in the eastern Cape Province, were more heavily infested than sheep, goats, cattle and scrub hares from the same locality (Horak & Knight, 1986).

No clear pattern of seasonal abundance could be seen on the eastern Cape kudu, but no ticks of this species were present on the animals examined during May and June (Horak *et al.*, 1992). The scrub hares from that particular locality, however, generally carried larger numbers of adult ticks during August and from November to April (Horak & Fourie, 1991). In the present survey the gemsbok in the Hardap Nature Reserve harboured the greatest numbers of ticks during November and February (Fig. 1). The largest numbers of ticks (a total of only 6 on 4 animals) were recorded on the kudus in the Etosha National Park during June and during August.

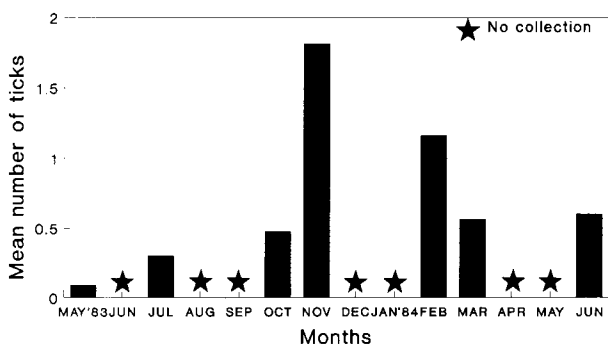


FIG. 1 The seasonal abundance of a *Rhipicephalus sp.* (near *R. oculatus*) on gemsbok in the Hardap Nature Reserve, Namibia [$\log_{10}(x+1)$].

Rhipicephalus zambeziensis

This tick has been recorded in northern Namibia in the Kunene (Kaokoland) and the Otjozondjupa (Grootfontein) districts (Norval, Walker & Colborne, 1982). Namutoni, in the Etosha National Park, lies

between these 2 regions. *R. zambeziensis* infests a large variety of hosts, including carnivores, suids and bovids (Walker, 1991). Within its distribution range kudu appear to be amongst the preferred hosts of all stages of development (Horak *et al.*, 1992).

R. zambeziensis can transmit *Theileria parva parva* and *Theileria parva bovis*, the cause of East Coast fever and January disease respectively in cattle (Lawrence, Norval & Uilenberg, 1983). It also transmits *Theileria parva lawrencei* to buffaloes and cattle. In the former animals *T. parva lawrencei* is not pathogenic, but it produces the usually fatal Corridor disease in cattle.

Lice

The springbok harboured the greatest number of lice species, but the total burdens of individual animals were low (Table 3). No pattern of seasonal abundance was evident. De Villiers *et al.*, (1985) examined springbok near Kimberly in the Cape Province, South Africa, for parasites at fairly regular intervals for a period of 14 months. They recovered 6 lice species from these animals and the 4 major species all exhibited peak burdens during September.

TABLE 3 Lice recovered from springbok, gemsbok and kudu in Namibia

Host and lice species	Number of hosts examined	Number infested	Number of lice recovered		
			Nymphs	Adults	Total
Springbok					
<i>Damalinea anti-dorcus</i>	48	8	3	16	19
<i>Linognathus antidorcitis</i>	48	23	45	43	88
<i>Linognathus armatus</i>	48	1	0	11	11
<i>Linognathus bedfordi</i>	48	1	3	2	5
<i>Linognathus euchore</i>	48	15	35	40	75
Gemsbok					
<i>Haematopinus oryx</i>	48	3	38	5	43
<i>Linognathus oryx</i>	48	28	3567	737	4304
Kudu					
<i>Linognathus taurotragus</i>	23	17	582	311	893

Two lice species were recovered from the gemsbok, of which *Linognathus oryx* was the most abundant. The seasonal abundance of the latter species on the gemsbok is illustrated in Fig. 2.

Lice numbers started to increase sooner on the animals in the Hardap Reserve than on those in the Etosha Park. Peak numbers were recorded during November and December respectively (summer).

In contrast peak burdens of the louse *Linognathus taurotragus* were recorded in June (winter) on the kudu examined at Namutoni in the Etosha National Park (Fig. 3). No lice were recovered from the giraffes.

