THE EPIZOOTIOLOGY OF THE HELMINTH FAUNA OF THE DIGESTIVE TRACT OF THE CHACMA BABOON *PAPIO URSINUS* (KERR, 1792) FROM DIFFERENT LOCALITIES IN THE TRANSVAAL

by

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ABSTRACT

One hundred and eleven baboons from the Loskop Dam, Suikerbosrand and Scrutton nature reserves and the Sabie-Tweefontein forest reserve were examined for 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 three, and some as many as six, species of helminths. Worm 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.* Higher worm burdens in the wet season were found for *Bertiella studeri* and *Oesophagostomum bifurcum*, whereas *Trichostrongylus falculatus* occurred in higher numbers during the dry season. No significant differences in worm burdens were found in male and female baboons, but *Physaloptera caucasica* was more prevalent in males. *Trichostrongylus falculatus* and *Enterobius vermicularis* are new records for the chacma baboon.

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CHAPTER 1

INTRODUCTION

This study was initiated when, during a baboon controlling programme on the Loskop Dam Nature Reserve, a large number of worms were noticed in the stomach of a baboon. Moolman & Breytenbach (1976) reported a similar finding when studying baboon diet by stomach contents analysis on the same reserve. Difficulty in having the worms identified and the scant literature on baboon helminthiosis prompted further investigation into the helminth species, their prevalence, distribution and possible pathological effects in baboons in their natural habitat.

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) very little is known of the disease spectrum of African baboons in the wild, which is surprising in view of their importance in biomedical investigations, behaviour studies and more recently space orientated projects (Myers & Kuntz, 1965). Furthermore, the close anatomical and physiological relationship of baboons to man would indicate that certain diseases are common to both. Fiennes (1967) has pointed out that although the dangers of man acquiring primate diseases by direct contact is of great consequence, for instance at primate research colonies or the keeping of pet primates, the threat posed by living in the same neighbourhood as wild primates is of far greater importance.

The taxonomic status of the African baboons is not satisfactory (Roth, 1965; Altmann & Altmann, 1970). Roberts (1951) recognises three subspecies of *Papio ursinus*. Stoltz & Saayman (1970), whilst studying baboon ecology in the Northern Transvaal assigned their study animals to *Papio ursinus*, being generally similar in physical characteristics to those studied in the Cape Penninsula by Hall (1962). Similarly, the baboons used in the present study are classified as *Papio ursinus* (Kerr, 1792).

Chacma baboons are omnivorous, with the bulk of their diet consisting of vegetable matter (Hall, 1961), although records of baboons preying on higher vertebrates including domestic stock are plentiful (Roberts 1951; Dorst & Dandelot, 1970; Stoltz &

Saayman, 1970; Jackson, 1978). Due to large-scale damage to crops, the chacma baboon is a declared problem animal throughout South Africa and is relentlessly hunted by farmers. Most of the material used for the present study became available while culling baboons as a result of complaints from farmers and silviculturalists.

Chacma baboons are highly social animals usually occurring in troops of 40–80 individuals (Hall, 1962; Stoltz & Saayman, 1970), but may number as many as 200 (Dorst & Dandelot, 1970). They are predominantly terrestrial and show a preference for sleeping on rocky outcrops, but will utilize tall trees, particularly along river banks, in the absence of suitable sleeping sites (Stoltz & Saayman, 1970). Home ranges of different troops often overlap extensively and vary in size according to food and water availability (Bolwig, 1959; Stoltz & Saayman, 1970). They are strictly diurnal (Stoltz & Saayman, 1970).

The chances of a varied parasite fauna in baboons is greatly enhanced by their diet and the diversity of habitats they utilize. Their strong social structure and utilization of specific sleeping sites would also enhance the chances of cross-infection between individuals of a troop. Likewise, the extensive overlap between the home ranges of various troops would enable cross-infection between troops.

Chacma baboons occur throughout the Transvaal, with the exception of the southwestern and southeastern regions where their absence is ascribed to eradication programmes (Rautenbach, 1982) (Fig. 1).

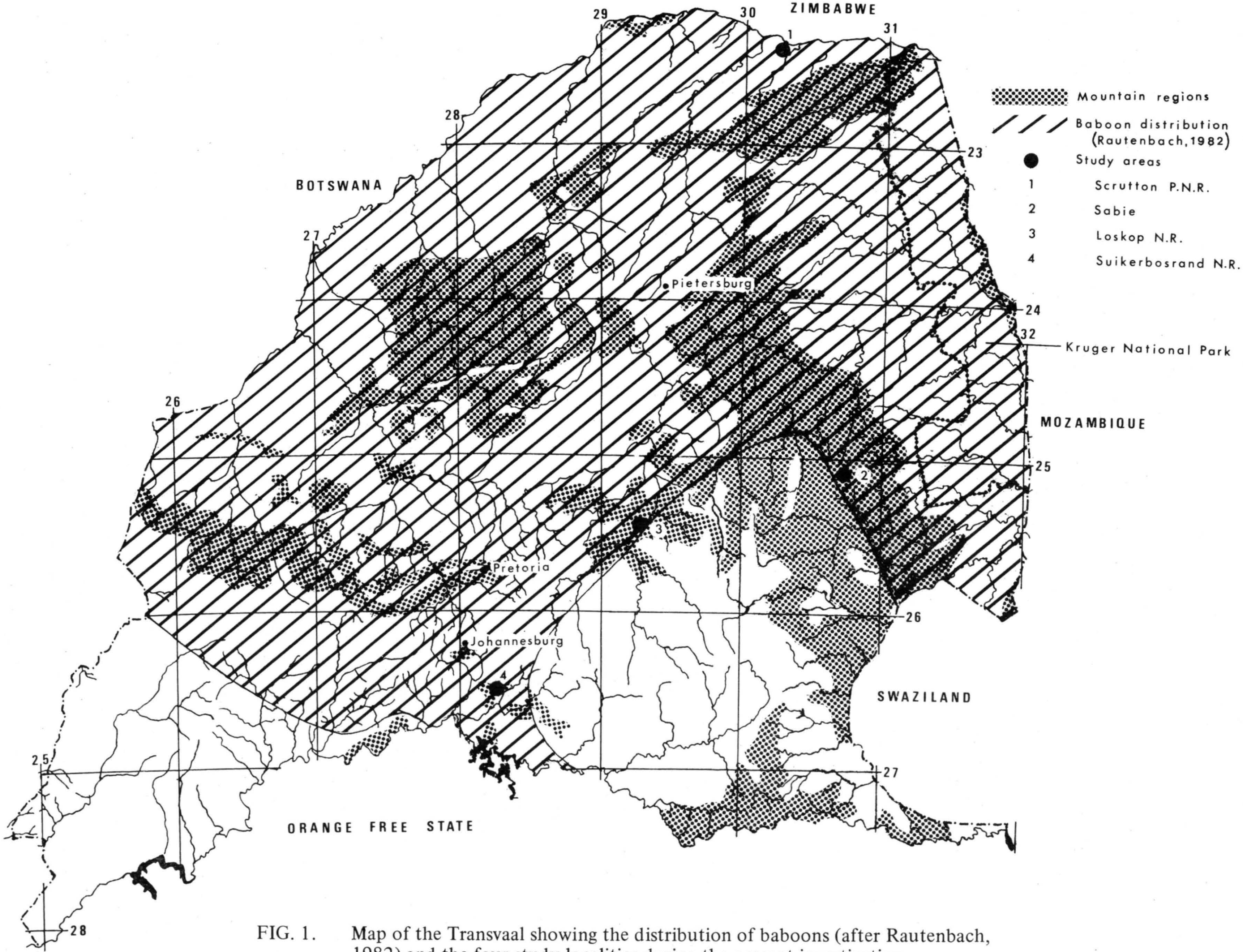

FIG. 1. Map of the Transvaal showing the distribution of baboons (after Rautenbach, 1982) and the four study localities during the present investigation.

CHAPTER 2

STUDY AREAS

Loskop Dam Nature Reserve

The Loskop Dam Nature Reserve is situated in the Olifants River Basin in the south-eastern Transvaal (25°22′– 25°31′S/29°12′ – 29°25′ E). During the period in which this survey was conducted the reserve was 12 754 ha in extent (Bigalke, 1968), but was increased to approximately 14 800 ha in 1979 by the addition of the farm Parys.

The reserve surrounds an irrigation dam with a surface area of 1 700 ha at maximum capacity. In 1979 the dam wall was raised a further 9 m increasing the surface area of the dam by approximately 700 ha to 2 400 ha.

The reserve is characterized by a rugged mountainous terrain. The northern section comprises a volcanic sequence of felsitic lava and interbedded pyroclastic material of the Rooiberg Group, whereas the southern section consists of argillaceous sedimentary material with interbedded conglomerate belonging to the overlaying Loskop Formation and Waterberg Group (Clubley-Armstrong, 1980).

The rainfall is erratic and unpredictable with frequent droughts. The annual rainfall for 1975, 1976, 1977 and 1978 was 874 mm, 622 mm, 578 mm and 604 mm respectively. Most of the rain (approximately 80%) falls in the months October to March, with very little or no rainfall in June, July and August. Theron (1973) states that the mean annual rainfall from two temporary weather stations differed by over 300 mm for two consecutive years (March 1967 – March 1969). It can be generally accepted that the higher regions, valleys and south-facing slopes have a more mesophytic climate.

The vegetation can be broadly classified as Mixed Bushveld and Sourish Mixed Bushveld (Acocks 1975). Wells (1960) divided the reserve structurally into 14 plant communities while Theron (1973) classified the reserve into 24 plant communities which form a complex mosaic related to altitude, aspect and soil depth.

Seventeen species of ungulates occur on the reserve. A small number of leopards, *Panthera pardus,* and brown hyaenas, *Hyaena brunnea*, are the only large predators on the reserve.

Suikerbosrand Nature Reserve

The Suikerbosrand Nature Reserve is situated approximately 40 km south of Johannesburg in the south-central Transvaal ($26^{o}27' - 26^{o}34'$ S/$28^{o}09' - 28^{o}21'$ E). The reserve, comprising some 13 400 ha, falls within Acocks' (1975) Bankenveld, characterized by predominantly open grassveld with dense thickets in some of the ravines. Bredenkamp & Theron (1976) classified the grasslands into 13 communities. These communities are greatly affected by the diversity of the topography, the altitudes ranging from 1 525 m to 1 916 m.

The reserve is bisected by an east-west ridge composed of two geological formations, namely the Ventersdorp System in the central and western region and the older Witwatersrand System which has undergone considerable faulting, folding and erosion (Du Toit, 1954) and is relatively game-free due to the sour vegetation on the leached quartzite soils.

The reserve falls within the summer rainfall region. Winters are cold and summers temperate with frequent thunder, lightening and hail storms. Annual rainfall varies between 560 mm – 730 mm, the majority falling between October and March. Monthly mean minimum temperatures are normally below 5^{o}C during winter whereas the monthly maximum temperatures seldom exceed 27^{o}C during summer.

Suikerbosrand supports 12 ungulate species. Cheetahs, *Acinonyx jubatus*, occur in reasonably large numbers. Brown hyaenas are the only other large carnivore on the reserve.

Scrutton Private Nature Reserve

Scrutton Private Nature Reserve is situated in the far Northern Transvaal ($22^{o}21'$ S/ $30^{o}23'$ E). The Limpopo River forms the northern boundary and the Nzhelele River the western boundary. Due to a crack in the Nzhelele Dam wall, the Nzhelele river was perennial during the survey, although normally both rivers are seasonal.

The reserve is small (approximately 1 000 ha) and falls within Acocks' (1975) Mopane veld type. The altitude ranges from 400 m – 500 m and annual rainfall, between 250 mm – 400 mm, is strictly confined to the summer months. The climate is very hot.

The riparian areas are characterized by tall trees, mostly *Ficus sycomorus* and *Spirostachys africana.* The rest of the reserve is made up of rocky granite terrain, sloping gently towards the rivers. Fairly dense stands of *Colophospermum mopane* and *Terminalia prunioides* with occasional large *Adansonia digitata* and *Sclerocarya caffra* make up the remainder of the reserve.

