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PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. XXIII. HELMINTH AND ARTHROPOD PARASITES OF WARTHOGS, *PHACOCHOERUS AETHIOPICUS,* IN THE EASTERN TRANSVAAL LOWVELD

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ABSTRACT

HORAK, I. G., BOOMKER, J., DE VOS, V. & POTGIETER, F. T., 1988. Parasites of domestic and wild animals in South Africa. XXIII. Helminth and arthropod parasites of warthogs, *Phacochoerus aethiopicus*, in the eastern Transvaal Lowveld. *Onderstepoort Journal of Veterinary Research*, 55, 145–152 (1988).

A total of 69 warthogs, *Phacochoerus aethiopicus*, were collected from 4 localities within the Kruger National Park, eastern Transvaal Lowveld. These animals harboured 16 nematode species, 2 trematodes, 1 or 2 species of adult cestodes and the larval stages of 4 cestodes. No pattern of seasonal abundance could be determined for any of the helminths.

The warthogs were also infested with 3 flea species, 1 louse species, 8 ixodid tick species. 1 argasid tick and the nymphae of a pentastomid. The seasonal abundance of fleas of the genus *Echidnophaga*, of the sucking louse *Haematopinus phacochoeri* and the ixodid ticks *Amblyomma hebraeum, Rhipicephalus appendiculatus, Rhipicephalus simus* and *Rhipicephalus zambeziensis* was determined.

INTRODUCTION

The prevalence of several endo- and ectoparasites of warthogs, *Phacochoerus aethiopicus*, in South West Africa/Namibia has recently been reported (Horak, Biggs, Hanssen & Hanssen, 1983). The warthogs were infested with 9 nematode species, 1 or 2 cestode species, 6 species of ixodid ticks, 1 argasid tick species, a flea and a louse species and the larvae of a dipteran fly. Only the spirurid stomach worm *Physocephalus sexalatus* and the sucking louse *Haematopinus phacochoeri* exhibited clear patterns of seasonal abundance.

The present paper describes a similar survey conducted on warthogs in the Kruger National Park in the eastern Transvaal Lowveld.

MATERIALS AND METHODS

Survey region

Warthogs were collected from 4 localities within the Kruger National Park. These were Skukuza (24° 58′ S, 31° 36′ E; Alt. 262 m), Crocodile Bridge (25° 22′ S, 31° 54′ E; Alt. 217 m) and Lower Sabie (25° 07′ S, 31° 55′ E; Alt. 180 m) all situated in a vegetation zone classified as Lowveld; and Pafuri (23° 27′ S, 31° 19′ E; Alt. 305 m) where the vegetation is classified as Mixed Bushveld (Acocks, 1975). Gertenbach (1983) has identified 35 landscape types within the Park. According to his classification Skukuza lies within a region classified as Thickets of the Sabie and Crocodile Rivers; Crocodile Bridge and Lower Sabie in *Sclerocarya caffra/Acacia nigrescens* Savanna; and Pafuri within the Limpopo/Levumbu Flood plains.

Survey animals

With the exception of June 1980, when 1 extra warthog was shot, 1 animal from the most recent litter of piglets (which are generally born in November or December) and 1 older animal were shot at Skukuza each month from January 1980 to January 1981. Except for 1 animal of approximately 11 months of age, 2 warthogs of 12 months or older were shot each month at Crocodile Bridge over the same period. A total of 53 warthogs were collected at the 2 localities in this manner.

In addition 5 warthogs were shot at Pafuri during July 1980 and 2 during October 1981; 2 were shot at Lower Sabie during July 1980, 3 were shot at Skukuza during October and November 1982; and 4 animals were shot at Crocodile Bridge during November 1982.

Parasite recovery

The carcasses of the warthogs shot at Skukuza, Crocodile Bridge and Lower Sabie were transported to the laboratory at Skukuza where they were processed for parasite recovery. Those shot near Pafuri were transported to a nearby field laboratory where they were similarly processed.

At the laboratories unattached fleas and ticks were collected and stored in 70 % alcohol. Thereafter the carcasses were skinned and the skins were processed for ectoparasite recovery as described by Horak, De Vos & De Klerk (1984).

Numerous fleas being deeply imbedded in the skin, were not loosened by the parasite recovery process, and could not be removed with forceps without damage. Consequently, they were counted *in situ* and a small number removed for identification. This procedure, however, made it impossible to determine the exact numbers of the stick-tight fleas *Echidnophaga inexpectata* and *Echidnophaga larina* separately.

The nasal passages and paranasal sinuses of the first 13 warthogs shot were cut open and examined for oestrid larvae as described by Horak (1977). When these contained no larvae no further nasal passages were examined.

The carcasses were eviscerated and all visible cestode cysts collected. The lungs, the livers and the gastro-intestinal tracts were processed for helminth recovery as described by Horak, De Vos & Brown (1983).

Parasite counts

The lung and liver washings were examined *in toto* under a stereoscopic microscope for helminths as were several of the digests of the gastro-intestinal mucosae. Representative samples of the remaining digests as well as of all the gastro-intestinal ingesta were examined under the same microscope. The remains of the gastro-intenstinal contents were examined macroscopically for large nematodes and for cestodes in a flat-bottomed tray.

