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# Prevalence and diversity of gastrointestinal parasites in primates at the JACK Sanctuary, Democratic Republic of Congo

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This study was conducted from April to July 2024 at the JACK Sanctuary in Lubumbashi (DRC), to determine the prevalence and diversity of gastrointestinal parasites among resident primates. A total of 150 fecal samples were collected from a population of 241 primates (45 chimpanzees and 196 other primates of different species). Coprological analyses, performed using direct examination and flotation techniques, revealed the presence of five parasite species: *Balantidium coli*: 26/150 (17.3%), *Strongyloides stercoralis*: 16/150 (10.7%), *Trichuris trichiura*: 8/150 (5.3%), *Ascaris lumbricoides*: 3/150 (2.0%), and *Capillaria hepatica*: 1/150 (0.67%). The results highlight a higher prevalence of protozoa compared to nematodes, underscoring the need to strengthen hygiene measures, implement regular veterinary monitoring, and adopt rational antiparasitic use to limit transmission and prevent resistance.

**Keywords:** Primates, gastrointestinal parasites, prevalence, JACK Sanctuary, Democratic Republic of Congo

## INTRODUCTION

Gastrointestinal parasites constitute a substantial part of global biodiversity and play key ecological roles by influencing host population dynamics and individual health. As highlighted by Vaumourin et al., (2015), parasite–host interactions are fundamental drivers of parasite community structure and can profoundly impact host demography. Beyond their direct pathogenic effects, parasites are deeply integrated into trophic networks and act as regulators of ecosystem functioning, a role emphasized in recent reviews describing parasites as “integrators of ecosystem health” (Dunn et al., 2023). Furthermore, parasites represent a considerable proportion of global biodiversity, yet remain largely neglected in conservation planning, despite evidence that they shape both population-level and community-level processes (Carlson et al., 2017).

In primates, these parasites can have significant health impacts, ranging from loss of body condition to mortality, and also represent a considerable zoonotic risk (Boundenga et al., 2021). Captive primates, particularly in sanctuaries and zoos, are especially exposed to parasitic infections. Captivity conditions, crowding, the diversity of animals’ geographic origins, and inter-individual interactions favor parasite transmission (Lacerda et al., 2023). Some protozoan and

nematode species can persist in the environment for long periods, making their control complex (Ferdous et al., 2023).

At the JACK Sanctuary in Lubumbashi, Democratic Republic of Congo, chimpanzees and various monkeys confiscated from illegal trade or orphaned are housed. The high species diversity and number of individuals create favorable conditions for the circulation and maintenance of gastrointestinal parasites.

In this context, this study was conducted to document, for the first time, the prevalence and diversity of gastrointestinal parasites in primates at the JACK Sanctuary through coprological analyses, and to provide baseline data for control and prevention strategies.

The general objective of this study was to contribute to improving the health and welfare of primates at the JACK Sanctuary through better knowledge of their gastrointestinal parasitofauna. Specifically, it aimed to:

• Identify the primate species present in the sanctuary;

• Determine the types of gastrointestinal parasites present in these primates;

• Assess overall and species-specific parasite prevalence;

• Compare parasite frequency across primate groups.

# MATERIAL AND METHODS

**Study setting**

The study was carried out at the "Jeunes Animaux Confisqués au Katanga (JACK)" Sanctuary, located within the Lubumbashi Zoological Garden, in the capital of Haut-Katanga Province, Democratic Republic of Congo. The sanctuary was created in 2006 at the initiative of Frank and Roxane Chanterau, in collaboration with the Congolese Institute for Nature Conservation (ICCN) and the Ministry of the Environment.

Originally intended to accommodate only confiscated chimpanzees, JACK became in 2021 a rehabilitation center for various species of primates confiscated from illegal trade or orphaned. Its main missions are:

• To combat the illegal trafficking of primates;

• To provide appropriate housing and care for confiscated individuals;

• To reintroduce rehabilitated animals into their natural habitat.

The sanctuary is located in the CW6 climatic zone (Leblanc and Malaisse, 1978) at the following GPS coordinates: Latitude: S 11°40’8.74” (–11.669094); Longitude: E 27°28’36.12” (27.476700).

