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PARASITES OF SOUTH AFRICAN WILDLIFE. VIII. HELMINTH AND ARTHROPOD PARASITES OF WARTHOGS, *PHACOCHOERUS AETHIOPICUS*, IN THE EASTERN TRANSVAAL

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ABSTRACT

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Helminth and arthropod parasites were collected from 41 warthogs, *Phacochoerus aethiopicus*, in the Hoedspruit Nature Reserve, eastern Transvaal. This reserve consists of a military base, which is a restricted area and is surrounded by a reserve, which is open to the public. Eleven nematode species, 1 or 2 cestode species and the larvae of 2 cestode species were recovered from the animals in the reserve, and 8 nematode species and 1 or 2 cestode species were recovered from those in the military base.

Oesophagostomum spp. were generally most abundant in warthogs in the reserve during the cooler months of the year, while *Probstmayria vivipara* also occurred in peak numbers during the cooler months, with an additional peak in October and November 1988 in warthogs in the reserve and the base, respectively. No pattern of seasonal abundance could be determined for the other helminth species.

The warthogs also harboured 8 ixodid and 1 argasid tick species, 3 flea species and 1 louse species. Adult and immature *Haematopinus phacochoeri* were most numerous during August and September, and the largest numbers of adult *Rhipicephalus simus* were present from December to April.

INTRODUCTION

The seasonal abundance of endo- and ectoparasites of warthogs, *Phacochoerus aethiopicus*, in northern Namibia and in the Kruger National Park (KNP) in the eastern Transvaal have recently been reported (Horak, Biggs, Hanssen & Hanssen, 1983; Horak, Boomker, De Vos & Potgieter, 1988). The warthogs from Namibia were infested with 9 nematode species, 1 or 2 cestode species, 6 ixodid tick species, 1 argasid tick species, a flea and a louse species and the larvae of a calliphorid fly. Those from the KNP harboured 13 nematode species, 1 trematode species, 1 or 2 cestode species, the larval stages of 4 cestode species, 7 ixodid tick species, 1 species of argasid, 3 flea species, 1 louse species and the nymphs of a pentastomid.

This paper describes a similar survey conducted on warthogs in the Hoedspruit Nature Reserve which is also situated in the eastern Transvaal Lowveld.

MATERIALS AND METHODS

Survey area

The warthogs were all shot in the Hoedspruit Nature Reserve (HNR) which is situated in a vegetation zone classified as Lowveld (Acocks, 1988). The temperature is warm to hot in summer and mild in winter, and frost does not occur.

The HNR is owned by the South African Defence Force and comprises approximately 4 000 ha. It consists of an inner area of about 2 000 ha, the restricted military base, around which lies another 2 000 ha, the reserve, which is open to the public. The base is separated from the reserve by a series of security fences, thus making it impossible for warthogs on either side to pass through. The outer fence of the reserve, however, is of such a nature that warthogs from the surrounding privately owned game farms can pass through with ease.

Climatological data

The mean monthly maximum and minimum atmospheric tempatures as well as the total monthly rainfall were recorded during the survey period.

Survey animals

With the exception of March 1989, when none could be located, warthogs were shot each month for 12 consecutive months from August 1988 to July 1989. Although often unsuccessful, an attempt was made at each occasion to collect the same number of warthogs of the same ages and sexes from the reserve and the base. A total of 41 warthogs was shot, of which 5 adult males, 11 adult females, 5 subadult males, 2 subadult females 1 juvenile male and 4 juvenile females were shot in the reserve and 1 adult male, 4 adult females, 2 subadult males, 2 subadult females, 1 juvenile male and 3 juvenile females were shot on the base.

Parasite recovery

The carcasses were transported to a field laboratory where they were eviscerated and macroscopically visible parasites removed and preserved in 70 % alcohol.

The carcasses were skinned and eviscerated, and the gastro-intestinal tracts were divided into the stomachs, the small intestines and the large intestines, and placed in shallow, flat-bottomed plastic trays. The stomachs were cut open and the ingesta carefully removed so as not to disturb the underlying mucosa. The ingesta were discarded, but the stomach was thoroughly washed in normal saline and the volume of the resulting suspension measured. The small and the large intestines were opened separately with bowel scissors and washed in saline. The washings were added to the respective ingesta. The volumes of the ingesta were measured and poured into separate plastic buckets. A $\frac{1}{4}$th aliquot by volume was made of the ingesta of each of the small intestines and a $\frac{1}{8}$th aliquot of the ingesta of each of the large intestines. The worms in the various aliquots as well as those in the various stomach contents were killed by adding an equal volume of boiling saline to each. The suspensions were then individually washed over a sieve with apertures of 0,15 mm and the residues preserved in separate bottles in 10 % formalin. Digests of the gastro-intestinal mucosae were not done.