A large variety of game species move freely through the reserve. Leopards are common and lions (*Panthera leo*) and spotted hyanas (*Crocuta crocuta*) occur occasionally.

Sabie-Tweefontein Forest Reserve

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

CHAPTER 3

MATERIAL AND METHODS

Collection of Helminths

Baboons were collected from four localities in the Transvaal between September 1976 and September 1978. To determine the seasonal incidence of helminths, baboons were collected in the dry and wet (i.e. rain) seasons. The numbers of baboons collected in each locality as well as the date and season are listed in Table 1.

Forty-two of the baboons from the Loskop Dam Nature Reserve, twenty from the Suikerbosrand Nature Reserve and fourteen from the Scrutton Private Nature Reserve were live trapped as described by Keith & Stoltz (1967), immobilized with gallamine triethiodide[1], succinylcholine chloride[2] or ketamine hydrochloride[3] and euthanized with sodium pentobarbitone[4]. The remaining baboons from these localities were shot using a ,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.

At the field base the digestive tracts were removed and separated into stomach, small intestine and large intestine. The stomachs were opened and a forceps used to collect the helminths which were heat-killed in a water-bath and preserved in alcohol-glycerine (70% ethyl alcohol + 5 % glycerol).

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1 Flaxedil, May & Baker, Port Elizabeth.

2 Scoline, Glaxo-Allenburys, Germiston.

3 Ketalar, Parke-Davis, Johannesburg.

4. Euthatal, May & Baker, Port Elizabeth.

TABLE 1: The number of baboons examined from four localities in the Transvaal.

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

To recover all the helminths from the intestines the entire contents of the small and large intestines were placed in separate stainless steel buckets. The mucosa of each of these parts was scraped with a scalpel handle and added to the contents in the appropriate bucket. The buckets were placed into a waterbath and the contents gently stirred until a temperature of 60°C was attained. Tapeworms were then removed and preserved in 10% buffered formaldehyde or alcohol-glycerine. On cooling, the contents of each bucket were placed into thick plastic bags and 40% formaldehyde added to give a final concentration of approximately 10%.. Specimens were then transferred to the laboratory for further processing.

The worms were separated from the ingesta by washing the intestinal contents through an Endecott sieve (apertures 38 μm) 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 grided perspex tray under a stereo scanning mircroscope (6x–50x). Twenty specimens of each species from each study locality were set aside for identification purposes. These worms were extracted using a bent hyperdermic needle attached to a thin glass rod and stored in alcohol-glycerine. For tapeworms, stomach worms and the larger nematodes of the intestine, total counts were undertaken using a large black tray with white grids 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, a total count was made, but in the remainder numbers were estimated from three aliquots of 10 % . Hand tally counters were used to record the numbers of each species.

Identification of Helminths

Cestodes

Tapeworms were sectioned and stained with haematoxylon and eosin for microscopic examination. Descriptions used to identify *Bertiella* are listed in Table 2.

Nematodes

Nematodes were cleared in lactophenol[1] and examined under a compound microscope or dissection microscope. Descriptions used in the identification of the various species are listed in Table 2.

TABLE 2: The descriptions used in the identification of helminths recovered from baboons from four localities in the Transvaal.

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

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

CHAPTER 4

RESULTS

Identification of Helminths

A total of 111 baboons from four localities in the Transvaal were examined for helminths of the digestive tract. The species of helminths recovered during this survey are listed below.

Classification of Cestodes follows that of Wardle, McLeod & Radinovsky (1974) and Nematodes that of Levine (1980).

Class Cestoda

Order Anoplocephalidea

Family Anoplocephalidae

Bertiella studeri (Blanchard, 1891) Stiles & Hassall, 1902.

Class Secernentasida

Order Ascaridorida

Family Oxyuridae

Enterobius vermicularis (Linnaeus, 1758) Leach, 1853.

Order Strongylorida

Family Strongylidae

Oesophagostomum bifurcum (Creplin, 1849) Railliet & Henry, 1906.

Family Trichostrongylidae

Trichostrongylus falculatus Ransom, 1911.

Order Spirurorida

Family Physalopteridae

Physaloptera caucasica Von Linstow, 1902.

Family Thelaziidae

Streptopharagus pigmentatus (Von Linstow, 1879) Railliet & Henry, 1918.

Order Rhabditorida

Family Strongyloididae

Strongyloides fülleborni Von Linstow, 1905.

Class Adenophorasida

Order Dorylaimorida

Family Trichuridae

Trichuris trichiura (Linnaeus, 1771) Stiles, 1901

Trichuris sp.

Diagnostic features of the various helminths can be briefly summarized as follows:

Bertiella studeri

Bertiella are medium-sized tapeworms with well-marked proglottides and a short neck. Each proglottid has one set of genitalia with genital pores alternating irregularly. The testes are numerous and scattered through the medulla in the area bounded by the osmoregulatory canals. The cirrus sac is well developed with an internal seminal vesicle. The vagina is surrounded by a layer of glandular cells, whilst the gravid uterus forms a transverse tube which does not overlap the osmoregulatory canals. Eggs have a well developed pyriform apparatus (Wardle & McLeod, 1952).

Considerable confusion exists regarding the genus *Bertiella.* Spasskii (1951) regards *Prototaenia* to be a synonym of *Bertiella* and lists 18 species. Baer (1927), however, considers *Prototaenia* a valid genus distinguished from *Bertiella* by a strongly developed cirrus sac, the situation of the dorsal osmoregulatory canals interior to the ventral canals and the uteri which protrude beyond the osmoregulatory canals.

At the specific level there are also widely differing views. Although nearly twenty species of *Bertiella* have been described, Baer (1927), D'Alessandro, Beaver & Pallares (1963) and many other authors recognize only two species as being valid, namely *Bertiella studeri* in the Eastern Hemisphere and *Bertiella mucronata* in the Western Hemisphere. Cameron (1929b), Stunkard (1940) and Wardle & McLeod (1952) recognize only

Bertiella studeri. Stunkard (1940) and Round (1964) point out that the confusion about the validity of the species can be attributed to the great variability that occurs when specimens are fixed.

D'Alessandro *et al.* (1963) differentiate between *Bertiella studeri* and *Bertiella mucronata* on the larger number of testes, the smaller glandular portion of the vagina and the larger eggs and pyriform apparatus in *Bertiella studeri.* The geographic locality of the worm may also be used in diagnosis, although Stunkard (1940) rightly cautions against using this feature alone.

In the present study the testes were arranged in three or four irregular transverse rows ($\bar{x}$ = 3,4; n = 20). Table 3 presents the measurements of the principle diagnostic features and compares them to those of Stunkard (1940) and Spasskii (1951) for *Bertiella studeri* and D'Alessandro *et al* (1963) for *Bertiella mucronata.* From this table it is clear that the worms from the present study conform to those of Stunkard (1940) in every respect, except that the size of the testes had a greater range in Stunkard's material. This can probably be attributed to the fact that in this study care was taken to measure only those testes which had been sectioned through the centre. Comparison of the data listed in Table 3 appears to indicate that the number of testes, and to a lesser extent the size of the cirrus sac, are the only reliable diagnostic features between these two species.

TABLE 3: Comparative measurements (mm) of principle diagnostic features of *Bertiella* spp. from various sources

	Bertiella studeri		*Bertiella mucronata*
Feature	Present study (n = 20)	Stunkard (1940)*	D'Allessandro *et al.* (1963)
Number of testes	193 – 268 ($\bar{x}$ = 226)	$\pm$ 250	120 – 140
Diameter of testes	96 – 112 ($\bar{x}$ = 103,6)	36 – 95	60
Length of cirrus sac	360 – 480 ($\bar{x}$ = 400)	360 – 440	267
Diameter of eggs	36 – 48 ($\bar{x}$ = 45,2)	40 – 60	38 – 46 ($\bar{x}$ = 42)

*Spasskii (1951) gives the same measurements.

Enterobius vermicularis

The mouth of worms in the genus *Enterobius* has three lips. There is no vestibule and the oesophagus is composed of a club-shaped corpus, very short isthmus and bulb. The cuticle has two vesicular cephalic expansions. The male tail is sharply truncate a little behind the anus. The caudal alae are supported by a pair of pedunculated preanal papillae and by two large papillae at the end of the tail and two pairs of postanal sessile papillae. The spicule is relatively long and there is no gubernaculum. The female tail is conical and relatively short. The vulva is in the anterior third of the body, not salient. The ovijector is very short, forming with the first part of the vagina a pyriform reservoir. The vagina is very short and the uteri parallel (Levine, 1980).

Enterobius specimens from baboons from Scrutton and Loskop Dam are morphologically similar to those described as *Enterobius vermicularis* by Cameron (1929a) and Sandosham (1950). Although slight variations in the measurements of *Enterobius vermicularis* from different primate hosts exist, those from the baboon in the present study lie well within the measurements given for *Enterobius vermicularis* from the chimpanzee, *Pan troglodytes*, the lar gibbon, *Hylobates lar*, and the lion marmoset, *Leontocebus rosalia* (Table 4).

From Table 4 it can be seen that there are great variations in the α , β and γ ratios. The validity of these ratios for specific differentiation is thus questionable.

Oesophagostomum bifurcum

The mouth in the genus *Oesophagostomum* is directed forward and is surrounded by a mouth collar which bears head papillae and which is sharply delimited posteriorly by a deep annular constriction. The ventral transverse groove extends around the body toward the dorsal surface just anterior to the excretory pore. The cuticle between the mouth collar and ventral groove is more or less dilated to form the cephalic vesicle. The buccal capsule is shallow, cylindrical or ring-shaped. The oesophageal funnel is sometimes dilated and contains lancets. The vulva of the female is a little distance anterior to the anus. The spicules are equal and a gubernaculum present (Levine, 1980).

The *Oesophagostomum* specimens recovered from baboons from all four localities are morphologically similar to the description of *Oesophagostomum bifurcum* of

TABLE 4: Comparative measurements (mm) of the principle diagnostic features of *Enterobius vermicularis* from primate hosts.

Author		Sandosham (1950)						Present study	
Host		*Pan troglodytes*		*Hylobates lar*		*Leontocebus rosalia*		*Papio ursinus*	
Sex		Male	Female	Male	Female	Male	Female	Male	Female
Length		2,5	6,52– 7,2	2,3	4,6 – 5,1	3,5	7,60– 8,15	3,30 – 3,60	5,70 – 6,70
Max. width		0,8	0,4	0,15	0,33– 0,4	0,16	0,37– 0,48	0,20 – 0,28	0,50 – 0,62
Cuticular inflation:									
	length	0,18	0,19– 0,22	0,13	0,12– 0,20	0,15	0,23– 0,24	0,14 – 0,27	0,13 – 0,20
	width	0,096	0,15– 0,16	0,10	0,13– 0,18	0,09	0,15– 0,19	0,10 – 0,17	0,13 – 0,17
Oesophagus:	length	0,54	1,0	0,49	0,73– 0,8	0,55	0,86– 0,90	0,50 – 0,60	0,68 – 0,79
Oesophageal bulb:									
	length	0,074	0,15– 0,16	0,067	0,14– 0,15	0,08	0,15– 0,16	0,097– 0,14	0,16 – 0,18
	width	0,11	0,19– 0,20	0,08	0,16	0,13	0,17– 0,18	0,092– 0,16	0,16 – 0,18
Spicule :	total length	0,097		0,083		0,094		0,84 – 0,11	
	distal spine	0,076		0,07		0,064		0,060– 0,075	
	prox. bulb	–		–		–		0,022– 0,26	
Vulva to tip of tail			4,6–4,97		3,0– 3,5		5,12– 5,80		3,67 – 4,20
α		14,0	16,3–18,0	15,3	12,75–14,0	22,0	17,0–20,5	13,0 – 16,1	10,8 – 11,3
β		4,6	6,52–7,2	4,7	6,1 – 6,4	6,4	8,8– 9,0	6,1 – 6,4	8,30 – 8,50
γ			5,0		3,8 – 4,0		5,0– 5,2		1,50 – 1,60

$$\alpha = \frac{\text{length}}{\text{max. width}} \qquad \beta = \frac{\text{length}}{\text{length oesophagus}} \qquad \gamma = \frac{\text{length}}{\text{length of tail (♀)}}$$

Travassos & Vogelsang (1932). Table 5 lists measurements of the principle diagnostic features of *Oesophagostomum bifurcum* from the chacma baboon from the present study compared to measurements of principle diagnostic features of specimens from other primate hosts (Travassos & Vogelsang, 1932). Although the spicules of the specimens from the baboons are shorter than in the other hosts, their lengths overlap that of males from *Papio porcarius*, and the specimens are thus assigned to *Oesophagostomum bifurcum*.

