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Gastrointestinal Parasites in Free-ranging Kenyan Baboons (*Papio cynocephalus* and *P. anubis*)

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*We screened fecal samples from 3 groups of wild-living baboons (*Papio cynocephalus *and* P. anubis*), involved in longitudinal behavioral studies, for evidence of gastrointestinal parasites. The two objectives of the study were: 1) to compare parasites from two of the groups with different foraging behavior from the same area and 2) to obtain fecal parasitic data on 3 groups of baboons to provide baseline reference data. We sampled individual baboons opportunistically from Lodge and Hook's groups, Amboseli National Park and from Mpala Group, Mpala Wildlife Research Centre, Kenya. Lodge Group baboons supplemented foraging on wild foods by daily foraging in human-source refuse, whereas Hook's and Mpala groups did not. We collected fecal samples from 55, 30 and 42 individuals in Hook's, Lodge and Mpala groups, respectively, and processed them via ether sedimentation. We identified strongylids,* Streptopharagus *sp.,* Physaloptera *sp.,* Trichuris *sp.,* Enterobius *sp., and* Strongyloides *sp., in the feces, but no parasite directly attributable to exposure to people. Garbage- and wild-feeding Amboseli baboons differed in the prevalence of* Streptopharagus *sp.,* Physaloptera *sp. and* Trichuris *sp.*

KEY WORDS: baboon; parasites; Kenya; *Papio*; human impact; longitudinal study.

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Habitat destruction, human population growth and tourism contribute to increased pressure on wildlife. Routine contact with people, their livestock, pets and refuse may introduce new diseases into a previously naïve population. For example, wild dogs are susceptible to domestic canine viruses, and exposure to domestic dogs has resulted in a severe decline of wild dogs in affected areas of East Africa (Alexander and Appel, 1994). Other wildlife species, such as yellow and olive baboons (*Papio cynocephalus* and *P. anubis)* are evidently more resilient. They can persist or even temporarily increase, in the face of human encroachment.

Lodge Group in the Amboseli National Park region of Kenya has adapted to conditions that have evolved around the tourist industry (Altmann & Muruthi, 1988). In addition to their natural diet, they forage daily on garbage generated by the tourist lodges and the associated small Ol Tukai settlement of lodge staff and their families. As a consequence of garbage-foraging, their daily activities and ranging patterns are different from that of the completely wild-foraging baboons in the same area. For instance, Lodge Group females spend about twice as much time resting and only one-third as much time feeding as that of their wild-feeding counterparts. Lodge Group baboons have significantly smaller home ranges than those of their wild-feeding counterparts (Altmann and Muruthi, 1988; Muruthi *et al.*, 1991).

Health-related effects on Lodge Group individuals associated with routine close proximity to people and their refuse are documented in two decades of research. Lodge Group baboons maintain significantly higher levels of antibiotic-resistant gastrointestinal bacteria (Rolland *et al.*, 1985), are fatter (Altmann *et al.*, 1993), are more likely to have reduced periodontal health (Phillips-Conroy *et al.*, 1993), and have higher serum insulin and lipid concentrations (Kemnitz *et al.*, 2002) than completely wild-feeding counterparts.

Baboons are susceptible to most human pathogenic organisms such as parasites and diarrhea-causing bacteria. Wild baboons have died from tuberculosis as a result of contact with human settlements (Sapolsky and Else, 1987; Tarara *et al.*, 1985). Tanzanian baboons with consistent contact with people were more likely to be infected with *Schistosoma mansoni* than baboons not associated with people (Müller-Graf *et al.*, 1997).

Fecal parasitic surveys of primates involved in longitudinal studies provide a valuable resource for studying ecological relationships between primates and their environment. They are noninvasive and can be repeated over time with minimal outlay of resources. Changes in patterns of fecal parasites may reflect differences in ease of parasitic transmission, host dietary preferences, and habitat utilization (Stuart *et al.*, 1998).

We surveyed the fecal parasites from 3 groups of Kenyan baboons that are part of longitudinal behavioral studies. The objectives of the

study were two-fold. The first objective was to compare parasites from fully wild-foraging and partially garbage-foraging Amboseli baboons to determine whether foraging in human refuse has resulted in exposure to human-related parasites. The second objective was to obtain fecal parasitic data on baboons to provide a baseline reference point for future comparison and comparison with results of past surveys.

