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THE HELMINTH FAUNA OF THE DIGESTIVE TRACTS OF CHACMA BABOONS, *PAPIO URSINUS*, FROM DIFFERENT LOCALITIES IN THE TRANSVAAL

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ABSTRACT

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All of the 111 baboons examined from the Loskop Dam, Suikerbosrand and Scrutton Nature Reserves and the Sabie-Tweefontein Forest Reserve were infested with helminths of the digestive tract. The helminths recovered were *Bertiella studeri, Enterobius vermicularis, Oesophagostomum bifurcum, Physaloptera caucasica, Streptopharagus pigmentatus, Strongyloides fülleborni, Trichostrongylus falculatus, Trichuris trichiura* and females of *Trichuris* which possibly belong to a new species. Most baboons harboured 3, and some as many as 6, species of helminths. Burdens of the various helminths varied greatly, even among baboons from the same locality, age group and sex. All helminths found in the present study can occur in very young animals. Worm burdens generally increased as the host aged, with a subsequent decrease among adult baboons for *Enterobius vermicularis, Strongyloides fülleborni* and *Trichostrongylus falculatus*. Heavier worm burdens were found in the wet season for *Bertiella studeri* and *Oesophagostomum bifurcum*, whereas *Trichostrongylus falculatus* occurred in greater numbers during the dry season. No significant differences between worm burdens in male and female baboons were found, but *Physaloptera caucasica* was more prevalent in males. *Trichostrongylus falculatus* and *Enterobius vermicularis* are new records for the chacma baboon.

INTRODUCTION

Very little is known about the disease spectrum of African baboons in the wild other than a study by McConnell, Basson, De Vos, Myers & Kuntz (1974) in the Kruger National Park and work conducted in East Africa (Kuntz & Myers, 1966; Kim, Eugster & Kalter, 1968). This is surprising in view of their importance in biomedical investigations and behavioural studies. Furthermore, the close anatomical and physiological relationship of baboons to man would indicate that certain diseases are common to both. The dangers of primate zoonoses have been emphasized by Blackie (1932), Hummer (1965), Fiennes (1967) and many others. Accidental human infestations by helminths normally occurring in the lower primates may have far more severe consequences in the humans than in their usual hosts (Cameron, 1927; Blackie 1932; Fiennes, 1967).

Graham (1960) suggests that parasitism, and, in particular, helminthiosis, is not a serious hazard for monkeys. Despite numerous accounts of fatalities among primates ascribed to various helminth species, parasitism as a population regulatory mechanism in wild primates has not received much attention. Stoltz (1977) submitted that contagious diseases could be a major population regulatory mechanism in natural baboon populations, but was unable to substantiate this.

This paper reports on the prevalence and worm burdens of helminths of the digestive tract of chacma baboons, *Papio ursinus*, from 4 areas of the Transvaal.

MATERIAL AND METHODS

Study areas

The 12 754 ha Loskop Dam Nature Reserve (25°22′–25°31′S., 29°12′–29°25′E) is situated in the Olifants River basin in the south-eastern Transvaal. The reserve, which surrounds an irrigation dam with a surface area of 1 700 ha at maximum capacity, is characterized by a rugged mountainous terrain. The vegetation can be broadly classified as Mixed Bushveld and Sourish Mixed Bushveld (Acocks, 1975). The rainfall is erratic and unpredictable: between 1975 and 1978 the annual rainfall ranged from 578 mm–874 mm. Approximately 80 % falls in the summer (October to March), with very little or no rainfall in winter (June, July and August). Summers are hot and winters temperate.

The Suikerbosrand Nature Reserve (26°27′–26°34′S., 28°09′–28°21′E) is situated approximately 40 km south of Johannesburg in the south-central Transvaal. The reserve, comprising some 13 400 ha, falls within the summer rainfall region and Acocks's (1975) Bankenveld, characterized by predominantly open grassveld with dense thickets in some of the ravines. The altitude ranges from 1 575 m–1 880 m. Winters are cold and summers temperate with frequent thunder, lightling and hail storms. Annual rainfall varies from 560 mm–730 mm, the majority falling between October and March. Monthly mean minimum temperatures are normally below 5 °C during winter, whereas the monthly maximum temperatures seldom exceed 27 °C during summer.

The Scrutton Private Nature Reserve (22°21′S., 30°23′E) is situated in the far Northern Transvaal. The Limpopo River forms its northern boundary and the Nzhelele River its western boundary. The reserve is small (± 1 000 ha) and falls within Acocks's (1975) Mopane veld type. The altitude ranges from 400 m–500 m and the annual rainfall, between 250 mm–400 mm, is strictly confined to the summer months. The climate is very hot with daily maximum temperatures during summer frequently in excess of 40 °C.

Only 3 baboons were collected in the Tweefontein Forest Reserve (25°05′S, 30°47′E) at a locality approximately 5 km north of Sabie. The area is at an altitude of approximately 1 200 m and falls within Acocks's (1975) North-Eastern Mountain Sourveld with high annual rainfall normally in excess of 900 mm. Most of the area is now planted with exotic silviculture species, mainly *Pinus* spp. and *Eucalyptus* spp.

The study areas, as well as the distribution of baboons in the Transvaal after Rautenbach (1982), are indicated in Fig. 1.

Collection of helminths

To determine the seasonal incidence of helminths, baboons were collected in both the dry and the wet (i.e. rainy) seasons between September 1976 and September 1978. The numbers of baboons collected in each locality as well as the dates and seasons are listed in Table 1.