TABLE 5: Comparative measurements (μm) of the principle diagnostic features of *Oesophagostomum bifurcum* from primate hosts.

Author	Travassos & Vogelsang (1932)			Present study (n = 10 ♂ 10 ♀)
Host	*Macaca rhesus*	*Papio hamadryas*	*P. porcarius*	*P. ursinus*
Length spicules	900 – 943	958 – 972	843 – 958	798 – 882
Length tail – anus	184 – 240	200 – 243	152 – 232	184 – 264
Length anus – vulva	–	186 – 214	280 – 357	200 – 260
Diameter ovijector	214 – 232	228 – 257	200 – 216	184 – 280

Physaloptera caucasica

The mouth in the genus *Physaloptera* has two large, simple triangular lateral pseudolabia, each armed with a variable number of teeth and with two external papillae. Submedium teeth are not present on the dorsal and ventral surfaces of the pseudolabia. The cuticule is usually reflected over the lips to form a large cephalic collarette. The cervical papillae are behind the nerve ring. The oesophagus is composed of an anterior muscular and posterior glandular part. The male has caudal alae meeting ventrally in front of the anus, with four pairs of stalked papillae supporting the alae and surrounding the anus and with a variable number of sessile papillae. The spicules are similar and subequal. The female vulva is in front of the middle of the body (Levine, 1980).

The family Physalopteridae, and in particular the subfamily Physalopterinae appears to remain in taxonomic chaos. Yorke & Maplestone (1926) recognise eight genera based on the number of uteri and the equal or unequal lengths of the spicules, namely *Physaloptera, Chlamydonema, Thubunaea, Turgida, Abbreviata, Heliconema, Proleptus* and *Leptosoma.* Irwin-Smith (1922), supported by Ortlepp (1922), considers it "undesirable to establish a new genus entirely on a character which can be determined only by dissection." For convenience, however, most taxonomists divide the genus *Physaloptera* into groups according to the number of uteri.

All specimens from the present study had four uteri (Group Tetradelphys) and unequal spicules, corresponding to descriptions of *Physaloptera caucasica* from Leiper (1911) and Ortlepp (1926, 1937a) in all respects.

Of the species of *Physaloptera* recognized by Yorke & Maplestone (1926) only four species have been recorded from primate hosts of which *Physaloptera caucasica* and *Physaloptera mordens* appear to be synonyms (Ortlepp, 1926). Yamashita (1963), however, lists twelve species of *Physaloptera* as occurring in primates.

Streptopharagus pigmentatus

Streptopharagus are medium-sized slender worms with no lips, but six large cephalic papillae. The mouth is hexagonal, leading into a buccal cavity with a thickened cuticular wall. The buccal cavity is continuous posteriorly with a tubular pharynx which forms at about the middle of its length a half turn of a spiral. The caudal end of the male forms several close spiral coils. Broad caudal alae are present. Spicules are very unequal and dissimilar, the left one being very long and slender, the right one short and stout. The tail of the female is conical with a pair of subventral papillae. The vulva is not prominent and is situated in front of the middle of the body. Eggs, when ready for laying, have thick shells and contain coiled embryos (Baylis, 1923).

Yorke & Maplestone (1926) list four species of *Streptopharagus* of which two occur in primate hosts, namely *Streptopharagus armatus* and *Streptopharagus pigmentatus.* These two species can be easily distinguished from each other on the lengths of the spicules. Myers & Kuntz (1965) list a third species as occurring in baboons, namely *Streptopharagus baylisi,* which differs from the previous two species on the length of the spicules and the conspicious alae (Ortlepp, 1925). Yamaguti (1961), however, lists six species of *Streptopharagus* as occurring in primates. Specimens from the present study correspond to descriptions of *Streptopharagus pigmentatus* from Baylis (1923) and Ortlepp (1925). The length of the left spicule was 4,6 – 5,5 mm and the right spicule 0,47 – 0,60 mm, whereas the lengths of the left and right spicules in *Streptopharagus baylisi* are 10 – 12 mm and 0,55 mm respectively (Myers, 1955).

Strongyloides fülleborni

Only parthenogenetic females are known in the parasitic form. The body is attenuated anteriorly, the oesophagus is very long and almost cylindrical, the vulva is in the posterior half of the body, the uterus is amphidelph, the tail is short and conical, and the eggs are embryonated when laid (Levine, 1980).

Comparative measurements of diagnostic features of the parasitic females of *Strongyloides fülleborni* from Suikerbosrand and Sabie from the present study and Little's (1966) data are listed in Table 6.

Corresponding sizes of diagnostic features are not sufficient grounds for specific identification since *Strongyloides cebus* has very similar measurements to *Strongyloides fülleborni*. These species are distinguished from each other on the shape of the ovaries (Little, 1966).

TABLE 6: Comparative measurements (mm) of the principle diagnostic features of parasitic females of *Strongyloides fülleborni* from various sources (n = 10).

	Present study					
	Sabie		Suikerbosrand		Little (1966)	
	Range	Mean	Range	Mean	Range	Mean
Length	3,30 –3,96	3,70	3,43 – 3,74	3,59	2,91 –4,20	3,47
Width*	0,039–0,053	0,047	0,044– 0,057	0,05	0,043–0,055	0,051
Length oesophagus	0,83 –0,96	0,89	0,80 – 0,93	0,88	0,71 –0,98	0,80
Mouth to vulva	1,80 –2,46	2,15	2,02 – 2,47	2,32	1,70 –2,70	2,21
Anus to tail	0,44 –0,67	0,49	0,49 – 0,66	0,56	0,45 –0,70	0,56

*Measured across the base of the oesophagus in the present study.

Trichostrongylus falculatus

Trichostrongylus are small, slender worms with a small head and without a buccal cavity or cervical papillae. The male bursa has large lateral lobes and a more or less well-defined, symmetrical dorsal lobe. There is no accessory bursal membrane. There are small prebursal papillae. The spicules are brownish, short, stout and ridged. There is a gubernaculum. The female vulva is a short distance behind the middle of the body and usually has prominent lips. The uteri are amphidelph (opposed). The eggs are thin-shelled and are segmenting when laid (Levine, 1980).

The spicules are the most important specific character of the various species of *Trichostrongylus* (Clapham, 1947). The spicules of *Trichostrongylus falculatus* are dissimilar and easily recognised by the anterior projections. The left spicules were 130 – 140 μm long and the right ones 120 – 130 μm.

Trichuris trichiura

The generic name *Trichuris* Roederer, 1761 is valid and not *Trichocephalus* Schrank, 1788 (Report of the committee on Nomenclature, 1941).

The body in the genus *Trichuris* is composed of a long and very slender anterior portion and a short much thicker posterior portion. The cuticle is transversely striated. On the ventral portion of the anterior part of the body and interrupting the transverse striations is a broad longitudinal bacillary band formed of punctiform projections which are the ends of small rods projecting from the subcuticular cells through the cuticle. The anus is terminal or subterminal. The male posterior end is rolled dorsally in a spiral. There is a single spicule surrounded by a prepuce-like sheath which evaginates when the spicule is protruded. The external surface of the spicule may be either smooth or covered with spines, these spines being different in the various species. The female posterior end is slightly curved. The vulva is near the junction of the anterior and posterior portions of the body. The females are oviparous, producing eggs with thick brown shells and with plugs at both ends (Levine, 1980).

TABLE 7: Comparative measurements (mm) of the principle diagnostic features of *Trichuris* males from various sources.

		Trichuris trichiura				*Trichuris suis*	
		Present study		Chandler (1930)	Sondak (1948)	Present study	Sondak (1948)
		Sabie	S 2089*			S 1227**	
Anterior portion:	length	28,9	17,64	–	29,7	–	29,74
	width	0,14–0,16	0,16–0,17	–	0,17	0,14– 0,16	0,183
Posterior portion:	length	16,8–18,9	10,5–11,1	11,5–14,8	15,71	12,78–13,3	17,92
	width	0,64–0,71	0,48–0,59	–	0,63	0,61– 0,63	0,71
Ratio ant: post. portion		1,62	–	–	1,83	–	1,66
Length spicule		2,66–3,15	2,3– 2,7	2,0– 3,4	3,39	2,52– 2,73	2,59
Length cloaca		4,2 –4,83	2,78–3,37	3,3– 3,6	4,73	3,15– 3,37	4,16
Length vas deferens		5,35–6,30	4,20–6,04	5,4– 8,0	4,93	5,25– 5,46	5,95
Length ejact. duct.		3,78–4,83	2,94–3,36	2,9– 3,4	3,50	2,73– 3,36	4,80

*S 2089 *Trichuris trichiura* from pig, Natal. (Onderstepoort Helminthological Collection)

**S 1227 *Trichuris suis* from pig. (Onderstepoort Helminthological Collection).

The male whipworms from baboons from Sabie were larger than *Trichuris trichiura* measured by Chandler (1930), but similar to those of Sondak (1948) (Table 7). The data summarized in Table 8 show that the female whipworms from Sabie have similar measurements to *Trichuris trichiura* from a human (O 150, Onderstepoort Helminthological Collection).

Schwartz (1926) found *Trichuris suis* from pigs to be morphologically identical to *Trichuris trichiura* from primates. He pointed out that the specific characters in the genus were largely limited to the size of the spicules, the structure of the spicular sheath and the size of the eggs. Less important features include the length of the anterior and posterior portions and the ratio between them. Dinnik (1938, from Levine, 1980) reported, however, that *Trichuris suis* has six chromosomes and *Trichuris trichiura* four, whilst Shtrom and Sondak (1938, from Levine, 1980) were unsuccessful in transmitting whipworms from man to swine or vice versa. It would thus appear that these two species are best differentiated from each other by their respective hosts, in which case the specimens from a pig from Natal in the Onderstepoort Helminthological Collection (S2089) should be assigned to *Trichuris suis* and not *Trichuris trichiura.*

Chandler (1930) points out that great variation exists in the lengths of spicules from the same species of *Trichuris* and that the length and thickness of the posterior portion of

TABLE 8 Comparative measurements (mm) of the principle diagnostic features of *Trichuris* females from various sources

	Trichuris trichiura				*Trichuris sp.*
	Sondak (1948)	Present study			Present study
		Sabie	S 2089*	0 150**	Loskop Dam
Anterior portion :					
length	24,0 –35,6	19,40–35,70	23,10	29,20–31,50	25,2–26,1
width	0,46– 0,50	0,12-- 0,17	0,16– 0,19	0,16– 0,18	0,096–0,128
Posterior portion.					
length	14,0 –16,8	17,85–19,74	9,24–12,60	19,53–20,52	10,18–10,71
width	0,75–0,82	0,67– 0,76	0,67– 0,74	0,78– 0,80	0,63– 0,71
Ratio ant. post. portion	1,7 – 2,1	1,65– 1,84	2,5	1,5– 1,54	2,44– 2,46
Length uterus	–	6,72– 8,19	5,04– 5,25	7,35–10,50	7,05– 7,77
Length tail-vagina	–	16,80–18,58	8,40–10,92	17,43–18,58	7,98– 8,82

*S 2089 *Trichuris trichiura* from pig, Natal (Onderstepoort Helminthological Collection)

**0 150 *Trichuris trichiura* from human. (Onderstepoort Helminthological Collection)

the body are more reliable than the length of the anterior portions. He included the relative lengths of certain parts of the male reproductive organs as also being useful in species differentiation.