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TABLE 1 The helminth parasite recovered from 52 warthogs in the Kruger National Park

Helminth species	Total numbers of helminths recovered				Number of warthogs infested
	3rd stage	4th stage	Adult	Total	
Ascaris phacochoeri	25	2	35	62	16
Impalaia tuberculata	0	236	566	802	11
Murshidia spp.	0	4 411	—	4 411	17
Murshidia hamata	—	—	87 506	87 506	39
Murshidia pugnicaudata	—	—	18 706	18 706	35
Oesophagostomum spp.	0	2 256	—	2 256	17
Oesophagostomum mocambiquei	—	—	52 291	52 291	43
Oesophagostomum mwanzae	—	—	5 185	5 185	26
Physocephalus sexalatus	196	36	666	898	25
Probstmayria vivipara	—	Millions	—	—	52
Strongyloides sp.	0	0	116	116	3
Trichostrongylus spp.	0	139	—	139	8
Trichostrongylus falculatus	—	—	50	50	1
Trichostrongylus instabilis	—	—	793	793	4
Trichostrongylus thomasi	—	—	7 892	7 892	39
Trichuris sp.	0	10	0	10	1
Schistosoma sp.	—	—	15	15	1
Moniezia/Paramoniezia sp.	—	—	58*	58	11
Echinococcus sp.		Cysts			8
Taenia crocutae		Cysticerci			4
Taenia hyaenae		Cysticerci			3
Taenia regis		Cysticerci			15

* Scolices

TABLE 2 The arthropod parasites recovered from 51 warthogs in the Kruger National Park

Arthropod species	Total numbers of arthropods recovered					Number of warthogs infested
Fleas	Adults				Total	
Echidnophaga inexpectata/larina	12 932				12 932	46
Moeopsylla sjoestedti	143				143	23
Lice	Nymphae		Adults		Total	
Haematopinus phacochoeri	2 902		533		3 435	34
Ixodid ticks	Larvae	Nymphae	Males	Females	Total	
Amblyomma hebraeum	3 777	3 014	1 028*	348* (24)	8 167	51
Boophilus decoloratus	112	63	39	24 (0)	238	29
Hyalomma truncatum	0	0	7	3 (0)	10	7
Rhipicephalus appendiculatus	—	1 537	—	—	1 537	23
Rhipicephalus appendiculatus/zambeziensis	904	—	27	10 (0)	941	20
Rhipicephalus evertsi evertsi	8	9	0	0	17	11
Rhipicephalus simus	0	0	387	173 (5)	560	27
Rhipicephalus zambeziensis	—	526	—	—	526	19
Argasid ticks	Larvae	Nymphae	Adults		Total	
Ornithodoros porcinus porcinus	0	374	0		374	27
Pentastomids		Nymphae			Total	
Linguatula nuttalli		91			91	18

* Including *A. hebraeum* 525 males, 128 females collected from a single male adult warthog

() Number of maturing female ticks, i.e. the idiosoma of *A. hebraeum* >9,0 mm; *B. decoloratus* >4,0 mm; *H. truncatum* >7,5 mm; *R. appendiculatus/zambeziensis* >5,0 mm, *R. simus* >6,0 mm

The cestodes were not specifically identified but belonged to the genera *Moniezia* or *Paramoniezia*. Ticks, lice and unattached fleas were counted by the methods described by Horak, Potgieter, Walker, De Vos & Boomker (1983). The larvae and adults of *Rhipicephalus appendiculatus* and *Rhipicephalus zambeziensis* were not separated and these were lumped as *Rhipicephalus appendiculatus/zambeziensis*. The length of the idiosoma of adult engorging female ticks of all species was measured. The *Ornithodoros* ticks recovered from the warthogs have been assigned to *Ornithodoros porcinus porcinus* on host preference as suggested by Walton (1962).

Blood parasites

Blood smears were prepared as soon as possible after death. Impression smears of the spleen and lymphnodes were made during necropsy. Smears were made from 18 animals in 3 localities: 8 each from Skukuza and Crocodile Bridge and 2 from Pafuri. All the smears were fixed in methanol, stained in 10 % Giemsa stain for 35

TABLE 3 A comparison of the burdens of *Amblyomma hebraeum* of warthogs examined during a normal and a dry year using the Mann-Whitney U-test

Months examined	Rainfall (mm) Feb–Nov	Number of warthogs examined (sex rations)	Mean numbers (range) of *A. hebraeum* recovered								
			Larvae	U (sign)	Nymphae	U (sign)	Males	U (sign)	Females	U (sign)	Total
Oct/Nov 1980	414,5	8 (1 male: 7 females)*	18,6 (0–35)		24,4 (11–44)		7,6 (2–28)		3,3 (1–11)		53,9
Oct/Nov 1982	175,4	7 (5 males: 2 females)*	416,0 (56–1233)	0 (<0,001)	259,7 (27–858)	8 (<0,01)	203,1 (12–75)	8 (<0,01)	88,6 (5–308)	16 (=0,052)	967,4

* There is no statistical difference between the burdens of the male and female warthogs
(sign) = (significance)

min and examined in immersion oil under 1 000 × magnification.

Climatic data

Mean monthly minimum and maximum atmospheric temperatures and monthly rainfall were recorded at Skukuza.