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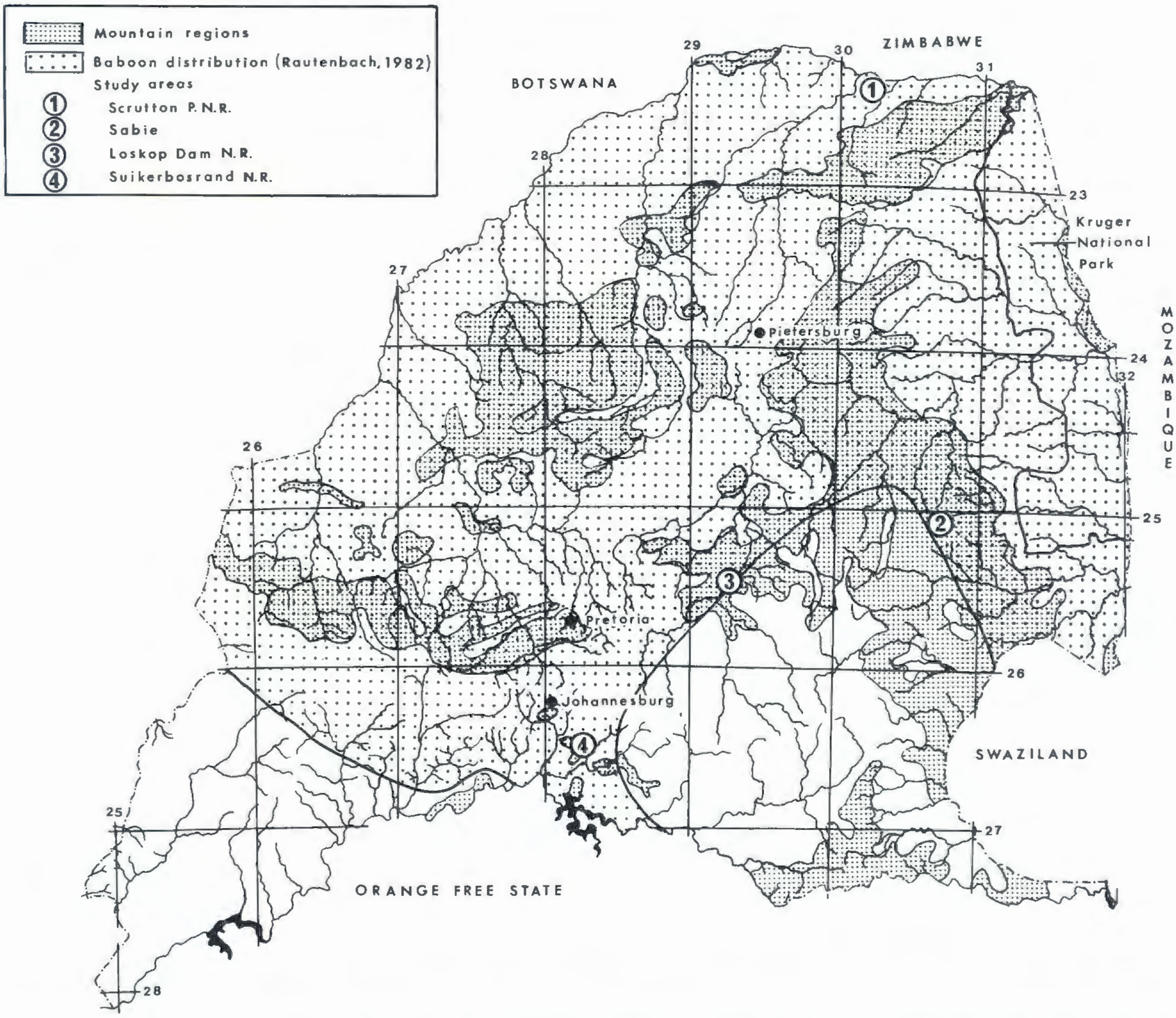

FIG. 1 Map of the Transvaal showing the distribution of baboons (after Rautenbach, 1982) and the four study localities during the present investigation

TABLE 1 The number of baboons examined from 4 localities in the Transvaal

Date	Season	Locality	Number examined	Examination	Total	
22 Sept. 1976	Dry	Loskopdam	20	Macroscopic		
05 Oct. 1976	Dry	Loskopdam	16	Macroscopic	42	
20 Oct. 1976	Dry	Loskopdam	4	Macroscopic		
17 Nov. 1976	Wet	Loskopdam	16	Microscopic	23	65
17 Mar. 1977	Wet	Loskopdam	9	Microscopic		
09 Feb. 1977	Wet	Suikerbosrand	5	Microscopic		
06 Oct. 1977	Dry	Suikerbosrand	8	Microscopic	25	
24 Oct. 1977	Dry	Suikerbosrand	7	Microscopic		
03 Nov. 1977	Wet	Suikerbosrand	5	Microscopic		
13 Dec. 1977	Wet	Sabie	3	Microscopic	3	
04 Feb. 1978	Wet	Scrutton	4	Microscopic		
23 Sept. 1978	Dry	Scrutton	7	Microscopic	18	
26 Sept. 1978	Dry	Scrutton	7	Microscopic		
				Total	111	

Baboons were live-trapped as described by Keith & Stoltz (1967) and a) immobilized either with gallamine triethiodide[1], succinylcholine chloride[2] or ketamine hydrochloride[3], then euthanized with sodium pentobarbitone[4], or b) shot, using a, 0,270 Winchester rifle. The baboons collected from Sabie were poisoned, using oranges baited with 10:80 (monofluroacetate). On expiration the baboons were mass measured to the nearest 0,5 kg using a spring balance. Thereafter the abdominal cavity was opened and ligatures tied at the pylorus and at the ileo-caecal junction to prevent the helminths migrating from one part of the intestinal tract to another.

(1) Flaxedil, May & Baker, Port Elizabeth
(2) Scoline, Glaxo-Allenburys, Germiston
(3) Ketalar, Parke-Davis, Johannesburg
(4) Euthatal, May & Baker, Port Elizabeth

At the field base the digestive tracts were removed and separated into stomach, small intestine and large intestine. To recover all the helminths from the intestines the entire contents of the small and large intestines were collected. The mucosa of each of these parts was scraped with a scalpel handle in order to facilitate recovery. The larger worms were removed from the ingesta with forceps and preserved in alcohol-glycerine (70 % ethyl alcohol + 5 % glycerine) or 10 % formaldehyde. The smaller worms were separated from the ingesta by washing the intestinal contents through an Endecott sieve (38 μm mestr) as described by Reinecke (1973). The worms and ingesta which remained on the sieves were preserved in 10 % formaldehyde. Three aliquots of 10 % were drawn from each sample.

Aliquots were stained with a few drops of iodine solution and examined in a gridded perspex tray under a stereo scanning microscope (6×–50×). Twenty specimens of each species from each study locality were set aside for identification. For tapeworms, stomach worms and the larger nematodes of the intestine, total counts were made using a large black tray with a white grid engraved on the bottom.

The numbers of the smaller nematodes were estimated according to the method of Clark, Tucker & Turton (1971). In cases where the estimated counts were less than 500 total counts were made, but in the remainder numbers were estimated from 3 eliquots of 10 % each.

Tapeworms were sectioned and stained with haematoxylin and eosin and nematodes cleared in lactophenol[1] for identification by microscopic examination.

RESULTS AND DISCUSSION

Identification of helminths

A total of 111 baboons from 4 localities in the Transvaal were examined for helminths of the digestive tract. The species of helminths recovered during this survey and the descriptions used for their identification are listed in Table 2.

TABLE 2 The helminth species recovered from baboons from 4 localities in the Transvaal and the descriptions used in their identification

Helminth	Authors
CESTODA	
Bertiella studeri	Baer (1927), Stunkard (1940), Spasskii (1951), Stunkard, Koivastik & Healy (1964)
NEMATODA	
Enterobius vermicularis........	Cameron (1929), Sandosham (1950)
Oesophagostomum bifurcum	Travassos & Vogelsang (1932)
Physalopetera caucasica.......	Leiper (1911), Ortlepp (1922, 1926, 1937)
Streptaopharagus pigmentatus	Baylis (1923), Ortlepp (1925)
Strongyloides fülleborni........	Von Linstow (1905), Chandler (1925), Sandground (1925), Goodey (1926), Premvati (1958)
Trichostrongylus falculatus....	Nagaty (1932), Clapham (1947)
Trichuris trichiura	Chandler (1930), Sondak (1948), Skrjabin, Shikhobalova & Orlov (1957)
Trichuris sp.	—

Prevalence and geographical distribution of helminths

The prevalence and percentage occurrence of gastro-intestinal helminths recovered from baboons from 3 study areas in the Transvaal are summarized in Table 3.

[1] 20 g pure carbolic acid crystals, 20 g lactic acid, 10 g glycerol and 20 g distilled water.

