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Variation over Time in Parasite Prevalence Among Free-ranging Chimpanzees at Gombe National Park, Tanzania

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Abstract From January to September, 2005, we collected fecal samples from 60 chimpanzees at Gombe National Park, Tanzania and examined them for parasites. We compared current parasite prevalence data with previous studies to obtain a pattern of parasitism over time. There were considerable similarities in the parasite species composition and prevalence, although we noted some variations. Generally, parasite prevalence decreased over time, with the present prevalence being lower than in previous surveys. We identified 8 types of parasites, all of which had previously been documented in the chimpanzees of Gombe. Three nematodes — *Oesophagostomum* sp., *Strongyloides fulleborni,* and *Abbreviata caucassica*— occurred at higher prevalence (41.2–45.5%) but relatively lower than previous findings of 50–91%. We also diagnosed unidentified strongyles at a moderate prevalence (33%), lower than a previous record of 41%. *Probstmayria gombensis* occurred at relatively low prevalence (16.4%) vs. past observations (23–59%), while the prevalence of *Trichuris* sp. (7.3%) was closely similar to previous records of 5–9%. We also observed unidentified ciliate at 9% within the same range as in previous studies (5–28%). The prevalence of *Troglodytella abrassarti* was 78%, closely similar to previous findings of 75%. There was no significant variation in parasite prevalence between chimpanzees of the Kasekela community and those of the Mitumba community, although the former tended to have higher prevalence of helminths than the latter. The causes of the similarities and variations in parasite prevalence over time are discussed. The study provides baseline data for monitoring of chimpanzee health at Gombe.

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Introduction

Parasites and diseases are among the most pressing challenges of present-day conservation programs for primates and other biodiversity (Wallis and Lee 1999; Woodford *et al.* 2002). Free-living chimpanzees have numerous health problems, and across their range they have been affected by a number of parasites and disease epidemics (Homsy 1999; Wallis and Lee 1999). For example, in Gombe National Park, ≥3 major epidemics of influenza and polio have killed many chimpanzees since the 1960s, when death records were first kept (Murray *et al.* 2000; Wallis and Lee 1999).

The problem of parasites and diseases in endangered species such as chimpanzees is exacerbated by, among other factors, human encroachment (Woodford *et al.* 2002). Chimpanzee habitats have decreased over the last millennium, confining them into small spots of forests where they also constantly interact with other animals and humans (Inskipp 2005). This scenario may introduce new pathogens with devastating consequences to the chimpanzees (Homsy 1999; Woodford *et al.* 2002). Emerging infectious diseases such as Ebola have added pressure on the survival of the great apes in Africa because there is great potential for cross-transmission from humans and vice versa (Krief *et al.* 2005). Further, it is widely held that the chimpanzee's simian immune virus (SIV) may have been the source of the devastating human HIV (Gao *et al.* 1999; Hahn *et al.* 2000). As such, it is important to understand the nature and dynamics of disease agents in wild primate populations, particularly in areas where they regularly come in contact with humans.

Chimpanzees share >99% of their genome with humans (Ken *et al.* 1982) and are thus exceptionally susceptible to an array of human diseases (Wolfe *et al.* 1998; Woodford *et al.* 2002). Humans and nonhuman primates can exchange pathogens such as bacteria, viruses, and gastrointestinal parasites (Nutter 1993; Wolfe *et al.* 1998). The transmission of these parasites and disease agents can occur through skin contact or the fecal-oral route, which is facilitated by poor sanitary conditions leading to fecal contamination of soil, food, and water sources (Homsy 1999). Because the impact of parasitic transmission among chimpanzees at Gombe is imminent, there should be an effective program to control the spread of parasites and diseases via continued health monitoring and provision of general hygiene and sanitation.

As part of the ongoing study on the health monitoring of chimpanzees at Gombe National Park, we investigated the status of the parasites of chimpanzees in the park and compared our findings with past surveys in the area. Our major objectives were to describe the intestinal parasite fauna of chimpanzees at Gombe and to compare the trends in the parasitic prevalence over time. Our study helps to provide an index on the health status of chimpanzees in Gombe and it also gives data for continued monitoring of the relative changes in the health of endangered chimpanzee species.

