J. Helminthol. Soc. Wash.
60(1), 1993, pp. 111–115

Research Note

A Coprological Survey of Parasites of Wild Muriquis, *Brachyteles arachnoides,* and Brown Howling Monkeys, *Alouatta fusca*

MICHAEL D. STUART,[1] KAREN B. STRIER,[2] AND SUZANNE M. PIERBERG[1]

[1] Department of Biology, University of North Carolina at Asheville, Asheville, North Carolina 28804 and

[2] Department of Anthropology, University of Wisconsin–Madison, Madison, Wisconsin 53706

ABSTRACT: One hundred twenty-eight fecal examinations from 57 muriquis or woolly spider monkeys, *Brachyteles arachnoides,* and 62 fecal samples from 9 brown howling monkeys, *Alouatta fusca,* that coexist in the Atlantic forest in southeastern Brazil were examined for evidence of parasite infections. Hosts from 4 sites, 2 in Minas Gerais (EBC and FE) and 2 in São Paulo (FBR and PECB), showed differences in parasite prevalence and diversity. Neither muriquis nor brown howling monkeys from site 1 (EBC) revealed parasites. Monkeys from site 2 (FE) had only eggs presumed to be *Strongyloides cebus* and those from site 3 (FBR) had only *Trypanoxyuris brachytelesi.* Eggs and larvae presumed to be *Strongyloides cebus, Trypanoxyuris brachytelesi, Graphidiodes berlai,* and an unidentified digenean were found at site 4 (PECB). The 4 study sites differ substantially in size (40–37,000 ha), degree of human disturbance, climate, plant species composition, and muriqui densities. Contrary to expectations, muriquis from the largest and least-disturbed forest (with the lowest population density) had the highest prevalence and diversity of parasitic infection. A variety of factors, including vegetation and climatic differences, could explain this paradoxical pattern. However, the fact that PECB is the site least affected by human disturbance also suggests that the complex ecological web involved in parasitic transmission has been disrupted at the other sites. Our findings reaffirm the importance of using parasites as ecological indicator species in studies of wild primates and suggest that management plans which involve translocations must be sensitive to the potential effects of parasites on naive hosts.

KEY WORDS: muriqui, Brazil, woolly spider monkey, *Brachyteles arachnoides,* brown howling monkey, *Alouatta fusca, Trypanoxyuris brachytelesi, Strongyloides cebus,* survey.

The Atlantic forest of southeastern Brazil is one of the world's most devastated tropical ecosystems with only isolated forest patches remaining (Fig. 1). Relatively little information has been published about parasitism in the muriqui or woolly spider monkey (*Brachyteles arachnoides*) and the sympatric brown howling monkey (*Alouatta fusca*), both endangered primate species from the Brazilian Atlantic forest. Deane et al. (1969) reported both *B. arachnoides* and *A. fusca* hosting *Plasmodium brasilianum* and *Plasmodium simium.* Other reports for *B. arachnoides* include *Entamoeba hartmannii, Trypanoxyuris brachytelesi,* and *Graphidiodes berlai* (Travassos, 1943; Hugot, 1985; Milton, 1985). Diesing (1851) reported a cestode, *Mathevotaenia megastoma* (=*Taenia megastoma*), and a nematode, *Dipetalonema gracile* (=*Filaria gracilis*) from *B. arachnoides.*

In conjunction with an ecological study of muriquis by one of the authors (K.B.S.), fecal samples were examined for parasite products (eggs, larvae, cysts, and oocysts) from 4 separate sites in the Atlantic forests of southeastern Brazil. All sites differ in size, elevation, vegetation, rainfall, and degree of human disturbance (Table 1). Two of the sites are in the state of Minas Gerais: Estação Biologica de Caratinga and Fazenda Esmeralda; 2 are in the state of São Paulo: Fazenda Barreiro Rico and Parque Estadual Carlos Botelho.