TABLE 3 The mean number, standard deviation and range of helminth species from baboons from 3 localities in the Transvaal

Species	Loskop Dam N.R. (n = 65*)			Suikerbosrand N.R. (n = 25)			Scrutton P.N.R. (n = 18)		
	Range	$\bar{x}\pm$SD	% infested	Range	$\bar{x}\pm$SD	% infested	Range	$\bar{x}\pm$SD	% infested
Bertiella studeri	0 – 54	4,14 ± 0,27	47,7	0 – 18	2,0 ± 3,71	52,0	0,5	1,2 ± 2,17	55,6
Enterobius vermicularis........	0 – 3	–	3,1	0	0	0	0 – 14297	3652 ± 407	83,3
Oesophagostomum bifurcum	0 – 670	326,4 ± 172,18	95,4	23 – 597	171,9 ± 136,85	100	20 – 797	328,5 ± 211,26	100
Physaloptera caucasica........	0 – 392	43,5 ± 59,51	96,9	0 – 39	9,9 ± 10,01	10,0	0 – 37	8,6 ± 9,52	77,8
Streptopharagus pigmentatus	0 – 237	41,6 ± 56,4	87,7	0 – 50	18,7 ± 12,75	96,0	2 – 187	41,76 ± 41,76	100
Strongyloides fülleborni........	0	0	0	0 – 47	5,7 ± 93,50	20,0	0	0	0
Trichostrongylus falculatus........	0 – 101	10,5 ± 24,55	30,4	0 – 260	48,6 ± 52,66	92,0	0 – 85	10,3 ± 21,81	44,4
Trichuris sp.	0 – 3	–	1,5	0	0	0	0	0	0

* n = 23 for *Oesophagostomum bifurcum*, *Strongyloides fülleborni* and *Trichostrongylus falculatus*

Because of the small sample size, data from the 3 baboons examined from the Sabie area are not included in calculations or comparisons. Microscopic examinations of material obtained from baboons No. 1–42 from Loskopdam were not undertaken.

The distribution of helminths recovered from baboons in the Transvaal from the 4 localities in the present study and from the Kruger National Park (McConnell *et al.*, 1974), is summarized in Table 4.

Approximately half of the baboons examined in each study area were infested with *Bertiella studeri*, this incidence being about twice that recorded by McConnell *et al.* (1974) for the Kruger National Park. It is clear, however, that the baboons from Loskop Dam were more heavily infested than elsewhere, with 1 animal harbouring as many as 54 tapeworms. The Suikerbosrand baboons showed a somewhat heavier infestation than those from Scrutton, which had burdens comparable with those recorded by McConnell *et al.* (1974). Spasskii (1951) gives the geographical distribution of *Bertiella studeri* as Africa, South Asia, Philippines and Mauritius.

Enterobius vermicularis occurred in over 80 % of baboons examined from Scrutton and in light infestations from 2 baboons from Loskop Dam. Of all the helminth species found in the baboon in the present study this worm occurred in the largest numbers, a single baboon harbouring over 14 000. This worm had not previously been recorded in baboons, but it has been reported in other non-human primates. It occurs throughout the world (Levine, 1980).

Nearly all the baboons examined in this study were infested with *Oesophagostomum bifurcum*. From Table 3 it is evident that baboons from Suikerbosrand showed lighter infestations than those at Loskop Dam and Scrutton, animals from the latter 2 areas having similar worm burdens. Reports of this worm from baboons elsewhere also show a high prevalence, e.g. 82 % for the Kruger National Park (McConnell *et al.*, 1974), 77 % for Kenya (Kuntz & Myers, 1966) and 62,5 % for the Northern Transvaal (Goldsmid & Rogers, 1978). *Oesophagostomum bifurcum* occurs in various parts of Africa and southern Asia (Levine, 1980).

Physaloptera caucasica occurred in almost all the baboons examined from Loskop Dam and in about 80 % of the baboons from Suikerbosrand and Scrutton. The Loskop Dam baboons showed significantly higher infestations than those in the other study areas (χ^2 of means = 114,04, P = 0,05). McConnell *et al.* (1974) reported a 36 % infestation rate of this worm for the Kruger National Park baboons, whilst Kuntz & Myers (1966) and Myers, Kuntz & Malherbe (1971) reported infestation rates of 46 % and 12 % for baboons from East and South Africa respectively. This worm occurs in Africa, the U.S.S.R, Asia Minor, South America (Levine, 1980) and Japan (Yamashita, 1963).

Streptopharagus pigmentatus had a high prevalence, although baboons from Suikerbosrand had a significantly lower worm burden (χ^2 of means = 28,04, P = 0,05). *Streptopharagus armatus* occurred in 57 % of baboons examined in the Kruger National Park (McConnell *et al.*, 1974). *Streptopharagus pigmentatus* occurs only in Africa (Ortlepp, 1925; Myers & Kuntz, 1965).

The absence of *Physaloptera caucasica* and *Streptopharagus pigmentatus* in the Sabie district can be ascribed either to the small number of baboons examined or to the use of the poison 10:80 to control baboons. It is reasonable to assume that these worms would absorb the poison rapidly and in such massive doses in proportion to their size that their death would precede that of the baboon, and vomiting is an early sign of toxicity (McIlroy, 1981). *Streptopharagus pigmentatus* and *Physaloptera caucasica* share the same habitat as the baboon, and the former was found to be dominant in the present study, particularly at Suikerbosrand and Scrutton, and also in the Kruger National Park. Although not the rule, a high infestation of 1 of these species in an individual was often accompanied by a low infestation of the other, indicating possible competition for habitat.

In the present study *Strongyloides fülleborni* occurred only in baboons from Suikerbosrand and Sabie. This species was reported from 37,5 % of baboons from the Northern Transvaal (Goldsmid & Rogers, 1978), whilst McConnell *et al.* (1974) found 4 % of baboons examined in the Kruger National Park to be infested with an unspecified *Strongyloides*. *Strongyloides fülleborni* has only been recorded in the Old World primates (Little, 1966).

Trichostrongylus falculatus occurred in significantly higher numbers in baboons from Suikerbosrand (χ^2 of means = 238,25, P = 0,05). This species and *Strongyloides fülleborni* are the only worms that have a higher prevalence at Suikerbosrand than elsewhere in the present study. *Trichostrongylus falculatus* has not previously been recorded in baboons. It has been reported in ruminants from South Africa, Australia and Europe (Levine, 1980) and has been found in blesbok *(Damaliscus dorcas philipsii)* (Horak, 1980) and impala *Aepyceros melampus* (Anderson 1978; Horak, 1980). Blesbok occur on the Suikerbosrand Nature Reserve whilst impala occur on the Loskop Dam and Scrutton Nature Reserves.

Trichuris spp. appear to be present only in localized populations of baboons. *Trichuris trichiura* occurred in baboons from Sabie whilst another *Trichuris* sp. was recovered from a baboon from Loskop Dam. This genus was absent in baboons from the Kruger National Park (McConnel *et al.*, 1974), but present in 1 baboon from the Northern Transvaal (Goldsmid & Rogers, 1978). Myers & Kuntz (1965) list several records of *Trichuris* spp. in baboons, particularly from zoological gardens. *Trichuris trichiura* occurs world-wide (Levine, 1980).