MATERIALS AND METHODS

Subjects

The two groups of Amboseli baboons, Hook's (almost exclusively *Papio cynocephalus* at the time of sampling, but in an increasingly hybrid zone between *P. cynocephalus* and *P. anubis* [Alberts and Altmann, 2001]) and Lodge (*P. cynocephalus*), have been followed extensively since 1980 and 1984, respectively, by Pereira (1988), Altmann and Muruthi (1988) and Muruthi (1990). Muruthi (1997) and assistants followed Mpala Group (*Papio anubis*) in 1992–1995. Lodge, Hook's and Mpala groups numbered 91, 65 and 63 individuals, respectively, at the time of the study and all were individually identified. The range limits of Lodge and Hook's groups extend to $\leq$1 km of each other. Male dispersal occurs occasionally from Hook's to Lodge Group. Mpala Group live in the Mpala Wildlife Research Centre in the Laikipia Region of Central Kenya, *ca.* 300 km from Amboseli. All 3 groups have access to water at sources that are frequented by other wildlife as well as by local herdsmen and their cattle. The primary water sources for the Lodge Group are associated with the tourist settlement: leaky pipes, water storage areas and sewage run-off pools.

Sample Collection

We collected samples from Lodge Group and Hook's Group during the dry season, between August and October of 1994. We collected samples from Mpala Group throughout the period between December, 1993 and March 1995. We collected fecal samples soon after an individual defecated. We placed *ca.* 1 g of feces into 10% formalin and noted the name of the subject and collection date on the sample. We attempted to collect $\geq$1 sample from as many animals in each group as possible.

Fecal Analysis

We examined the fecal samples after concentration via ether sedimentation (Richie, 1948). We took multiple fecal samples from some baboons,

particularly those in the Mpala Group. A finding of a parasite in any one of multiple samples for a given individual resulted in a positive report of that parasite for it, and no baboon is represented more than once in the final data set.

Statistical Analysis

We performed a test of independence (Chi-square analysis) to determine differences in parasitic prevalence between Lodge and Hook's Groups. We used Fisher's exact test when numbers were too low to provide meaningful results with Chi-square analysis. We did not calculate differences in parasitic prevalence between Amboseli and Mpala groups because of differences in fecal sample collection: sampling in all seasons at Mpala and more than one opportunity for some Mpala individuals.

RESULTS

We collected fecal samples from 55, 30 and 42 individuals from Hook's, Lodge and Mpala Groups, respectively (Table I). We report Strongylid nematode eggs (*Oesophagostomum* sp., *Trichostrongylus* sp., *Ternidens* sp., etc.) based on morphology and, did not further identify them (Table I).

There is significant differences between Lodge and Hook's Groups for *Trichuris* sp. (82% Hook's, 57% Lodge; Chi-square, $p < 0.01$), *Physaloptera* sp. (67% Hook's, 7% Lodge; Fisher's exact $p < 0.01$), and *Streptopharagus* sp. (2% Hook's, 43% Lodge; Fisher's exact $p < 0.01$).

DISCUSSION

All of the parasites in our samples have been noted in previous surveys of Kenyan baboons by Kuntz and Meyers (1966), Kuntz and Moore (1973), Meade (1983), Eley *et al.* (1989), and Munene *et al.* (1998). Zoonotic parasites were not dectected in Amboseli and Mpala samples. This was unexpected considering the routine access, particularly of Lodge Group, to human refuse and sewage run-off. For instance, the human roundworm *Ascaris lumbricoides*, is common in Kenya, and ascarids infest wild Kenyan baboons (Eley *et al.*, 1989). Meade (1983) reported that 8 of 16 Masai herdsboys tested in the Amboseli Basin were positive for *Ascaris*. However, none of the sampled baboons were infected with *Ascaris*. Ashford *et al.* (1990) also remarked on the striking lack of *Ascaris* infection in gorillas (*gorilla gorilla beringei*) versus people of the same region. The actual parasitic burden of the human population in Amboseli at the time of sample collection

Table I. Prevalence of gastrointestinal parasites in fecal samples of baboons from Amboseli and Mpala Research Centre

	Strongylids	*Trichuris*	*Physaloptera*	*Streptopharagus*	*Enterobius*	*Schistosoma mansoni*	*Strongyloides*
Amboseli							
Hooks Group ($n = 55$)	16/55 (29%)	45/55 (82%)	35/55 (67%)	1/55 (2%)	0	0	1/55 (2%)
Lodge Group ($n = 30$)	4/30 (13%)	17/30 (57%)	2/30 (7%)	13/30 (43%)	0	0	0
Mpala Research Centre							
Mpala Group ($n = 42$)	17/42 (40%)	0	0	0	5/42 (12%)	1/42 (2%)	32/42 (76%)

is unknown so the assumption that Lodge Group baboons are more likely to be exposed to infectious stages of human parasites may be faulty.