Materials and Methods

Study Area

Gombe National Park is 16 km north of Kigoma town in Tanzania (4°53′S, 29°38′E) on the eastern side of Lake Tanganyika. The park, which is a narrow strip of rugged terrain along the lakeshore, covers an area of *ca.* 52 km^2 (Goodall 1986). The terrain rises from 773 m above sea level at the lakeshore to >1500 m at the top of the rift escarpment on the east (Goodall 1986; Muller-Graf *et al.* 1997). Vegetation ranges from evergreen forest along the river valleys, deciduous forest, and thicket on the upper slopes, to grassland near and on the ridges. Rainfall averages *ca.* 1500 mm/yr (Collins and McGrew 1988), with the wet season spreading over 8 mo (October–May) and the dry season experienced from June to September (Goodall 1986). In addition to chimpanzees, the park is also home to other mammals, reptiles, birds, and invertebrates (Collins and McGrew 1988; Goodall 1986).

Fecal Sample Collection

We followed individual chimpanzees from dawn when they leave their nests and collected stool immediately after defecation, mainly picking up its central part to avoid soil and other contaminants (Roepstorff and Nansen 1998). We preserved samples in 4% formalin (Appleton and Henzi 1993; Roepstorff and Nansen 1998) and 5% potassium dichromate (Mtambo 2001) ≤3–5 h after defecation and examined them within 6 mo of preservation. We collected ≥2 samples from each chimpanzee, 1 sample for each dry season and wet season from January to September 2005, resulting in a total of 170 samples.

Examination and Identification of Parasites

We examined the fecal samples in the veterinary laboratory at Sokoine University of Agriculture, Tanzania via modified Ziehl-Neelsen and formal-ether concentration techniques (Allen and Ridley 1970; Cheesbrough 1998; WHO 1991). We identified parasites based on morphology, size and appearance of eggs or larvae and cysts or trophozoites, via identification guidelines, keys, and photographs in the literature (Cheesbrough 1998; Spencer and Monroe 1982; WHO 1991), and took measurements of each parasite stage (eggs, larvae, cysts, and trophozoites) via a micrometer. Owing to the overlap in egg size and other characteristics, we could not identify some of the parasites to species level.

Data Analysis

We used ecological terms per Bush *et al.* (1997, 2001) and as recommended by Rózsa *et al.* (2000) and Gillespie (2006). We calculated parasite prevalence for each parasitic species according to Bush *et al.* (1997). We performed a χ^2 test to evaluate variations in parasite prevalence among the localities of Kasekela and Mitumba. For statistical analysis, we included only the common parasitic species

(prevalence >40%), unless stated otherwise, and set the value of $p<0.05$ as significant.

Results

Species Composition and Overall Prevalence of Chimpanzee Parasites at Gombe National Park

We detected 8 parasitic taxa, comprising 6 nematodes (*Strongyloides fulleborni*, *Probstmayria gombensis*, *Abbreviata caucassica*, *Oesophagostomum* sp., *Trichuris* sp., and an unidentified strongyle) and 2 ciliate protozoans (*Troglodytella abrassarti* and an unidentified ciliate; Fig. 1). Every individual sampled was infected by at least 1 parasite taxon. Nematodes were the predominant group of parasites, comprising 6 species (77.8%) whereas ciliates were represented by 2 species (22.2%). *Troglodytella abrassarti* was the most prevalent (78%), followed in that order by the nematodes *Oesophagostomum* sp., *Strongyloides fuelleborni,* and *Abbreviata caucassica* (>40% prevalence; Fig. 1). We found unidentified nematodes referred to as strongyles at relatively low prevalence (33%), followed by *Trichuris* sp. as the least prevalent parasite (7.4%; Fig. 1).

Comparison of Parasite Prevalence Between the Kasekela and Mitumba Chimpanzee Groups at Gombe National Park

In most cases, parasite prevalence tended to be higher among the chimpanzees of Kasekela than those of Mitumba (Fig. 2). However, statistical analysis of the prevalence indicated no significant differences between the 2 areas (*Strongyloides fulleborni*: $\chi^2=0.06206$, $p=0.8032$; *Oesophagostomum* sp.: $\chi^2=0.0889$, $p=0.7655$).