RESULTS

Helminths

The total numbers of helminths recovered from 52 warthogs slaughtered at monthly intervals at Skukuza and Crocodile Bridge are summarized in Table 1 (the ingesta of 1 animal were mislaid).

Thirteen nematode species, 1 trematode, 1 or 2 cestode species and the larval stages of 4 cestodes were recovered. *Probstmayria vivipara, Murshidia hamata* and *Oesophagostomum mocambiquei* were the most abundant helminths recovered. A large proportion of the total numbers of the latter 2 worms came from a single animal, which harboured 5 000 adult *O. mocambiquei* and 38 200 adult *M. hamata*.

All the *Impalaia tuberculata* recocvered from the warthogs were considerably smaller than normal and the males' spicules were markedly reduced in length.

A young warthog, 1 month of age, was infested with *Strongyloides* sp. This was the only helminth recovered from this animal. No *Strongyloides* sp. were recovered from the piglets of 2 or 3 months of age, but the 4-month-old animal and an adult animal from Crocodile Bridge were also infested. No other warthogs harboured this parasite.

Ascaris phacochoeri, O. mocambiquei, P. sexalatus, Trichostrongylus thomasi and *Trichostrongylus instabilis* and *Moniezia/Paramoniezia* sp. were recovered from the 2-month-old warthog. *M. hamata* and *Murshidia pugnicaudata* were first encountered when the warthogs were 6 months of age and *Oesophagostomum mwanzae* in a 7-month-old animal.

No pattern of seasonal abundance could be determined for any of the helminths.

The animals shot at Skukuza and Crocodile Bridge during October and November 1982 harboured the same parasites as those examined 2 years earlier at these localities and in addition 1 harboured 28 adult *Haemonchus krugeri* and another 100 adult *Oesophagostomum santos-diasi*. Those examined at Pafuri harboured only *A. phacochoeri, I. tuberculata, M. hamata, M. pugnicaudata, O. mocambiquei, P. vivipara* and *Moniezia/Paramoniezia* sp. One was also infested with 2 *Gastrodiscus aegyptiacus*. The 2 arthogs examined at Lower Sabie harboured only *M. hamata, M. pugnicaudata, O. mocambiquei* and *T. thomasi*.

Two of the warthogs had unidentified adult filarid nematodes in the lymphatic vessels adjacent to peripheral and visceral lymph nodes and 13 had microfilariae in the lymph nodes and the circulating blood (Palmieri, Pletcher, De Vos & Boomker, 1985).

Arthropods

The total numbers of ectoparasites recovered from 51 warthogs slaughtered at monthly intervals at Skukuza and Crocodile Bridge are summarized in Table 2 (no preservative had been added to the skin scrubbings of 2 animals and these could not be examined).

These animals harboured 3 flea species, a louse species, 7 ixodid tick species, 1 argasid tick and the nymphae of a pentastomid. All the animals were infested with *Amblyomma hebraeum* and the majority with 1 or both *Echidnophaga* species.

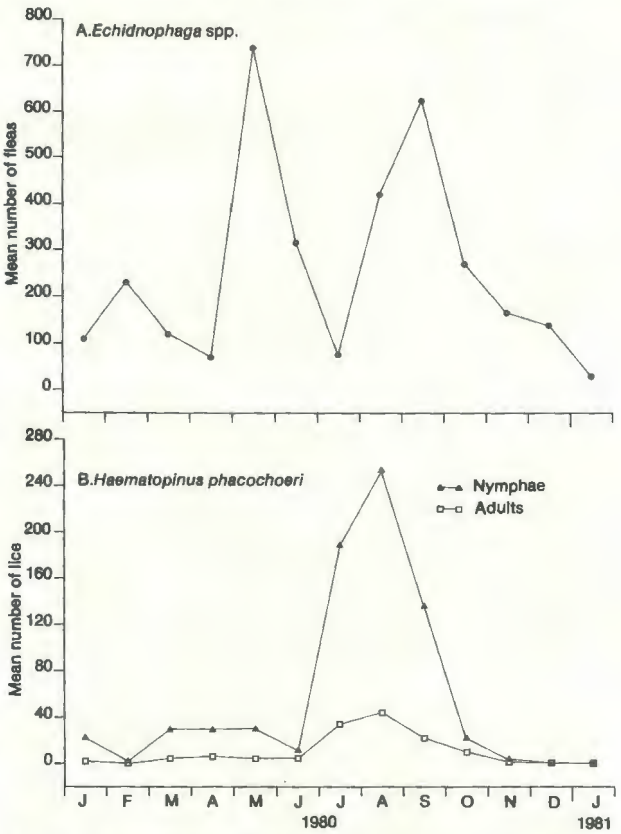

FIG. 1 The seasonal abundance of
A. *Echidnophaga* spp. and
B. *Haematopinus phacochoeri*
on warthogs in the Kruger National Park

At 1 month of age a warthog piglet had acquired infestation with *H. phacochoeri* and with 3 ixodid tick species. At 2 months of age a piglet harboured *H. phacochoeri, Echidnophaga* spp., 4 ixodid tick species and *Ornithodoros porcinus porcinus*. The piglets were 5 months old before the nymphae of *Linguatula nuttalli* were recovered from 1 of them.