Unexpectedly, between Lodge and Hook's Groups, there is a striking difference in the prevalence of spirurid nematodes *Streptopharagus* (43% in Lodge, 2% in Hooks) and *Physaloptera* (7% in Lodge, 67% in Hook's) (Table I). Past surveys of Amboseli baboons showed low *Streptopharagus* (0–2%), and high *Physaloptera* (37%) prevalence in all baboons sampled (Meade, 1983, Reid and Altmann, 1989–90, unpublished data). Therefore, *Streptopharagus* appears to have increased, and *Physaloptera* to have decreased, in Lodge, but not Hook's baboons.

Whether the spirurid differences are biologically as well as statistically significant is unknown, but the ecological significance may be worth further investigation. The exact life-cycle of these stomach nematodes is unknown, but all known spirurids have an indirect life-cycle that involves an arthropod an intermediate host (Flynn, 1973; Owen, 1992). Both Lodge and Hook's baboons eat arthropods (Meade, 1983; Muruthi, 1990), and arthropods are undoubtedly associated with the refuse pile. The shift in spirurid nematodes in Lodge, but not Hook's baboons, may be a result of feeding in the refuse pile. Follow-up studies could confirm whether Lodge baboons are exposed to either different intermediate host arthropods, e.g., cockroaches, or different quantities of arthropods from those of Hook's baboons.

Several conditions have changed in the Amboseli Basin in the years preceding our study, which could also affect baboon exposure to parasites. Both baboon and human densities were much lower during earlier surveys; the size of Lodge Group had increased more than 3-fold since Meade's survey (1983) and had almost doubled since Reid and Altmann's, study (unpublished data). Hook's Group size had also increased, by approximately 50%, since Meade's earlier study. Available standing water had also increased for both groups since earlier studies; the rising water table in the area has resulted in the enlargement of several small swamp-like areas as well as the creation of new ones.

Trichurids were more likely to occur in Hook's than in Lodge baboons. This is contrary to what would be expected based on baboon behavior and potential parasitic exposure. Hook's baboons tended to change sleeping sites every 2–3 nights (rarely returning to the same spot), whereas Lodge baboons slept every night in a large grove of acacia trees (*Acacia xanthophloea*) in the Amboseli Lodge area. The resulting dung heaps should cause the Lodge baboons to have a greater probability of exposure to their own feces containing the eggs of the directly-transmissable parasite, *Trichuris*.

Pinworms (*Enterobius* sp.) infested 12% of Mpala baboons. This is consistent with previous fecal surveys that reported *Enterobius* in baboons from Marigat, which is in the same region as Mpala, but no other region of Kenya

(Kuntz and Meyers, 1966; Kuntz and Moore, 1973; Munene *et al.*, 1998). The lack of *Trichuris*, and relatively high prevalence of *Strongyloides*, in Mpala baboons is also consistent with results of earlier surveys.

Schistosoma mansoni infested one adult female from Mpala Group. Muchemi (1992) reported this human parasite in baboons, which can maintain infection in endemic areas. However, *Schistosoma mansoni* is not known to occur in the Mpala area because of the lack of the obligate intermediate snail host. Adult female baboons reside in the group into which they were born, i.e. are highly local in origin. It is therefore difficult to explain the presence of *Schistosoma mansoni* in the Mpala female.

In conclusion, despite proximity to humans, and more specifically, foraging in human-source refuse, we found no parasite attributable to exposure to people in Amboseli baboons. However, there are significant differences in nematodes, in the two groups of Amboseli baboons that differed in foraging behavior, which represent isolated snapshots in time and not the actual dynamics of parasite-host interactions. If the differences remain consistent over time, they could be associated with changes in ecological, behavioral or other unidentified factors. Follow-up studies comparing arthropod eating habits of the Amboseli baboons, focusing on water sources and refuse piles, could provide information on the ecology and behavior of the baboons and the life-cycles of the baboon parasites. Finally, although sampling differences precluded statistical comparisons between Mpala and Amboseli, perusal of the data suggests either populational or seasonal variability in parasites, which warrant further investigation.

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