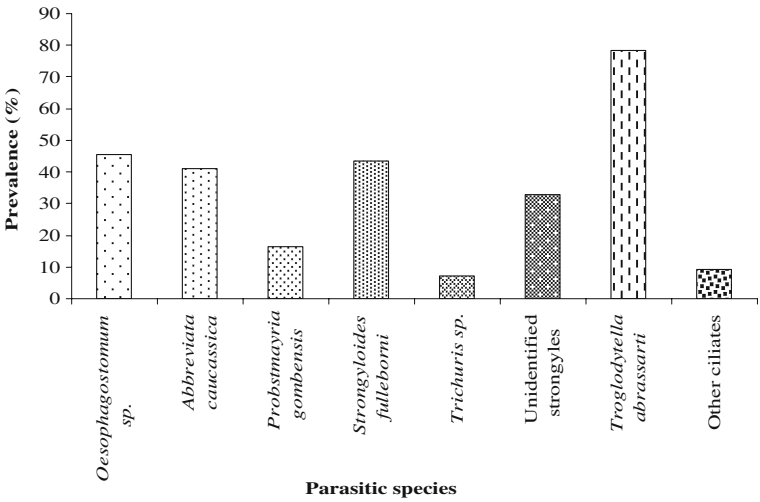


Fig. 1 Species composition and prevalence of chimpanzee parasites at Gombe National Park.

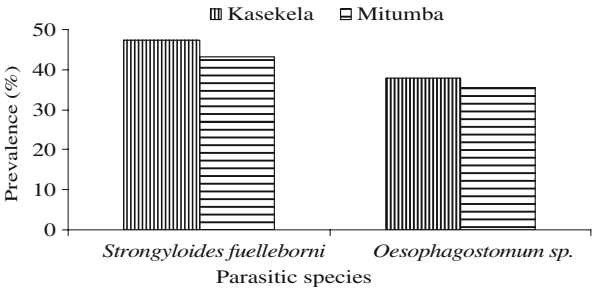


Fig. 2 Variation of parasite prevalence between the chimpanzee communities of Kasekela and Mitumba at Gombe National Park.

Seasonal Variation of Parasite Prevalence in the Chimpanzees of Gombe National Park

Most chimpanzees had a relatively higher prevalence of parasites during the dry season than the wet season (Fig. 3). However, statistical tests indicated no significant differences in parasitic prevalence between seasons (e.g., *Abbreviata caucassica*: χ^2= 0.9809, p=0.3220; *Oesophagostomum* sp.: χ^2=0.4876, p=0.4850; *Strongyloides fulleborni*: χ^2=1.356, p=0.2442; *Troglodytella abrassarti*: χ^2=1.254, p=0.2629).

Discussion

Species Composition of Chimpanzee Parasites at Gombe National Park

Our findings are similar to those of previous studies at Gombe, both in the types of parasitic species found and in their infection patterns (Table 1). We recorded approximately the same number of parasite taxa of nematodes and protozoa as in past surveys, all of which infect chimpanzees at Gombe and in other sites (File *et al.* 1976; Healy and Myers 1973; Landsoud-Soukate *et al.* 1995). We did not find a few species, such as *Ascaris lumbricoides* and *Schistosoma mansoni* and some protozoa, that Nutter (1993) and Murray *et al*. (2000) recorded. Nutter (1993) reported *Ascaris lumbricoides* at high prevalence in the 1990s and Murray *et al.* (2000) also found *Endamoeba coli*, though at lower prevalence (Table 1). The absence of such parasites in our study could be an indication of their low prevalence or absence in the environment during the period of study. The absence of *Schistosoma mansoni* in our study is perhaps not surprising because trematodes are generally rare in

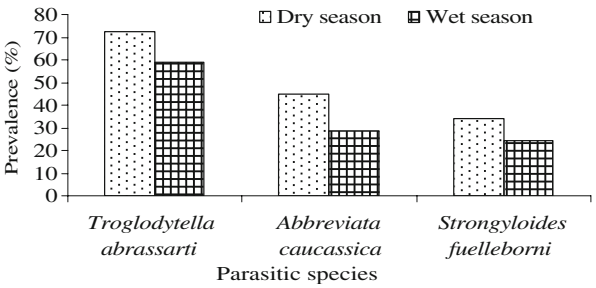


Fig. 3 Seasonal variation in parasite prevalence in chimpanzees at Gombe National Park.

Table 1 Prevalence (%) of chimpanzees parasites at Gombe from previous surveys and the present study

Reference/study	File *et al.*	Nutter	Murray *et al.*	Present study
Year of study	(1976)	(1993)	(2000)	(2006)
Examination method(s) used	FEC/ZF	FEC/DS	DS/ZF	FEC/ZN
Sample size (*N*)	32	39	22	55
Nematodes				
Ascaris lumbricoides		77		
Oesophagostomum sp.	91	54	73	45.5
Abbreviata caucassica	66	18	18	41.2
Probstmayria gombensis	59	33	23	16.4
Strongyloides fulleborni	87	72	59	43.6
Trichuris sp.	9	8	5	7.3
Unidentified strongyles	41	15	41	32.7
Trematodes				
Schistosoma mansoni		5		
Protozoa				
Endamoeba coli		56	23	
Troglodytella abrassarti	75	59	14	78.2
Balantidium coli		3		
Other ciliates	28	5	9	9.1
Giardia sp.		8		

DS = direct smear; FEC = formol-ether/ethyl concentration; ZF = zinc flotation; ZN = Ziehl-Nielsen.

chimpanzees, and researchers have recorded only a few cases (Healy and Myers 1973; Myers and Kuntz 1972). At Gombe, *Schistosoma mansoni* is recorded from only 2 individual chimpanzees (Nutter 1993).

