COPROLOGIC EVIDENCE OF GASTROINTESTINAL HELMINTHS OF FOREST BABOONS, PAPIO ANUBIS, IN KIBALE NATIONAL PARK, UGANDA

Authors: Bezjian, Marisa, Gillespie, Thomas R., Chapman, Colin A., and Greiner, Ellis C.

Source: Journal of Wildlife Diseases, 44(4) : 878-887

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-44.4.878

Journal of Wildlife Diseases, 44(4), 2008, pp. 878–887

COPROLOGIC EVIDENCE OF GASTROINTESTINAL HELMINTHS OF FOREST BABOONS, *PAPIO ANUBIS*, IN KIBALE NATIONAL PARK, UGANDA

Marisa Bezjian,[1] Thomas R. Gillespie,[2,3] Colin A. Chapman,[4] and Ellis C. Greiner[1,5]

[1] Department of Infectious Diseases and Pathology, College of Veterinary Medicine, University of Florida, PO Box 110880, Gainesville, Florida 32610, USA
[2] Department of Pathobiology, College of Veterinary Medicine, University of Illinois, Urbana, Illinois 61802, USA
[3] Department of Anthropology, University of Illinois, Urbana, Illinois 61801, USA
[4] Department of Anthropology and McGill School of Environment, McGill University, Montreal, Quebec H3A 2T7, Canada
[5] Corresponding author (email: greinere@mail.vetmed.ufl.edu)

ABSTRACT: The gastrointestinal parasites of baboons have been well characterized from savannah and desert habitats, but little is known about their gastrointestinal parasites in forest habitats. From May to June 2004, we collected 41 fecal samples from free-ranging olive baboons (*Papio anubis*) within the forested Kibale National Park, Uganda. Samples were examined to determine the prevalence of gastrointestinal helminths in this forest dwelling population of olive baboons. The prevalence of nematodes identified from fecal flotation was *Oesophagostomum* sp. (85%), *Trichostrongylus* sp. (22%), *Trichuris* sp. (46%), *Strongyloides* sp. (44%), *Ternidens* sp. (5%), *Abbreviata* sp. (2%), and *Molineus* sp. (2%). Flotation techniques also recovered unidentified eggs, probably of hookworm origin (22%). No parasite eggs were recovered by sedimentation of eight samples. Coproculture techniques using 13 of the 41 samples recovered larvae from *Oesophagostomum* sp., *Strongyloides* sp., and *Trichostrongylus* sp. The high prevalence of nematodes recovered in this study seems to support previous theories of high nematode infections in forested habits.

Key words: Fecal survey, gastrointestinal parasites, olive baboon, *Papio anubis*, Uganda.

INTRODUCTION

Gastrointestinal parasites of baboons living in savannah and desert habitats are well documented from decades of studies using necropsy (Kuntz and Myers, 1966, 1967; Fenwick, 1969; Kuntz and Moore, 1973; Crockett and Dipeolu, 1984; Pettifer, 1984; Ghandour et al., 1995) and fecal surveys (Eley et al., 1989; Ghandour et al., 1995; Muller-Graf et al., 1997; Munene et al., 1998; Muriuki et al., 1998; Murray et al., 2000; Hahn et al., 2003; Ocaido et al., 2003; Legesse and Erko, 2004). In contrast, patterns of gastrointestinal parasite infection in forest-dwelling baboons remain largely unknown. An understanding of the variability in patterns of parasite infection in baboons across desert, savannah, and forest habitats would improve our knowledge of the role climatic variation and habitat structure have in determining patterns of infection observed in a given host species.

Climate, concurrent infections, and seasonality are expected to affect parasite prevalence. A study of baboons in West Bugwe Forest Reserve in Uganda found a high prevalence of *Strongyloides* sp. (60.7%) and *Trichostrongylus* sp. (60.7%; Ocaido et al., 2003). Gastrointestinal parasites studied from baboons in the Namib Desert were predominantly protozoans. This is in contrast to the more common helminth populations seen from baboons living in savannah conditions (Appleton and Brian, 1995). In more arid conditions, baboons will harbor only parasite species that can complete their life cycles without prolonged exposure to the abiotic environment. In a study with Hamadryas baboons (*Papio hamadryas*) in an area of hot, dry climatic conditions, low baboon density and minimum human contact, the prevalence of gastrointestinal parasites was low (Ghandour et al., 1995). In this study, the prevalence of parasites was high in areas of mild, cool climatic conditions, where baboons were at high density and had maximum human contact.

In a study of baboons in Mount Assirik, Senegal, a higher prevalence of protozoans was found in this habitat that experiences five wet months and seven dry months. In the same study, baboons in the Gombe National Park, Tanzania had a higher prevalence of nematodes than protozoans: this site experiences eight wet months and four dry months (McGrew et al., 1989).

