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Research Article

Gastrointestinal Helminths of Captive Non-human Primates in Cameroon

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Abstract

Background and Objective: Gastrointestinal helminths prevail in non-human primates in captive sites of Cameroon. This study aimed at evaluating the prevalence of gastrointestinal parasites in captive non-human primates (NHPs). **Materials and Methods:** The faeces of 240 NHPs were analysed using standard parasitological techniques in 4 captive sites. **Results:** The overall prevalence was 62.5%. The prevalence with respect to site was 95% in Garoua zoo, 50.6% in Limbe Wildlife Centre, 82.9% in Mvog-Betsi Zoo-Botanical Garden and 58.2% in Mefou Primate Sanctuary. Sixteen parasite species were identified including: 6 protozoans, 6 nematodes, 1 trematode, 2 cestodes and 1 unidentified cyst. *Balantidium coli* was the most prevalent protozoa (18.3%), *Trichuris* sp. was the most prevalent nematode (12.9%), *Taenia* sp. was the most prevalent cestode (2.9%) and *Schistosoma* sp. was the only trematode (0.4%). High parasite prevalence was noticed in guenons and mangabeys, followed by papionines with baboons being the most infected. Apes like Chimpanzees had the lowest prevalence (50.7%). Mangabeys and guenons had the highest egg per gram count (EPG) (350 ± 0 and 387.5 ± 151.83), followed by papionines and baboons. Apes had the lowest EPG and was higher in chimpanzees (149.32 ± 178.05). Body condition score decreased as EPG increased. It was noticed that EPG differed greatly with NHP. Enhancing risk factors like housing, group size, density and category of captive sites, all influenced EPG. **Conclusion:** Gastrointestinal helminths occur in non-human primates of Cameroon and their infestation rates and burden depends on associated risk factors.

Key words: Prevalence, gastrointestinal parasites, captive, non-human primates, Cameroon, risk factors

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Considering the important role of NHPs in public entertainment, they are one of the most common groups of animals in zoological gardens¹. Also, they are known to be host of different gastrointestinal parasites which have physiologic effects on their digestive and reproductive performances; such effects range from gastroenteritis haemorrhage, extra-intestinal infection, spontaneous abortion and death could result²⁻³. These parasites do so either directly through pathologic effects or indirectly by reducing host condition. Considering the parasitic load, severe cases can lead to blood loss, tissue damage, spontaneous abortion, congenital malformations and even death⁴⁻⁵.

Non-human primates when transferred from their natural environment where they live freely to captivity, this action influences their ecology, natural resistance and destabilisation of the host-parasite system that can result in high sensitivity to parasite infection⁶. Despite proper attention to feeding, water and hygiene, confined areas in zoo enclosures make captive animals more vulnerable to different parasitic infections. There is a frequent exchange of pathogens between humans and NHP through the following mechanisms: their close phylogenetic relationship, the intrusion of humans into NHP habitats and human closeness to them in zoological gardens¹⁻⁷. Emerging zoonosis threatens global health and result in a decline in NHP population in the wild and in captivity⁸. Recent data show that more than half of the known parasitic helminth species occur between NHP and humans⁹.

Helminth and protozoan infections of NHP have been extensively studied in several African countries¹⁰⁻¹⁷. Studies on the prevalence of gastrointestinal parasite infection rate of NHP have been document for several zoological gardens^{1,18-21}. Considering the importance and the effects of these parasites on NHP and their zoonotic potential, little information exists on them in Cameroon zoos. In order to contribute to the prevalence of gastrointestinal parasites of NHP in Cameroon and associated risk factors, the present study was designed to identify the species and intensity of these parasites among captive NHP in 4 captive sites of Cameroon.