The Estação Biologica de Caratinga (EBC) is a privately owned, 800-ha forest located at 19°50′S, 41°50′W, on Fazenda Montes Claros near the city of Caratinga, Minas Gerais. Altitudes in the forest range from 320 to 680 m above sea level. Annual rainfall is between 1,000 and 1,200 mm, with most of the rain falling from October through April (Strier, 1987a). Selective logging and natural disturbances such as fires and tree falls have resulted in only about 30% primary forest remaining. Secondary forest, good regenerating forest, scrub, and bracken comprise the rest (see Strier, 1987b).

Fazenda Esmeralda (FE) is also a privately owned farm that supports a 40-ha forest at about 100 m above sea level. It is located at 20°13′S, 42°39′W, about 170 km east of the city of Belo Horizonte, Minas Gerais. Vegetation and climatic conditions are quite similar to those at

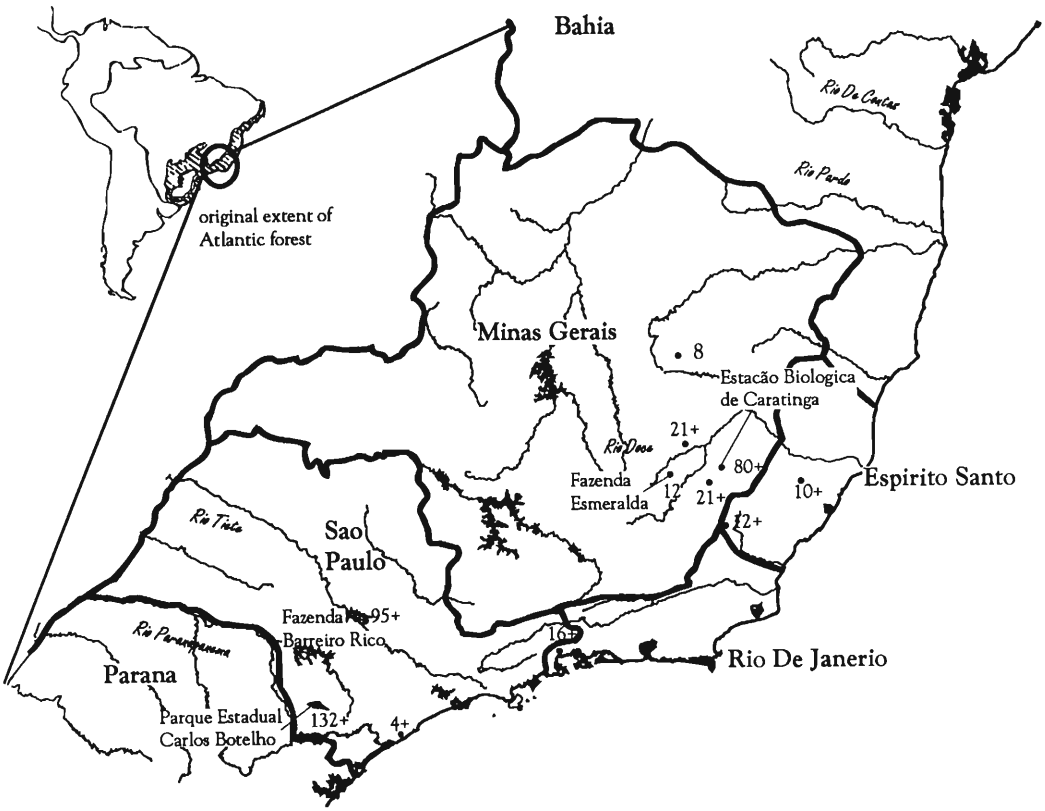

Figure 1. Atlantic forest remnants with *Brachyteles arachnoides* populations indicating minimum known numbers of individual muriquis at each site. Map modified from Mittermeier et al. (1987), Hatton et al. (1984), and Strier (pers. obs.).