The hearts, lungs and livers of the first 16 animals were processed for helminth recovery as described by Boomker, Horak & De Vos (1989) and examined. When no parasites were found, these organs were no longer processed or examined.

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TABLE 1 Amended list of the helminth parasites of warthogs in the Republics of South Africa and Namibia with reference to the first record and the authors of the descriptions used to assist with the identification

Helminth species	First record	Identification
Trematodes		
Gastrodiscus aegyptiacus Railliet, 1893	Horak *et al.*, 1988	+
Schistosoma sp.	Horak *et al.*, 1988	+
Cestodes		
Echinococcus sp. larvae	Horak *et al.*, 1988	+
Moniezia mettami Baylis, 1934	Ortlepp, 1964	Baylis, 1934
Paramoniezia phacochoeri Baylis, 1927	Baylis, 1927	Baylis, 1927
Taenia crocutae larvae	Horak *et al.*, 1988	+
Taenia hyaenae larvae	Horak *et al.*, 1988	+
Taenia regis larvae	Horak *et al.*, 1988	+
Nematodes		
Ascaris phacochoeri Gedoelst, 1916	Ortlepp, 1939	Ortlepp, 1939
Cooperia hungi Mönnig, 1931	This paper	Gibbons, 1981
Haemonchus krugeri Ortlepp, 1964	Horak *et al.*, 1988	+
Impalaia nudicollis Mönnig, 1931	Horak *et al.*, 1983	+
Impalaia tuberculata Mönnig, 1923	Horak *et al.*, 1988	Boomker, 1977
Microfilaria sp. (*sensu* Neitz, 1931)	Neitz, 1931	+
Microfilariae	Palmieri *et al.*, 1985	+
Murshidia hamata Daubney, 1923	Daubney, 1923	Daubney, 1923
Murshidia pugnicaudata (Leiper, 1909)	Daubney, 1923	Daubney, 1923
Odontogeton phacochoeri Allgrén 1921	Allgrén, 1921*	+
Oesophagostomum mocambiquei Ortlepp, 1964	Ortlepp, 1964	Ortlepp, 1964
Oesophagostomum mpwapwae Duthy, 1947	Horak *et al.*, 1983	+
Oesophagostomum mwanzae Daubney, 1924	Ortlepp, 1964	Ortlepp, 1964
Oesophagostomum roubaudi Daubney, 1926	Horak *et al.*, 1983	+
Oesophagostomum santosdiasi Ortlepp, 1964	Ortlepp, 1964	+
Oesophagostomum simpsoni Goodey, 1924	Ortlepp, 1964	+
Physocephalus sexalatus Diesing, 1861	Horak *et al.*, 1983	Yorke & Maplestone, 1926
Probstmayria vivipara Ransom, 1911	Le Roux, 1940	Yorke & Maplestone, 1926
Strongyloides spp.	Horak *et al.*, 1988	+
Trichostrongylus falculatus Ransom, 1911	Horak *et al.*, 1988	+
Trichostrongylus deflexus Boomker & Reinecke, 1989	Horak *et al.*, 1983	Boomker & Reinecke, 1989
Trichostrongylus thomasi Mönnig, 1932	Horak *et al.*, 1988	Mönnig, 1932
Trichuris sp.	Horak *et al.*, 1988	+

\+ Not found in this survey

* After Round (1968)

The ectoparasites were collected as described by Horak *et al.* (1988).

Parasite counts and identification

The lung, heart and liver washings of the first 16 animals, as well as the washings of the stomach walls and the aliquots of the small intestinal ingesta were examined under a stereoscopic microscope and all the worms removed.

The ingesta of the large intestines were examined in a flat-bottomed tray and all the macroscopically visible worms removed. Because of the large numbers of *Probstmayria vivipara* present, a 1/100th aliquot was made of each of the large intestinal ingesta after they had been macroscopically examined. The aliquot was examined under a stereoscopic microscope and *Probstmayria vivipara* counted.

With the exception of *Probstmayria vivipara*, all the worms were cleared in lactophenol and examined under a standard microscope with Nomarski's differential intereference illumination. They were identified with the aid of the descriptions by the authors listed in Table 1. This table also lists the helminth recovered to date from warthogs in South Africa and Namibia.

The ectoparasites were counted as described by Horak *et al.* (1988).

RESULTS

The total monthly rainfall and the mean monthly minimum and maximum atmospheric temperatures for the period August 1988–July 1989 are graphically illustrated in Fig. 1.