TABLE 4 The geographical distribution of helminths from baboons from 5 localities in the Transvaal

Species	Loskop Dam	Scrutton	Suiker-bosrand	Sabie	K.N.P.[1]
Bertiella studeri	+	+	+	+	+
Enterobius vermicularis	+	+			
Oesophagostomum bifurcum	+	+	+	+	+
Physaloptera caucasica	+	+	+		+
Streptopharagus pigmentatus	+	+	+		+[2]
Strongyloides fülleborni			+	+	+[2]
Trichostrongylus falculatus	+	+	+	+	+[2]
Trichuris trichiura				+	
Trichuris sp.	+				

(1) Kruger National Park, from McConnell *et al.*, 1974

(2) Not the same species

In the present study the most striking feature is the very great variation in worm burdens, even among baboons from the same locality. Since there have been few investigations on the helminths of wild primates, data on their prevalence and geographical distribution are scant. Reports of helminthiosis of captive foreign primates are often misleading in the absence of the history of their origins. Captive primates, being confined to small areas, also tend to have increased parasitic burdens (Ruch, 1959).

Habitat of helminths

Streptopharagus pigmentatus and *Physaloptera caucasica* occurred in both the stomach and proximal third of the small intestine. They were found to be strongly hooked into the mucosal lining of the stomach fundus, but appeared to be free and embedded in mucus in the small intestine. Stomachs of baboons with severe infestations were markedly inflamed. Feng (1931) states that there is little doubt that *Physaloptera caucasica* produces some secretion that liquefies the cells of the stomach mucosa. McConnel *et al.* (1974) found the local pathological effect of *Physaloptera* and *Streptopharagus* in baboons to be directly related to the level of infestation. Where several worms were attached to the same focus, ulceration of the stomach wall occurred.

Strongyloides fülleborni and *Trichostrongylus falculatus* were recovered from the small intestine. Gravid proglottides of *Bertiella studeri* were occassionally encountered in the large intestine. These tapeworms were normally present in the jejunum. *Enterobius vermicularis, Oesophagostomum bifurcum* and *Trichuris* spp. occurred only in the large intestine, particularly in the proximal caecal regions. Numerous black nodules the size of garden peas were present in the submucosa or muscularis of the caecum and proximal colon of the baboons. These nodules contained black tarry material in which the *Oesophagostomum* larvae were embedded. *Oesophagostomum* is considered the most serious of primate parasites (Ruch, 1959; Fiennes, 1967; Orihel & Seibold, 1972).

Although histopathological studies were not undertaken in the present investigation, only *Physaloptera caucasica, Streptopharagus pigmentatus* and *Oesophagostomum bifurcum* appeared to have detrimental effects on the baboons.

Effect of age of the host on the prevalence of helminths

Estimating the age of wild baboons is unsatisfactory. Stoltz (1977) showed that dentition and body mass parameters are often unreliable for determining age since diet and environmental factors can exert a considerable influence, particularly in baboons over 1 year old. Baboons are sexually dimorphic. Stoltz (1977) found the mean mass of adult males and females to be 25,4 kg (range 19,3–33,1 kg) and 14,5 kg (range 13,6–19,5 kg) respectively. Female baboons at puberty have a mean mass of 11,45 kg and mean age of 3,21 years (Gilbert & Gillman, 1960). These authors also found that baboons are weaned at a mean mass of 3,23 kg when they are approximately 40 weeks old.

For the purposes of the present study baboons were divided into 6 age classes according to their body mass and sex (Table 5).

TABLE 5 Division of baboons into age classes according to body mass

Class	Mass (kg) ♂	Mass (kg) ♀	Development stage
I	< 3	< 3	Infant
II	3 – 5	3 – 5	Weaner
III	5 – 8	5 – 8	Intermediate juvenile
IV	8 – 15	8 – 12	Pre-puberty
V	15 – 20	12 – 15	Adolescent
VI	> 20	> 15	Adult

Table 6 presents the percentage of baboons from each age class infested by the various helminths, whilst Fig. 2 illustrates the correlation between the age of the host and the mean worm burdens for baboons from Loskop Dam, Suikerbosrand and Scrutton.

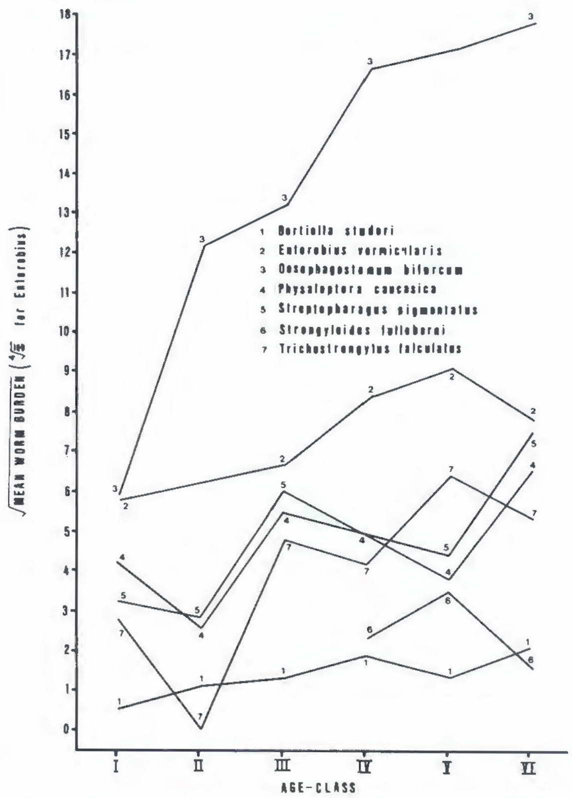

FIG. 2 Correlation between the age of the host and the mean worm burdens of the various helminths recovered from baboons from three localities in the Transvaal

TABLE 6 The percentage of baboons from each age class infested by the various helminths from three localities in the Transvaal

Age class	*Bertiella studeri* n	*Bertiella studeri* %	*Oesophagostomum bifurcum* n	*Oesophagostomum bifurcum* %	*Physaloptera caucasica* n	*Physaloptera caucasica* %	*Streptopharagus pigmentatus* n	*Streptopharagus pigmentatus* %	*Trichostrongylus falculatus* n	*Trichostrongylus falculatus* %	*Strongyloides fülleborni* n	*Strongyloides fülleborni* %
I	7	14,3	7	85,7	7	85,7	7	57,1	2	50,0	1	0
II	6	66,6	6	83,3	6	66,6	6	100	3	0	1	0
III	12	41,7	12	91,7	12	100	12	91,7	9	55,5	1	0
IV	25	40,0	25	96,0	25	100	25	88,0	14	53,8	6	20,0
V	15	46,7	15	100	15	86,7	15	93,3	9	80,0	8	37,5
VI	43	62,8	43	97,6	43	86,0	43	97,6	29	58,6	8	12,5
Totals	108	50,0	108	97,1	108	93,5	108	92,6	66	50,0	25	20,0

The prevalence of *Bertiella studeri* was low in baboons in age Class I, but became progressively higher as the age of the host increased. The exceptionally high frequency for age Class II is attributed to the small sample size (Table 6). The worm burdens of this cestode likewise slowly increased as the host got older (Figure 2).