MATERIALS AND METHODS

Captive NHP species sampled: The captive NHP species sampled included: *Gorilla gorilla* (Gorillas), *Pan troglodytes* (Chimpanzees), *Papio anubis* (Olive Baboon), *Mandrillus leucopheus* (Drill), *Mandrillus sphinx* (Mandrill), *Lophocebus albigena* (Gray chick mangabeys), *Cercocebus torquatus*

(Redcap mangabeys), *Cercocebus agilis* (Agille mangabeys), *Cercopithecus mona* (Mona monkeys), *Cercopithecus nictitans* (Putty nosed monkeys), "*Cercopithecus cephus* (Moustache monkeys), *Cercopithecus tantalus* (Tantalus monkeys), *Erythrocebus patas* (Patas monkeys), *Cercopithecus neglectus* (De Braza monkeys), Preus monkeys, *Cercopithecus preussi* (Preus monkeys) and *Cercopithecus erythotis* (Red eared monkeys).

Captive sites included: Limbe Wildlife Centre (LWC) in Fako division (South west region) located within the geographical limit i.e., latitude 3°57'- 4°27'N and longitude 8°58'-9°24'E with average temperature and precipitation of 26.6°C and 7000 mm, respectively; Garoua zoo (GZ) in Benue division (North region) located at latitude 9°18' N and longitude 13°24' E with average temperature and precipitation of 27.8°C and 1005 mm, respectively; Mefou Primate Sanctuary (MPS) in Mefou and Afamba division (Centre region) located at latitude 3°57' 36"N and longitude 11°55' 48"E with average temperature and precipitation of 22.8-24.7°C and 720 mm, respectively and Mvog-Betsi Zoo-Botanical Garden (MZBG) in Mfoundi division (Centre region) located at latitude 3°52' N and longitude 11°31' E with average temperature and precipitation of 23.2-25°C and 19-199.3 mm, respectively²².

Collection and screening of faecal samples: Each NHP was identified and faecal sample collected. Physical examination of the faecal sample was immediately carried out within 3-4 h to check for tapeworm proglottids²³. Faecal samples were processed using the wet preparation Evergreen kit (Evergreen scientific. L.A. USA)²⁴ through the sedimentation parasite concentrator technique. Egg and oocyst counts per gram of faeces (EPG) were determined using the Mac Master technique with saturated sodium chloride solution as floating medium²⁵.

Determination of the body condition score (BCS): The body condition was evaluated by palpating key anatomical sites including the hips, pelvis, thorax and abdomen²⁶. Animals were laid side ways during assessment and the prominence of bony structures, muscle mass and subcutaneous fat examined. The following semi quantitative scale: 1: Emaciated, 1.5: Very thin, 2: Thin, 2.5: Lean, 3: Optimum, 3.5: Slightly overweight, 4: Heavy, 4.5: Obese and 5: Grossly obese²⁷ was used.

Predisposing risk factors (factors linked to the host individual like sex, age, body condition score and host species) together with enhancing risk factors (factors linked to the environment like housing of NHP, group size, density and category of captive site) were considered in this study.

Statistical analysis: The stat graphics 5.0 software was used for statistical analysis. The frequency of the parasite by site and species of NHP was compared using the Kruskal-Wallis test. The mean EPG and the associated risk factors were compared using one way ANOVA and a *post hoc* tukey's test. The level of significance was stated at $p < 0.05$.

RESULTS

The overall prevalence of gastrointestinal parasites of captive NHP in Cameroon was 62.5%. The various gastrointestinal parasites of the NHP species in the various captive sites are presented in Table 1 and 2. Table 1 presents the prevalence of protozoans and unknown cyst of NHP while Table 2 presents nematodes, cestodes and trematodes.

Predisposing risk factors, parasite frequency and EPG: The predisposing risk factors such as age and sex of NHP had no effect on the parasitic load ($p > 0.05$). The body condition score (BCS) and NHP species differed significantly ($p < 0.05$) with parasitic load. More precisely, the mean EPG of NHP with BCS of 1.5 and 2 (516.67 ± 301.38 and 313.64 ± 123.94 , respectively) was significantly higher than that of those individuals with BCS of 2.5 and 3 i.e., 197.01 ± 176.77 and 189.55 ± 165.22 respectively. Regarding the EPG with respect to NHP species, it was noticed that the mean EPG of guenons and mangabeys were significantly higher than those of papionines and great apes (Table 3).