EBC (Fonseca, 1983). At both sites some selective logging continues, although the smaller size of the forest at FE means that any disturbance has a greater overall effect.

Fazenda Barreiro Rico (FBR) is a large privately owned cattle ranch with 3,259 ha of forest remaining. FBR is flat and at an altitude of 480 m above sea level. It is located at 22°40′S, 48°11′W, near the city of Piracicaba, São Paulo. Annual rainfall at FBR is slightly greater than at the Minas Gerais forests, averaging 1,263 mm (Milton, 1984). Some selective logging, especially around the edges, has disturbed this primary and secondary forest.

Parque Estadual Carlos Botelho (PECB) is a large, 37,432-ha forest located at 24°44′–24°15′S, 47°46′–48°10′W, near the cities of São Miguel Arcanjo in the north and Sete Barros in the south. PECB is the wettest of the 4 sites, with annual rainfall between 1,475 and 2,189 mm. Altitudes vary from 30 to 970 m above sea level. The forest was designated and protected as a state park in 1982. It consists of primary forest and has not been subjected to selective logging. It is the least disturbed of the forests discussed here.

Because both the muriqui and brown howling monkey are highly endangered, only fecal samples as noninvasive indices of parasitic infection were permitted. Between June 1989 and April 1991, 128 fecal samples were collected from 57 muriquis, *Brachyteles arachnoides,* from the 4 sites described above and 62 fecal samples from 9 brown howling monkeys, *Alouatta fusca,* occurring sympatrically with *B. arachnoides* at EBC. Fresh fecal samples were collected during the course of systematic behavioral observations on recognized individuals at EBC and PECB and during the course of a live capture–release project at FE and FBR. Feces were preserved immediately in 10% buffered formalin in FeKal (Trend Scientific, Inc., St. Paul, Minnesota 55112) or Para-Pak (Meridian Diagnostics, Inc., Cincinnati, Ohio 45244) plastic transport vials. The presence of parasite products was determined us-

Table 1. Prevalence of parasitic infections in 4 populations of *Brachyteles arachnoides* in Brazil.

Sites	EBC	FE	FBR	PECB	Total
Estimated no. of muriquis*	80	12	95	132–500	–
Size in hectares	800	40	3,259	37,000	–
Density (no. of muriquis/ha†)	0.1	0.3	0.03	0.01–0.03	–
Level of disturbance (1 = most, 4 = least)	2–2.5	1	2.5–3	4	–
Trypanoxyuris brachytelesi (no. positive/no. examined) (%)	0/31	0/9	1/2 (50%)	1/15 (7%)	2/57 (3.5%)
Strongyloides cebus (no. positive/no. examined) (%)	0/31	8/9 (89%)	0/2	7/15 (47%)	15/57 (26%)
Graphidiodes berlai (no. positive/no. examined) (%)	0/31	0/9	0/2	12/15 (80%)	12/59 (21%)
Unidentified digenean (no. positive/no. examined) (%)	0/31	0/9	0/2	1/15 (7%)	1/57 (1.75%)
Total no. positive muriquis	0/31	8/9	1/2	13/15	22/57 (39%)

* These numbers are based on Mittermeier et al. (1987) and updated for EBC by Strier (1991) and for FE by Lemos de Sá (pers. comm.)

† Density comparisons were based on the number of animals and the total area of each site because all parts of the sites are assumed to be equally available to these large active monkeys.

EBC = Estação Biologica de Caratinga, FE = Fazenda Esmeralda, FBR = Fazenda Barreiro Rico, PECB = Parque Estadual Carlos Botelho.

ing Trend Scientific's CON-trate system®, a formalin/ethyl acetate centrifugation technique (Long et al., 1985). Since adult helminths were not collected, identification of parasitic products must remain tentative. However, when egg shape and size and larval structures closely matched previously described parasites from these host species, identification of the parasite to the species level was presumed correct.