Prevalence of Parasites Between the Kasekela and Mitumba Chimpanzee Groups at Gombe National Park

We did not find any significant variation in parasite prevalence between the Kasekela chimpanzee community and those at Mitumba, although the Kasekela group had slightly higher prevalence than their conspecifics at Mitumba. This is similar to previous observations (Nutter 1993), and may be caused by the larger population size of chimpanzees at Kasekela vs. that of Mitumba (Goodall 1986). Host group size affects parasitic infection patterns in mangabeys (*Cercocebus albigena*) and blue monkeys (*Cercopithecus mitis*; Freeland 1979). For example, species richness of protozoans in *Cercocebus albigena* was found to relate to the density of host social groups, and group fission resulted in the reduction of the group's protozoan species richness. Generally, large mammals living in larger groups tend to have higher parasite prevalence than those in smaller groups (Freeland 1979; McGrew *et al.* 1989). We therefore propose that the larger chimpanzee group size (median) at Kasekela may partly account for the marked increase in parasite abundance there. Overcrowding in the chimpanzees may result in repeated use of sleeping nests/areas and gathering sites among the Kasekela community, which in turn can increase the chances for parasitic reinfection and cross-infection. In our study, most parasites were transmitted via soil, and their successful transmission is a function of the density of infective stages (Anderson and Gordon 1982).

The human population —researchers, park and research employees and their families together with tourists— is higher at Kasekela than at Mitumba. Increased human activities may be implicated in the dynamics of parasitic transmission in the Kasekela area, particularly because most of the parasites, e.g., *Trichuris*, *Oesophagostomum*, and *Strongyloides fulleborn*i are human pathogens (Cheesborough 1998). Human activities influence the levels of parasite infections among primates in many areas (Ocaido *et al.* 2003; Woodford *et al.* 2002). The variations in infection statistics between Kasekela and Mitumba may also be caused by heterogeneities in the topography and microhabitats between the 2 areas.

Seasonality of Parasitic Prevalence in the Chimpanzees of Gombe National Park

Our results have shown that the prevalence of parasites of chimpanzees was higher during the dry season than during the wet season. There was particularly a general trend for high prevalence of nematodes during the dry season, which is possibly caused by seasonal fluctuations in food resources, leading to nutritional deficiency, stress, and compromised immunity in chimpanzees. The dry season at Gombe National Park is characterized by marked food shortages and loss of weight in chimpanzees due to low food intake (Goodall 1986). Goodall (1986) linked some deaths of otherwise weak chimpanzees to food scarcity during the dry season. Because water becomes scarce during the dry season, we suggest that the congregation of chimpanzees and other species such as baboons at drinking points may also enhance parasite transmission, particularly because most parasites (nematodes) in our study are geo-helminths.

Researchers studying other primates have also reported higher parasite infection during the dry season (Appleton and Henzi 1993; van Geldorp and van Veen 1976). For instance, Chacma baboons (*Papio ursinus*) in Natal, South Africa, had higher parasitic prevalence in the dry season than during the wet season, which Appleton and Henzi (1993) attributed to lowered immunity caused by low food intake and nutritional stress. Our findings could also be due to sampling bias because we collected fewer samples during the wet season because of the difficulty in tracking chimpanzees in dense thickets. Vegetation at Gombe National Park is relatively open during the dry season (Goodall 1986), which makes it easier to follow subjects.