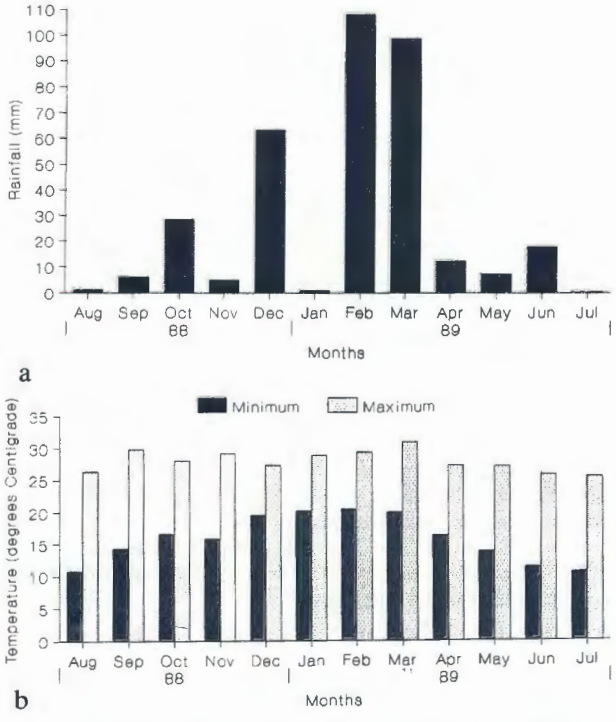

FIG. 1 Mean monthly rainfall (a) and minimum and maximum temperatures (b) at the Hoedspruit Nature Reserve

Helminths

The total numbers of helminths recovered from all the warthogs are summarised in Table 2.

TABLE 2 The helminths recovered from 41 warthogs from the Hoedspruit Nature Reserve

Helminth species	Larvae	Adults	Total	Number of warthogs infected
Reserve (28 warthogs)				
*Moniezia/Paramoniezia**	#	109	109	12
Taenia regis	2	#	2	2
Echinococcus	1	#	1	1
Ascaris phacochoeri	0	114	114	13
Cooperia hungi	0	100	100	1
Impalaia tuberculata	0	150	150	5
Murshidia hamata	+	34 361	34 361	28
Murshidia pugnicaudata	+	6 215	6 215	28
Murshidia spp.	118	–	118	8
Oesophagostomum mocambiquei	+	90 058	90 058	27
Oesophagostomum mwanzae	+	37 684	37 684	28
Oesophagostomum spp.	2 901	–	2 901	13
Physocephalus sexalatus	80	9 494	9 574	23
Probstmayria vivipara	$	$	267,255 million	28
Trichostrongylus deflexus	0	20	20	2
Trichostrongylus thomasi	0	60	60	4
Trichostrongylus spp. females	–	50	50	5
Mean nematode burden**	111	6 368	6 479	
Base (13 warthogs)				
*Moniezia/Paramoniezia**	#	53	53	5
Ascaris phacochoeri	0	32	32	5
Murshidia hamata	+	21 734	21 734	13
Murshidia pugnicaudata	+	4 588	4 588	12
Murshidia spp.	222	–	222	5
Oesophagostomum mocambiquei	+	8 507	8 507	12
Oesophagostomum mwanzae	+	4 090	4 090	12
Oesophagostomum spp.	94	–	94	3
Physocephalus sexalatus	0	610	610	10
Probstmayria vivipara	$	$	148,331 million	13
Trichostrongylus spp. females	–	10	10	1
Mean nematode burden**	24	3 044	3 068	

* Scoleces
** Excluding *Probstmayria vivipara*
\# Not found in warthogs
$ Larvae and adults not counted separately
\+ Counted together under the respective genera
– Not applicable

Eleven namatode species, 1 or 2 cestode species and the larval stages of 2 cestode were recovered from warthogs shot in the reserve. Of these, *Murshidia hamata, Murshidia pugnicaudata, Oesophagostomum mwanzae,* and *Probstmayria vivipara* occurred in all the warthogs. *Oesophagostomum mocambiquei* was recovered from 27 warthogs and *Physocephalus sexalatus* from 23. The remaining nematodes occured in less than 50 % of the animals examined.

Probstmayria vivipara was the most abundant of the nematodes, followed by *Oesophagostomum mocambiquei, Oesophagostomum mwanzae, Murshidia hamata, Physocephalus sexalatus* and *Murshidia pugnicaudata.*

Individual adult nematode burdens, excluding *Probstmayria vivipara* varied from 445 to 41 950 and the mean total adult nematode burden, excluding *Probstmayria vivipara,* was 6 368.