To improve our understanding of the interplay between habitat type and parasite infections, we examined the patterns of gastrointestinal helminth infection in forest-dwelling olive baboons (*Papio anubis*) in the Kibale National Park, Uganda. We compare patterns of infection observed with previous studies examining sympatric primate species at Kibale National Park.

MATERIALS AND METHODS

In May and June 2004, we collected 41 fecal samples from free-ranging baboons at the Dura site (0°27′N, 30°23′E; 1,427 m elevation) within Kibale National Park, Uganda (766 km^2; 0°13′–0°41′N, 30°19′–30°32′E; Struhsaker, 1975). The region experiences a bimodal pattern of seasonal rainfall, with peaks occurring in March–May and August–November. Mean annual rainfall (1990–2001) was 1,749 mm (Chapman et al., 2002). Daily temperature minima and maxima averaged 14.9 C and 20.2 C, respectively, from 1990 to 2001.

Olive baboons are group-living, omnivorous, habitat generalists with the largest geographic distribution of all African primates (Rowe, 1996). They are quadrupedal and more terrestrial compared to most other African primates (Rowe, 1996).

Samples were collected along two transects; a 5-km transect following the single-lane dirt road that traverses the forested park, and a 2-km transect following the banks of the Dura River. Although we did not observe baboons defecating during this study, two of us (T.R.G. and C.A.C.) verified, based on size, consistency, color, and odor, that all feces collected were from baboons (Gillespie, 2006). Approximately 2 g of fecal material were removed from the center of each fecal mass, stored individually in 10.0-ml vials, and transported to our laboratory for analysis within 12 hr. All samples were examined for helminth eggs and larvae with the use of concentration by sodium chloride flotation. With remaining fecal material, eight samples were randomly examined by sedimentation (Sloss and Kemp, 1978).

Parasite eggs were microscopically identified by size, color, shape, and contents. Measurements were made to the nearest 0.1 μm, with the use of an ocular micrometer fitted to a compound microscope, and representatives were photographed. Three coprocultures were made with the use of 13 of the 41 fecal samples collected to match parasite eggs to larvae for positive identification of strongylate nematodes (Gillespie, 2006).

The capacity to identify most parasite species from host fecal examination, even with cultured larvae, was limited. The majority of our identifications were at the level of superfamily or genus.

RESULTS

Oesophagostomum sp. was identified on the basis of egg size and morphology and by cultured larvae. The eggs were elliptic, with large dark cells in the morula, and nonlarvated (Fig. 1a). The mean measurement for *Oesophagostomum* sp. was 74.9×44.7 μm (67.5–86.4×40.5–51.3 μm). The prevalence of *Oesophagostomum* sp. based on egg identification via fecal flotation was 85%. Fecal coprocultures revealed the presence of L3 larvae. The larvae were filariform with a sheath and a long, thin tail consistent with the morphology of L3s of *Oesophagostomum* sp. (Fig. 1b). The average sheath length of the *Oesophagostomum* sp. larvae was 839.7 μm (699.6–943.0 μm).

Trichostrongylus sp. was identified on the basis of egg size and morphology. The eggs had one end smaller than the other and were nonlarvated (Fig. 1c). The mean measurement for *Trichostrongylus* sp. was 80.2×43.2 μm (75.6–89.1×40.5–45.9 μm). The prevalence of *Trichostrongylus* sp. based on egg identification via fecal flotation was 22%. Several larvae isolated from the coproculture were consistent with those of *Trichostrongylus* species. The larvae were filariform with a large anterior sheath and a nonfilamentous, short tail (Fig. 1d). The average length for this larva was 794.35 μm (742.0–861.3 μm).