Enhancing risk factors, parasite frequency and EPG of NHP: The enhancing risk factors such as housing and category of

Table 1: Species of protozoans and unknown cyst with respect to NHP species

Species	Nil	Unknown cyst	<i>Endolimax</i> sp.	<i>Entamoeba coli</i>	<i>Entamoeba histolytica</i>	<i>Balantidium coli</i>	<i>Giardia lamblia</i>	<i>Troglodytella abressarti</i>
<i>Mandrillus leucopheus</i>	8 (33.3)	4 (16.7)	0 (0.0)	1 (4.2)	1 (4.2)	2 (8.3)	0 (0.0)	0 (0.0)
<i>Mandrillus sphinx</i>	6 (33.3)	1 (5.6)	0 (0.0)	5 (27.8)	1 (5.6)	0 (0.0)	1 (5.6)	0 (0.0)
<i>Papio anubis</i>	5 (11.1)	1 (2.2)	1 (2.2)	4 (8.9)	0 (0.0)	11 (24.4)	0 (0.0)	0 (0.0)
<i>Cercocebus torquatus</i>	6 (40.0)	2 (13.3)	0 (0.0)	2 (13.3)	0 (0.0)	1 (6.7)	0 (0.0)	0 (0.0)
<i>Gorilla gorilla</i>	11 (45.8)	1 (4.2)	0 (0.0)	5 (20.8)	1 (4.2)	3 (12.5)	1 (4.2)	0 (0.0)
<i>Pan troglodites</i>	36 (49.3)	2 (2.7)	0 (0.0)	10 (13.7)	0 (0.0)	13 (17.8)	0 (0.0)	4 (5.5)
<i>Cercopithecus nictitans</i>	6 (28.6)	1 (4.8)	0 (0.0)	1 (4.8)	0 (0.0)	2 (9.5)	0 (0.0)	0 (0.0)
<i>Cercopithecus mona</i>	5 (45.5)	1 (9.1)	0 (0.0)	1 (9.1)	0 (0.0)	2 (18.2)	0 (0.0)	0 (0.0)
<i>Cercopithecus erythotis</i>	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus preussi</i>	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercocebus agilis</i>	3 (23.1)	7 (7.7)	0 (0.0)	0 (0.0)	2 (15.4)	2 (15.4)	0 (0.0)	0 (0.0)
<i>Erythrocebus patas</i>	0 (0.0)	0 (0.0)	0 (0.0)	5 (22.2)	0 (0.0)	2 (11.1)	0 (0.0)	0 (0.0)
<i>Cercopithecus tantalus</i>	1 (5.0)	0 (0.0)	0 (0.0)	3 (15.0)	1 (5.0)	4 (20.0)	0 (0.0)	0 (0.0)
<i>Lophocebus albigena</i>	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus neglectus</i>	0 (0.0)	1 (20.0)	0 (0.0)	3 (60.0)	0 (0.0)	1 (20.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus preussi</i>	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	90 (37.5)	15 (6.3)	1 (0.4)	40 (16.7)	6 (2.5)	44 (18.3)	2 (0.8)	4 (1.7)

Nil: Non-infected

Table 2: Species of nematodes, cestodes and trematodes with respect to NHP species