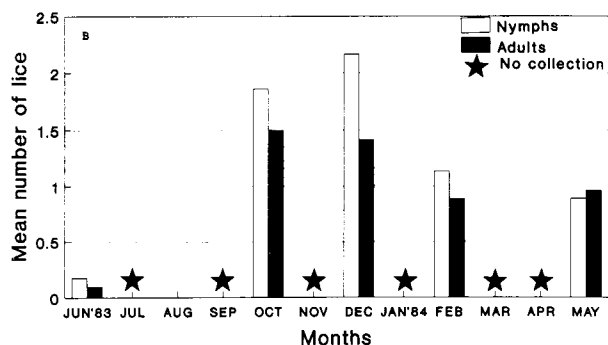
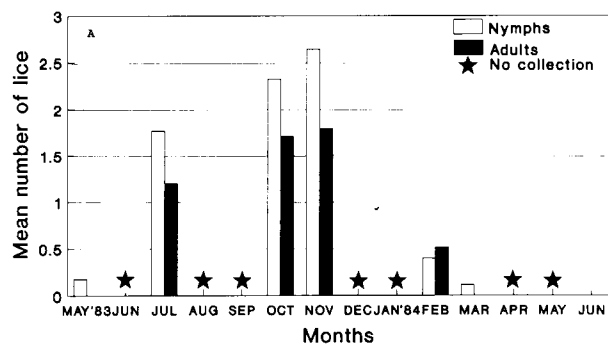


FIG. 2 The seasonal abundance of *Linognathus oryx* on gemsbok in Namibia [$\log_{10}(x + 1)$]
A. in the Hardap Nature Reserve
B. in the Etosha National Park

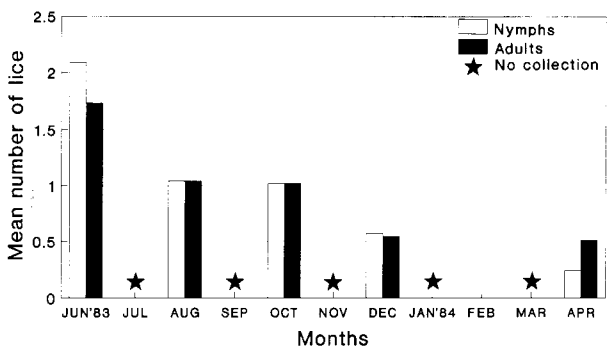


FIG. 3 The seasonal abundance of *Linognathus taurotragus* on kudu in the Etosha National Park, Namibia [$\log_{10}(x + 1)$]

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with the identification of *R. longiceps*. Miss Andrea van Niekerk drew the graphs.