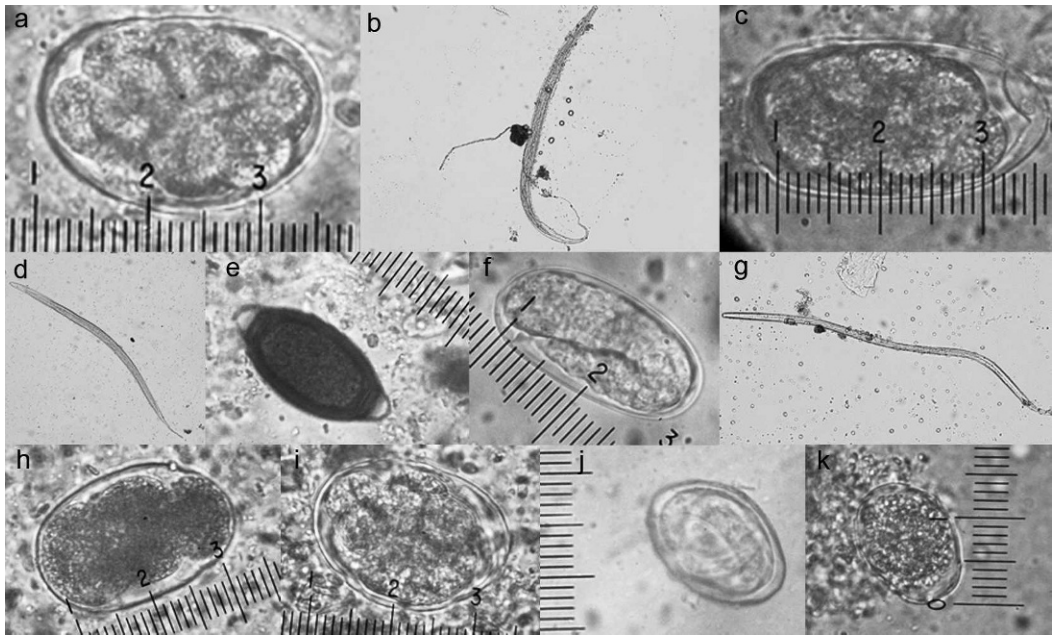

FIGURE 1. (a) *Oesophagostomum* sp. egg (70.2×48.6 μm). (b) *Oesophagostomum* sp. larvae. (c) *Trichostrongylus* sp. egg (78.3×43.2 μm). (d) *Trichostrongylus* sp. larvae. (e) *Trichuris* sp. egg (59.4×29.7 μm). (f) *Strongyloides* sp. egg (62.1×29.7 μm). (g) *Strongyloides* sp. larvae. (h) Unknown hookworm egg (70.2×45.9 μm). (i) *Ternidens* sp. egg (62.1×45.9 μm). (j) *Abbreviata* sp. egg (43.2×24.3 μm). (k) *Molineus* sp. egg (40.5×29.7 μm).

Trichuris sp. was identified on the basis of egg size and morphology. The color varied from yellow to a reddish brown. Eggs of *Trichuris* sp. have bipolar plugs (Fig. 1e). The mean measurement for *Trichuris* sp. was 56.5×27.5 μm (29.7–62.1×27.0–29.7 μm). The prevalence of *Trichuris* sp. based on egg identification via fecal flotation was 46%. *Trichuris* sp. was not identified via coproculture because this parasite remains in the egg and does not develop to the L3 stage in culture medium.

Strongyloides sp. were identified on the basis of egg size and morphology and by cultured larvae. The eggs were oval, thin-shelled, with larvae folded once (Fig. 1f). The mean measurement for *Strongyloides* sp. was 61.5×37.2 μm (48.6–81.0×29.7–48.6 μm). The prevalence of *Strongyloides* sp. based on egg identification via fecal flotation was 44%. Fecal coprocultures verified the presence of *Strongyloides* sp. larvae. These larvae were filariform and did not have a sheath (Fig. 1g). The average length of the larvae was 479.1 μm (154.0–594.0 μm). *Strongyloides* sp. nematodes have two adult forms that reflect their dual life-cycle pattern: a parasitic, parthenogenetic female and a smaller, free-living, soil-dwelling male and female (Flynn, 1973). This variation of life cycles reflects the range of lengths measured for these larvae.

Unknown hookworm eggs were identified at a prevalence of 22.0%. The species identification of these hookworms could not be determined (Fig. 1h). *Ternidens* sp. was believed to be found at a prevalence of 5%. Only two eggs were identified and measured that might have been *Ternidens* species. The mean measurement for *Ternidens* sp. was 58.1×45.9 μm (54.0–62.1×45.9 μm) (Fig. 1i).

Our best deduction of the identification of other unknown eggs would include *Abbreviata* sp. (2%) and *Molineus* sp. (2%). Only one egg was identified to

represent *Abbreviata* sp. and *Molineus* species. *Abbreviata* sp. measured 43.2× 24.3 μm (Fig. 1j). *Molineus* sp. measured 40.5×29.7 μm (Fig. 1k). No fluke eggs were recovered from eight fecal sedimentations.

DISCUSSION

The most prevalent parasite detected was *Oesophagostomum* sp., with a prevalence of 85%. The second most prevalent genus recovered was *Trichuris* sp., at 46%, and *Strongyloides* sp. at 44%. *Trichostrongylus* sp., which is a common parasite of ruminants, was identified at a prevalence of 22%. The prevalence of unidentified hookworms was 22%. *Ternidens* sp. were identified at a prevalence of 5%, *Abbreviata* sp. at 2%, and *Molineus* sp. at 2%. The presence of *Oesophagostomum* sp., *Strongyloides* sp., and *Trichostrongylus* sp. was confirmed by the presence of L3 larvae obtained by coproculture.