Species	<i>Ancylostoma</i> sp.	<i>Trichurus trichura</i>	<i>Enterobius</i> sp.	<i>Strongyloides</i> sp.	<i>Capillaria</i> sp.	<i>Toxocara</i> sp.	<i>Schistosoma</i> sp.	<i>Bestiella</i> sp.	<i>Taenia</i> sp.
<i>Mandrillus leucopheus</i>	2 (8.2)	1 (4.2)	0 (0.0)	2 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.2)
<i>Mandrillus sphinx</i>	0 (0.0)	0 (0.0)	1 (5.6)	2 (11.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.6)
<i>Papio anubis</i>	1 (2.2)	15 (33.3)	0 (0.0)	3 (6.7)	2 (4.4)	1 (2.2)	0 (0.0)	0 (0.0)	1 (2.2)
<i>Cercocebus torquatus</i>	1 (6.7)	0 (0.0)	1 (6.7)	0 (0.0)	1 (6.7)	0 (0.0)	0 (0.0)	0 (0.0)	1 (6.7)
<i>Gorilla gorilla</i>	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Pan troglodites</i>	1 (1.4)	1 (1.4)	0 (0.0)	3 (4.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (4.1)
<i>Cercopithecus nictitans</i>	0 (0.0)	2 (9.5)	1 (4.8)	4 (19.0)	4 (19.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus mona</i>	0 (0.0)	0 (0.0)	0 (0.0)	1 (9.1)	1 (9.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus erythotis</i>	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus preussi</i>	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercocebus agilis</i>	0 (0.0)	2 (15.4)	0 (0.0)	3 (23.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Erythrocebus patas</i>	0 (0.0)	6 (33.3)	0 (0.0)	2 (11.1)	0 (0.0)	1 (5.6)	1 (5.6)	2 (11.1)	0 (0.0)
<i>Cercopithecus tantalus</i>	0 (0.0)	4 (20.0)	0 (0.0)	3 (15.0)	3 (15.0)	1 (5.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Lophocebus albigena</i>	0 (0.0)	0 (0.0)	0 (0.0)	2 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus neglectus</i>	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cercopithecus cephus</i>	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	5 (2.1)	31 (12.9)	4 (1.7)	28 (11.7)	11 (4.6)	3 (1.3)	1 (0.4)	2 (0.8)	7 (2.9)

Table 3: Predisposing risk factors of NHP with respect to parasitic load

Factors	Frequency	EPG	References
Age			
1-5	36	193.10±173.005 ^a	Dawet <i>et al.</i> ¹ , Chapman <i>et al.</i> ² , Akpan <i>et al.</i> ³ , Chandra and Newberne ⁴ and Despommier <i>et al.</i> ⁵
6-10	74	210.81±168.27 ^a	Thawait <i>et al.</i> ⁶ , Ott-Joslin ⁷ , Leroy <i>et al.</i> ⁸ , Pedersen <i>et al.</i> ⁹ and Appleton <i>et al.</i> ¹⁰
11-15	71	209.86±187.01 ^a	Bakkar <i>et al.</i> ¹¹ , Bezjian <i>et al.</i> ¹² , Brack ¹³ , Hope <i>et al.</i> ¹⁴ and Landsoud-Soukate <i>et al.</i> ¹⁵
16-20	74	198.65±162.403 ^a	Müller-Graf <i>et al.</i> ¹⁶ , Munene <i>et al.</i> ¹⁷ , Nath <i>et al.</i> ¹⁸ , Lim <i>et al.</i> ¹⁹ and Opara <i>et al.</i> ²⁰
21-25	23	236.96±151.877 ^a	Mutani <i>et al.</i> ²¹ , INS ²² , Gillespie <i>et al.</i> ²³ , Wendi ²⁴ and Zajac and Conboy ²⁵
26-30	13	138.46±200.16 ^a	Clingerman and Summers ²⁶ , IACUC ²⁷ , Adetunji ²⁸ , Akinboye <i>et al.</i> ²⁹ and Troncy and Chartier ³⁰
31-35	2	175.00±247.4879 ^a	Kouassi <i>et al.</i> ³¹ , McGrew <i>et al.</i> ³² , Howells <i>et al.</i> ³³ , Ashford <i>et al.</i> ³⁴ and Krief <i>et al.</i> ³⁵
p-value	0.63		
Sex			
Female	130	188.85±172.23 ^a	
Male	176	217.90±170.31 ^a	
p-value	0.14		
Body condition score			
1.5	3	516.67±301.38 ^a	
2	22	313.64±123.94 ^a	
2.5	67	197.01±176.77 ^b	
3	201	189.55±165.22 ^b	
p-value	0.00		
Species			
Drill	24	150.00±145.96 ^a	
Mandrill	18	177.78±155.509 ^{ab}	
Olive baboon	45	243.33±149.396 ^b	
Red cap mangabey	15	156.67±153.375 ^{ab}	
Gorilla	24	108.33±109.014 ^a	
Chimpanzee	73	149.32±178.048 ^a	
Putty nosed monkey	21	195.24±150.752 ^{abc}	
Mona monkey	11	190.91±189.497 ^{abc}	
Red eared monkey	1	350.00±0 ^{abc}	
Preus monkey	1	0.00±0 ^{abc}	
Agile mangabey	13	215.39±146.322 ^{abc}	
Patas monkey	18	341.66±180.888 ^d	
Tantalus monkey	20	387.50±151.83 ^e	
Gray cheeked mangabey	4	287.50±125.0 ^{bc}	
Debrazza monkey	5	340.00±96.177 ^{fc}	
Moustache monkey	1	350.00±0 ^{abc}	
p-value	0.00		