**Study design and period**

This was a descriptive and analytical epidemiological cross-sectional study conducted from April to July 2024, corresponding to the dry season in the region.

**Population and sampling**

The target population included all primates housed at the sanctuary during the study period.

In total, 241 individuals were recorded, including 45 chimpanzees (Pan troglodytes) and 196 other primates belonging to various species (Table 1).

A total of 150 fecal samples were collected using a stratified random sampling method to proportionally represent the different species present.

Inclusion criteria: primates in apparent good health, present at the sanctuary for at least three months, and not having received antiparasitic treatment within the six months preceding the study.

Exclusion criteria: primates with severe pathology or under medical treatment at the time of the study.

**Sample collection and laboratory analyses**

Fecal samples were collected in the night enclosures after the animals had been released into the day enclosures, using sterile spatulas. Samples were then placed in sterile containers and immediately transported to the laboratory.

Macroscopic examination: evaluation of consistency, color, and the presence of blood or mucus in the feces.

Microscopic examination: direct smears (saline solution) and flotation technique using saturated NaCl were performed to identify parasitic eggs, larvae, and cysts (Thienpont et al., 2003).

**Data analysis**

Data were entered and processed using Excel 2016. A descriptive analysis with 95% confidence intervals (CI) was performed to estimate the prevalence of parasitic infections according to animal categories.

# RESULTS

**Primate species recorded**

A total of 241 primates were recorded at the JACK Sanctuary during the study period, including 45 chimpanzees (Pan troglodytes) and 196 other primates belonging to various species. Adults represented 60.6% of the population, juveniles 19.1%, and infants 20.3% (Table 1).

**Parasites identified by primate group**

Coprological analyses identified five species of gastrointestinal parasites: Balantidium coli, Strongyloides stercoralis, Trichuris trichiura, Ascaris lumbricoides, and Capillaria hepatica. The distribution by primate group is presented in Table 2.

**Overall prevalence of the identified parasites**

The results presented below correspond to the coprological analysis of 150 fecal samples collected from primates at the JACK Sanctuary (Lubumbashi, DRC). Prevalence was calculated as the ratio of the number of positive cases to the total sample size (n = 150). Ninety-five percent confidence intervals (95% CI) were estimated using Wilson’s method.

Prevalence (Tables 3 and 4) is expressed as the number of positive samples divided by the total

examined (n = 150). Prevalence values are calculated based on 150 samples, confidence intervals (95% CI) were calculated using Wilson's method. The column "Share among observed positives" indicates the relative proportion of each parasite among all positive detections (n = 54).

The minimum value assumes that all detected parasites occurred in the same individuals (i.e., complete overlap of infections). The maximum value assumes no co-infections (each parasite detected in a different individual). The true prevalence of "at least one parasite" value lies between these two extremes.

**Analysis and Interpretation**

The high prevalence of B. coli (≈17%) suggests significant oro-fecal transmission within the sanctuary environment, likely linked to crowding and contamination of surfaces or food.

S. stercoralis (≈11%) indicates the persistence of nematodes, consistent with environmental survival and soil contact. As the second most frequent parasite, it reflects a transmission cycle favored by moist soils and the prolonged survival of infective larvae in the environment.

T. trichiura (≈5%), although less common, points to older infestations due to its longer developmental cycle in the external environment.

The low frequencies of A. lumbricoides and C. hepatica may reflect either sporadic transmission or partial effectiveness of hygiene measures and deworming programs.

Some primate species (e.g., C. mitis, E. patas) showed no detectable parasitic infection, possibly due to more arboreal behavior reducing exposure to contaminated sources.

# DISCUSSION

This study highlights moderate gastrointestinal parasitic diversity among primates at the JACK Sanctuary, with relatively high prevalence for some species, notably Balantidium coli (17%) and Strongyloides stercoralis (11%).

**Intensity and distribution among primate species**

The predominance of B. coli is consistent with findings from other captive primate populations in Central Africa and Asia (Boundenga et al., 2021; Ma et al., 2024), where protozoa often surpass nematodes in prevalence. This may be explained by their simple life cycle and immediate infectivity upon excretion (Medkour et al., 2021).