A study of gastrointestinal parasites of four species of guenons from the Kibale National Park had an average prevalence of 9.4% for *Oesophagostomum* sp., 30.1% for *Trichuris* sp., and 9.1% for *Strongyloides fulleborni* (Gillespie et al., 2004; Table 1). Despite the fact that guenons are not distantly related to baboons, the prevalence of gastrointestinal infection varied between the guenons and the baboons, with the baboons having a higher prevalence of *Oesophagostomum* sp., *Trichuris* sp., and *Strongyloides* sp. This may be due to the more terrestrial nature of baboons versus the arboreal nature of guenons.

The prevalence of gastrointestinal parasites from three species of colobus monkeys from the Kibale National Park was also studied (Gillespie et al., 2005; Table 1). The prevalence of gastrointestinal parasite infection varied between the colobus species and the baboons. The colobus species had an overall prevalence of 5.9% for *Oesophagostomum* sp., 79.7% for *Trichuris* sp., and 4.3% for *Strongyloides* species. The baboons had a higher prevalence of *Oesophagostomum* sp. and *Strongyloides* sp. than the colobus species; however, the colobus species had a higher prevalence of *Trichuris* sp. This may be because the first-stage larvae of *Trichuris* sp. are infective. Colobus species may also be a more suitable host for *Trichuris* sp. infections than olive baboons. This may be because colobus species are folivores and have a larger cecum, which may be a more favorable environment for *Trichuris* sp. than the omnivorous baboon cecum.

TABLE 1. The prevalence (%) of gastrointestinal helminth infection of guenons and colobus monkeys in western Uganda.

Parasite	Prevalence	
	Guenons[a]	Colobus monkeys[b]
Strongyloides fulleborni	9.1	4.3
Strongyloides stericalis	0	0.0014
Oesophagostomum sp.	9.4	5.9
Unidentified strongyle	1.7	1.4
Ascaris sp.	0	1.2
Trichuris sp.	30.1	79.7
Coloenterobius sp.	0	0.6
Streptopharagus sp.	16.8	0
Enterobius sp.	0.8	0
Bertiella sp.	<0.8	0.2
Dicrocoeliidae sp.	2.2	0.6

[a] Gillespie et al., 2004.

[b] Gillespie et al., 2005.

Oesophagostomum sp. is the most common nematode of Old World monkeys and apes, and has been reported from various gastrointestinal parasite surveys of baboons (Table 2). Several of these studies have identified *Oesophagostomum* sp. by necropsy recovery or by identification of nodules caused by *Oesophagostomum* sp. larvae in the submucosa or muscularis of the cecum and proximal colon (Table 3; Myers and Kuntz, 1965; Kuntz and Myers, 1966, 1967; Kuntz and Moore, 1973; Crockett and Dipeolu, 1984; Pettifer, 1984). Infection is via ingestion of the L3 larvae, which pass directly to the colon (Flynn, 1973). *Oesophagostomum* sp. are considered among the more debilitating

gastrointestinal parasites because of the pathology larvae can create within the lower GI tract when in high intensities. It has been noted that higher worm intensities of *Oesophagostomum* sp. have been found during the wet season (Pettifer, 1984); however, in this study, by the prevalence of eggs during fecal analysis, we found *Oesophagostomum* sp. to be a common infection of baboons during the beginning of the dry season. Previous studies of gastrointestinal parasites of guenons and colobus monkeys in the Kibale National Forest also found that the prevalence of infection was not correlated to monthly rainfall patterns (Gillespie et al., 2004, 2005). This parasite may resist desiccation due to the lush habitat of the Kibale National Forest and the presence of the Dura River. It has also been noted that during the dry season, *Oesophagostomum* sp. larvae can avoid adverse weather conditions by arresting their development (Pettifer, 1984).

Trichuris sp. infection is very common among baboons. The prevalence of this whipworm has been reported in most gastrointestinal parasite surveys of baboons (Table 2). Transmission is direct following ingestion of eggs containing first-stage infective larvae. The eggs will hatch only when ingested by a suitable host (Flynn, 1973). *Trichuris* sp. fecal egg shedding has been reported to be related to female reproductive status. One study showed that fecal shedding was highest in lactating host females, and less intense in pregnant host females (Muller-Graf et al., 1996). Adult whipworms reside in the proximal cecal regions of the large intestine (Pettifer, 1984). *Trichuris trichiura* is the whipworm of humans, and even though it has been more frequently found in people, it is not as pathogenic as other zoonotic gastrointestinal infections (Crockett and Dipeolu, 1984; Pettifer, 1984; Muriuki et al., 1998).