The numbers of *A. hebraeum* larvae, nymphae and males recovered from the animals shot at Skukuza and Crocodile Bridge in October and Novemvber 1982, during a severe drought, were significantly greater ($P<0,01$) than those recovered from the animals shot at the same sites during the same months in 1980, a year of normal rainfall. The tick burdens of the 2 groups of animals are summarized in Table 3.

With the exception of adult *Rhipicephalus kochi*, which were recovered in small numbers from 4 out of the 7 warthogs shot at Pafuri, the animals from Pafuri and those from Lower Sabie were infested with the same parasites as those shot at Skukuza and Crocodile Bridge.

Some of the arthropod parasites exhibited distinct patterns of seasonal abundance. These are graphically illustrated in Fig. 1 & 2.

Peak burdens of the 2 *Echidnophaga* species were present during May and September. Peak numbers of *H. phacochoeri* were recovered from July to September.

The larvae of *A. hebraeum* peaked from February to May, the nymphae during May and during August and September, while peak adult burdens were recovered from January to March and during September 1980 and January 1981. The larvae of *R. appendiculatus/zambeziensis* were recovered in the greatest numbers from April to June and the adults from March to May. The nymphae of both *R. appendiculatus* and *R. zambeziensis*

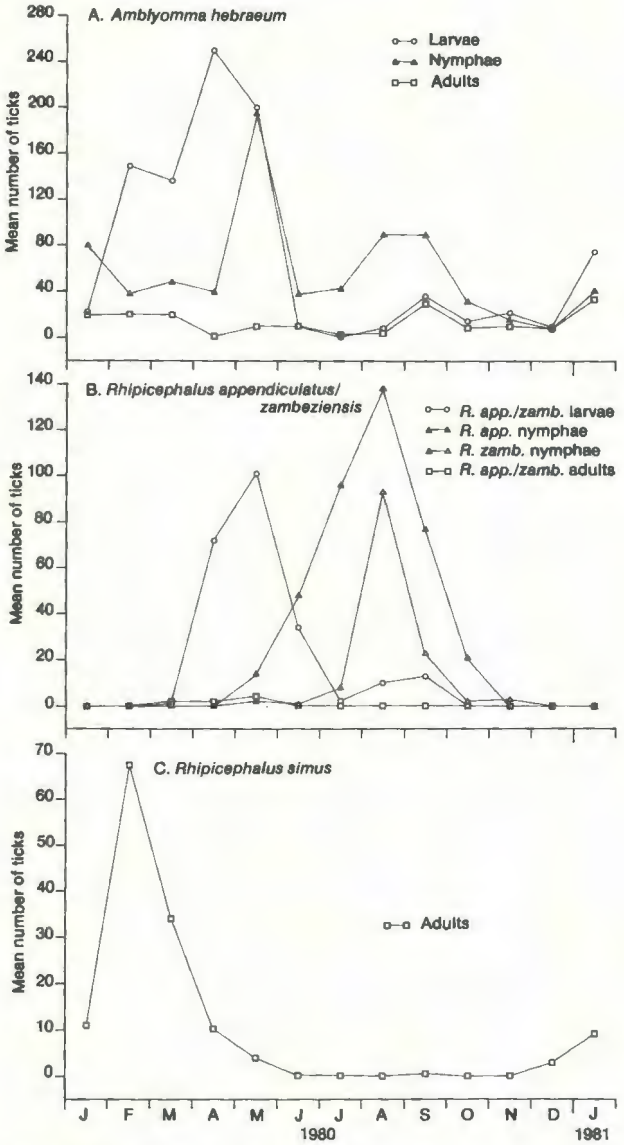

FIG. 2 The seasonal abundance of
A. *Amblyomma hebraeum* (excluding 1 animal with an exceptionally large adult burden)
B. *Rhipicephalus appendiculatus/zambeziensis* and
C. *Rhipicephalus simus*
on warthogs in the Kruger National Park

peaked during August. Peak burdens of adult *Rhipicephalus simus* were present during February.

Blood parasites

All smears examined were negative for blood parasites.

Climate

The mean monthly atmospheric temperatures and total monthly rainfall at Skukuza for the period January 1980 to January 1981 are graphically illustrated in Fig. 3.

The highest maximum temperatures were recorded during January to April and December 1980 and during January 1981, and the lowest minimum temperatures during June and July 1980. Rain fell mainly during January and February 1980 and during November 1980 to January 1981. Total annual rainfall for 1980 at Skukuza was 660,0 mm. Total annual rainfall during 1982 (the year of the severe drought) was 437,2 mm, 202,5 mm of which fell during January 1982 and 59,3 mm during December 1982, leaving 175,4 mm for the remaining 10 months.