Enterobius vermicularis occurred in large numbers in all age classes, although the highest worm burdens were found in adolescent baboons in age Class V (Fig. 2). This high prevalence can be ascribed to the direct and rapid life cycle of the worm. *Oesophagostomum bifurcum* was the commonest worm in the present study, with a high prevalence in every age class, particularly in subadult baboons (Table 6). The worm burdens of this helminth showed a definite increase as the age of the host increased, possibly as a result of continuous exposure to the infective larvae which are ingested along with plant material (Fig. 2). Nodules caused by L_3 and L_4 larvae in the hindgut of the host also appeared to be more numerous in older baboons.

The prevalence of *Physaloptera caucasica* and *Streptopharagus pigmentatus* was high in every age class, though somewhat lower in age Class I for the latter species and age Class II for the former species (Table 6). From Fig. 2 it can be seen that the worm burdens in relation to age were similar in both these species. The decreases in worm burdens in age Classes IV and V are probably the result of acquired immunity. The increase in worm burdens in age Class VI can be attributed to individual baboons which harboured numerous worms; these would increase the mean worm burdens. These individuals probably had a lowered resistance to these parasites as a result of malnutrition. Old baboons on the Loskop Dam Nature Reserve were often in poor physical condition, particularly during the dry season.

Strongyloides fülleborni was absent in age Classes I–III, which is surprising since it has been shown that this species, like other members of the genus, may utilize the transmammary route of transmission (Brown & Girardeau, 1977; Miller, 1981). The absence of this species in the younger age classes however, may be ascribed to the very small sample size of these age groups (Table 6).

Trichostrongylus falculatus was present in 1 baboon in age Class I and absent in age Class II, but the sample size of both these classes was too small to draw any conclusions other than that the worm can occur in very young animals. *Trichuris* spp. were obtained from an insufficient number of baboons to make any age-correlated comparisons. *Trichuris trichiura* was present in 2 of the 3 baboons examined from Sabie, 1 being in age Class II and the other in age Class VI. A female baboon in age Class I from Loskop Dam harboured 3 individuals of *Trichuris* which could not be assigned to a species owing to the lack of material. It would thus appear that this genus can occur in baboons of every age class including very young animals.

Seasonal incidence of helminths

Baboons could not be obtained monthly during the present study. Material was collected, however, during both the wet and the dry seasons in all the study localities except Sabie.

Comparisons of the worm burdens of *Bertiella studeri, Oesophagostomum bifurcum, Physaloptera caucasica, Streptopharagus pigmentatus* and *Trichostorngylus falculatus* in baboons in the wet and the dry seasons were made and are shown histographically in Fig. 3. Seasonal comparisons for *Strongyloides fülleborni* and *Trichuris* spp. could not be made because of the small sizes of the samples.

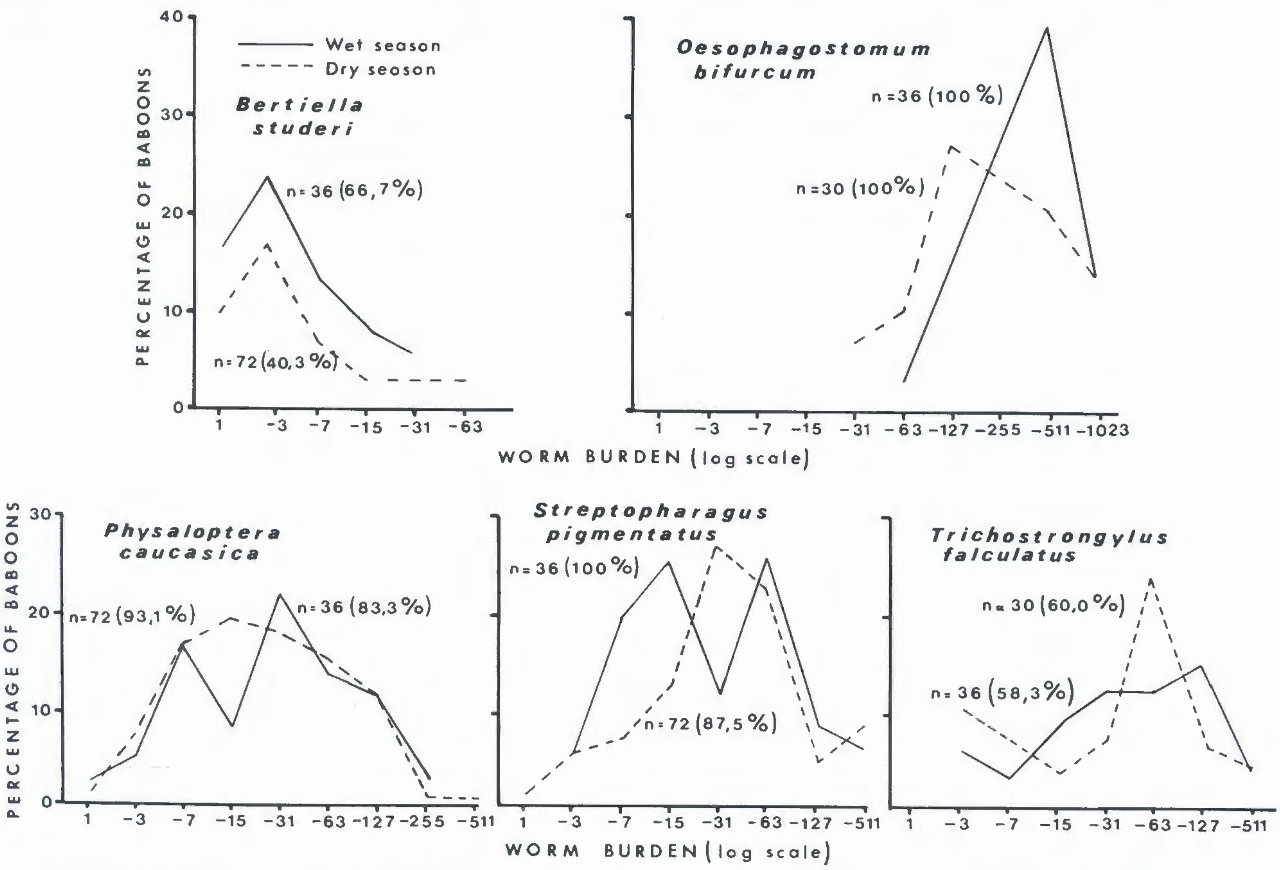

FIG. 3 Frequency distribution of worm burdens in baboons in the wet and dry season. Percentage of baboons infested with the relevant helminth in parantheses

Bertiella studeri is more prevalent and present in greater numbers in the summer wet season (Fig. 3). Stunkard (1940) demonstrated experimentally that this helminth, like other anoplocephaline cestodes, utilizes free-living soil mites of the order Oribatoidea (*Schleloribates laevigatus* and *Galumna* spp.) as intermediate hosts. Oribatid mites occur in very large numbers in the soil (Chandler & Read, 1961). Sengbusch (1954) established that reproduction in some *Galumna* spp. is correlated with temperature and that they are thus more abundant during the summer months. Baboons spend most of their time on the ground (Dorst & Dandelot, 1970; Stoltz & Saayman, 1970) and spend considerable time digging for roots and bulbs (Hall, 1961). They are thus constantly exposed to oribatid mites, and the higher incidence of *Bertiella studeri* during the wet season probably coincides with a greater abundance of these mites then.