Strongyloides sp. is also a common gastrointestinal parasite of baboon species and has been reported in many previous studies (Table 2). Because *Strongyloides* sp. has a direct life cycle, as well as an indirect life cycle, baboons infected with this parasite provide a threat to both human and animal communities they encounter. Infective third-stage larvae penetrate the skin or oral mucosa of the host, migrate through the bloodstream to the heart and lungs, penetrate the alveoli into the bronchioles, pass up the trachea to the mouth, and are swallowed (Flynn, 1973). This intestinal threadworm is unique in primates because only females can be parasitic, and they pass larvated eggs or larvae into the feces. Adults are found in the small intestine, and high-intensity infections may cause diarrhea and weight loss. In one study, *Strongyloides* sp. infection was shown to have a significantly higher prevalence in young baboons, and is thought to utilize a transmammary route of transmission (Pettifer, 1984; Muller-Graf et al., 1996). Worm intensities of *Strongyloides fulleborni* decrease with age, possibly as a result of acquired immunity, and this is also true for *Trichostrongylus* sp. (Pettifer, 1984).

Trichostrongylus sp. has also been reported in baboons (Table 2). *Trichostrongylus* sp. have been recovered from the small intestine of baboons at necropsy (Pettifer, 1984). The prevalence of this parasite in baboons is interesting, because *Trichostrongylus* sp. is commonly encountered in the feces of wild and domestic ruminants (Crockett and Dipeolu, 1984). It has been noted that wild-trapped primates may have a higher prevalence of this parasite because of contamination of their environment with ruminant waste (Munene et al., 1998). However, the species of *Trichostrongylus* recovered from these studies of baboons and ruminants may be different. Further identification of *Trichostrongylus* species in baboons and ruminants may provide insight as to whether species of this genus can cause infections in baboons and ruminants. The life cycle of *Trichostron-*

TABLE 2. The prevalence (%) of gastrointestinal parasite infections in African baboons recovered by fecal analysis.

Baboon species, year (location)[b,c]	Prevalence (%)[a]										
	Nematodes										
	Number examined (*n*)	*Strongyloides* sp.	*Oesophagostomum* sp.	*Ternidens diminuta*	*Trichostrongylus* sp.	*Necator americanus*	Hookworm eggs	Strongyles	*Enterobius* sp.	*Oxyuris* sp.	*Streptopharagus* sp.
P.a. 2004 (Uganda)[1]	140	37.1		42.1							
P.a. 2004 (Ethiopia)[2]	59	37.3	10.2		8.5						
P.a. 2003 (Uganda)[3]	56	60.7	8.9		60.7		35.7		5		
P.c. and P.a. 2003 (Kenya)[4]	127	34						29	12		16.5
P.a. 2000 (Tanzania)[5]	35	25	17				44				48
P.a. 1998 (Kenya)[6]	111	30.6						9			
P.a. 1998 (Kenya)[7]	92	63	76		43.5				30.4		42.4
P.a. 1997 (Tanzania)[8]	205										
P.a. 1996 (Tanzania)[9]	256	68.9						36.4			67
P.a. 1989 (Kenya)[10]	67	16.4						95.5			
P.a. 1989 (Tanzania)[11]	52	58	42								35
P.a. 1984 (Nigeria)[12]	9	+		+			+	+			
P.a. 1969 (Tanzania)[13]	277										
P.c. 1973 (Kenya)[14]	127		34		17				53		55
P.d. 1967 (Kenya)[15]	43		53.5								23.3
P.d. 1966 (Kenya & Tanzania)[16]	13		77		7.7	7.7				7.7	46.2
P.u. 1995 (Namibia)[17]	16	18.8					12.5				62.5
P.u. 1991 (South Africa)[18]	191	29.3	15.2	6.8	0.5				0.5		30.4
P.u. 1986 (South Africa)[19]	122							49	5.7		1.1
P.u. 1984 (Transvaal)[20]	108	4.6	97.2		47				15.7		91.7
P.u. 1978 (Rhodesia)[21]	24	41.7	62.5	4.2	8.4						4.2
P.h. 1995 (Saudi Arabia)[22]	633						1.26		1.26		
Baboon checklist 1965 [23]	na[a]	+	+		+	+	[A]+		+	+	+

[a] na = sample size not reported in this study; + = parasite present; [A]+ = *Ancylostoma* sp.; [T]+ = *Taenia* sp.; Ac = *Abbreviata caucasica*; Ds = *Dipylidium* sp.; Hs = *Hymenolepis* sp.

[b] Species notation: P.a. = *Papio anubis*; P.c. = *Papio cynocephalus*; P.d. = *Papio doguera*; P.u. = *Papio ursinus*; P.h. = *Papio hamadryas*.