Variation in Parasitic Prevalence Over Time Among the Chimpanzees of Gombe National Park

The overall prevalence of parasites in the present study was relatively similar to the findings from previous parasitological surveys at Gombe, although there were variations for some parasite species (File *et al.* 1976; Murray *et al.* 2000; Nutter 1993). Like previous researchers, we identified *Troglodytella abrassarti* at higher prevalence. *Troglodytella,* the entodiniomoprh ciliates, occur in large numbers in mammals and are thought to be indispensable commensals to their hosts (Kirby 1964). *Troglodytella abrassarti* aids in cellulose digestion owing to its morphological similarity to commensal ciliates of ruminants, but also because of its occurrence in high frequencies across all populations of wild African apes (Hasegawa *et al.* 1983; Landsoud-Soukate *et al.* 1995). In Gombe National Park, as in other sites, chimpanzees include in their diet cellulose-rich food materials, such as fruit, leaves, and piths (Goodall 1986), and

Troglodytella abrassarti may thus help in their digestion. Researchers have also reported many unidentified ciliates in chimpanzees in Gombe and at Mount Assirik, Senegal (McGrew *et al.* 1989), in Lope, Gabon (Landsoud-Soukate *et al.* 1995), and in Kibale National Park, Uganda (Ashford *et al.* 2000).

The prevalence of most parasites we recorded was markedly lower than previous records (Table 1), possibly as an indication of the decline of parasite abundance over time. The changes may also be a result of sanitation and hygiene programs that park authorities at Gombe have introduced to limit the potential of disease transmission between humans and nonhuman primates (Lukasik 1999) which, include, among others, banning all fisheries activities along the shores in the park. Other measures have included limiting the number of tourists and other visitors in the park and vicinity of chimpanzees, and reduction of people employed in the park. There have also been regular health checks for park rangers, guides, and researchers and the introduction of health protocol and safety regulations in the park and holding regular educational seminars to raise health awareness among research and park staff and their families.

As a result, the number of people in the park has been dramatically curtailed, fishermen can no longer camp in the park, and passages in the park have been restricted to official trails for researchers and tourists. The surrounding human communities in villages have also been sensitized on conservation and health education trough TACARE, a conservation and development project of the Jane Goodall Institute. However, more remains to be done, particularly on raising awareness on more hygienic practices among the local people and continued monitoring of the health of both the wildlife and the local human population.

The length of the sampling period, sample size, and differences in methods employed to detect parasite may have contributed to the differences observed between the present and previous surveys.

Thus, future studies may benefit by collecting at least 3 samples per subject as recommended by Gillespie (2006). The small sample size and the preservation and examination techniques may also account for the absence of protozoan amoebae and flagellates in our study. However, it is not possible to detect and identify all the parasites completely in a single study, hence the need for continued regular surveys and monitoring.

Patterns of Parasitic Infections Across Chimpanzee Sites in Africa

Our findings on parasitic infection among the chimpanzees of Gombe are consistent with results from other chimpanzee sites in Africa in terms of the types of parasites and their rates of occurrence. Researchers have recorded ≤13 parasite species among the chimpanzees of Gombe (File *et al.* 1976; Murray *et al.* 2000; Nutter 1993), while reporting >12 parasitic species from chimpanzees in other locations (Ashford *et al.* 2000; Huffman *et al.* 1997; Landsoud-Soukate *et al.* 1995). As at Gombe, chimpanzees in Mahale Mountains National Park harboured about the same species of parasites, notably *Oesophagostomum, Strongyloides, Abbrevieta, Probstmayria*, and *Trichuris,* at approximately similar prevalence (Kawabata and Nishida 1991; Lily *et al.* 2002).

Similarities in the chimpanzee parasitic fauna between the different sites may reflect an overall similarity in feeding patterns among chimpanzees. Chimpanzees are primarily vegetarian, feeding mostly on seeds, plant leaves, and a wide variety of fruits (Goodall 1986). They also feed on other food items including birds, small mammals, and some invertebrates, e.g., insects (Goodall 1986; Myers *et al.* 1973). The feeding patterns may expose the chimpanzees to biological conditions that support parasitism, e.g., contaminated soil and vegetation or infected preys. The observed differences may reflect variation in the survival conditions for parasites in the respective regions and differences in climate and habitats as noted by Lilly *et al.* (2002). However, proper comparison of the parasite fauna between different chimpanzee sites is made difficult by different techniques that various authors have used.

Conclusion

In summary, all the animals sampled had ≥1 parasitic species, indicating that parasites are an essential component of the chimpanzee ecology. Parasites recorded were similar to those in previous studies on the chimpanzee at Gombe. Chimpanzees clearly harbor a variety of intestinal parasites, and some of them such as *Oesophagostomum* sp., *Strongyloides fuelleborni,* and *Troglodytella Abrassarti*, can occur at higher prevalence. The lower parasite prevalence in our study could be a result of the measures introduced since 2000 that have improved sanitation and hygiene at Gombe. The larger chimpanzee group, ranging patterns, and human influence may account for the high parasite prevalence in the Kasekela chimpanzee community at Gombe National Park.

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