Eight species of nematodes and 1 or 2 cestode species were recovered from the 13 warthogs shot in the base. *Probstmayria vivipara* and *Murshidia hamata* were recovered from all these warthogs and *Murshidia pugnicaudata, Oesophagostomum mocambiquei* and *Oesophagostomum mwanzae* from 12 warthogs each. *Physocephalus sexalatus* occurred in 10 animals.

Probstmayria vivipara was again the most abundant nematode, followed by *Murshidia hamata, Oesophagostomum mocambiquei, Murshidia pugnicaudata* and *Oesophagostomum mwanzae.*

The individual adult nematode burdens, excluding *Probstmayria vivipara,* varied from 91 to 7 260 and the mean total adult nematode burden, excluding *Probstmayria vivipara,* was 3 044.

Ascaris phacochoeri and the *Moniezia/Paramoniezia* spp. were only recovered from animals younger than 18 months, while *Oesophagostomum* spp., *Murshidia* spp., *Physocephalus sexalatus* and *Probstmayria vivipara* were already present in the youngest animal in the survey, a male, 3–4 months old, shot in the reserve during August 1988.

No differences in the mean monthly nematode burdens or nematode species composition between the ages or the sexes of the warthogs shot at either locality, were evident.

The seasonal fluctuations of *Oesophagostomum* spp., *Murshidia* spp. and *Probstmayria vivipara* are graphically illustrated in Fig. 2–4.

In both groups of warthogs, peaks in the numbers of *Oesophagostomum* spp. occurred during the cooler months of the year. The high peak seen in warthogs from the reserve shot during August 1988, however, is due to 1 animal harbouring 30 700 *O. mocambiquei,* and probably does not reflect the true situation. No seasonal pattern of abundance was evident for the *Murshidia* spp. The largest numbers of *Probstmayria vivipara* were recovered during the cooler months of the year, with a peak occurring during October and November 1988 in the warthogs from the reserve and the base, respectively.

TABLE 3 Arthropod parasites recovered from 28 warthogs from the Hoedspruit Nature Reserve, eastern Transvaal

Arthropod species	Total numbers of arthropods recovered					Number of warthogs infested
Fleas	Males		Females		Total	
Echidnophaga inexpectata/larina	7 098*				7 098	27
Moeopsylla sjoestedti	72		132		204	18
Lice	Nymphs	Males	Females		Total	
Haematopinus phacochoeri	1 228	170	200		1 598	14
Ixodid ticks	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	158	1 228	254	80 (0)	1 720	28
Amblyomma marmoreum	2	0	0	0	2	1
Boophilus decoloratus	126	0	0	0	126	3
Hyalomma truncatum	0	0	10	4 (0)	14	3
Rhipicephalus appendiculatus	2	0	0	0	2	1
Rhipicephalus evertsi evertsi	2	2	0	0	4	2
Rhipicephalus simus	0	0	82	40 (2)	122	16
Rhipicephalus zambeziensis	0	4	2	0	6	2
Argasid ticks	Larvae	Nymphs	Adults		Total	
Ornithodoros porcinus porcinus	0	232	0		232	13

() = Number of maturing female ticks, i.e. the idiosoma of *A. hebraeum* > 9,0 mm; *H. truncatum* > 7,5 mm; *R. simus* > 6,0 mm
* = Sexes not determined

TABLE 4 Arthropod parasites recovered from 13 warthogs on a military base near Hoedspruit, eastern Transvaal

Arthropod species	Total numbers of arthropods recovered				Number of warthogs infested
Fleas	Males	Females		Total	
Echidnophaga inexpectata/larina	1 036*			1 036	13
Moeopsylla sjoestedti	2	6		8	3
Lice	Nymphs	Males	Females	Total	
Haematopinus phacochoeri	534	46	68	648	8
Ixodid ticks	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	0	18	2	2 (2)	30	8
Rhipicephalus simus	0	0	40	12 (2)	52	8
Argasid ticks	Larvae	Nymphs	Adults		Total	
Ornithodoros porcinus porcinus	0	2	2		4	2

() = Number of maturing female ticks, i.e. the idiosoma of *A. hebraeum* > 9,0 mm and *R. simus* > 6,0 mm
* = Sexes not determined

Arthropods

The total numbers of arthropods recovered from the warthogs in the reserve and on the base are summarised in Tables 3 and 4.

The warthogs harboured 3 flea species, 1 louse species 8 ixodid tick species and 1 argasid tick species. The animals in the reserve not only harboured a greater variety but also greater numbers of parasites than the animals on the base.