It is felt that the specimens obtained from baboons resemble *Trichuris trichuira* the closest morphologically and are thus assigned as such. The genus, and in particular the morphologically similar species *Trichuris trichiura* and *Trichuris suis* warrant further experimental investigation.

Trichuris sp.

Three female whipworms were recovered from a baboon from the Loskop Dam Nature Reserve. These worms were smaller than those from Sabie and all had a prominent projection on the distal vulval lip (Fig. 2). Since no male worms were found the species could not be determined. In South Africa *Trichuris barbertonensis* from cattle is the only whipworm in which the female has a similar projection (Ortlepp, 1937b).

Measurements for the whipworms from Loskap Dam are given in Table 8.

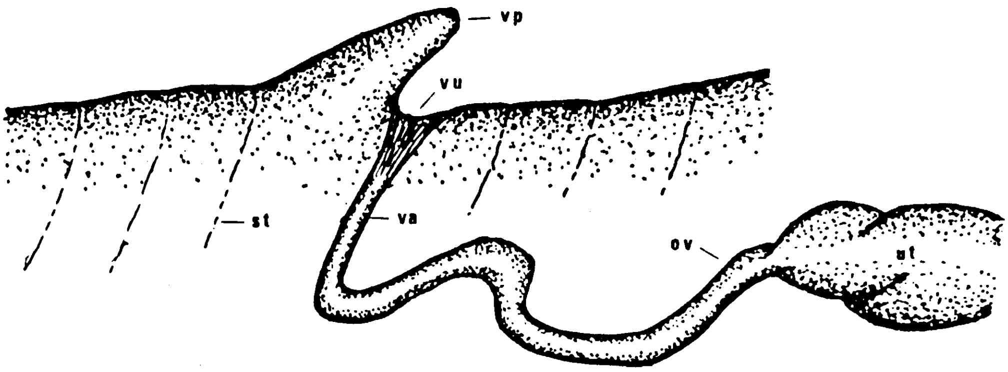

FIG. 2. Camera lucida sketch of the vulval region of a *Trichuris* female recovered from a baboon from the Loskop Dam Nature Reserve.

Prevalence of Helminths

The prevalence and percentage occurrence of gastro-intestinal helminths recovered from baboons from three study areas in the Transvaal is summarized in Table 9. Due to the small sample size, data from the three baboons examined from the Sabie area are not included in calculations or comparisons.

The number of each helminth species recovered from each baboon examined is shown in Appendix 1 for Loskop Dam Nature Reserve, Appendix 2 for Suikerbosrand Nature Reserve, Appendix 3 for Scrutton Private Nature Reserve and Appendix 4 for Sabie.

Microscopic examinations of material obtained from baboons No. 1 – 42 from Loskop Dam were not undertaken. Infestations of *Oesophagostomum bifurcum* were visually estimated using the 3-plus ranking scale.

Habitat of Helminths

The habitat of the various helminths recovered from baboons in the present study is summarized in Table 10.

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.

Strongyloides fülleborni and *Trichostrongylus falculatus* were only recovered from the small intestine.

Gravid proglottides of *Bertiella studeri* were occasionally encountered in the large intestine. These tapeworms were normally present in the jejunum. *Enterobius vermicularis, Oesophagostomum bifurcum* and *Trichuris* spp. were found to occur only in the large intestine, particularly in the proximal caecal regions.

TABLE 9: The mean number, standard deviation and range of helminth species from baboons from three localities in the Transvaal

	Loskop Dam N.R. (n = 65*)			Suikerbosrand N.R. (n = 25)			Scrutton P.N.R. (n = 18)		
Species	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	80,0	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	2–189	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*

TABLE 10: The habitat of helminths from baboons from four localities in the Transvaal

Species	Stomach	Small intestine	Large intestine
Bertiella studeri		+	+[1]
Enterobius vermicularis			+
Oesophagostomum bifurcum			+
Physaloptera caucasica	+	+	
Streptopharagus pigmentatus	+	+	
Strongyloides fülleborni		+	
Trichostrongylus falculatus		+	
Trichuris spp.			+

[1]Gravid proglottides only.

Effect of Age of the Host on Prevalence of Helminths

Estimating the age of wild baboons is unsatisfactory. Stoltz (1977) showed that dentition and body mass parameters were often unreliable in determining age since diet and environmental factors can exert a considerable influence, particularly in baboons over one year old. Baboons are sexually dimorphic. Stoltz (*op cit.*) 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). Gilbert & Gillman (*op cit.*) also found that baboons were weaned at a mean mass of 3,23 kg at approximately 40 weeks of age.

For the purposes of the present study baboons were divided into six age classes according to their body mass and sex as shown in Table 11.

Table 12 presents the percentage of baboons from each age class infested by the various helminths whilst Fig. 3 illustrates the correlation between the age of the host and the mean worm burdens for baboons from Loskop Dam, Suikerbosrand and Scrutton.

TABLE 11: Division of baboons into age classes according to body mass

Class	Mass (kg)		Developmental 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 12: The percentage of baboons from each age class infested by the various helminths from three localities in the Transvaal

Age class	*Bertiella studeri*		*Oesophagostomum bifurcum*		*Physaloptera caucasica*		*Streptopharagus pigmentatus*		*Trichostrongylus falculatus*		*Strongyloides fülleborni*	
	n	%	n	%	n	%	n	%	n	%	n	%
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
TOTAL	108	50,0	108	97,1	108	93,5	108	92,6	66	50,0	25	20,0

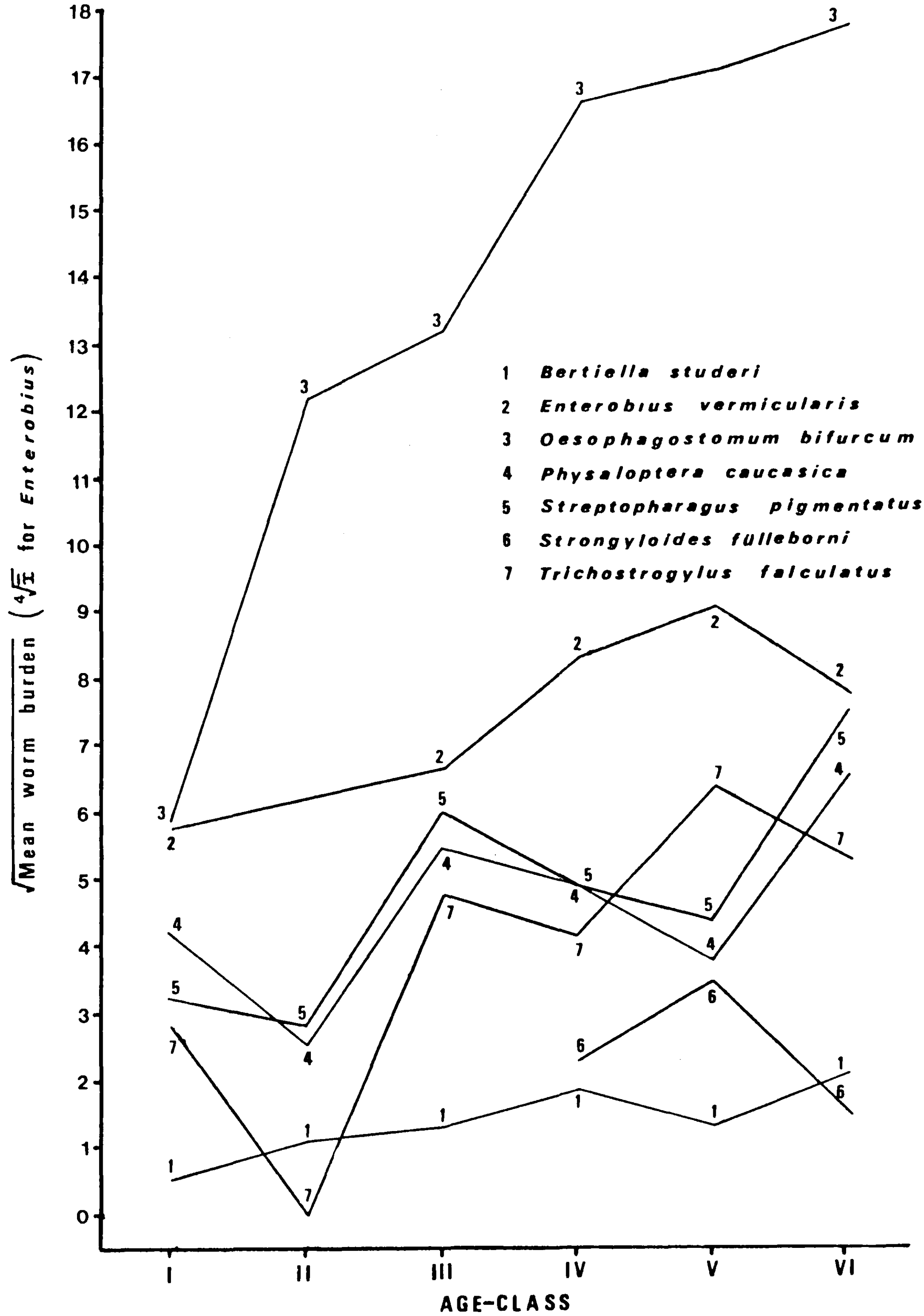

FIG. 3. Correlation between the age of the host and the mean worm burdens of the various helminths recovered from baboons from three localities in the Transvaal.

Seasonal Incidence of Helminths

Baboons could not be obtained on a monthly basis during the present study. Material was, however, collected during the wet and the dry season for all study localities other than Sabie.

Comparisons of the worm burdens of *Bertiella studeri, Oesophagostomum bifurcum, Physaloptera caucasica, Streptopharagus pigmentatus* and *Trichostrongylus falculatus* in baboons in the wet and dry seasons were made and are shown histographically in Figure 4. Seasonal comparisons for *Strongyloides fülleborni* and *Trichuris* spp. could not be made due to the small sample sizes.

Effect of Sex of the Host on 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 makes these comparisons meaningless. Comparisons of worm burdens for the various helminth species between the sexes were, however, made. The worm burdens of the various helminths in male and female baboons from Loskop Dam, Suikerbosrand and Scrutton are illustrated histographically in Fig. 5.

Comparisons for *Strongyloides fülleborni* and *Trichuris* spp. were not made due to the small sample sizes.