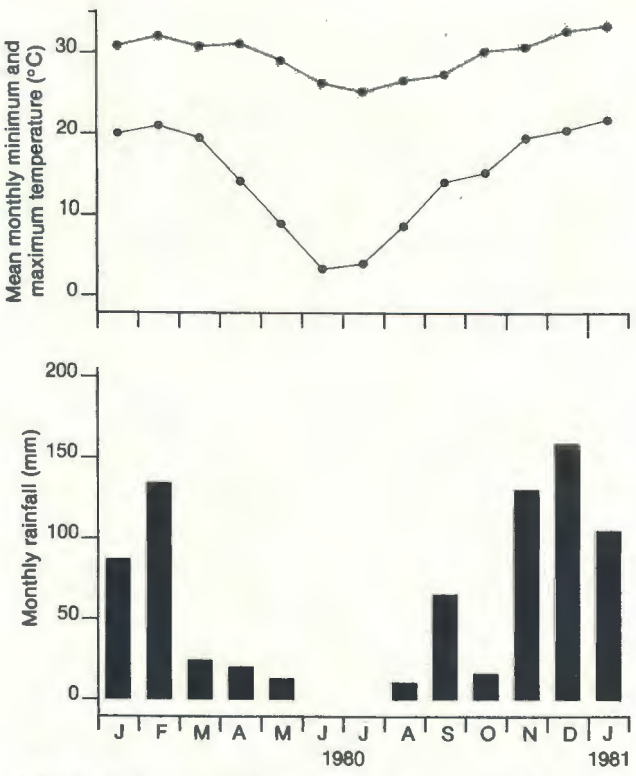

FIG. 3 Monthly mean minimum and maximum atmospheric temperatures and monthly rainfall at Skukuza from January 1980 to January 1981

Comment: The 60 year mean rainfall for February to November at Skukuza is 375,1 mm (Gertenbach, unpublished data, 1981). If the annual rainfall is calculated per season, i.e. from 1 July to 30 June (Gertenbach, 1980), the total for 1982/83 (275,6 mm) is the lowest ever recorded at Skukuza since records were started in 1919 (Gertenbach, unpublished data, 1985).

DISCUSSION

The warthogs examined in Namibia by Horak, Biggs, Hanssen & Hanssen (1983) harboured at least 10 helminth species and 10 arthropod species. Those examined in the Kruger National Park were infested with at least 19 helminth species (plus the larval stages of 4 cestodes), and 14 species of arthropod parasites. The helminths harboured in common by the 2 groups of warthogs are *O. mwanzae, P. sexalatus, P. vivipara* and *Moniezia/Paramoniezia* sp. and the arthropods are *E. larina, H. phacochoeri, Hyalomma truncatum, R. simus* and *O. porcinus porcinus*.

Helminths

Ascaris phacochoeri

This helminth has previously been recovered from warthogs in Zululand by Ortlepp (1939). The percentage of warthogs infested (30,8 %) in the present survey is identical to that of a group of domestic pigs infested with *Ascaris suum* (Horak, 1978a). These pigs had been consigned by farmers to the Pretoria Municipal Abattoir over a period of 1 year. The mean burden of adult *A. phacochoeri* (0,67 worms, range 0–7 worms) in the warthogs is, however, slightly lower than that of adult *A. suum* in the domestic pigs (2 worms, range 0–15 worms).

Impalaia tuberculata

This nematode, and the related species *Impalaia nudicollis,* are usually recovered from antelope, particularly impala *(Aepyceros melampus)* (Horak, 1978d) and blesbok *(Damaliscus dorcas phillipsi)* (Horak, 1978c). However, *I. nudicollis* has been recovered from warthogs in Namibia (Horak, Biggs, Hanssen & Hanssen, 1983), while those examined in the Kruger National Park harboured *I. tuberculata*. The measurements of both these worms from the warthogs were considerably smaller than those given by Gibbons, Durette-Desset & Daynes (1977) and Boomker (1977) in their reviews of the genus *Impalaia*. Contrary to the findings for *I. nudicollis* in the Namibian warthogs, in which few worms were adult, the majority of *I. tuberculata* in the Kruger National Park warthogs were adult (Table 1). Nevertheless the small size of the latter worms indicates that warthogs are not definitive hosts of this nematode.

Mushidia *spp.*

Ortlepp (1964) noted that there were no worms of the genus *Murshidia* in warthogs from Moçambique, while warthogs at Pilgrim's Rest and in Zululand were infested. Moçambique lies to the east and north of the Kruger National Park, Pilgrim's Rest to the west and Zululand to the south-east. It is possible that the warthogs from Moçambique examined by Ortlepp (1964), were by chance not infested with *Murshidia* spp. If, however, *Mushidia* spp. are indeed absent in warthogs in Moçambique it would be interesting to determine the exact boundary of infestation between the Kruger National Park and that territory. Very large burdens of worms of this genus are possible as 1 of the warthogs from Crocodile Bridge harboured a total of 48 000 immature and adult *M. hamata* and *M. pugnicaudata* and 1 from Pafuri harboured 40 775 immature and adult *M. hamata*.

Oesophagostomum *spp.*

Ortlepp (1964) identified *O. mocambiquei, O. mwanzae* and *O. santos-diasi* in material collected from warthogs in Moçambique and Pilgrims' Rest. No oesophagostomes were present in the specimens he examined from warthogs in Zululand. *O. mwanzae* has a very widespread distribution being present in warthogs in northern Moçambique and at Pilgrim's Rest (Ortlepp, 1964), in the Kruger National Park (present survey) and in northern Namibia (Horak, Biggs, Hanssen & Hanssen, 1983). In both Namibia and the Kruger National Park it was not the dominant oesophagostome, being outnumbered by *Oesophagostomum mpwapwae* at the former and *O. mocambiquei* at the latter locality.