No parasites were detected at the EBC site in either the 31 *B. arachnoides* or the 9 *A. fusca* individuals sampled. FE had only *Strongyloides cebus*. FBR had only *Trypanoxyuris brachytelesi*. PECB showed *Graphidiodes berlai, Strongyloides cebus, Trypanoxyuris brachytelesi,* and an unidentified digenean egg. Six of the 15 monkeys had 2 or more parasites (see Table 1).

Both eggs and larvae presumed to be *Graphidiodes berlai* (Strongylida: Trichostrongylidae) were found in 80% (12 of 15) of the animals at PECB only. Worms of the genus *Graphidiodes* have been reported only from *B. arachnoides* and cavimorph rodents (Travassos, 1943). The eggs from our samples were relatively large. Travassos (1943) reported uterine eggs 68–76 × 45–60 μm while the eggs observed in these fecal samples (N = 10) measured 81–84 × 51–77 μm.

Both larvated eggs and larvae of what is believed to be *Strongyloides cebus* (Rhabditida: Strongyloididae) were found in 15 of 24 animals from FE and PECB. Larvated eggs in feces measured 44–62 × 35–43 μm (average 57 × 40 μm; N = 10). Little (1966) described the eggs of *S. cebus* as in early cleavage when passed in the feces of the common spider monkey, *Ateles geoffroyi. Brachyteles arachnoides,* however, has a more elongated intestinal tract than *A. geoffroyi,* and its proportionally longer gut passage rates could account for the advanced development of these eggs and larvae. This parasite is presumably transmitted by fecal contamination rather than skin penetration by third larval stages. However, one investigator, at a different site (MDS in Costa Rica), noted surprisingly little opportunity for fecal contamination of branches in mantled howling monkeys, *Alouatta palliata,* because the feces usually fall directly to the ground or into the substory without contaminating troop pathways. Another possible source of infection is contamination by filariform larvae during human handling in capture and transport procedures although this is considered doubtful. Although some of the muriquis at FE have been captured and handled, muriquis at PECB and both muriquis and howling monkeys at ECB were never handled.

Eggs and larvae similar to *Trypanoxyuris brachytelesi* (Oxyurata: Oxyuridae) were seen in only 2 of 57 muriquis. We suspect a much higher level of infection. Bogitsh and Cheng (1990) reported human pinworm eggs were only found in the feces of about 5% of cases. A similar survey

in Costa Rica (Stuart et al., 1990) showed only 22% of fecal samples from mantled howling monkeys, *Alouatta palliata,* with *Trypanoxyuris minutus* eggs or larvae, although direct observation indicated 100% of animals over 4 wk of age were infected.

A single very small (27 × 17 μm), light golden, operculated egg was observed in 1 specimen from PECB. Whether this represents a spurious parasite or a dicrocoelid similar to *Controrchis biliophilus* observed in other platyrrhine monkeys (Stuart et al., 1990) is unknown.

The results of the comparative data on *Brachyteles arachnoides* indicate an unusual pattern of parasite distribution. Intraspecific variation in parasite infections has been associated with population densities and climatic factors in other primates. Comparative studies of both chimpanzees, *Pan troglodytes* (McGrew et al., 1989), and mantled howler monkeys, *Alouatta palliata* (Stuart et al., 1990), indicate that higher prevalences of parasitic infections occur in primates inhabiting more humid environments than among those in drier areas. The muriqui data described here are consistent with this pattern, as the population from the forest with the highest annual rainfall and highest humidity, PECB, had the highest prevalence of infection.