[c] Superscript numbers designate the following references: 1 = Hope et al. (2004), 2 = Legesse and Erko (2004), 3 = Ocaido et al. (2003), 4 = Hahn et al. (2003), 5 = Murray et al. (2000), 6 = Muriuki et al. (1998), 7 = Munene et al. (1998), 8 = Muller-Graf et al. (1997), 9 = Muller-Graf et al. (1996), 10 = Eley et al. (1989), 11 = McGrew et al. (1989), 12 = Crockett and Dipeolu (1984), 13 = Fenwick (1969), 14 = Kuntz and Moore (1973), 15 = Kuntz and Myers (1967), 16 = Kuntz and Myers (1966), 17 = Appleton and Brian (1995), 18 = Appleton et al. (1991), 19 = Appleton et al. (1986), 20 = Pettifer (1984), 21 = Goldsmid and Rogers (1978), 22 = Ghandour et al. (1995), 23 = Myers and Kuntz (1965).

TABLE 2. Extended.

Baboon species, year (location)[b,c]	Prevalence (%)										
	Nematodes							Cestodes		Trematodes	
	Number examined (*n*)	*Physaloptera* sp.	*Abbreviata caucasica*	*Protospirura muricola*	*Ascaris* sp.	*Trichuris* sp.	Unknown nematodes	*Bertiella studeri*	Other tapeworms	*Schistosoma mansoni*	Unidentified trematodes
P.a. 2004 (Uganda)[1]	140				78.6	16.4			7.1(Hs)		
P.a. 2004 (Ethiopia)[2]	59					27.1				20.3	
P.a. 2003 (Uganda)[3]	56				21				12.5(Ac), 1.8(Ds)		
P.c. and P.a. 2003 (Kenya)[4]	127	43.5				73				2	
P.a. 2000 (Tanzania)[5]	35	23				66	63			3	43
P.a. 1998 (Kenya)[6]	111					38.7				3.6	
P.a. 1998 (Kenya)[7]	92					73.9				4.3	
P.a. 1997 (Tanzania)[8]	205									19.5	
P.a. 1996 (Tanzania)[9]	256	65.5				80.6				21.3	14.6
P.a. 1989 (Kenya)[10]	67				1.5	22.4					
P.a. 1989 (Tanzania)[11]	52	44				42					2
P.a. 1984 (Nigeria)[12]	9				+						
P.a. 1969 (Tanzania)[13]	277									28.2	
P.c. 1973 (Kenya)[14]	127		4					27			
P.d. 1967 (Kenya)[15]	43		34.9	4.7		30.2		20.9			
P.d. 1966 (Kenya & Tanzania)[16]	13		46.2			15.4		7.7		7.7	
P.u. 1995 (Namibia)[17]	16										
P.u. 1991 (S. Africa)[18]	191	1.6				5.8	4.7	3.7			
P.u. 1986 (S. Africa)[19]	122	44.3				56.7		9.6			
P.u. 1984 (Transvaal)[20]	108	73.6				0.9		50			
P.u. 1978 (Rhodesia)[21]	24		4.2			4.2		4.2			
P.h. 1995 (Saudi Arabia)[22]	633					3.5			5.1(Hs)	1.1	
Baboon checklist 1965[23]	na	+	+			+		+	[T]+	+	

TABLE 3. The prevalence (%) of gastrointestinal parasites recovered from necropsy of African baboons.

Baboon species, year (location)	Prevalence (%)[a]									
	Nematodes									
	Number necropsied (*n*)	*Strongyloides* sp.	*Oesophagostomum* sp.	*Ternidens diminuta*	*Trichostrongylus* sp.	*Necator americanus*	Hookworm eggs	*Enterobius* sp.	*Oxyuris* sp.	*Streptopharagus* sp.
P.a. 1984 (Nigeria)[1]	1		+	+			+			
P.a. 1969 (Tanzania)[2]	7									
P.c. 1973 (Kenya)[3]	127		34		17			53		55
P.d. 1967 (Kenya)[4]	43		53.5							23.3
P.d. 1966 (Kenya and Tanzania)[5]	13		77		7.7	7.7			7.7	46.2
P.u. 1984 (Transvaal)[6]	108	4.6	97.2		47			15.7		91.7
P.h. 1995 (Saudi Arabia)[7]	76							3.6		
Baboon checklist 1965 [8]	na[a]	+	+		+	+	[A]+	+	+	+

TABLE 3. Extended.

Baboon species, year (location)	Prevalence (%)[a]								
	Nematodes (cont.)					Cestodes		Trematodes	
	Number necropsied (*n*)	*Physaloptera* sp.	*Abbreviata caucasica*	*Protospirura muricola*	*Trichuris* sp.	*Bertiella studeri*	Other tapeworms	*Schistosoma mansoni*	*Brodenia laciniata*
P.a. 1984 (Nigeria)[1]	1	+			+				
P.a. 1969 (Tanzania)[2]	7							100	
P.c. 1973 (Kenya)[3]	127		4			27			
P.d. 1967 (Kenya)[4]	43		34.9	4.7	30.2	20.9			
P.d. 1966 (Kenya and Tanzania)[5]	13		46.2		15.4	7.7		7.7	7.7
P.u. 1984 (Transvaal)[6]	108	73.6			0.9	50			
P.h. 1995 (Saudi Arabia)[7]	76				8.3		5.9(Hs)	1.2	
Baboon checklist 1965 [8]	na[a]	+	+		+	+	[T]+	+	

[a] na = sample size not available; + = parasite present; [A]+ = *Ancylostoma* sp.; [T]+ = *Taenia* sp.; Hs = *Hymenolepis* sp.