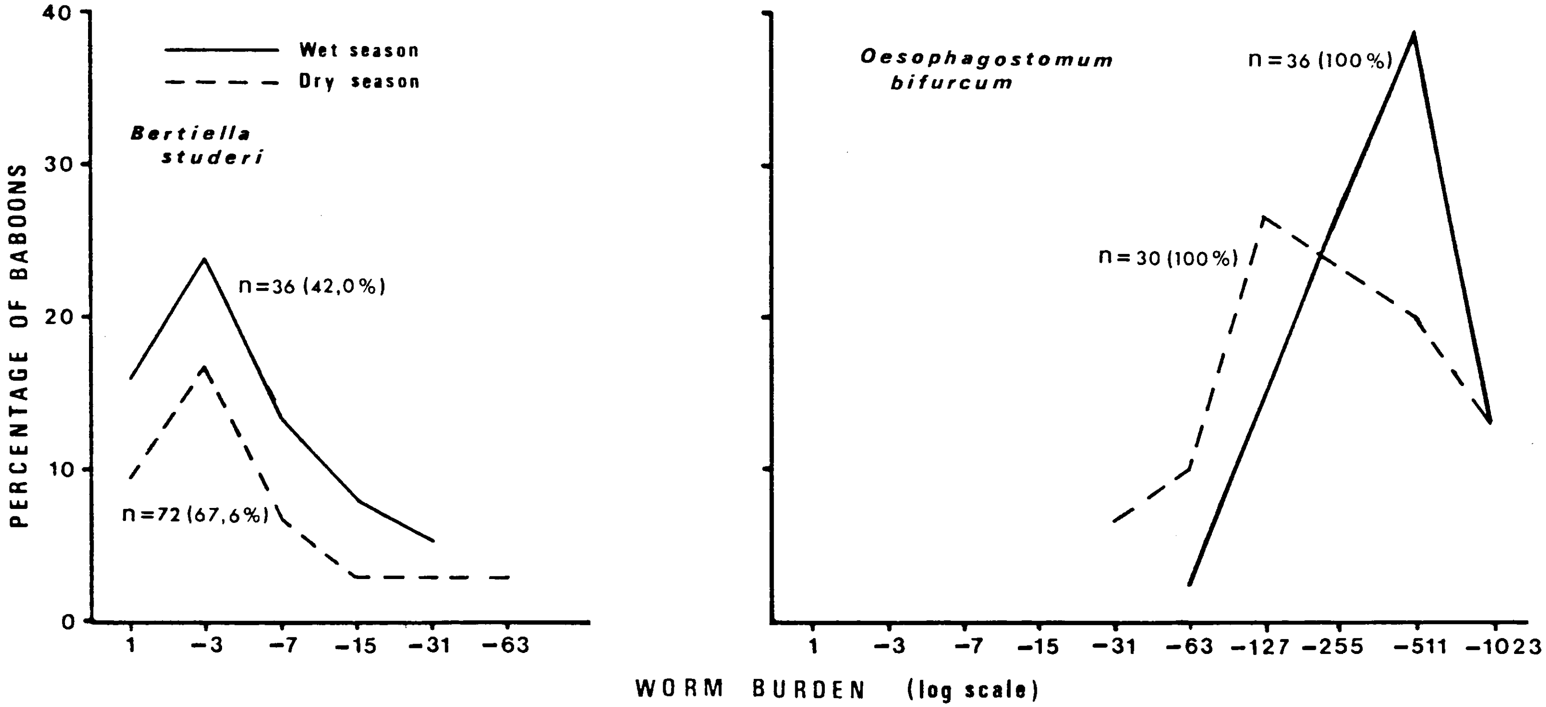

FIG. 4. Frequency distribution of worm burdens in baboons in the wet and dry season. Percentage of baboons infested with the relevant helminth in parantheses.

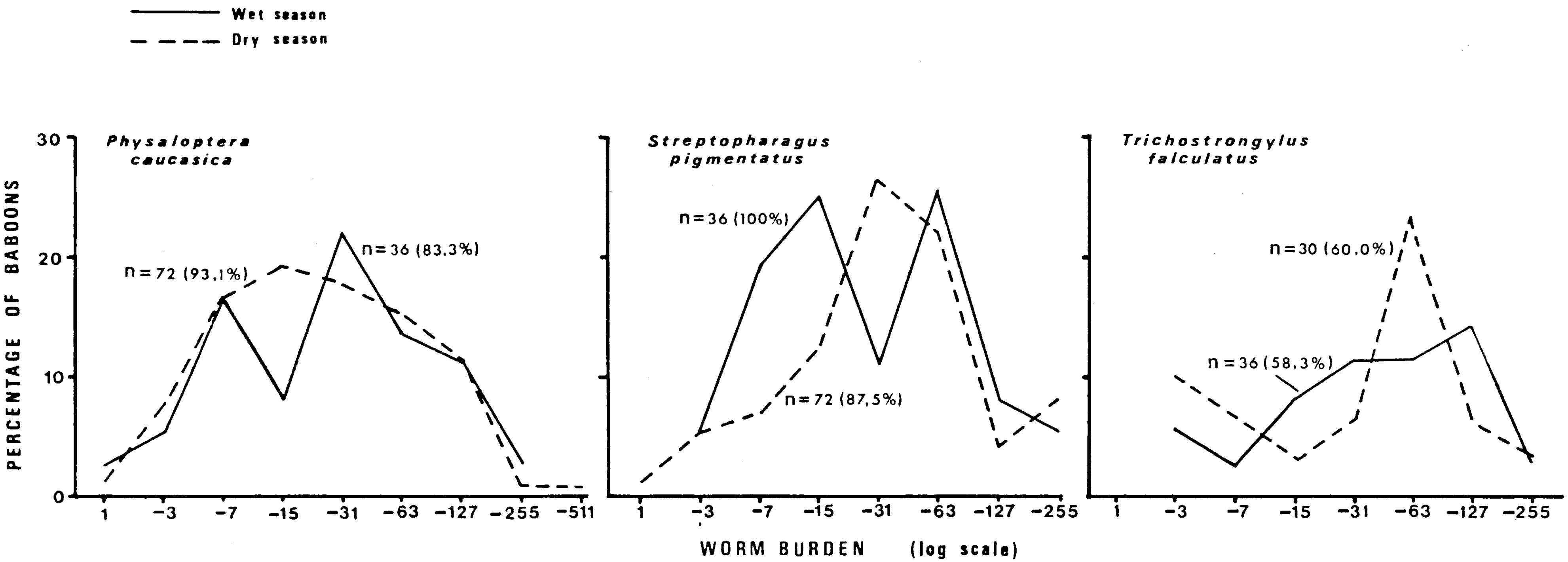

FIG. 4. – Continued

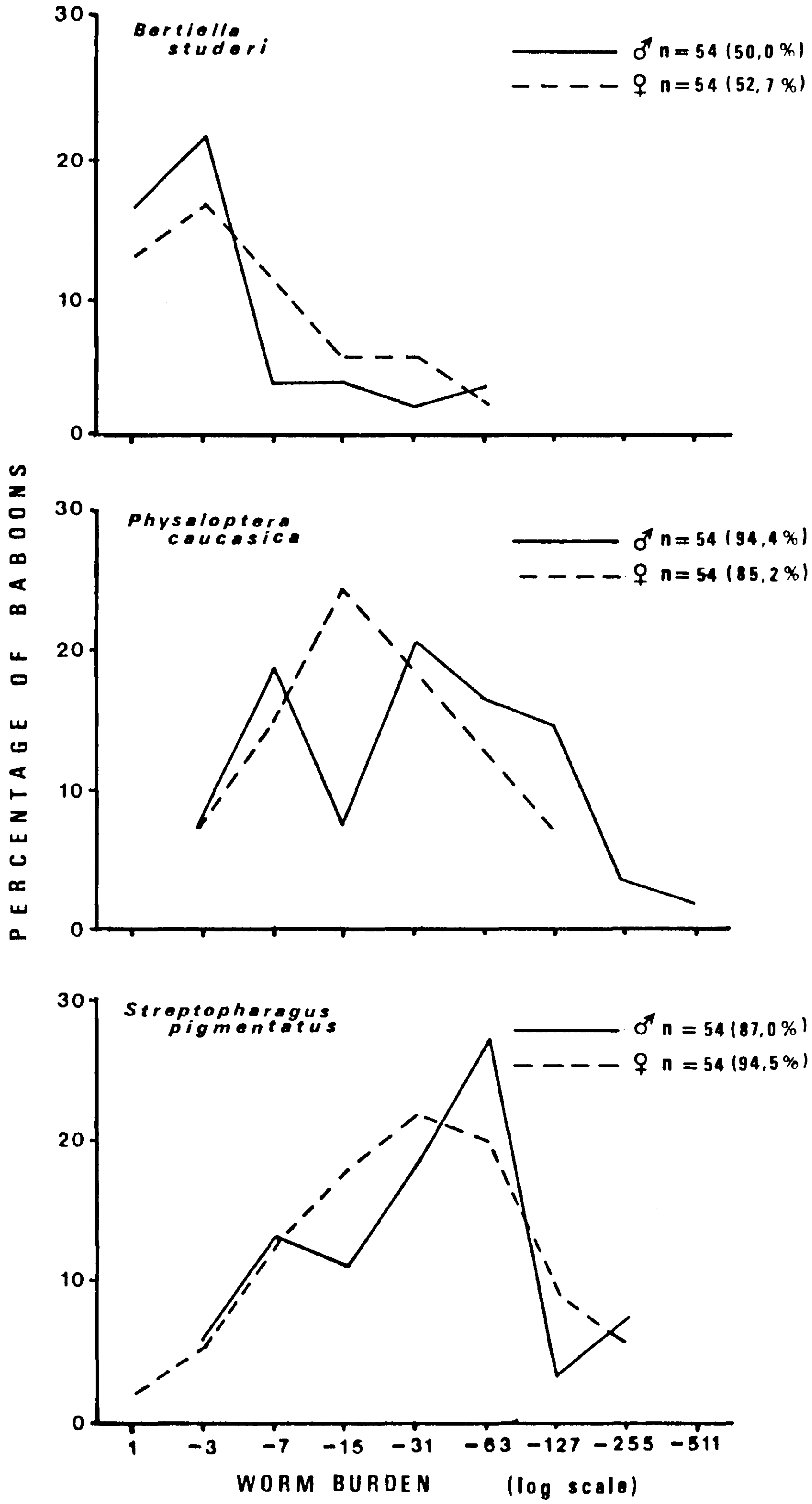

FIG. 5. Frequency distribution of worm burdens in male and female baboons. Percentage of baboons of each sex infested with the relevant helminth in parantheses.

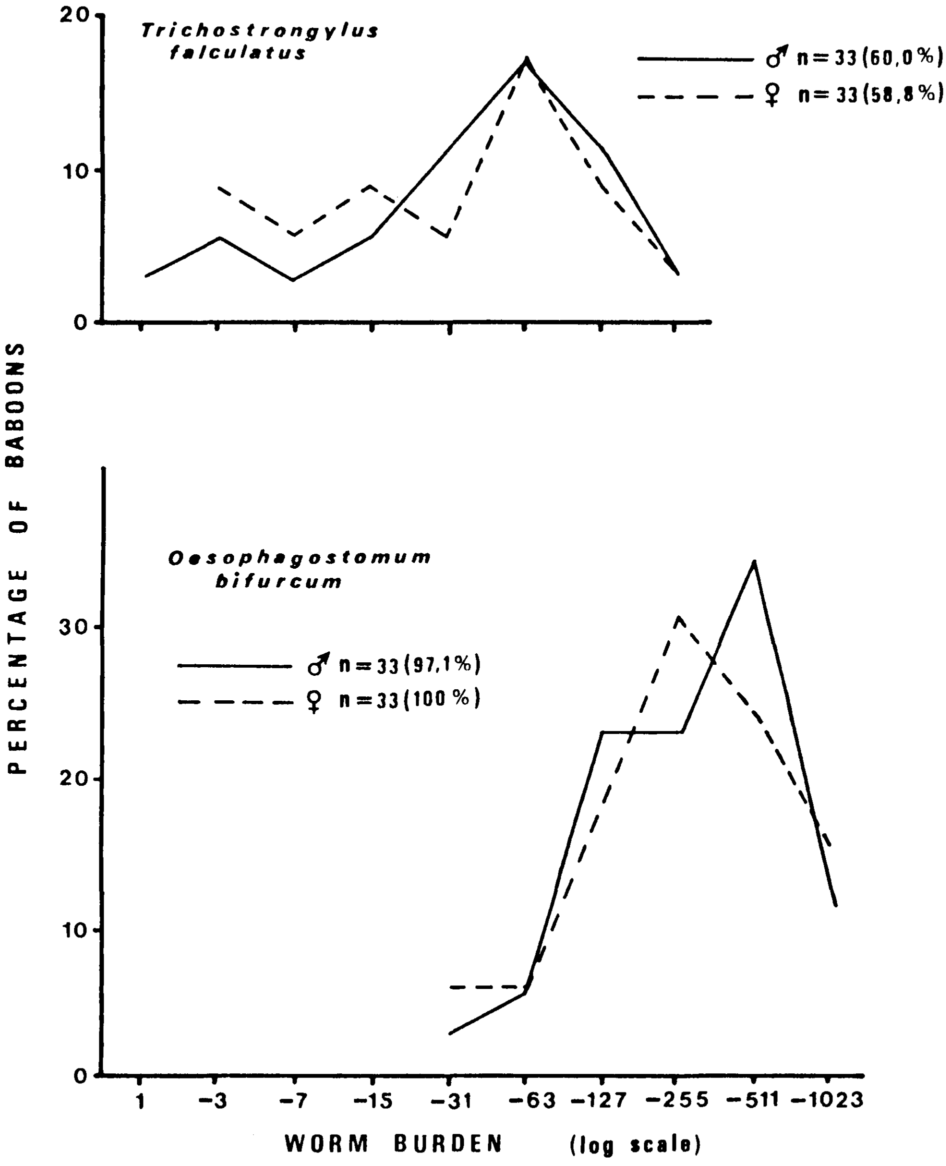

FIG. 5. – Continued

CHAPTER 5

DISCUSSION

Prevalence and geographical distribution of helminths

This is the first study in which an attempt was made to quantify worm burdens in baboons. Kuntz & Myers (1966), Myers, Kuntz & Malherbe (1971) and Goldsmid & Rogers (1978) reported on the prevalence of helminths in baboons, but made no attempt to count the number of each species. This situation is probably due to the tedious and time-consuming nature of counting worms, particularly in the case of very small species.