The seasonal abundance of the adults of the tick *Rhipicephalus simus*, the fleas *Echidnophaga inexpectata* and *Echidnophaga larina* combined and the louse *Haematopinus phacochoeri* for both groups of warthogs are graphically illustrated in Fig. 5–7. Because of the large variation in the burdens of the lice, the burdens have been transformed to their square roots (Fig. 7).

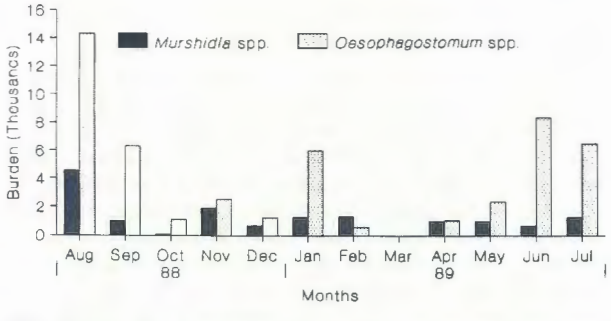

FIG. 2 Seasonal fluctuation in the numbers of *Oesophagostomum* spp. and *Murshidia* spp. in warthogs in the reserve

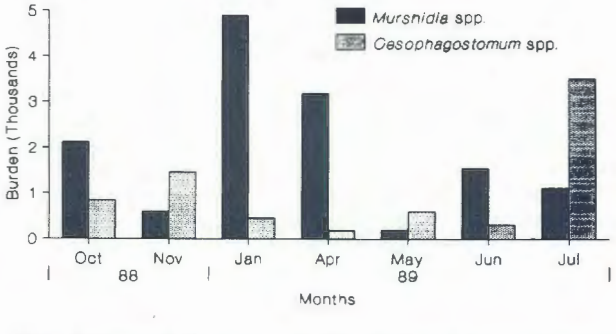

FIG. 3. Seasonal fluctuation in the numbers of *Oesophagostomum* spp. and *Murshidia* spp. in warthogs on the military base

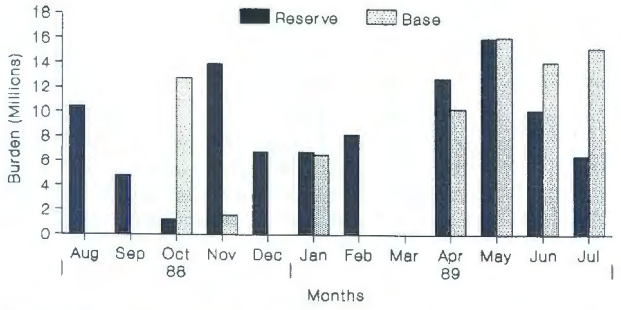

FIG. 4 Seasonal fluctuation in the numbers of *Probstmayria vivipara* in warthogs in the reserve and the military base

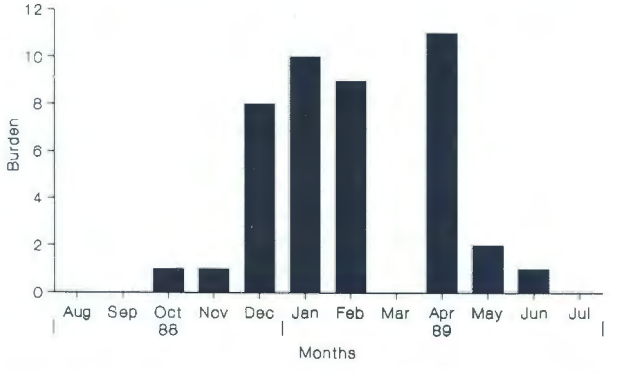

FIG. 5 Seasonal fluctuation in the numbers of *Rhipicephalus simus* on warthogs in the Hoedspruit Nature Reserve

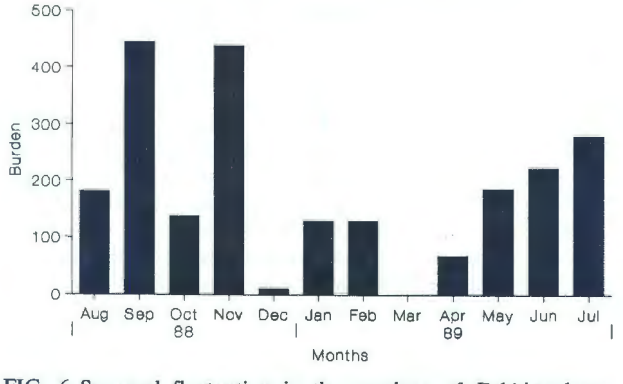

FIG. 6 Seasonal fluctuation in the numbers of *Echidnophaga* spp. on warthogs in the Hoedspruit Nature Reserve