[b] Species notation: P.a. = *Papio anubis*; P.c. = *Papio cynocephalus*; P.d. = *Papio doguera*; P.u. = *Papio ursinus*; P.h. = *Papio hamadryas*.

[c] Superscript numbers designate the following references: 1 = Crockett and Dipeolu (1984), 2 = Fenwick (1969), 3 = Kuntz and Moore (1973), 4 = Kuntz and Myers (1967), 5 = Kuntz and Myers (1966), 6 = Pettifer (1984), 7 = Ghandour et al. (1995), 8 = Myers and Kuntz (1965).

gylus sp. is direct. One report of olive baboons in the West Bugwe Forest Reserve of Uganda reported a high prevalence of 60.7% (Ocaido et al., 2003).

The fecal flotation of baboon feces revealed several unknown gastrointestinal parasite eggs. It is important to consider the possibility of environmental contamination of the feces post-defecation, as they were collected from the ground. One must also consider the scavenging nature of baboons when one is examining feces. It is possible that parasite eggs may be transient in the baboon as a result of consuming a previous host. This may be true for the *Molineus* sp. infection. This parasite occurs in the potto (*Perodicticus potto*), which is endemic to central Africa (Flynn, 1973; Rowe, 1996) and is abundant in Kibale. It is possible that if a baboon consumed a potto infected with *Molineus* sp., the baboon could pass *Molineus* sp. eggs transiently. Further studies with a larger sample size and potential adult recovery post-treatment or at necropsy could resolve such ambiguities.

This study reports the prevalence of gastrointestinal nematodes from fecal analysis of 41 samples of olive baboon feces along two transects in Kibale National Park. There were no cestode or trematode species recovered. These baboons were studied within the national park, although it is possible that these troops could travel to villages surrounding the forest, because home ranges of these forest baboons are unknown. It is possible that wild baboon troops with gastrointestinal parasites can serve as a source of infection for other forest-dwelling species, as well as for domestic livestock and humans; however, the relationship between domestic and nondomestic species needs further evaluation to assess the transmission of disease between wildlife species and domestic species. This transmission of disease can also be studied with relation to humans.

ACKNOWLEDGMENTS

This research was supported in part by the University of Florida, College of Veterinary Medicine.

LITERATURE CITED

APPLETON, C. C., AND C. BRIAN. 1995. Gastrointestinal parasites of *Papio cynocephalus ursinus* living in the central Namib desert, Namibia. African Journal of Ecology 33: 257–265.

———, S. P. HENZI, A. WHITEN, AND R. BYRNE. 1986. The gastrointestinal parasites of *Papio ursinus* from the Drakensberg Mountains, Republic of South Africa. International Journal of Primatology 7: 449–456.

———, ———, AND S. I. WHITEHEAD. 1991. Gastrointestinal helminth parasites of the chacma baboon *Papio cynocephalus ursinus*, from the coastal lowlands of Zululand, South Africa. African Journal of Ecology 29: 149–156.

CHAPMAN, C. A., L. J. CHAPMAN, AND T. R. GILLESPIE. 2002. Scale issues in the study of primate foraging: Red colobus of Kibale National Park. American Journal of Physical Anthropology 117: 349–363.

CROCKETT, E. C., AND O. O. DIPEOLU. 1984. A survey of helminth parasites of game animals in Kainji Lake National Park of Nigeria. International Journal of Zoonoses 11: 204–215.

ELEY, R. M., S. C. STRUM, G. MUCHEM, AND G. D. F. REID. 1989. Nutrition, body condition, activity patterns, and parasitism of free-ranging troops of olive baboons (*Papio anubis*) in Kenya. American Journal of Primatology 18: 209–219.

FENWICK, A. 1969. Baboons as reservoir hosts of *Schistosoma mansoni*. Transactions of the Royal Society of Tropical Medicine and Hygiene 63: 557–567.

FLYNN, R. 1973. Parasites of laboratory animals. The Iowa State University Press, Ames, Iowa. pp. 203–301.

GHANDOUR, A. M., N. Z. ZAHID, A. A. BANAJA, K. B. KAMAL, AND A. I. BOUQ. 1995. Zoonotic intestinal parasites of hamadryas baboons *Papio hamadryas* in the western and northern regions of Saudi Arabia. Journal of Tropical Medicine and Hygiene 98: 431–439.

GILLESPIE, T. R. 2006. Non-invasive assessment of gastro-intestinal parasite infections in free-ranging primates. International Journal of Primatology 27: 942–956.