Almost all the baboons examined in the present study were infested with *Oesophagostomum bifurcum* during both the wet and the dry seasons, although adult worm burdens appeared to be higher during the wet season. Graham (1960) assumed that primate infestation with this genus is similar to that of domestic stock and that nodule formation is a product of long and continuous exposure to infective larvae. Although they were not counted, it appeared that nodules were more numerous during the dry season, indicating possible hypobiosis, a process that is known to occur in this genus (Michell, 1974).

The burdens of *Physaloptera caucasica* and *Streptopharagus pigmentatus* were very similar in both seasons (Fig. 3). The fluctuations in the graphs for the wet seasons are indicative of the smaller sample size. *Enterobius vermicularis* was more prevalent, and occurred in greater numbers, during the dry season. Since this species has a direct and rapid life cycle seasonal fluctuations in prevalence and worm burdens would not be expected, but rather sporadic outbreaks.

Trichostrongylus falculatus was equally prevalent in baboons in both seasons. The worm burdens were higher, however during the dry season. Levine (1963) stated that the optimal mean monthly temperature for *Trichostrongylus* spp. in ruminants is 6–20 °C. Scrutton and Loskop Dam have mean monthly temperatures well in excess of this range during the summer wet season. Levine (1980) points out that climatic factors are of great importance in determining the development, survival and transmission of nematode parasites, but that our knowledge about the effects of climate on parasites is rudimentary. He differentiates 2 basic climatic zones, 1 being temperate with a high rainfall (generally *Trichostorongylus-Ostertagia* areas), the other being temperate to hot, with rainfall confined to the summer months (generally *Haemonchus* areas). Based on this broad division, Suikerbosrand and Sabie would fall into the former category and Loskop Dam and Scrutton into the latter. In the present study the prevalence of *Trichostrongylus falculatus* and *Strongyloides fülleborni* was significantly higher at Suikerbosrand, which corresponds with Levine's (1980) *Trichostrongylus-Ostertagia* areas. *Oesophagostomum bifurcum, Physaloptera caucasica* and *Streptopharagus pigmentatus* were significantly more prevalent at Loskop Dam and Scrutton, which correspond with Levine's (1980) *Haemonchus* areas. The cestode *Bertiella studeri* was more or less equally prevalent in all the study areas, although worm burdens were highest at Loskop Dam. Worm burdens, however, were lowest at Scrutton, possibly because this area is excessively hot and arid.

Effect of the sex of the host on the prevalence of helminths

In the present study the social rank of baboons could not be determined. Female baboons were noted as being pregnant, lactating, menstruating or anoestrus, but the small sample sizes and considerable individual variation in parasite burdens make these comparisons meaningless. However with 2 exceptions, comparisons of worm burdens for the various helminth species between the sexes were made. Comparisons for *Strongyloides fülleborni* and *Trichuris* spp. were not made because of the small sizes of the samples.

In a highly social species such as the baboon, descrepancies in parasite infestation between the sexes would not be expected from an ecological point of view, since the same environment is shared by both sexes. The normal diet of the baboon would be equally and proportionately available to both sexes, but certain supplementary items, such as small mammals and birds, appear to be more favoured by large males (Jackson, 1978).

With the possible exception of *Physaloptera caucasica,* no helminth species in the present study proved to be so much more prevalent or abundant in either male or female baboons that this could not be attributed to individual variation. *Physaloptera caucasica* was more prevalent and occurred in larger worm burdens in male baboons, both in the present study and in that of McConnell *et al.* (1974) for the Kruger National Park, possibly because of physiological differences. Hausfater & Watson (1976), in a preliminary survey, showed that the social rank and reproductive condition of yellow baboons, *Papio cynocephalus,* influenced parasite ova emissions. The alternative explanation, that male baboons consume larger quantities of arthropods, lacks documented proof. If this were the case a similar finding for *Streptopharagus pigmentatus,* which also utilizes arthropods in its lifecycle, would be expected.

Helminth epizootiology

The ecological relationships between parasites and primates are poorly understood. The transmission of various helminth species, however, can be directly related to the habits and food of the baboon. This correlation for primates in general has been proposed by Yamashita (1963).

The strong social cohesion between members of a baboon troop and the time spent in allogrooming (Bolwig, 1959; Hall, 1962; Stoltz & Saayman, 1970) would ensure cross-infection of parasites with a direct lifecycle such as that of *Enterobius vermicularis,* where infestation occurs by ingestion of the eggs. Retro-infestation may also occur, which would explain the large worm burdens of this species. In the present study this worm was present in large numbers at Scrutton, which is close to primitive human settlements. The probability of baboons acquiring this worm from humans is perfectly feasible since baboons are notorius scavengers around human settlements. Stoll (1947) estimated that over 10 % of humans world-wide become infested by *Enterobius vermicularis* during their life-spans. Sandosham (1950) pointed out that the possibility of human infestation by *Enterobius* through the keeping of pet monkeys cannot be disregarded.

Faecal contamination is greatly enchanced by the fact that baboons are territorial and utilize certain sleeping sites, often on a rotational basis with other troops of baboons (Stoltz & Saayman, 1970). Eggs and larvae of parasites thus become concentrated in areas which are regularly utilized by the baboons, Helminths such as *Strongyloides fülleborni, Oesophagostomum bifurcum,* *Trichostrongylus falculatus* and *Trichuris trichiura* have lifecycles whereby ova are passed out of the host and then undergo further development on the ground. The larvae gain access to another host by being ingested, or, as in the case of *Strongyloides fülleborni*, by penetrating the host's skin (Levine, 1980).

The feeding habits and omnivorous diet of baboons would ensure infestation by helminths that utilize an intermediate host which is consumed by baboons. The cockroach *Blattella germanica* and the grasshoper *Schistocerca grefaria* are the intermediate hosts of *Physaloptera caucasica* (Poinar & Quentin, 1972; Poinar & Hess, 1974). The intermediate hosts of *Streptopharagus pigmentatus* are unkown. Yamaguti (1961) and Yamashita (1963) suggest that arthropods, and in particular cockroaches, crickets and beetles may act as intermediate hosts for this nematode.

The habits of baboons, their food and the diversity of habitats that they utilize would thus enchance their chances of becoming infested with a variety of helminths. Furthermore, these parasites can occur in large numbers, since the baboons are continuously exposed to infection. Generally speaking, however, it would appear that helminths maintain a safe balance with their primate hosts and do not appear to have any significant detrimental effect upon them. I would suggest that baboons have evolved to cope with a wide range of helminth parasites and that fatalities due to helminthiosis are a secondary result of certain environmental conditions, for instance, malnutrition, that lower the host's resistance.

CONCLUSIONS

Of the 9 species of helminths recovered from baboons in the present study, only *Enterobius vermicularis* and *Trichostrongylus falculatus* are new records for this host. The latter species is normally a parasite of ruminants and has only once previously been recorded from a primate host. A species of *Trichuris* that may be new was found in a baboon from Loskop Dam, but unfortunately only 3 females were present.