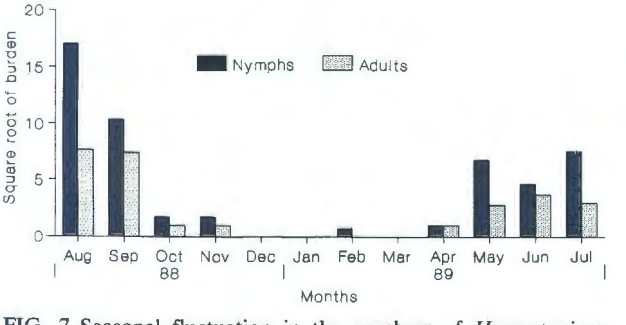

FIG. 7 Seasonal fluctuation in the numbers of *Haematopinus phacochoeri* on warthogs in the Hoedspruit Nature Reserve.

Although variation was considerable, peak flea burdens were generally recorded from August to November and May to July, while peak burdens of immature and adult *H. phacochoeri* were present during August and September. No lice were recovered during December and January. Adult *R. simus* were present from October to June, with the largest numbers being recovered from December to April. The other ectoparasites did not exhibit clear patterns of seasonal abundance.

DISCUSSION

Helminths

Fourteen helminth species were recovered in this study from the warthogs in the reserve. This is 5 species fewer than from warthogs in the KNP, but 4 more than from warthogs in Namibia (Horak, Biggs, Hanssen & Hanssen, 1983; Horak *et al.*, 1988). At least 9 helminths species were recovered from the animals on the base.

The small number of species recovered from warthogs on the base is probably firstly due to the fact that they are an isolated population, consisting of about 80 animals, that has no contact with other warthogs, and secondly because very few other animals species occur on the base. Thus, if cross-infection does take place it can only occur to a limited degree. Neither the carnivore associated *Taenia* sp. and *Echinococcus* sp. larvae, nor *Cooperia hungi, Impalaia tuberculata* or the *Trichostrongylus* spp. were recovered from these warthogs, although they were present in those in the reserve.

The difference in the mean total adult nematode burdens between the 2 groups of warthogs is presumably also due to the above-mentioned factors.

Ascaris phacochoeri, which we consider a definitive parasite of warthogs, has previously been recorded from warthogs from Zululand (Ortlepp, 1939, 1964) and the KNP (Horak *et al.,* 1988). The mean adult burden of the warthogs from the reserve was approximately double that of those in the KNP, while that of the warthogs from the base was about the same (Horak *et al.,* 1988). Only 1 immature *Ascaris* sp. was recovered from the warthogs from Namibia (Horak, Biggs, Hanssen & Hanssen, 1983).

C. hungi is a common parasite of impala, *Aepyceros melampus* (Horak, 1978b). Although the spicules of the specimens recovered during this survey were of normal size, the fact that they were present in only 1 animal confirms their status as an accidental parasite of warthogs. This assumption is augmented by the fact that although large numbers of impala occur in the area in the KNP where warthogs were previously surveyed, *C. hungi* was not found in a single warthog (Horak *et al.,* 1988).

All the *I. tuberculata* recovered in this survey were considerably smaller and the males' spicules shorter than those in antelope (Boomker, 1977; Gibbons, Durette-Desset & Daynes, 1977). This agrees with the findings of Horak *et al.* (1988) for *I. tuberculata* from warthogs in the KNP and those of Horak, Biggs, Hanssen & Hanssen (1983) for *Impalaia nudicollis* from warthogs in Namibia. It indicates that both *Impalaia* species can survive in warthogs but that these animals are not preferred hosts.

Worms of the genus *Murshidia* were not recovered from warthogs in Mozambique or Namibia (Ortlepp, 1964; Horak, Biggs, Hanssen & Hanssen, 1983). Two species of this genus were, however, present in warthogs in the Central African Republic (Troncy, Graber & Thal, 1972), Zululand (Daubney, 1923; Ortlepp, 1964), on the escarpment of the eastern Transvaal and in the eastern Transvaal Lowveld (Ortlepp, 1964; Horak *et al.,* 1988). Only

Murshidia hamata was present in a warthog from the north-western Transvaal (Boomker & Horak, unpublished data, 1989). Horak *et al.* (1988) found large numbers of *Murshidia* spp. in warthogs in the KNP but only moderate numbers were recovered during this survey.

It appears that certain individuals harbour large numbers of *Oesophagostomum* spp. or *Murshidia* spp. but the factors predisposing to such burdens are not known.