The relatively high frequency of S. stercoralis aligns with environmental studies showing that post-excretion larvae can survive and reproduce in the environment, thereby contributing to indirect reinfection (White, 2019). Conversely, studies conducted in open environments such as safari parks (Kvapil et al., 2017; Martin et al., 2017) report higher prevalence of nematodes than protozoa, likely due to ecological conditions more favorable to indirect life cycles.

Across sanctuaries and ex-situ facilities, parasite profiles vary widely with management, climate, host composition, and diagnostics. In two captive chimpanzee populations in southeastern Gabon, a high parasite diversity was reported multiple nematodes (Ascaris, Enterobius, Strongyloides, Trichuris, Hymenolepis, etc.) plus protozoa (Balantioides/Entamoeba/Troglodytella) underscoring sustained exposure in confined settings (Boundenga et al., 2021). By contrast, a recent survey at Gabon's primatology center found very high overall prevalence (≈94%), attributing the surge partly to a two-year deworming lapse highlighting how treatment gaps can rapidly change epidemiology.

Outside Central Africa, patterns also diverge. In captive capuchins and free-ranging groups from the western Amazon (Ecuador), overall prevalence reached 84%, with Strongyloides dominating; serial sampling increased detection, arguing for repeated fecal testing in management plans (Martin et al., 2017). In Asian facilities, large series from China show lower composite prevalence in some captive collections (e.g., 26.5% overall; Trichuris often predominant), illustrating how climate, housing, and routine prophylaxis can suppress transmission relative to high-burden sites (Ma et al., 2024). Long-term zoo monitoring in Europe similarly emphasizes routine surveillance and interspecies transmission risks in mixed-species exhibits, supporting strict hygiene and enclosure-level biosecurity (Kvapil et al., 2017).

Regarding protozoa versus nematodes, our finding that Balantidium/Balantioides coli features prominently aligns with reviews noting this ciliate as one of the most frequent zoonotic protozoa reported in NHPs and capable of severe disease in great apes reinforcing the need for fecal management and water/food control (Medkour et al., 2021). Conversely, Strongyloides tends to persist under diverse conditions due to autoinfection and favorable microclimates; global syntheses tie higher prevalence to moderate humidity and tropical wet-dry climates, consistent with year-round risk even when rainfall is seasonal (Steinbaum et al., 2016).

**Influence of ecological and behavioral factors**

Differences in parasite prevalence between primate species appear to be strongly linked to their lifestyle and environmental interactions. Arboreal species, such as Cercopithecus mitis, may have a reduced risk of exposure to soil-transmitted helminths due to less frequent ground contact, which helps explain the absence of detectable infections in some groups. Similar patterns have been reported in field studies, where reduced terrestrial activity or exclusive arboreality correlates with lower prevalence of soil-transmitted parasites (Bezjian et al., 2008). In contrast, Erythrocebus patas is predominantly terrestrial, and its low prevalence in the present study likely reflects enclosure management factors, recent treatments, or limited sample size rather than arboreality per se. Comparative research across African sites has shown that microhabitat use, ranging patterns, and feeding behaviors are key determinants of parasite exposure in primates (Gillespie et al., 2005).

High population density within enclosures and the use of shared feeding or resting areas may facilitate the transmission of directly transmitted parasites. These factors have been consistently identified as significant risk contributors in epidemiological studies conducted across zoological institutions. For instance, Vonfeld et al., (2022) found that high animal density within enclosures and participation in research protocols significantly increased infection risk, whereas quarantine and antiparasitic treatments had protective effects.

Crowding increases contamination of soil and water, creating hotspots for infection. For instance, Balantidium coli transmitted fecal-orally via contaminated food and water has been repeatedly associated with inadequate sanitation and pooled water in captive primate enclosures (Schuster and Ramirez, 2008). Similarly, Trichuris trichiura requires embryonation of eggs in the environment; thus, fecal contamination of shared substrates significantly increases the likelihood of transmission in confined spaces (Bethony et al., 2006).

Zoo-based surveys further confirm that Old World monkeys tend to show higher gastrointestinal parasite prevalence compared to other primate groups, reflecting both biological susceptibility and husbandry practices (Chapman et al., 2005). Multi-site reviews also demonstrate that protozoa often dominate over helminths in captive contexts, underscoring the role of water and food hygiene in parasite transmission (Boundenga et al., 2021).