This is the first study in which the worm burdens of baboons were determined. It was found that there is a very great variation in the worm burdens of all the helminth species, even among baboons from the same locality, age group and sex. Most baboons harboured at least 3 species of intestinal helminths and some as many as 6 species. It would appear that *Streptopharagus pigmentatus* and *Physaloptera caucasica* compete for the same habitat in the baboon.

Apart from burdens of the nematodes *Strongyloides fülleborni* and *Trichostrongylus falculatus*, baboons from Suikerbosrand generally had lower worm burdens than those from Loskop Dam and Scrutton. The higher worm burdens at Suikerbosrand for these 2 species is attributable to the more temperate climate there. A high prevalence of *Enterobius vermicularis* occurred at Scrutton, possibly as a result of nearby human habitation. *Trichuris trichiura* was found only in baboons from the Sabie locality. This species and *Strongyloides fülleborni* were the only ones that did not occur in baboons from all the localities studied during the present investigation. The absence of *Physaloptera caucasica* and *Streptopharagus pigmentatus* at the Sabie locality can be ascribed either to the small size of this sample or the use of the poison 10:80 to cull the baboons.

An attempt was made to correlate worm burdens with the age of the baboons. It can be concluded that all the species of helminths found in the present study can occur in very young animals, that worm burdens increased with the age of the host and that the numbers of *Enterobius vermicularis* and *Strongyloides fülleborni* decrease in adult baboons, possibly as a result of acquired immunity.

No significant differences in worm burdens between the sexes of baboons for any helminth other than *Physaloptera caucasica* could be found. The higher incidence of this nematode in male baboons can probably be ascribed to physiological factors. Alternatively, though it is less likely, it may be because male baboons eat more of the arthropod intermediate hosts of this worm.

Higher worm burdens in the wet season were found for *Bertiella studeri* and *Oesophagostomum bifurcum*, the former being ascribed to the abundance of the intermediate host mites during the wet season, and the latter to the arrested development or hypobiosis of the worm during the adverse conditions of the dry season. *Trichostrongylus falculatus* occurred in higher numbers during the dry season, probably because the infective larvae can more easily tolerate the cooler climate at this time of the year.

No helminth recovered from baboons in the present study is host specific. With the exception of *Streptopharagus pigmentatus* and *Trichostrongylus falculatus* all species have previously been recorded as occurring in man. The baboon is thus an ideal biological model for studies on human parasites. By the same token, the baboon must be regarded as a potential source of zoonoses and the keeping of monkeys and baboons as pets should thus be strongly discouraged by the authorities.

Of the 111 baboons examined in the present study, none was found to be free of intestinal helminths. Apparently, individual baboons may be naturally infested simultaneously with a variety of intestinal parasites. They can cope with these parasites without undue detrimental effects under normal environmental conditions.

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REFERENCES

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

ANDERSON, IRMGARD G., 1978. Parasitological studies on impala, *Aepyceros melampus* (Lichtenstein, 1812) in Natal. Ph. D. thesis, Rand Afrikaans University.

BAER, J. G., 1927. Monographie des Cestodes de la Famille des Anoplocephalidae. *Supplements au Bulletin Biologique de France et de Belgique*, 10. Paris: Les Presses Universitaires de France.

BAYLIS, H. A., 1923. On the nematode genus *Streptopharagus*, with some remarks on the genus *Spirocerca*. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 16, 486–497.

BLACKIE, W. E., 1932. A helminthological survey of Southern Rhodesia. *London School of Hygiene and Tropical Medicine Memoir Series*, 5, 91 pp.

BOLWIG, N., 1959. A study of the behaviour of the Chacma baboon *Papio ursinus*. *Behaviour*, 14, 136–163.

BROWN, R. C. & GIRARDEAU, MARTHA H. F., 1977. Transmammary passage of *Strongyloides* sp. larvae in the human host. *American Journal of Tropical Medicine and Hygiene*, 26, 215–219.

CAMERON, T. W. M., 1927. The helminth parasites of animals and human disease. *Proceedings of the Royal Society of Medicine*, 20, 547–556.

CAMERON, T. W. M., 1929. The species of *Enterobius* in primates. *Journal of Helminthology*, 7, 161–182.

CHANDLER, A. C., 1925. The species of *Strongyloides* (Nematoda). *Parasitology*, 17, 426–433.

CHANDLER, A. C., 1930. Specific characters in the genus *Trichuris*, with a description of a new species, *Trichuris tenuis*, from a camel. *Journal of Parasitology*, 16, 198–208.

CHANDLER, A. C. & READ, C. P., 1961. Introduction to parasitology. 10th ed. New York: John Wiley & Sons Inc.

CLAPHAM, PHYLLIS A., 1947. On the identification of some species of *Trichostrongylus*. *Journal of Helminthology*, 22, 37–46.

CLARK, C. F., TUCKER, A. M. & TURTON, J. A., 1971. Sampling techniques for estimating roundworm burdens of sheep and cattle. *Experimental Parasitology*, 30, 181–186.

DORST, J. & DANDELOT, P., 1970. A field guide to the larger mammals of Africa. London: Collins.

FENG, L. C., 1931. Studies on tissue lesions produced by helminths. *Archiv für Schiffs und Tropen-Hygiene*, 35, 1–10.

FIENNES, R., 1967. Zoonoses of primates. The epidemiology and ecology of simian diseases in relation to man. London: Weidenfeld & Nicolson.

GILBERT, CHRISTINE & GILLMAN, J., 1960. Puberty in the baboon *(Papio ursinus)* in relation to age and body weight. *South African Journal of Medical Sciences*, 25, 99–103.

GOLDSMID, J. M. & ROGERS, SUE, 1978. A parasitological study of the chacma baboon *(Papio ursinus)* from the Northern Transvaal. *Journal of South African Veterinary Association*, 49, 109–111.

GOODEY, T., 1926. Observations on *Strongyloides fülleborni* Von Linstown, 1905, with some remarks on the genus *Strongyloides*. *Journal of Helminthology*, 4, 75–86.

GRAHAM, G. L. 1960. Parasitism in monkeys. *Annals of the New York Academy of Science*, 842–860.

HALL, K. R. L., 1961. Feeding habits of the chacma baboon. *Advancements in Science, London*, 17, 559–567.

HALL, K. R. L., 1962. The sexual agonistic and derived social behaviour patterns of the wild chacma baboon, *Papio ursinus*. *Proceedings of the Zoological Society, London*, 139, 283–327.

HAUSFATER, G. & WATSON, D. F., 1976. Social and reproductive correlates of parasite ova emmissions by baboons. *Nature, London*, 262, 688–689.

HORAK, I. G., 1980. The incidence of helminths in pigs, cattle, impala and blesbok in the Transvaal. Ph. D. thesis, University of Natal, Pietermaritzburg.

HUMMER, R. L., 1965. Principles of public health importance in the management of subhuman primate colony. *Journal of the American Veterinary Medical Association*, 147, 1063–1067.

JACKSON, H. D., 1978. Chacma baboons preying on higher vertebrates. *Arnoldia, Rhodesia*, 8, 1–8.

KEITH, M. E. & STOLTZ, L. P., 1967. Baboon capture. *Miscellaneous Publication of the Transvaal Division of Nature Conservation*. 10 pp.

KIM, C. S., EUGSTER, A. K. & KALTER, S. S., 1968. Pathological study of the African baboon (*Papio* sp.) in his native habitat. *Primates*, 9, 93–104.