With the exception of *Oesophagostomum santosdiasi,* which was recovered from only 1 warthog in the KNP (Horak *et al.,* 1988), the same *Oesophagostomum* spp. as those in the KNP were present in warthogs in this survey. *Oesophagostomum mwanzae* appears to have a very wide distribution and has been recovered from warthogs in the Central African Republic (Troncy *et al.,* 1972), in Uganda, Kenya, Tanzania and Malawi (Daubney 1924; Goodey, 1924), in northern Mozambique and on the escarpment of the eastern Transvaal (Ortlepp, 1964), in the eastern Transvaal Lowveld (Horak *et al.,* 1988), in the north-western Transvaal (Boomker & Horak, unpublished data, 1989) and in northern Namibia (Horak, Biggs, Hanssen & Hanssen, 1983). In the survey of warthogs in Namibia it was outnumbered by *Oesophagostomum mpwapwae* and in the eastern Transvaal Lowveld by *Oesophagostomum mocambiquei.* The latter worm has only been recorded from warthogs on the eastern side of the continent, namely northern Mozambique (Ortlepp, 1964) and the eastern Transvaal escarpment and Lowveld (Ortlepp, 1964; Horak *et al.,* 1988; present survey).

The largest number of *Oesophagostomum* spp. recovered from a single warthog in the present survey was 35 000 worms. This is 4 490 more than recovered from a single animal in Namibia (Horak, Biggs, Hanssen & Hanssen, 1983) and 27 600 more than from an animal in the KNP (Horak *et al.,* 1988). As is apparent from the various surveys, burdens of nematodes of this genus may vary considerably.

From Fig. 1a & 2 it seems that peak numbers of *Oesophagostomum* spp. occurred in warthogs in the reserve approximately 3 months after good rainfall, and that the size of the peak depends on the amount of rain. During October 1988 approximately 30 mm rain fell and a small peak occurred during January 1989. Rainfall in excess of 100 mm was measured during February 1989 and 98 mm during March 1989. Small numbers of *Oesophagostomum* spp. were recovered during May 1989 but a peak was reached during June 1989. No such pattern was, however, seen in the warthogs on the base, nor was it apparent for the *Murshidia* spp. or *Probstmayria vivipara* in both groups of warthogs.

Physocephalus sexalatus occurs in warthogs, bushpigs and domestic pigs in South Africa (Ortlepp, 1964, Horak, 1978a; Reinecke, 1983; Horak *et al.,* 1988). The numbers of *Physocephalus sexalatus* recovered during this survey are similar to those in warthogs in Namibia, but are considerably greater than those in warthogs in the KNP. Contrary to the findings of Horak *et al.* (1988), no seasonal pattern of abundance was evident in this survey.

The related *Ascarops strongylina* has been recorded from bushpigs in the northern Transvaal (Ortlepp, 1964) and domestic pigs (Horak, 1978a) but has as yet not been recorded from warthogs.

As in the case of the warthogs in Namibia and the KNP, *Probstmayria vivipara* occurred in vast numbers and peak burdens were present during the cooler months of the year.

Trichostrongylus deflexus (= Trichostrongylus colubriformis of Horak, Biggs, Hanssen & Hanssen, 1983 and *Trichostrongylus instabilis* of Horak *et al.,* 1988) is a recently described nematode of several antelope species (Boomker & Reinecke, 1989). It appears to infect a wide range of hosts, but its presence in warthogs should be regarded as accidental.

Trichostrongylus thomasi is an abomasal parasite of a number of antelope species (Round, 1968; Horak, Meltzer & De Vos, 1982; Horak, Brown, Boomker, De Vos & Van Zyl, 1982; Horak, De Vos & Brown, 1983; Boomker, Horak & De Vos, 1986, 1989) and also occurs in the stomach of Burchell's zebra (Scialdo, Reinecke & De Vos, 1982) and warthogs (Horak *et al.,* 1988; present survey). It fills the same niche in wild animals as is occupied by *Trichostrongylus axei* in domestic animals, but should be regarded as an accidental parasite of warthogs.

Since *Moniezia/Paramoniezia* sp. were recovered only from the younger animals, we postulate that immunity against these tapeworms develops after initial infection, similar to that seen in domestic ruminants infected with *Moniezia expansa* (Reinecke, 1983).

Arthropods

The smaller numbers of species and smaller overall numbers of ectoparasites recovered from the warthogs on the military base than from those in the nature reserve are probably due to the same factors affecting their respective helminth burdens, as mentioned earlier.