^{a-f}Significant difference between variables (p<0.05)

Table 4: Enhancing risk factors with respect to the parasitic load of NHP

Factors	Frequency	EPG
Housing		
Satellite	73	226.71±156.56 ^a
Enclosure	83	205.42±171.20 ^a
Both	97	146.39±161.09 ^{bd}
Cage	32	339.06±80.91 ^c
Out	5	280.00±174.35 ^{abc}
Maternal care	4	0.00±0 ^d
p-value	0.00	
Category		
Zoo	80	306.25±162.46 ^a
Sanctuary	128	187.89±128.89 ^b
Rehabilitation centre	86	133.72±175.09 ^c
p-value	0.00	

^{a-d}Significant difference between variables (p<0.05)

captive site differed significantly (p<0.05) with EPG. More precisely, the mean EPG of NHP living in satellites was significantly higher (p<0.05) than that of those individuals in satellite+enclosure and under maternal care (0±0). Also, the EPG of NHP living in cages (339.06±80.91) was

significantly higher than that of individuals living in enclosure (205.42±171.20) and those under maternal care. Based on the category of captive sites, the mean EPG of NHP found in zoos (306.25±162.46) was significantly higher than that of those found in the sanctuary (187.89±128.89) and the rehabilitation centre (133.72±175.09). The NHP group size and density increased with parasitic load (Table 4).

DISCUSSION

The overall prevalence of gastrointestinal parasites of captive NHP in Cameroon was 62.5%. This infection rate is similar to that of the Agodi Zoological Garden and University of Ibadan Zoological Garden²⁸. A similar prevalence was reported in NHP at UIZG by Akinboye *et al.*²⁹ and in a zoological garden in Kenya¹⁷. This high prevalence shows that tropical environments are favourable for gastrointestinal

parasites³⁰. This prevalence was higher in GZ (95.0%) and MZBG (82.9%) as compared to LWC (50.6%) and MPS (58.2%). The difference in prevalence could be explained by the poor management procedure in GZ and MZBG compared to LWC and MPS.