The distribution of helminths recovered from baboons in the Transvaal from four localities in the present study and from the Kruger National Park (McConnell *et al.*, 1974) is summarized in Table 13. 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, however, clear that the baboons from Loskop Dam were more heavily infested than elsewhere with one animal harbouring as many as 54 tapeworms. The Suikerbosrand baboons showed a somewhat heavier infestation than those from Scrutton which had burdens comparable to 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 two 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 has not previously been recorded in baboons, but 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 9 it is evident that baboons from Suikerbosrand showed lighter infestations than at Loskop Dam and Scrutton, the latter two areas having about similar worm burdens. Reports of this worm from baboons elsewhere also show a high pre-

TABLE 13: The geographic distribution of helminths from baboons from five localities in the Transvaal

Species	Loskop Dam	Suikerbos-rand	Scrutton	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.

valence 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 baboons examined from Loskop Dam and about 80% of baboons from Suikerbosrand and Scrutton. The Loskop Dam baboons showed significantly higher infestations than 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, whilst Kuntz & Myers (1966) and Myers *et al.* (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 was absent in animals from Sabie, but had a high prevalence in the other three areas, although the 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* at the Sabie locality can either be ascribed to the small number of baboons examined or to the use of the poison 10:80 to control baboons. Vomiting is an early sign of toxicity (McIlroy, 1981), and 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.

Streptopharagus pigmentatus and *Physaloptera caucasica* share the same habitat in the baboon and the former was found to be dominant in both the present study, particularly at Suikerbosrand and Scrutton and in the Kruger National Park. Although not the rule, high infestations of one of these species in an individual were often accompanied by a low infestation of the other species, indicating possible competition for habitat (Appendices 1 – 3).

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). Together with *Strongyloides fülleborni* these are the only worms to have a higher prevalence at Suikerbosrand than elsewhere in the present study. This species has not previously been recorded in baboons. It has been reported in ruminants from South Africa, Australia and Europe (Levine, 1980). This species has been found in blesbok *Damaliscus dorcas philipsii* (Horak, 1980) which occur on the Suikerbosrand Nature Reserve and impala *Aepyceros melampus* (Anderson 1978; Horak, 1980) which 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. The genus was absent in baboons from the Kruger National Park (McConnell *et al.*, 1974), but present in one 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* occur world-wide (Levine, 1980).

From 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 helminthology of wild primates, data on the prevalence and geographic distribution of these helminths is 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 parasite burdens (Ruch, 1959).

Effect of Age of the Host on Prevalence of Helminths

Vertebrates develop acquired immunity against nematodes, but this immunity is much weaker than that which develops against micro-organisms and is rarely a solid immunity so that some nematodes are generally present even in relatively immune animals. Most earlier workers ascribed this to age resistance. Although this phenomenon does occur, it is not clear how it functions. Acquired immunity is more important and explains, for instance, why the worm burdens of adult ewes are much lower than those of lambs grazing the same pasture with them (Levine, 1980). In the present study worm burdens of most helminth species in the baboon increased as the age of the host increased up to adolescense, after which the worm burdens decreased.

The prevalence of *Bertiella studeri* was low in baboons in age class I, but at progressively higher frequencies as the age of the host increased, with the exception of the high frequency for age class II, this being attributed to the small sample size (Table 12). Similarly, the worm burdens of this cestode increased as the age of the host increased (Fig. 3).

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. 3). This high prevalence can be ascribed to the direct and rapid life-cycle of the worm. The decrease in worm burdens of adult baboons could be as a result of acquired immunity (Chandler & Read, 1961; Tromba, 1962).

Oesophagostomum bifurcum was the most common worm in the present study with a high prevalence in every age class, particularly in sub-adult and adult baboons (Table 12).

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. 3). 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, albeit somewhat lower in age class I for the latter species and age class II for the former species (Table 12). From Fig. 3 it can be seen that both these species showed a similar worm burden in relation to age. The decrease in worm burdens in age classes IV and V is 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 which would increase the mean worm burdens (Appendices 1 – 3). These individuals probably had a lowered resistance to these parasites as a result of malnutrition. According to Chandler & Read (1961) Read (1958) pointed out that malnutrition may increase cortisone production which in turn depresses resistance responses. Old baboons on the Loskop Dam Nature Reserve were often in poor physical condition, particularly during the dry season.

Strongyloides fülleborni were 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 can, however, be ascribed to the very small sample size of these age groups (Table 12). The decrease in both the mean worm burden (Fig. 3) and the prevalence (Table 12) in age class VI can be ascribed to acquired immunity.

Trichostrongylus falculatus was present in one baboon in age class I and absent in age class II, the sample size of both these classes being too small to draw any conclusions other than that the worm can occur in very young animals. The decrease in both the mean worm burden (Fig. 3) and the prevalence (Table 12) of this worm in age class VI can again be attributed to acquired immunity or the "self-cure" mechanism as described by Stoll (1928). Bull (1955) in his studies on *Trichostrongylus retortaeformis* in rabbits found a similar pattern which he attributed to the "self-cure" mechanism, stating that the alternative explanation that the wide range in the size of infestations be matched by an equally wide range in natural resistance among individual rabbits appears less likely and lacks any experimental support.

Trichuris spp. were obtained from an insufficient number of baboons to make any age-correlated comparisons. *Trichuris trichiura* was present in two of the three baboons examined from Sabie, one being in age class II and the other in age class VI. A female beboon in age class I from Loskop Dam harboured three individuals of *Trichuris* which could not be assigned to a species due 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

Many helminth species have been known to show seasonal fluctuations in prevalence and worm burdens (Levine, 1980).

Bertiella studeri is more prevalent and present in greater numbers in the summer wet season (Fig. 4). Stunkard (1940) showed experimentally that the intermediate hosts of *Bertiella* spp. are free-living oribatid mites. Oribatid mites occur in very large numbers in the soil (Chandler & Read, 1961). Sengbusch (1954) established that reproduction in species of *Galumna* is correlated with temperature. The mites 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). Baboons 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 oribated mites.

Almost all the baboons examined in the present study were infested with *Oesophagostomum bifurcum* during both the wet and dry seasons, although adult worm burdens appeared to be higher during the wet season. Graham (1960) made the assumption 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. Michel (1974) postulated that the majority of nematodes could interrupt their development, possibly as a result of certain environmental stimuli. In his review on arrested development he quotes ample evidence of this phenomenon in several species of *Oesophagostomum*.

This process, known as hypobiosis, usually only affects a proportion of the worm population and usually occurs during unfavourable conditions for the free-living stages of the parasite i.e. winter periods when the condition of the host drops, and is a plausible explanation for the lower worm burdens of adults during the dry season. Although nodules were not counted, it appeared that nodules were more numerous during the dry season, indicating possible hypobiosis.

Physaloptera caucasica and *Streptopharagus pigmentatus* showed very similar worm burdens for both seasons (Fig. 4). The fluctuations in the graphs for the wet season indicate smaller sample sizes.

Trichostrongylus falculatus were equally prevalent in baboons in both seasons. The worm burdens were, however, higher during the dry season. Anderson (1978) also found higher worm burdens of this species in impala during the dry season in Natal. 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. Suikerbosrand with a milder summer climate had a very much higher rate of infestation of this worm. It would thus appear that worm burdens of *Trichostrongylus falculatus* in baboons are affected by temperature as in ruminants.

From Appendix 3 it can be clearly seen that *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.

Effect of the Sex of the Host on the Prevalence of Helminths

Hausfater & Watson (1976) showed in a preliminary survey that the social rank and reproductive condition of yellow baboons, *Papio cynocephalus*, influenced parasite ova emissions. Jackson & Farmer (1970) and Mankau & Hamilton (1972) demonstrated that the social and reproductive condition of several rodent species could affect the susceptibility of the host to intestinal parasites as well as the development of established parasites.

In a highly social species such as the baboon, discrepancies 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 complimentary items to the diet, such as small mammals and birds, appear to be more favoured by large males (Jackson, 1978). Where such homoiotherms were to act as intermediate hosts in the transmission of a parasite, a higher prevalence of the parasite could be expected among male baboons, but this was not the case for any of the helminths recovered from baboons in the present study.

No helminth species in the present study proved to be more prevalent or abundant in male or female baboons to the extent that it could not be attributed to individual variation, with the possible exception of *Physaloptera caucasica.* This species was more prevalent and occurred in larger worm burdens in male baboons, both in the present study and that of McConnell *et al.* (1974) for the Kruger National Park.

Physaloptera caucasica utilizes arthropods as intermediate hosts in its life-cycle. The possibility for the higher prevalence of this worm in male baboons due to a higher consumption of arthropods lacks documented support. Furthermore, if this were the case, a similar finding for *Streptopharagus pigmentatus* which also utilizes arthropods in its life-cycle would be expected.

The more probable explanation for this higher prevalence of *Physaloptera* in male baboons is physiological differences between the sexes. The worm has a wide habitat tolerance occurring in both the stomach and small intestine (see page 23). Possible physiological differences are thus likely to be involved with the immune responses of the host. Various studies have shown that the sex of the host influences the localization of nematodes and that many nematodes exhibit chemically mediated sexual attraction (Mettrick & Podesta, 1974). This possibility warrants further investigation.

Host Specificity of Helminths

Nearly 250 species of helminths have been reported from non-human primates of which only about 30 are found exclusively in this host group (Orihel, 1970). Myers & Kuntz (1965) list 35 helminth genera from baboons.

The subject of host specificity has received much attention in recent years. Perhaps the best known example of a morphologically similar, but physiologically different worm, is that of *Ascaris lumbricoides* of man and *A. suum* of swine, the validity of two separate species being a controversial point among many parasitologists. Sprent (1952) has, however, shown that there are in fact certain anatomical differences in the denticles on the lips. Likewise, the morphologically similar *Trichuris trichiura* of man and

Trichuris suis of swine have been shown to be genetically different (Dinnik, 1938, from Levine, 1980). Premvati (1958b), however, demonstrated experimentally that the parasitic females of *Strongyloides fülleborni* showed morphological differences when the cultures were incubated at different temperatures, suggesting that species recovered from different hosts or from different localities may in fact be synonyms.

Baer (1940) states that *Bertiella studeri* is probably the only tapeworm acquired by man through evolution dating prior to the Ice-Age. Baer's (1927) earlier attempt to trace the phylogenetic relationships of the Anoplocephalids was rejected by Spasskii (1951). Both authors agree, however, that *Bertiella studeri* is now a rare parasite of man. Additional records of human infestation include Adams & Webb (1933), Stunkard (1940), Stunkard *et al.* (1964) and Buckley & Fairley (1950). *Bertiella studeri* has been reported as occurring in the chimpanzee, *Pan troglodytes*, by Cram (1928), the rhesus monkey, *Macacus rhesus*, by Stunkard (1940) and the gibbon, *Hylobates lar*, by Chandler (1925b) Infestations of *Bertiella studeri* from chacma baboons were reported by McConnell *et al.* (1974) and Goldsmid & Rogers (1978) and *Papio* spp. by Round (1964) and Kuntz & Myers (1966).