Only *Echidnophaga larina* was recovered from the warthogs in Namibia (Horak, Biggs, Hanssen & Hanssen, 1983), while the animals in the KNP and the present survey harboured both *Echidnophaga larina* and *Echidnophaga inexpectata* (Horak *et al.,* 1988). As in the case of the KNP warthogs, the 2 flea species could not be counted separately because of their stick-tight habit, and consequently many were counted *in situ.* This also prevented the determination of their sex. Although considerable variation occurred in the monthly mean flea burdens of the warthogs in Namiba, the KNP and the present survey, it would appear as if the largest numbers of fleas are present during the period May or June to November or December.

The mean burdens of *Moeopsylla sjoestedti* on the warthogs in the HNR were higher than those on the warthogs in the KNP (Horak *et al.,* 1988). The warthogs examined in Namibia did not harbour this flea (Horak, Biggs, Hanssen & Hanssen, 1983). No pattern of seasonal abundance was evident and more female than male fleas were recovered.

In Namibia peak burdens of *Haematopinus phacochoeri* were recorded on warthogs in September of 1 year and June the following year (Horak, Biggs, Hanssen & Hanssen, 1983), while in the KNP peak burdens were present from July to September (Horak *et al.,* 1988). The recovery of large numbers of lice during August and September in the present survey confirms the winter to early spring abundance of this species.

The complete absence of lice on the KNP warthogs during January 1981 (Horak *et al.,* 1988) and during December and January in this survey leads

one to speculate as to where and in what stage these permanent ectoparasites oversummer. The most likely explanation would seem to be as eggs attached to the hair of the warthogs or loose in the burrows of the animals. It could also be that the piglets, which are generally born during November or December in South Africa (Smithers, 1983), acquire infestation from their dams and ensure the survival of the lice during the summer months. This was indeed so in the KNP where a 1-month old piglet examined during January 1980 was fairly heavily infested compared with the absence of infestation on the other warthogs slaughtered at the same time. The same, however, did not apply in the case of a similarly aged warthog examined during January 1981.

If one excludes the adult ticks of the single warthog in the KNP that carried an exceptionally large burden of *Amblyomma hebraeum,* then the mean burdens for the warthogs examined there were 74 larvae, 59 nymphs and 14 adults (Horak *et al.,* 1988). The mean burden for the warthogs examined in the reserve in the present survey was 6 larvae, 44 nymphs and 12 adults. With the exception of the larval numbers (for which we have no explanation), the mean burdens of the 2 groups of warthogs were thus reasonably similar. These findings confirm that warthogs are one of the preferred hosts of adult ticks of this species. The immature stages, and more particularly the larvae, feed on a large variety of mammals and also one some ground-nesting birds (Theiler, 1962; Horak, MacIvor, Petney & De Vos, 1987). Consequently, the immature stages which feed on warthogs are not solely responsible for generating the adult burdens on the same animals.

The warthogs in Namibia, the KNP and the present survey were infested with adult *Hyalomma truncatum* but burdens were never very large (Horak, Biggs, Hanssen & Hanssen, 1983: Horak *et al.,* 1988). Preferred hosts of the adults are large herbivores such as zebras, eland and cattle (Horak, 1982; Rechav, 1986; Horak & MacIvor, 1987). Scrub hares are preferred hosts of the immature stages, which are also found on rodents (Rechav, 1986: Horak & MacIvor, 1987).

Horak *et al.* (1988) state that in the KNP adult *Rhipicephalus simus* seem to prefer monogastric animals such as Burchell's zebras, carnivores and wart-hogs rather than ruminants. The fairly large numbers of adults recovered from the warthogs in the present investigation confirm their observations for this host species. The immature stages of *R. simus* feed on rodents (Norval & Mason, 1981).

The period of peak adult abundance from December to April corresponds to that of January to April with a peak in February on the warthogs in the KNP (Horak *et al.,* 1988). The mean burden of *R. simus* on the warthogs in that survey was more than double that in the present study.

The larvae of *Amblyomma marmoreum* utilise a large number of mammals and some ground-frequenting birds as hosts (Horak *et al.,* 1987). Their presence on the warthogs, albeit in small numbers, is therefore not unexpected. We consider *Boophilus decoloratus, Rhipicephalus appendiculatus, Rhipicephalus evertsi evertsi* and *Rhipicephalus zambeziensis* to be accidental infestations. Their occurrence on the warthogs probably reflects their periods of peak seasonal abundance rather than host preference.

The presence of *Ornithodoros porcinus porcinus* on warthogs that are out of their burrows has been discussed by Horak *et al.* (1988). Its recovery from warthogs in Namibia, the KNP and the present survey indicates that this must be considered a normal occurrence.

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