Two species of Amoeba were found (*Entamoeba coli* and *Entamoeba histolytica*) with *Entamoeba coli* being more prevalent. Munene *et al.*¹⁷ found that *Entamoeba coli* was cosmopolitan. The work done by Kouassi *et al.*³¹ on NHP in Tai National Park in Cote D'ivoire showed that Amoebae was found in all seven NHP taxa and relatively high prevalence was recorded. Several studies have highlighted amoebae in African NHP (*Entamoeba coli*, *E. histolytica*, *E. dispar* and *Iodamoeba butschlii*)³¹. *Balantidium coli* were the most prevalent parasite and were found in the 4 captive sites where it had the following prevalence: GZ (15.0%), MZBG (28.0%), LWC (10.7%) and MPS (20.0%). This is in line with the report of Kouassi *et al.*³¹ who found that *B. coli* is widely distributed in NHP. *Balantidium coli* were most prevalent in baboons. This high prevalence in baboons is similar to the result of Kouassi³¹ where a high prevalence was recorded in baboons of Mole National Park, Ghana. *Troglodytella abressarti* was the least prevalent and was found only in chimpanzees (1.7%) and in LWC (2.7%) and MPS (1.8%). This low prevalence is like that of savanna chimpanzees at Mt. Assirik³² and Fongoli³³ as well as in some forest-dwelling communities like Kibale in Uganda³⁴⁻³⁵ and Gombe in Tanzania³⁶. Also, commensal ciliates (*Troglodytella abressarti* and *Troglocorys cava*) were found to be ubiquitous inhabitants of the chimpanzee colonic ecosystem³⁷⁻³⁸. *Giardia lamblia* was present only in 2 captive sites and in two NHP species i.e., in Gorilla (2.7%) in LWC and in Mandrill (2.9%) in MZBG. This low prevalence is contrary to that of Kouassi *et al.*³¹, who found high prevalence of *Giardia* sp. in wild *Colobus* in Ghana. He also found high *Giardia* infection in NHP living in disturbed forest or human encroached environments. The low prevalence in captivity compared to the wild could be due to the implementation of bio-security measures in the former than in the latter.

Trichuris sp., *Strongyloides* sp. and *Ancylostoma* sp. were the most abundant nematodes in captive NHP. This is similar to the results found in Cameroonian wild and pet monkeys by Pourrut *et al.*³⁹. *Trichuris* sp. was the most prevalent nematode (12.9%) and was present in all the 4 captive sites. This is in agreement with the findings of Akinboye *et al.*²⁹, Munene *et al.*¹⁷, Nath *et al.*¹⁸ and Dawet *et al.*¹. Worms of the genus *Trichuris* are common parasites of baboons and Tantalus monkeys¹⁰. A comparative study on *Colobus* species exhibited a very high prevalence of *Trichuris* sp., such as that found in NHP of Boabeng-Fiema

in Ghana and Kibale Forest in Uganda¹⁰. This confirms the wide spread range of *Trichuris* sp. The NHP are known to be the major hosts of *Strongyloides stercoralis* especially *S. fuelleborni*⁴¹. This explains why *Strongyloides* sp. was the second most prevalent nematode after *Trichuris trichura*. This result was similar to that reported by Akpan *et al.*³. In addition, *Strongyloides* sp. was predominant in the work done by Kouassi¹ on the Taï Forest primates.

Hookworms (*Ancylostoma duodenale*, *Necator americanus*) are transmitted transcutaneously by infectious larvae, which are abundant in the gastrointestinal tract of monkeys³⁹. This explains the low prevalence of *Ancylostoma* sp. and the reason why it was present only in captive sites of humid regions like LWC, MPS and MZBG. *Enterobius* sp. and *Toxocara* sp. were the least prevalent nematodes. *Enterobius* sp. was found in LWC and MZBG. *Toxocara* sp. was found only in GZ in a Patas and Tantalus monkey. This result is similar to that of Drakulovski *et al.*⁴⁰.

Schistosoma sp. was the only trematode found in the present study and found only in GZ in a stray Patas monkey. This is similar to the work carried out by Ratard *et al.*⁴¹ and reported that *S. mansoni* was found in a pet monkey (*Erythrocebus patas*) living in Yaoundé. They explained that this monkey was probably infected in northern Cameroon, where this parasite is endemic. Since this parasite requires an intermediate snail host to complete its lifecycle, the stray monkey must have acquired it from the water pond that was found behind the zoo. However, this finding supports the potential role of primates in the transmission and maintenance of schistosomiasis¹⁶.