The largest total number of immature and adult *Oesophagostomum* spp. recovered from a single warthog in the present survey was 7 400 worms, compared with 30 510 adult worms from a warthog in Namibia (Horak, Biggs, Hanssen & Hanssen, 1983).

Physocephalus sexalatus

Horak, Biggs, Hanssen & Hanssen (1983) recovered speak burdens of this nematode from January to March in warthogs from northern Namibia, while Horak (1978b) found that the related *Ascarops strongylina* was most abundant in domestic pigs in the Transvaal from November to March. No pattern of seasonal abundance could be determined in the present survey. Ortlepp (1964) has recorded both *A. strongylina* and *P. sexalatus* from bushpigs *(Potamochoerus porcus)* in the northern Transvaal, but *A. strongylina* has apparently not been recovered from warthogs (Round, 1968).

Probstmayria vivipara

As in the case of the animals in Namibia (Horak, Biggs, Hanssen & Hanssen, 1983) extremely large burdens, of which we did not attempt to ascertain the numbers, were present.

Strongyloides *sp.*

The fact that a 1-month-old animal and another young animal were infested with this worm seems to indicate a milk-borne route of infestation as in the case of *Strongyloides papillosus* in sheep and goats (Moncol & Grice, 1974).

Trichostrongylus *spp.*

We think that the small number of warthogs infested with *Trichostrongylus falculatus* and *T. instabialis*, and the small burdens of these worms in the infested warthogs, indicate that these are accidental infestations, as the true hosts are 1 or more of the antelope species in the park.

In the same way that *Trichostrongylus axei* appears to be an abomasal parasite in both domestic ruminants and horses (Soulsby, 1968), *T. thomasi* fills this niche in antelope (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), Burchell's zebras (Scialdo, Reinecke & De Vos, 1982) and warthogs (present survey).

Larval cestodes

The *Echinococcus* sp. cysts could have originated from adult cestodes of this genus present in a variety of carnivore species in the park. Adult *Taenia crocutae* and *Taenia hyaenae* are parasites of hyaenas while adult *Taenia regis* is found in lions (Round, 1968).

Arthropods

Echidnophaga *spp.*

Both *E. inexpectata* and *E. larina* are stick-tight fleas found firmly attached mainly along the softer undersides of the warthogs. *E. larina* is frequently encountered on warthogs, while *E. inexpectata* is supposedly a rarer parasite of these animals (Haeselbarth, Segerman & Zumpt, 1966). Although because of their stick-tight habit, it was not possible to obtain exact counts for either species in the present survey, the numbers of *E. inexpectata* generally seemed to exceed those of *E. larina*.

Whether the peak early winter and spring abundances of these fleas were real or due to large variations in individual burdens could not be ascertained. In Namibia no clear pattern of seasonal abundance of *E. larina* on warthogs could be determined (Horak, Biggs, Hanssen & Hanssen, 1983).

Moeopsylla sjoestedti

This is a jumping flea and was found mainly around the necks and heads of the warthogs. This species has been recovered from warthogs in east Africa from Kenya in the north to the eastern Transvaal Lowveld in the south (Haeselbarth *et al.*, 1966).

Haematopinus phacochoeri

This is the large sucking louse of warthogs (Ledger, 1980). In Namibia peak burdens were present on the warthogs in September of 1 year and during June of the following year (Horak, Biggs, Hanssen & Hanssen, 1983). In the present survey there was a clear peak of abundance of both nymphae and adults from July to September.

The months of peak abundance are also the months during which the available feed is at its driest. Perhaps the warthogs conserve energy during this time of nutritional stress by reducing the time spent on grooming and increasing the time devoted to foraging, hence the increasae in lice burdens.

Amblyomma hebraeum

Excluding the burdens of the 1 warthog carrying exceptionally large numbers of adult ticks (Table 2), warthogs must still be considered 1 of the preferred hosts of the adults of this tick. They carry more adult ticks than do blue wildebeest (Horak, De Vos & Brown, 1983), Burchell's zebras (Horak *et al.*, 1984), large and small carnivores (Horak, Jacot Guillarmmod, Moolman & De Vos, 1987) and impala (Horak, Boomker & De Vos, unpublished data, 1987) examined in the park. The ratio of larvae to nymphae to adults indicates a high proportion of adults, and this suggests that the warthog is a better host of adult *A. hebraeum* than of the immature stages.

The very large burdens of *A. hebraeum* recovered from the warthogs shot during the drought of 1982 do not imply that these ticks prefer dry conditions. They reflect rather that the animals' resistance was markedly reduced because of nutritional stress, and that they probably conserved energy by reducing grooming to a minimum, both these factors presumably leading to increased tick burdens (O'Kelly & Seifert, 1969).

The seasonal abundance of immature *A. hebraeum* on the warthogs is similar to that observed by Knight & Rechav (1978) on kudu, by Rechav (1982) on cattle, and by MacIvor & Horak (1984) on goats in the eastern Cape Province. The period of adult abundance on the warthogs, however, was longer than that observed on the other hosts.