Data from both chimpanzees and mantled howler monkeys also indicate that the prevalence of parasites is higher in populations occurring at higher densities, presumably because of the greater opportunities for infectious transmission. The muriqui data, however, deviate from this relationship in important ways. Although PECB is the largest forest included in the study, it supports the lowest muriqui density (0.03 individual/ha). Yet, *B. arachnoides* from this site had the highest prevalence and diversity of parasite species found. The smallest forest in the study, FE, has the highest muriqui density (0.30 individual/ha). While FE had the highest proportion of infected individuals, only 1 species of parasite, *Strongyloides cebus,* was detected. EBC, in contrast, has the second-highest muriqui density (0.10 individual/ha), yet no parasites were detected in any of the individuals sampled at this site. These results are interesting because a much larger number of *B. arachnoides* was sampled across different seasons at EBC than at any of the other sites, and because no parasites were detected in the fecal samples from the small number of sympatric *A. fusca* individuals examined from the same site. The sample size at the FBR site was too small to be considered in analysis of differences between sites.

It is possible that differences in the degree of habitat disturbance at the 4 sites may be responsible for the unusual patterns of variation in parasitic infection across populations. The fact that *Brachyteles arachnoides* from the largest, least-disturbed forest at PECB had the greatest number of species of parasites while no parasites were detected from those in the moderately disturbed forest at EBC suggests that the complex ecological relationships between parasites and their primate hosts may have been disrupted by human interference.

The results of this study reinforce the idea that parasites are valuable ecological indicator species. Such assessments may be particularly important for primates because many species, such as *Brachyteles arachnoides* and *Alouatta fusca,* are highly adaptable and may be able to survive in disturbed areas. Understanding the effects of altered parasite–host relationships in endangered primate species such as these will be important in evaluating management plans for surviving populations. The evidence for pronounced intraspecific variation in parasite species composition and prevalence of infection in *B. arachnoides* must be considered in any translocation or reintroduction projects in order to avoid introducing unfamiliar parasites into naive hosts.

Permission to conduct research in Brazil and transport fecal samples was granted by CNPq. Field collections at EBC and PECB, and the purchase of analyses kits were financed by NSF grants BNS 8619442 and BNS 8958298 and the University of Wisconsin–Madison. R. Lemos de Sá provided an opportunity for K.B.S. to collect samples at FE and provided the samples from FBR; O. Carvalho, Jr., collected the samples from PECB. We are grateful to the Instituto Florestal and especially Bento Vieira de Moura Netto, director of PECB, and Gustavo da Fonseca of Universidade Federal de Minas Gerais for their collaboration and support. The Undergraduate Research Council of the University of North Carolina–Asheville supported S.P. for her senior research. Research instrumentation was financed by North Carolina Board of Science and Technology grant 89SE01.

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J. Helminthol. Soc. Wash.
60(1), 1993, pp. 115–117

Research Note

Subcutaneous Helminths of the Raccoon (*Procyon lotor*) in Southern Florida

NICOLA G. KEELING,[1] MELODY E. ROELKE,[2] AND DONALD J. FORRESTER[1]

[1] Department of Infectious Diseases, College of Veterinary Medicine, University of Florida, Gainesville, Florida 32610 and

[2] Florida Game and Fresh Water Fish Commission, 4005 South Main Street, Gainesville, Florida 32601

ABSTRACT: Examination of the subcutaneous tissues of 54 raccoons (*Procyon lotor*) from southern Florida revealed the presence of spargana of 1 cestode, *Spirometra mansonoides* (prevalence 40.7%), and adults of 3 species of nematodes, *Dracunculus insignis, Dirofilaria tenuis,* and *Dipetalonema procyonis* (prevalences 16.7, 14.8, and 1.9%, respectively).

KEY WORDS: Cestoda, *Spirometra mansonoides,* Nematoda, *Dracunculus insignis, Dirofilaria tenuis, Dipetalonema procyonis,* raccoon, *Procyon lotor,* Florida.

The raccoon, *Procyon lotor,* is distributed throughout southern Canada, the continental United States, Mexico, and Central America. Previous studies on the parasite fauna of this mammal throughout its range have resulted in some helminthological information for raccoons in Florida (Harkema and Miller, 1964; Schaffer et al., 1981; Telford and Forrester, 1991; Forres-