The cestodes encountered were *Taenia* sp. found in 3 captive sites LWC, MPS, MZBG and *Bertiella* sp. found only in GZ. This result is similar to that of Gillespie *et al.*²³ in NHP of Uganda and in the Cameroonian pet and bush primates by Pourrut *et al.*³⁹. Since the Northern region of Cameroon is highly populated with cattle and small ruminants and considering the fact that they have lots of mites and ticks, this might have led to the presence of *Bertiella* sp. in GZ as their intermediate host are mites. *Bertiella* sp. was also found in Uganda primates²³ and in Cameroon pet and wild primates³⁹.

There was no significant difference between the EPG of males and females. This result concurs with that of Mbora and Munene *et al.*¹⁷, who found that sex did not influence parasitic load. Those with a lower BCS (1.5 and 2) had a higher EPG (516.67±301.38 and 313.64±123.94, respectively) compared to those with higher BCS (2.5 and 3) (197.01±176.77 and 189.55±165.22). The finding of Olsen⁴², Chapman *et al.*⁴³ and Tompkins *et al.*⁴⁴ confirmed that animals with poor BCS are heavily parasitized than individuals with good BCS. Guenons and mangabeys had a higher EPG as

compared to that of other primate species. This could be due to their high degree of sociality and grooming⁴⁵. Unlike apes these species do not have self-medication instinct⁴⁶. This explains why apes like Gorilla (108.33 ± 109.01) and chimpanzee (149.32 ± 178.05) had a lower EPG. Regarding the housing of NHPs, those under maternal care and satellites+enclosures alternated eating, defecating and sleeping sites⁴⁷. This explains their low parasitic load as compared to those confined in satellite and cages.

The category of captive sites had a great effect on the parasitic load. The EPG of NHP in the sanctuary (187.89 ± 128.89) and that of those in the rehabilitation centre (133.72 ± 175.09) were significantly lower as compared to those in zoos (306.25 ± 162.46). In sanctuaries, NHP are conserved in a natural milieu and they have the opportunity to express certain aspects of their natural behaviours. NHP may avoid gastrointestinal parasites through a variety of behaviours involving movement patterns⁴⁸, alternating sleeping sites⁴⁹ and use of different defecation sites that reduce subsequent exposure to parasites⁵⁰. Self-medication habit in some NHP aid in the control of intestinal nematodes and tapeworms or provide relief from related gastrointestinal upset, or both⁴⁶. The positive correlation found between EPG and density indicated that an increase in NHP population density led to an increase in the intensity of parasitism. This confirms the work of Stuart and Strier⁵¹, who found a higher prevalence of intestinal parasites in howler monkeys (*Alouatta palliata*) in a dense population than a less dense one. Similarly, Nunn and Altizer⁵² found that population density was an important predictor of protozoan and viral parasite diversity.

CONCLUSION

The overall gastrointestinal parasites in 4 captive sites of Cameroon was 62.5%. Garoua zoo had the highest prevalence of gastrointestinal parasites, followed by Mvog-Betsi Zoo-Botanical Garden, then Mefou Primate Sanctuary and finally Limbe Wildlife Centre. Among the 16 captive NHP species, 16 parasite species were diagnosed. *Balantidium coli* was the most prevalent parasite, *Trichuris trichura* was the most prevalent nematode, *Taenia* sp. was the most prevalent Cestode and *Schistosoma* sp. was the only trematode. These parasites were more prevalent in guenons and mangabeys. Mangabeys and guenons had the highest EPG (350 ± 0 and 387.5 ± 151.83) followed by papionines. It was observed that sex and age had no influence on the EPG, whereas body condition score decreased with increase in EPG. The EPG differed with the species of NHP. An increase in group size and density led to an increase in the EPG. Housing of NHP and category of captive site differed with EPG.

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SIGNIFICANT STATEMENTS

This study discovered 16 species of helminths in NHPs that influenced their health and reducing the burden of these parasites is beneficial for their conservation. This study will help the researcher to uncover the critical areas of ecological parasitology of NHPs that many researchers were not able to explore. Thus a new theory on parasite co evolution in NHPs may be arrived at.

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