Rhipicephalus appendiculatus/zambeziensis

Judging by the numbers recovered, warthogs are not important hosts of these ticks and particularly not of the adults. Burchell's zebra (Horak *et al.*, 1984) and more particularly impala and kudu (Horak, Boomker & De Vos, unpublished data, 1987) are better hosts. The seasonal abundance of all stages of development is similar to that of *R. appendiculatus* on impala and cattle in the northern Transvaal (Horak, 1982). The larvae of the 2 species were most abundant on the warthogs during the same months in which maximum abundance of this developmental stage has been recorded on blue wildebeest in the park (Horak, De Vos & Brown, 1983). The nymphal peak of *R. appendiculatus* on the warthogs corresponds to that on blue wildebeest and Burchell's zebra in the park (Horak, De Vos & Brown, 1983; Horak *et al.*, 1984).

Not only are *R. appendiculatus* and *R. zambeziensis* similar in appearance (Walker, Norval & Corwin, 1981), but their distributions overlap in certain regions and their seasonal abundance is similar (Norval, Walker & Colborne, 1982; present study).

Rhipicephalus kochi

This tick has previously been recovered from animals at Pafuri (Gertrud Theiler, unpublished data, 1964, as *Rhipicephalus neavei;* Horak, Potgieter, Walker, De Vos & Boomker, 1983). This is as yet the only site in the Republic of South Africa at which *R. kochi* is known to occur (Clifford, Walker & Keirans, 1983). The warthog does not appear to be a preferred host of this tick as no immature stages and few adults were recovered. Kudu, nyala and bushbuck examined at Pafuri during October 1981 harboured fairly large numbers of nymphae and adults (Horak, Potgieter, Walker, De Vos & Boomker, 1983), while only 1 of the 2 warthogs examined at the same time was infested and that with only 4 male *R. kochi*.

Rhipicephalus simus

In the park the adults of this tick seem to prefer monogastric animals such as Burchell's zebra (Horak *et al.*, 1984), carnivores (Horak *et al.*, 1987) and warthogs (present survey) rather than ruminants. Norval & Mason (1981) state that the larger ungulate and carnivore species are the most important wild hosts with warthogs frequently being parasitized.

The seasonal abundance on the warthogs roughly corresponds to the times of maximum abundance on Burchell's zebra in the park (Horak *et al.*, 1984) and on cattle in the northern Transvaal (Horak, 1982).

Other ixodid ticks

We consider *Boophilus decoloratus, H. truncatum* and *Rhipicephalus evertsi evertsi* to be accidental infestations on the warthogs. They are more a reflection of ticks present in the environment rather than host preference.

Ornithodoros porcinus porcinus

Chorley (1943) cited by Hoogstraal (1956) and Horak, Biggs, Hanssen & Hanssen (1983) recovered this tick on warthogs, although it is usually encountered in their burrows (Hoogstraal, 1956). In the present study 1 animal harboured 97 nymphae and another 107. These ticks had probably not completed feeding when the warthogs left their burrows in the mornings and some would presumably have remained on the animals until they returned to the burrows in the evenings. This would probably explain how the ticks spread from 1 burrow to the next.

Linguatula nuttalli

The recovery of the nymphae of this pentastomid from a high proportion of warthogs is a reflection of the large number of lions, the final host of this parasite, in the park. Horak, De Vos & Brown (1983) have recovered the nymphae of *L. nuttalli* from a fairly large proportion of blue wildebeest in the park.

Blood parasites

Trypanosomes, resembling *Trypanosoma vivax*, were seen by Curson (1928) in the blood of a single warthog in Zululand. Neitz (1931) examined blood, spleen and lymphnode smears of 56 warthogs from Zululand and, with the exception of 5 animals with microfilarial infections, no other haemoparasites were observed. In a subsequent investigation, 7 out of 34 warthogs in Zululand were found to be infected with microfilariae and a small *Theileria*-like piroplasm was found in the blood of 1 of these animals (Neitz, 1933). According to Neitz (1933) this was the 1st observation of small piros in the red cells of a warthog. No trypanosomes were seen.

In the persent survey an effort was made to detect *Theileria*-like parasites in the blood smears of the warthogs, but none were found. More animals from different geographical regions should be examined, however, as vector distribution may play a role in the prevalence of this parasite.

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REFERENCES

ACOCKS, J. P. H., 1975. Veld types of South Africa with accompanying veld type map. 2nd edn. *Memoirs of the Botanical Survey of South Africa*, No. 40, 128 pp.

BOOMKER, J., 1977. A revision of the genus *Impalaia* Mönnig, 1924. *Onderstepoort Journal of Veterinary Research*, 44, 131–138.

BOOMKER, J., HORAK, I. G. & DE VOS, V., 1986. The helminth parasites of various artiodactylids from some South African nature reserves. *Onderstepoort Journal of Veterinary Research*, 53, 93–102.

CLIFFORD, C. M., WALKER, JANE, B. & KEIRANS, J. E., 1983. Clarification of the status of *Rhipicephalus kochi* Dönitz, 1905 (Ixodoidea, Ixodidae). *Onderstepoort Journal of Veterinary Research*, 50, 77–89.

CURSON, H. H., 1928. Nagana in Zululand. *Report of the Director of Veterinary Education and Research, Union of South Africa*, 13/14, 309–411.

GERTENBACH, W. P. D., 1980. Rainfall patterns in the Kruger National Park. *Koedoe*, 23, 35–43.

GERTENBACH, W. P. D., 1983. Landscapes of the Kruger National Park. *Koedoe*, 26, 9–121.