———, E. C. GREINER, AND C. A. CHAPMAN. 2004. Gastrointestinal parasites of the guenons of western Uganda. Journal of Parasitology 90: 1356–1360.

———, ———, AND ———. 2005. Gastrointestinal parasites of the colobus monkeys of Uganda. Journal of Parasitology 91: 569–573.

GOLDSMID, J. M., AND S. ROGERS. 1978. A parasito-

logical study on the chacma baboon (*Papio ursinus*) from the northern Transvaal. Journal of the South African Veterinary Association 49: 109–111.

HAHN, N., D. PROULX, P. MURUTHI, S. ALBERTS, AND J. ALTMANN. 2003. Gastrointestinal parasites in free-ranging Kenyan baboons (*Papio cynocephalus* and *P. anubis*). International Journal of Primatology 24: 271–279.

HOPE, K., M. L. GOLDSMOTH, AND T. GRACZYK. 2004. Parasitic health of olive baboons in Bwindi Impenetrable National Park, Uganda. Veterinary Parasitology 122: 165–170.

KUNTZ, R., AND J. A. MOORE. 1973. Commensals and parasites of African baboons (*Papio cynocephalus* L. 1766) captured in Rift Valley Province of central Kenya. Journal of Medical Primatology 2: 236–241.

———, AND B. J. MYERS. 1966. Parasites of baboons (*Papio doguera* (Pucheran, 1856)) captured in Kenya and Tanzania, East Africa. Primates 7: 27–32.

———, AND ———. 1967. Parasites of the Kenya baboon: Arthropods, blood protozoa and helminths (Kenya, 1966). Primates 8: 75–82.

LEGESSE, M., AND B. ERKO. 2004. Zoonotic intestinal parasites in *Papio anubis* (baboon) and *Cercopithecus aethiops* (vervet) from four localities in Ethiopia. Acta Tropica 90: 231–236.

MCGREW, W. C., C. E. G. TUTIN, D. A. COLLINS, AND S. K. FILE. 1989. Intestinal parasites of sympatric *Pan troglodytes* and *Papio* spp. at two sites: Gombe (Tanzania) and Mt. Assirik (Senegal). American Journal of Primatology 17: 147–155.

MULLER-GRAF, C. D. M., D. A. COLLINS, AND M. E. J. WOOLHOUSE. 1996. Intestinal parasite burden in five troops of olive baboons (*Papio cynocephalus anubis*) in Gombe Stream National Park, Tanzania. Parasitology 112: 489–497.

———, ———, C. PACKER, AND M. E. J. WOOLHOUSE. 1997. *Schistosoma mansoni* infection in a natural population of olive baboons (*Papio cynocephalus anubis*) in Gombe Stream National Park, Tanzania. Parasitology 115: 621–627.

MUNENE, E., M. OTSYULA, D. A. N. MBAABU, W. T. MUTAHI, S. M. K. MURIUKI, AND G. M. MUCHEMI. 1998. Helminth and protozoan gastrointestinal tract parasites in captive and wild-trapped African non-human primates. Veterinary Parasitology 78: 195–201.

MURIUKI, S. M. K., R. K. MURUGU, E. MUNENE, G. M. KARERE, AND D. C. CHAI. 1998. Some gastrointestinal parasites of zoonotic (public health) importance commonly observed in old world non-human primates in Kenya. Acta Tropica 71: 73–82.

MURRAY, S., C. STEM, B. BOUDREAU, AND J. GOODALL. 2000. Intestinal parasites of baboons (*Papio cynocephalus anubis*) and chimpanzees (*Pan troglodytes*) in Gombe National Park. Journal of Zoo and Wildlife Medicine 31: 176–178.

MYERS, B. J., AND R. KUNTZ. 1965. A checklist of parasites reported for the baboon. Primates 6: 137–194.

OCAIDO, M., C. DRANZOA, AND P. CHELI. 2003. Gastrointestinal parasites of baboons (*Papio anubis*) interacting with humans in West Bugwe Forest Reserve, Uganda. African Journal of Ecology 41: 356–359.

PETTIFER, H. L. 1984. The helminth fauna of the digestive tracts of chacma baboons, *Papio ursinus*, from different localities in the Transvaal. Onderstepoort Journal of Veterinary Research 51: 161–170.

ROWE, N. 1996. The pictorial guide to the living primates. Pogonias Press, New York, New York. pp. 136–137.

SLOSS, M. W., AND R. L. KEMP. 1978. Veterinary clinical parasitology. 5th Edition. Iowa State University Press, Ames, Iowa. pp. 1–23.

STRUHSAKER, T. T. 1975. The red colobus monkey. University of Chicago Press. Chicago, Illinois, 258 pp.

Received for publication 28 May 2008.