Cameron (1929a) proposed the theory that each primate genus has its own species of *Enterobius*. He suggested (Cameron, 1927) that *Enterobius vermicularis* was originally a simian parasite that attacked man in his pre-human days and due to its direct life cycle has since become specialized to humans. Sandosham (1950), however, recorded *Enterobius vermicularis* from the chimpanzee, gibbon, and lion marmoset (*Leontocebus rosalia*). This species was recovered from a gorilla, *Gorilla gorilla*, from the National Zoological Gardens, Pretoria by Verster[1] (pers. comm.) and has also been recorded in Norway- and black rats, swine and various other mammals (Yamaguti, 1961; Levine, 1980). Sandosham (*op. cit.*) states that although *Enterobius vermicularis* is not host specific, there is little doubt that the genus *Enterobius* evolved with and parallel to its primate hosts. It would appear that this is the first record of *Enterobius vermicularis* in baboons.

Oesophagostomum bifurcum occurs exclusively in primates (Travossos & Vogelsang, 1932; Yamaguti, 1961; Yamashita, 1963). Chabaud & Lariviere (1958) and Orihel (1970)

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reported frequent human infestation of this strongyle. It is a common parasite of baboons (Myers & Kuntz, 1965; Kuntz & Myers, 1966; Kim, *et al.*, 1968; McConnell *et al.*, 1974).

Physaloptera caucasica has only been reported from man and Old-World monkeys and baboons (Leiper, 1911; Ortlepp, 1922, 1926 & 1937a; Baylis, 1939). *Streptopharagus pigmentatus* occurs only in Old-World monkeys and baboons (Ortlepp, 1925; Graham, 1960).

Strongyloides fülleborni was originally described from material recovered from a chimpanzee and baboon (Von Linstow, 1905). It has been recorded in rhesus monkeys (Sandground, 1925; Premvati, 1958a), man (Blackie, 1932; Wallace, Mooney & Sanders 1948; Hira & Patel, 1980), and baboons (Goodey, 1926; Blackie, 1932; Goldsmid & Rogers, 1978).

Trichostrongylus falculatus occurs in goats, sheep, springbok (*Antidorcas marsupialis*) and blesbok, (Skrjabin, Shikhobalova & Shults, 1954), impala, (Anderson, 1978; Horak, 1980) and cattle (Horak, 1980). Yamaguti (1961) mentions a record of *Trichostrongylus falculatus* from the New World monkey *Cebus* sp. indent., this being the only prior record of this worm in a primate, but no further information is given. Myers & Kuntz (1965) list four other species of *Trichostrongylus* from baboons, namely *Trichostrongylus attenuatus, Trichostrongylus columbriformis, Trichostrongylus instabilis* and *Trichostrongylus subtilis.*

Faust & Russell (1964) claim that man is the only proven host of *Trichuris trichiura.* Kuntz & Myers (1966) and Canavan (1929), however, report *Trichuris trichiura* from baboons, Yamashita (1963) from macaques, whilst Orihel & Seibold (1972) state that this whipworm is common among African and Asian monkeys and the chimpanzee.

No helminth recovered from the baboon in the present study proved to be host specific. Of the species recovered from the baboon in this study only *Streptopharagus pigmentatus* and *Trichostrongylus falculatus* have not been recorded from man.

Helminth Epizootiology

The ecological relationships between parasites and primates is poorly understood. The life histories of helminth parasites vary a great deal, some having direct life cycles and being transmitted from animal to animal by way of faecal contamination and/or direct contact, while others require one or more intermediate hosts. Other parasites may undergo a period of development outside the host.

The transmission of various helminth species can be directly related to the habits and food of the baboon, this correlation for primates in general having 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 a parasite with a direct life-cycle such as *Enterobius vermicularis* where infestation occurs by ingestion of the eggs. Retro-infestation may also occur when larvae hatch from eggs and crawl back into the anus to develop further in the intestine (Levine, 1980). Sandosham (1950) pointed out that the possibility of human infestation of *Enterobius* through the keeping of pet monkeys cannot be disregarded. In the present study this worm was present in large numbers at Scrutton, this locality being in close proximity to primitive human settlements. The probability of baboons acquiring this worm from humans is equally 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.

Faecal contamination is greatly enhanced by the fact that baboons are territorial and that they 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 life-cycles whereby ova are passed out of the host where they undergo further development on the ground and gain access to the host by being ingested or, as in the case of *Strongyloides fülleborni,* by penetration of the skin of the host (Levine, 1980). Stunkard (1940) demonstrated experimentally that *Bertiella studeri*, like other anoplocephaline cestodes, utilizes free-living soil mites of the Order Oribatoidea (*Schleloribates laevigatus* and *Galumna* spp.) as intermediate hosts. Transmission of *Bertiella studeri* is thus also enhanced by the territorial habits of baboons and their foraging behaviour in search of roots, bulbs and rhizomes.

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

The climate at the four study localities in the present investigation differs markedly. 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 on the effects of climate on parasites is rudimentary. He differentiates between two basic climatic zones, one being temperate with a high rainfall (generally *Trichostrongylus – 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 corresponds with Levine's (1980) *Haemonchus* areas. The cestode *Bertiella studeri* was about equally prevalent in all the study areas, although worm burdens were highest at Loskop Dam. Worm burdens were, however, the lowest at Scrutton, possibly because this area is excessively hot and arid.

The habits of baboons, their food and the diversity of habitats that they utilize would thus enhance their chances of harbouring a variety of helminths which can occur in large numbers due to continuous exposure to infection.

Helminth Pathogenesis

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. From the present study and investigations by Kuntz & Myers (1966), Kim *et al.* (1968), McConnell *et al.* (1974) and Goldsmid & Rogers (1978) it would appear that an African baboon free of intestinal helminths would be a very rare phenomenon indeed.

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. The former two species were found to be firmly hooked into the mucosa of the stomach, particularly in the fundic regions, or embedded in mucus in the small intestine. Stomachs of baboons with severe infestations were markedly inflamned. Feng (1931) states that there is little doubt that *Physaloptera caucasica* produces some secretion that liquifies the cells of the stomach mucosa. McConnell *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.

Oesophagostomum is considered the most serious of primate parasites (Ruch, 1959; Fiennes, 1967; Orihel & Seibold, 1972). In the present study large numbers of black nodules the size of garden peas were present in the submucosa or muscularis of the caecum and proximal colon of the baboons. The nodules contained a black tarry material in which the larval stage of the worm was embedded. Secondary invasion of these lesions by colonic bacteria can lead to ulceration, perforation of the intestine or fatal septicemia (Orihel & Seibold, 1972). Orihel (1970) states that an increasing number of cases of human infestation with *Oesophagostomum bifurcum* are being reported, often requiring the surgical removal of nodules. He also points out that patent infestations of this worm are difficult to recognise during faecal examinations since there are insufficient reliable criteria to differentiate the eggs from those of hookworms and other strongyles. Eggs of *Ternidens deminutus* are also commonly mistaken for hookworm eggs. Eggs of this species can be differentiated from *Oesophagostomum* on the basis of egg volume, but still presents a diagnostic problem (Goldsmid, 1967).

The dangers of primate zoonoses have been accentuated by Blackie (1932), Hummer (1965), Fiennes (1967) and many others. Accidental human infestations of helminths normally occurring in the lower primates may have far greater consequences (Cameron, 1927; Blackie, 1932; Fiennes, 1967). Generally speaking, 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 to certain environmental conditions, for instance malnutrition, that lower the host's resistance.

Hummer (1965) draws attention to the fact that little thought has been given to the Workman's Compensation Act regarding the handling of wild primates. The problems of establishing a specific diagnosis and determining whether or not the infection was an occupationally acquired one should not deter the importance of providing adequate cover for professional animal handlers.

SUMMARY

Of the nine 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 being normally a parasite of ruminants and only once previously being recorded from a primate host. A possible new species of *Trichuris* was found in a baboon from Loskop Dam, but unfortunately only three females were present.

There appears to be considerable taxonomic confusion with some of the helminths recovered from baboons, in particular regarding the cestode, *Bertiella studeri*, and the nematode, *Trichuris trichiura.* In the case of *Bertiella* it would appear that the methods employed in killing and fixing the worms has contributed to the description of a number of species which are probably synonyms of the two species *Bertiella studeri* and *Bertiella mucronata* which are now generally accepted as being the only valid species by most parasitologists other than the Russian school (Spasskii, 1951). The only reliable diagnostic features between these species appears to be the number of testes and the size of the cirrus sac. *Trichuris trichiura* appears to vary morphologically in different host species and under different environmental conditions. There is no reliable diagnostic feature to distinguish species of this genus from each other, but rather a combination of measurements of features that appear to show considerable variation. The α, β and γ ratios used in the identification of *Enterobius* species are considered unreliable and invalid due to the considerable variation in these ratios even among individuals of the same population.

This was 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 three species of intestinal helminths and some as many as six species. It would appear that *Streptopharagus pigmentatus* and *Physaloptera caucasica* compete for the same habitat in the baboon.

Baboons from Suikerbosrand generally had lower worm burdens than those from Loskop Dam and Scrutton with the exception of the nematodes *Strongyloides fülleborni* and *Trichostrongylus falculatus*, the higher worm burdens for the latter species being attributed to the more temperate climate at Suikerbosrand. A high prevalence for *Enterobius*

vermicularis occurred at Scrutton, possibly as a result of nearby human habitation. *Trichuris trichiura* was only found 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 either be ascribed to the small sample size or the use of the poison 10:80 to cull the baboons.

An attempt was made to correlate worm burdens to 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. Decreased numbers of *Trichostrongylus falculatus* can possibly be attributed to the "self-cure" mechanism.

Higher worm burdens for 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, this being attributed to the cooler climate which coincides with the temperature tolerence of the infective larvae.

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 differences, or alternatively, albeit less likely, to the possible higher consumption of the arthropod intermediate hosts by male baboons.

No helminth recovered from baboons in the present study is host specific. All species with the exception of *Streptopharagus pigmentatus* and *Trichostrongylus falculatus* 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 zoonosis and the keeping of pet monkeys and baboons should thus be stringently discouraged by the authorities.

Of the 111 baboons examined in the present study, no single individual was found to be free of intestinal helminths. It can be concluded that baboons are naturally infested with intestinal parasites and have evolved to cope with a variety of parasites that may simultaneously infect a single individual without undue detrimental effects under normal environmental conditions.

OPSOMMING

Van die nege helmintspesies vanuit bobbejane in die huidige ondersoek herwin, is slegs *Enterobius vermicularis* en *Trichostrongylus falculatus* nuwe gasheerrekords. Laasgenoemde wurmsoort parasiteer gewoonlik herkouers en is slegs eenkeer voorheen in 'n primaat beskryf. 'n Moontlike nuwe *Trichuris* spp. is in 'n bobbejaan van Loskopdam gevind, maar ongelukkig was slegs drie wyfies teenwoordig en die spesies kon dus nie bepaal word nie.

Dit blyk dat daar aansienlike verwarring oor die benaming van sommige wurmparasiete van bobbejane bestaan, veral met betrekking tot die lintwurm, *Bertiella studeri*, en die sambokwurm, *Trichuris trichiura.* Die prosedures wat gebruik word vir die doodmaak en fiksering van lintwurms het daartoe bygedra dat verskeie nuwe *Bertiella* spp. beskryf is, maar, met die uitsondering van die Russiese parasitoloë (Spasskii, 1951), word dit algemeen aanvaar dat daar slegs twee geldige spesies is, nl. *Bertiella studeri* en *Bertiella mucronata.* Die enigste geldige onderskeidende kenmerke tussen hierdie twee spesies is die aantal testes teenwoordig en die grootte van die sirrusbeurs. *Trichuris trichiura* toon morfologiese variasie in verskillende gasheersoorte en onder verskillende omgewingstoestande. Daar bestaan geen enkele kenmerk om die verskillende spesies in hierdie genus van mekaar te onderskei nie en onderskeid berus op 'n kombinasie van afmetings van strukture wat 'n aansienlike variasie toon. Die α-, β- en γ-verhoudings wat gebruik word vir die identifikasie van *Enterobius* spp. is onbetroubaar en ongeldig as gevolg van die aansienlike variasie wat in die verhoudings bestaan, selfs in individue van dieselfde bevolking.