KUNTZ, R. E. & MYERS, BETTY J., 1966. Parasites of baboons captured in Kenya and Tanzania, East Africa. *Primates*, 7, 27–32.

LEIPER, R. T., 1911. On the frequent occurrence of *Physaloptera mordens* as an intestinal parasite of man in tropical Africa. *Journal of Tropical Medicine and Hygiene*, 14, 209–211.

LEVINE, N. D., 1963. Weather, climate and bionomics of ruminant nematode larvae. *Advancement in Veterinary Science*, 8, 215–261.

LEVINE, N. D., 1980. Nematode parasites of domestic animals and of man. 2nd ed. Minneapolis: Burgess Publishing Co.

LITTLE, M. D., 1966. Comparative morphology of six species of *Strongyloides* (Nematoda) and redefinition of the genus. *Journal of Parasitology*, 52, 69–84.

McCONNELL, E. E., BASSON, P. A. DE VOS, V., MYERS, BETTY J. & KUNTZ, R. E., 1974. A survey of diseases among 100 free-ranging baboons *(Papio ursinus)* from the Kruger National Park. *Onderstepoort Journal of Veterinary Research*, 41, 97–168.

McILROY, J. C., 1981. The sensitivity of Australian animals to 10:80 posion. 1. Intraspecific variation and factors affecting acute toxicity. *Australian Wildlife Research*, 8, 369–383.

MICHELL, J. F., 1974. Arrested development of nematodes and some related phenomena. *Advancements in Parasitology*, 12, 297–366.

MILLER, G. C., 1981. Helminths and the transmammary route of infection. *Parasitology*, 82, 335–342.

MYERS, BETTY J. & KUNTZ, R. E., 1965. A checklist of parasites reported for the baboon. *Primates*, 6, 137–194.

MYERS, BETTY J., KUNTZ, R. E. & MALHERBE, H., 1971. Intestinal commensals and parasites of the South African baboon *(Papio cynocephalus)*. *Transactions of the American Microscopical Society* 90, 80–83.

NAGATY, H. F., 1932. The genus *Trichostrongylus* Looss, 1905. *Annals of Tropical Medicine and Parasitology*, 26, 457–518.

ORIHEL, T. C. & SEIBOLD, H. R., 1972. Nematodes of the bowel and tissues. *Pathology of Simian Primates*, Part II, 76–103. Basel: Karger.

ORTLEPP, R. J., 1922. The nematode genus *Physaloptera* Rud. *Proceedings of the Zoological Society of London*, 999–1107.

ORTLEPP, R. J., 1925. A review of the members of the genus *Streptopharagus* Blanc, 1912. *Journal of Helminthology*, 3, 209–216.

ORTLEPP, R. J., 1926. On the identity of *Physaloptera caucasica* Von Linstow, 1902, and *Physaloptera mordens* Leiper, 1908. *Journal of Helminthology*, 4, 199–202.

ORTLEPP, R. J., 1937. Some undescribed species of the nematode genus *Physaloptera* Rud., together with a key to sufficiently known forms. *Onderstepoort Journal of Veterinary Science and Animal Industry*, 9, 71–84.

POINAR, G. O. & HESS, ROBERTA, 1974. An ultrastructural study of the response of *Blattella germanica* (Orthoptera: Blattidae) to the nematode *Abbreviata caucasica* (Spirurida: Physalopteridae). *International Journal of Parasitology*, 58, 23–28.

POINAR, G. O. & QUENTIN, J. C., 1972. The development of *Abbreviata caucasica* (Von Linstow) (Spirurida: Physalopteridae) in an intermediate host. *Journal of Parasitology*, 58, 23–28.

PREMVATI, 1958. Studies on *Strongyloides* of primates. I. Morphology and life history of *Strongyloides fülleborni* Von Linstow, 1905. *Canadian Journal of Zoology*, 36, 65–71.

RAUTENBACH, I. L., 1982. Mammals of the Transvaal. *Ecoplan Monograph*, No. 1.

REINECKE, R. K., 1973. The larval anthelmintic test in ruminants. *Department of Agricultural Technical Services, Republic of South Africa, Technical Communication* No. 106.

RUCH, T. C., 1959. Diseases of laboratory primates. Philadelphia: W. B. Saunders & Co.

SANDGROUND, J. H., 1925. Speciation and specificity in the nematode genus *Strongyloides*. *Journal of Parasitology*, 12, 59–82.

SANDOSHAM, A. A., 1950. On *Enterobius vermicularis* (Linnaeus, 1758) and some related species from primates and rodents. *Journal of Helminthology*, 14, 171–204.

SENGBUSCH, H. G., 1954. Studies on the life history of three oribatoid mites with observations on other species. *Annals of the Entomological Society of America*, 47, 646–667.

SKRJABIN, K. I., SHIKHOBALOVA, N. P. & ORLOV, I. V., 1957. Trichocephalidae and Capillariidae of animals and man and the diseases caused by them. *In:* SKRJABIN, K. I. (ed.). Essentials of Nematology, Vol. 6. Moscow: Academy of Sciences.

SONDAK, V. A., 1948. Independence of the whipworm species *Trichocephalus trichiurus* and the swine whipworm *Trichocephalus suis*. *Parazitologicheskiĭ Sbornik Zoologicheskogo Insituta AN SSSR*, 10, 197–204.

SPASSKII, A. A., 1951. Anoplocephalate tapeworms of domestic and wild animals. *In:* SKRJABIN K. I. (ed.). Essentials of cestodology, Vol. 1. Moscow: Academy of Sciences.

STOLL, N. R., 1947. This wormy world. *Journal of Parasitology*, 33, 1–18.

STOLTZ, L. P., 1977. The population dynamics of baboons *Papio ursinus* Kerr, 1792, in the Transvaal. D. Sc. (Wildl. Mgmt) thesis, University of Pretoria.

STOLTZ, L. P. & SAAYMAN, G. S., 1970. Ecology and behaviour of baboons in the Northern Transvaal. *Annals of the Transvaal Museum*, 26, 99–143.

STUNKARD, H. W., 1940. The morphology and life history of the cestode, *Bertiella studeri*. *American Journal of Tropical Medicine*, 20, 305–333.

STUNKARD, H. W., KOIVASTIK, T. & HEALY, G. R., 1964. Infection of a child in Minnesota by *Bertiella studeri* (Cestoda: Anoplocephalidae). *American Journal of Tropical Medicine and Hygiene*, 13, 402–409.

TRAVASSOS, L. & VOGELSANG, E., 1932. Pesquizas helminthologicas realisadas em Hamburgo. X. Contribuição ao conhecimento das especies de *Oesophagostom* dos primatas. *Memorias do Instituto Oswaldo Cruz*, 26, 251–328, pls. 55–91, fig. 1–198.

VON LINSTOW, O., 1905. *Strongyloides fülleborni* n. sp. *Centralblad für Bakteriologie*, 38, 532–534.

YAMAGUTI, A., 1961. Systema Helminthum, Vol. 3: The nematodes of vertebrates. New York: Interscience Publishing Inc.

YAMASHITA, J., 1963. Ecological relationships between parasites and primates. I. Helminth parasites and primates. *Primates*, 4, 1–97.

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