GIBBONS, LYNDA M., DURETTE-DESSET, MARIE-CLAUDE & DAYNES, P., 1977. A review of the genus *Impalaia* Mönnig, 1923 (Nematoda: Trichostrongyloidea). *Annales de Parasitologie (Paris)*, 52, 435–446.

HAESELBARTH, E., SEGERMAN, J. & ZUMPT, F., 1966. The arthropod parasites of vertebrates in Africa south of the Sahara. Vol III. (Insecta excl. Phthiraptera). Publication No. 52 of the South African Institute for Medical Research, Johannesburg.

HOOGSTRAAL, H., 1956. African Ixodoidea. 1. 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.

HORAK, I. G., 1977. Parasites of domestic and wild animals in South Africa. I. *Oestrus ovis*. *Onderstepoort Journal of Veterinary Research*, 44, 55–63.

HORAK, I. G., 1978a. Parasites of domestic and wild animals in South Africa. VII. Helminths in pigs slaughtered at the Pretoria Municipal Abattoir. *Onderstepoort Journal of Veterinary Research*, 45, 43–47.

HORAK, I. G., 1978b. Parasites of domestic and wild animals in South Africa. VIII. Helminths in pigs kept under semi-intensive conditions. *Onderstepoort Journal of Veterinary Research*, 45, 49–53.

HORAK, I. G., 1978c. Parasites of domestic and wild animals in South Africa. IX. Helminths in blesbok. *Onderstepoort Journal of Veterinary Research*, 45, 55–58.

HORAK, I. G., 1978d. Parasites of domestic and wild animals in South Africa. X. Helminths in impala. *Onderstepoort Journal of Veterinary Research*, 45, 221–228.

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., BIGGS, H. C., HANSSEN, TAMMY S. & HANSSEN, 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., 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. Parasitres 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., JACOT GUILLARMOD, AMY, MOOLMAN, L. C. & DE VOS, V., 1987. Parasites of domestic and wild animals in South Africa. XXII. Ixodid ticks on domestic dogs and on wild carnivores. *Onderstepoort Journal of Veterinary Research*, 54, 573–580.

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. Vol. 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.

MONCOL, D. J. & GRICE, M. J., 1974. Transmammary passage of *Strongyloides papillosus* in the goat and sheep. *Proceedings of the Helminthological Society of Washington*, 41, 1–4.

NEITZ, W. O., 1931. Blood parasites of game in Zululand. Preliminary report. *Report of the Director of Veterinary Services and Animal Industry, Union of South Africa*, 17, 45–60.

NEITZ, W. O., 1933. Blood parasites of game in Zululand. Further report. *Onderstepoort Journal of Veterinary Science and Animal Industry*, 1, 411–417.

NORVAL, R. A. I. & MASON, C. A., 1981. The ticks of Zimbabwe. II. The life cycle, distribution and hosts of *Rhipicephalus simus* Koch, 1844. *Zimbabwe Veterinary Journal*, 12, 2–9.

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.

O'KELLY, J. C. & SEIFERT, G. W., 1969. Relationships between resistance to *Boophilus microplus*, nutritional status, and blood composition in Short-horn × Hereford cattle. *Australian Journal of Biological Sciences*, 22, 1497–1506.

ORTLEPP, R. J., 1939. Observation on *Ascaris phacochoeri* Gedoelst, 1916, a little known nematode parasite from the warthog. *Volumen Jubilare pro Prof Sadao Yoshida*, 2, 307–309.

ORTLEPP, R. J., 1964. Observations on helminths parasitic in warthogs and bushpigs. *Onderstepoort Journal of Veterinary Research*, 31, 11–37.

PALMIERI, J. R., PLETCHER, J. M., DE VOS, V. & BOOMKER, J., 1985. A new filarial nematode (Onchocercidae) from warthogs *(Phacochoerus aethiopicus)* of the Kruger National Park. *Journal of Helminthology*, 59, 241–245.

RECHAV, Y., 1982. Dynamics of tick populations (Acari: Ixodidae) in the eastern Cape Province of South Africa. *Journal of Medical Entomology*, 19, 679–700.

ROUND, M. C., 1968. Check list of the helminth parasites of African mammals of the orders Carnivora, Tubulidentata, Proboscidea, Hyracoidea, Artiodactyla and Perissodactyla. *Technical Communication of the Commonwealth Bureau of Helminthology*, 38, 252 + vi pp.

SCIALDO, ROSINA, C., REINECKE, R. K. & DE VOS, V., 1982. Seasonal incidence of helminths in the Burchell's zebra. *Onderstepoort Journal of Veterinary Research*, 49, 127–130.

SOULSBY, E. J. L., 1968. Helminths, arthropods and protozoa of domesticated animals. London: Bailliére, Tindall & Cassel.

WALKER, JANE, B., NORVAL, R. A. I. & CORWIN, M. D., 1981. *Rhipicephalus zambeziensis* sp. nov., a new tick from eastern and southern Africa, together with a redescription of *Rhipicephalus appendiculatus* Neumann, 1901 (Acarina, Ixodidae). *Onderstepoort Journal of Veterinary Research*, 48, 87–104.

WALTON, G. A., 1962. The *Orinothodoros moubata* superspecies problem in relation to human relapsing fever epidemiology. *Symposia of the Zoological Society of London*, No. 6, 83–156.

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