Hierdie is die eerste studie waarin die wurmladings van bobbejane bepaal is. Daar was variasie in wurmgetalle van die verskillende spesies in bobbejane van dieselfde omgewing, ouderdomsgroep en geslag. Die meerderheid van die bobbejane is deur drie, en sommige deur ses, verskillende helminte geparasiteer. Dit wil voorkom of *Streptopharagus pigmentatus* en *Physaloptera caucasica* met mekaar vir dieselfde habitat in die bobbejaan kompiteer.

Oor die algemeen het bobbejane van Suikerbosrand laer wurmladings as dié van Loskopdam en Scrutton gehad. Hoër wurmladings van *Strongyloides fülleborni* en *Trichostrongylus falculatus* is egter in diere van Suikerbosrand opgemerk, heelwaarskynlik as gevolg van die gematigde klimaat. Die groot aantal bobbejane op Scrutton wat met

Enterobius vermicularis besmet was kan moontlik aan 'n nabygeleë menslike nedersetting toegeskryf word. *Trichuris trichiura* is in bobbejane in die omgewing van Sabie gevind, en tesame met *Strongyloides fülleborni* was dit die enigste wurmparasiete wat nie in diere afkomstig van al die verskillende areas van die huidige ondersoek, gevind is nie. Die afwesigheid van *Physaloptera caucasica* en *Streptopharagus pigmentatus* in bobbejane van Sabie kan moontlik aan die min diere wat ondersoek is toegeskryf word of aan die feit dat die diere met 10:80 van kant gemaak is.

'n Poging om die wurmladings met die ouderdom van die bobbejane te korreleer is aangewend. Al die wurmsoorte wat in hierdie studie gevind is, kom in jong bobbejane voor, maar wurmladings neem toe hoe ouer die diere word. In die geval van *Enterobius vermicularis* en *Strongyloides fülleborni* kan die vermindering in die wurmlading in volwasse diere aan verworwe immuniteit toegeskryf word en in die geval van *Trichostrongylus falculatus* aan die "selfgenesingsmeganisme."

Gedurende die reënseisoen kan die hoër getalle van *Bertiella studeri* aan die teenwoordigheid van groter getalle myte wat as tussengashere optree toegeskryf word – insgelyks word die vermeerdering van *Oesophagostomum bifurcum* deur onderdrukte groei of hipobiose gedurende voorafgaande ongunstige droogtetoestande veroorsaak. Die vermeerdering in die getalle *Trichostrongylus falculatus* in die winter kan aan die koeler klimaat wat gunstig is vir die oorlewing van besmetlike larwes toegeskryf word.

Behalwe vir *Physaloptera caucasica* kan daar geen betekenisvolle verskille in die wurmladings van manlike en vroulike diere gevind word nie. Die hoër voorkoms van *Physaloptera caucasica* in mannetjies kan aan fisiologiese verskille óf aan die groter inname van die insektussengashere deur manlike bobbejane toegeskryf word, alhoewel laasgenoemde onwaarskynlik is.

Geeneen van die helminte wat in hierdie studie gevind is, is gasheerspesifiek nie, en met die uitsondering van *Streptopharagus pigmentatus* en *Trichostrongylus falculatus* is al die spesies voorheen in die mens gevind. Die bobbejaan is dus 'n ideale biologiese model vir die bestudering van menslike wurmparasiete. Om hierdie rede moet die bobbejaan ook as 'n bron vir soönotiese besmetting beskou word en die aanhouding van ape en bobbejane as troeteldiere behoort sterk ontmoedig te word.

Daar is gevind dat alle bobbejane in hierdie ondersoek met wurmparasiete besmet was. Daar kan dus afgelei word dat bobbejane uiteraard met ingewandswurms besmet is en dat individue onder normale omstandighede gelyktydige besmettings met verskillende parasiete kan verdra.

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APPENDIX 1 The number of helminths recovered from baboons from the Loskop Dam Nature Reserve. Worm burdens for *Oesophagostomum bifurcum* for baboons Nos. 1–42 were estimated on the 3-plus ranking scale.

No. & sex	Mass kg	Date	*Bertiella studeri*	*Oesophagostomum bifurcum*	*Physaloptera caucasica*	*Streptopharagus pigmentatus*	*Trichostrongylus falculatus*
1 ♂	23,5	22/09/76	0	+++	48	54	–
2 ♂	3,5	"	1	++	5	10	–
3 ♀	10,0	"	0	+	16	22	–
4 ♀	12,0	"	54	+	0	0	–
5 ♀	11,5	"	0	+	10	17	–
6 ♀	6,5	"	10	+++	21	35	–
7 ♀	5,0	"	0	+	2	1	–
8 ♀	5,5	"		+	16	0	–
9 ♀	12,5	"	0	+	13	9	–
10 ♀	10,5	"	0	+++	12	14	–
11 ♀	9/5	24/09/76	0	+++	25	138	–
12 ♂	4,5	"	3	++	6	10	–
13 ♀	11,0	"	5	0	38	2	–
14 ♂	2,5	"	0	++	7	0	–
15 ♂	27,0	"	40	+++	3	0	–
16 ♀	11,0	"		+	32	20	–
17 ♀	15,0	"	2	+	20	50	–
18 ♀	13,5	"	6	+++	18	30	–
19 ♀*	3,0	"	0	+	5	13	–
20 ♂	27,5	20/10/76	3	+++	231	42	–
21 ♂	22,5	"	1	++	3	52	–
22 ♂	21,5	"	0	+++	46	12	–
23 ♂	5,5	"	0	++	6	0	–
24 ♀*	15,5	5/10/76	0	+++	37	81	–
25 ♂	24,0	"	7	+++	71	164	–
26 ♂	8,5	"	0	+	6	0	–
27 ♀	8,0	"	1	+++	70	191	–
28 ♀	1,0	"	0	0	13	7	–
29 ♂	22,0	"	0	++	33	31	–
30 ♂	9,0	"	0	+	29	0	–
31 ♂*	3,0	6/10/76	0	++	81	36	–
32 ♀	6,0	"	0	+	68	22	–
33 ♂	22,5	"	12	++	392	207	–
34 ♀	18,0	"	0	+	39	130	–
35 ♀	16,5	7/10/76	0	+++	99	114	–
36 ♂	20,0	"	7	++	31	7	–
37 ♂	14,0	"	0	+++	82	5	–
38 ♂	12,0	"	0	+	89	25	–
39 ♀	18,0	"	16	++	53	37	–
40 ♂	21,0	"	0	++	34	55	–
41 ♂	20,5	"	2	++	117	22	–
42 ♂	2,0	"	0	+	12	0	–
43 ♂	23,0	18/10/76	2	511	29	48	0
44 ♂	8,5	17/11/76	1	394	19	2	30
45 ♀	18,5	"	0	537	64	2	2
46 ♂	22,0	"	3	411	24	7	0
47 ♀	18,0	"	5	263	56	4	16
48 ♂	5,5	"	2	320	46	26	101
49 ♂	5,0	"	1	243	27	19	0
50 ♀	6,0	"	2	190	14	11	0
51 ♂	14,0	"	0	640	45	41	0
52 ♂	5,5	"	0	0	82	53	0
53 ♂	7,0	"	4	296	29	7	0
54 ♂	15,0	"	0	313	76	56	13
55 ♂	28,0	18/11/76	0	217	177	205	69
56 ♀	18,0	19/11/76	0	350	9	4	0
57 ♀	17,0	17/03/77	11	540	41	67	0
58 ♀	16,5	"	2	123	7	4	11
59 ♀	18,5	"	11	40	5	53	0
60 ♂	24,5	"	9	470	37	237	0
61 ♀	15,0	"	0	670	30	43	0
62 ♀	11,0	28/03/77	1	260	2	13	0
63 ♂	22,0	29/03/77	29	223	66	127	0
64 ♀	10,0	"	0	313	6	7	0
65 ♀	5,0	"	0	183	0	7	0

– Not examined
* Baboon No. 19 harboured three individuals of *Trichuris* sp. ident.
* Baboon No. 24 & 31 had light infestations of *Enterobius vermicularis*.

APPENDIX 2: The number of helminths recovered from baboons from the Suikerbosrand Nature Reserve.

No. & Sex	Mass kg	Date	*Bertiella studeri*	*Oesophagostomum bifurcum*	*Physaloptera caucasica*	*Streptopharagus pigmentatus*	*Strongyloides fülleborni*	*Trichostrongylus falculatus*
1♀	12,5	9/2/77	3	180	0	14	0	5
2♀	18,0	”	7	80	9	9	0	69
3♀	19,0	”	3	107	0	10	0	20
4♀	14,5	”	0	243	19	21	4	69
5♀	18,0	”	18	133	23	15	0	260
6♂	17,0	6/10/77	2	597	7	3	0	50
7♂	1,5	”	0	50	0	0	0	16
8♂	10,0	”	0	100	17	32	33	67
9♂	18,5	”	0	233	8	16	47	130
10♀	8,0	”	0	81	14	32	0	57
11♀	12,0	”	2	127	10	27	0	57
12♀	20,0	”	3	187	0	3	0	77
13♀	5,5	”	0	82	2	17	0	34
14♀	15,0	24/10/77	0	167	26	39	0	41
15♂	22,5	”	0	120	11	19	11	13
16♀	12,0	”	0	47	6	24	0	0
17♂	27,0	”	0	123	3	8	0	33
18♂	28,5	”	1	363	16	25	0	55
19♀	3,5	24/10/77	2	23	0	7	0	0
20♂	23,0	”	2	87	39	50	0	3
21♂	16,0	3/11/77	0	117	7	8	0	17
22♀	14,5	”	0	153	4	15	47	60
23♂	10,0	”	1	79	25	45	0	43
24♀	10,0	”	1	323	2	17	0	2
25♂	13,5	”	5	495	1	12	0	36

APPENDIX 3: The number of helminths recovered from baboons from the Scrutton Private Nature Reserve

No. & Sex	Mass kg	Date	*Bertiella studeri*	*Enterobius vermicularis*	*Oesophagostomum bifurcum*	*Physaloptera caucasica*	*Streptopharagus pigmentatus*	*Trichostrongylus falculatus*
1♀	16,0	4/2/78	1	0	396	0	28	0
2♂	29,0	7/2/78	2	137	700	0	37	85
3♀	17,5	8/2/78	2	0	340	6	69	13
4♀	16,5	10/2/78	5	0	160	0	33	49
5♂	16,0	23/9/78	0	6723	283	3	2	0
6♂	12,5	”	1	9033	243	6	31	4
7♂	1,5	”	2	1167	20	7	14	0
8♀	22,5	”	0	14297	797	8	42	0
9♂	6,0	”	0	4071	57	26	30	2
10♂	14,0	”	0	953	126	1	6	0
11♂	8,5	”	3	4370	376	37	53	0
12♀	19,0	”	1	10280	531	15	94	4
13♀	18,0	26/9/78	1	6349	641	4	27	0
14♂	30,5	”	0	1953	330	6	189	0
15♂	28,0	”	0	3823	233	9	12	26
16♂	30,0	”	0	607	146	0	48	0
17♀	8,0	29/9/78	4	1743	303	15	28	2
18♀	8,0	”	0	230	231	12	17	0

APPENDIX 4: The number of helminths recovered from baboons from Sabie

No. & sex	Mass kg	Date	*Bertiella studeri*	*Oesophagostomum bifurcum*	*Strongyloides fülleborni*	*Trichostrongylus falculatus*	*Trichuris trichiura*
1 ♀	4,5	13/12/77	1	16	–	9	19
2 ♂	22,0	"	–	113	–	63	–
3 ♂	26,0	"	1	114	121	1	27