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REFERENCES

- BERRY, H. H., 1980. Behavioural and eco-physiological studies on blue wildebeest (*Connochaetes taurinus*) at the Etosha National Park. Vol. 1. Ph.D. thesis, University of Cape Town.
- BIGGS, H. C. & LANGENHOVEN, J. W., 1984. Seasonal prevalence of ixodid ticks on cattle in the Windhoek District of South West Africa/Namibia. *Onderstepoort Journal of Veterinary Research*, 51, 175–182.
- BOOMKER, J., ANTHONISSEN, M. & HORAK, I. G., 1988. Parasites of South African wildlife. II. Helminths of kudu, *Tragelaphus strepsiceros*, from South West Africa/Namibia. *Onderstepoort Journal of Veterinary Research*, 55, 231–233.
- DE VILLIERS, I. L., LIVERSIDGE, R. & REINECKE, R. K., 1985. Arthropods and helminths in springbok (*Antidorcas marsupialis*) at Benfontein, Kimberley. *Onderstepoort Journal of Veterinary Research*, 52, 1–11.
- FOURIE, L. J., VRAHIMIS, S., HORAK, I. G., TERBLANCHE, H. J. & KOK, O. B., 1991. Ecto- and endoparasites of introduced gemsbok in the Orange Free State. *South African Journal of Wildlife Research*, 21, 82–87.
- 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., BIGGS, H. C., HANSSSEN, TAMMY, S. & HANSSSEN, ROSE E., 1983. The prevalence of helminth and arthropod parasites of warthog, *Phacochoerus aethiopicus*, in South West Africa/Namibia. *Onderstepoort Journal of Veterinary Research*, 50, 145–148.
- HORAK, I. G., BIGGS, H. C. & REINECKE, R. K., 1984. Arthropod parasites of Hartmann's mountain zebra, *Equus zebra hartmannae*, in South West Africa/Namibia. *Onderstepoort Journal of Veterinary Research*, 51, 183–187.
- HORAK, I. G., KNIGHT, M. M. & DE VOS, V., 1986. Parasites of domestic and wild animals in South Africa. XX. Arthropod parasites of the Cape mountain zebra (*Equus zebra zebra*). *Onderstepoort Journal of Veterinary Research*, 53, 127–132.
- HORAK, I. G. & KNIGHT, M. M., 1986. A comparison of the tick burdens of wild animals in a nature reserve and on an adjacent farm where tick control is practised. *Journal of the South African Veterinary Association*, 57, 199–203.
- HORAK, I. G., FOURIE, L. J., NOVELLIE, P. A. & WILLIAMS, E. J., 1991. Parasites of domestic and wild animals in South Africa. XXVI. The mosaic of ixodid tick infestations on birds and mammals in the Mountain Zebra National Park. *Onderstepoort Journal of Veterinary Research*, 58, 125–136.
- I. G. HORAK, M. ANTHONISSEN, R. C. KRECEK & J. BOOMKER
- HORAK, I. G. & FOURIE, L. J., 1991. 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. *Onderstepoort Journal of Veterinary Research*, 58, 261–270.
- HORAK, I. G., BOOMKER, J., SPICKETT, A. M. & DE VOS, V., 1992. Parasites of domestic and wild animals in South Africa. XXX. Ectoparasites of kudus in the eastern Transvaal Lowveld and the eastern Cape Province. *Onderstepoort Journal of Veterinary Research*, 59, 259–273.
- 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.
- KRECEK, ROSSINA C., REINECKE, R. K. & MALAN, F. S., 1987. Studies on the parasites of zebras. V. Nematodes of the Burchell's and Hartmann's mountain zebras from the Etosha National Park, South West Africa/Namibia. *Onderstepoort Journal of Veterinary Research*, 54, 71–78.
- KRECEK, R. C., BOOMKER, J., PENZHORN, B. L. & SCHEEPERS, L., 1990. Internal parasites of giraffes (*Giraffa camelopardalis angolensis*) from Etosha National Park, Namibia. *Journal of Wildlife Diseases*, 26, 395–397.
- LAWRENCE, J. A., NORVAL, R. A. I. & UILENBERG, G., 1983. *Rhipicephalus zambeziensis* as a vector of bovine Theileriae. *Tropical Animal Health and Production*, 15, 39–42.
- NORVAL, R. A. I., 1981. The ticks of Zimbabwe. III. *Rhipicephalus evertsi evertsi*. *Zimbabwe Veterinary Journal*, 12, 31–35.
- NORVAL, R. A. I., WALKER, JANE B. & COLBORNE, J., 1982. The ecology of *Rhipicephalus zambeziensis* and *Rhipicephalus appendiculatus* (Acarina, Ixodidae) with particular reference to Zimbabwe. *Onderstepoort Journal of Veterinary Research*, 49, 181–190.
- PEGRAM, R. G., CLIFFORD, C. M., WALKER, JANE B. & KEIRANS, J. E., 1987. Clarification of the *Rhipicephalus sanguineus* group (Acari, Ixodoidea, Ixodidae). I. *R. sulcatus* Neumann, 1908 and *R. turanicus* Pomerantsev, 1936. *Systematic Parasitology*, 10, 3–26.
- POTGIETER, F. T., 1981. Tick transmission of anaplasmosis in South Africa. *Proceedings of the International Conference on Tick Biology and Control, Grahamstown, South Africa, 27–29 January 1981*, 53–56.
- RECHAV, Y., ZEEDERBERG, M. E. & ZELLER, D. A., 1987. Dynamics of African tick (Acari: Ixodidae) populations in a natural Crimean-Congo hemorrhagic fever focus. *Journal of Medical Entomology*, 24, 575–583.
- 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. 260 pp. Mimeographed.
- VAN, DER MERWE, J. H., 1983. National atlas of South West Africa (Namibia). National Book Printers: Goodwood Cape.
- WALKER, JANE B., 1991. A review of the ixodid ticks (Acari, Ixodidae) occurring in southern Africa. *Onderstepoort Journal of Veterinary Research*, 58, 81–105.