These findings reinforce that ecological traits (arboreality, terrestriality, social behavior) and management conditions (density, hygiene, enclosure design) jointly shape parasite exposure risks. In practice, limiting crowding, enforcing vacancy periods, improving cleaning protocols, and controlling access to shared feeding/water points represent key strategies to reduce transmission

within sanctuaries.

**Seasonality and environmental persistence**

The study period (April–July, dry season) may have influenced the observed parasitic profiles. Indeed, Strongyloides stercoralis has been documented to maintain endogenous autoinfective cycles, allowing persistence throughout the year, regardless of external environmental conditions (Shao et al., 2023). Similar observations have been reported by Steinbaum et al., (2016) in rural Kenya, where S. stercoralis prevalence remained relatively stable across seasons due to the parasite's capacity for internal autoinfection and its adaptation to moist microenvironments within enclosures.

Conversely, Trichuris trichiura requires a warm and humid environment for embryonation of eggs in the soil before becoming infective, which often restricts its transmission during dry periods (Bethony et al., 2006). For example, Jourdan et al., (2018) demonstrated that soil-transmitted helminths show significant seasonal variation in tropical ecosystems, with T. trichiura prevalence increasing during rainy seasons due to favorable moisture conditions for egg maturation. These findings are consistent with the lower prevalence observed in this study during the dry season in Lubumbashi.

Seasonality is heterogeneous across settings. While many STHs (e.g., Trichuris/Ascaris) peak with higher soil moisture and rainfall (Jourdan et al., 2018), other datasets show dry-season peaks in specific locales likely reflecting behavior, soil conditions, and sanitation so local monitoring remains essential (Bethony et al., 2006).

Finally, the detection of Capillaria hepatica at JACK, albeit rare, is epidemiologically meaningful: rodents are primary hosts and environmental stages can persist, so rodent control and habitat hygiene are warranted alongside staff training (Fuehrer et al., 2011).

**Implications for animal health and sanctuary management**

The presence of zoonotic parasites such as Balantidium coli, S. stercoralis, and Ascaris lumbricoides represents an important occupational risk for sanctuary staff and even visitors. This zoonotic potential has been highlighted in several studies on non-human primates in captivity, notably by Ekanayake et al., (2006) in Sri Lanka, where primate handlers showed higher exposure rates to intestinal parasites compared to the general population. Similarly, Mbaya et al., (2011) in Nigeria reported zoonotic transmission of gastrointestinal parasites between primates and humans in zoological gardens.

Reinforced hygiene measures including regular disinfection of enclosures, monitoring of food and water hygiene, and rational antiparasitic protocols are considered essential to prevent cross-species transmission (Ryan and Cacciò, 2013). The detection of Capillaria hepatica, albeit at low frequency, further raises concern, as this parasite has been associated with sylvatic cycles involving rodents and can indicate indirect transmission pathways (Fuehrer et al., 2011). This suggests the need for broader ecological surveillance beyond the primates themselves.

Moreover, regular veterinary monitoring and systematic staff training in biosecurity are critical to reducing the risk of gastrointestinal parasite outbreaks in sanctuaries such as JACK. Experiences from accredited zoos worldwide highlight that staff awareness of parasite life cycles, transmission routes, and sanitation protocols greatly limits cross-contamination. The Association of Zoos and Aquariums (AZA), for instance, mandates standardized quarantine, disinfection, and hygiene measures combined with continuous staff education as a cornerstone of preventive health management (NASPHV, 2023; AZA Secure Zoo Strategy, 2019). Applying similar frameworks in JACK would strengthen parasite control, protect animal welfare, and reduce zoonotic risk for personnel and visitors. Nyokabi et al., (2024) emphasize that enhancing veterinary personnel's

awareness of zoonotic transmission, including parasite life cycles and infection control practices, is essential for preventing occupational and cross-species infections.

Implication for JACK: Compared with high-burden African and Neotropical sites, JACK's profile (protozoa-skewed, with Strongyloides second) is plausible for an urban sanctuary in the dry season. Priorities that are consistently effective across facilities include regular fecal surveillance (ideally serial sampling), enclosure sanitation, controlled water/food chains, targeted deworming schedules, and rodent management, all backed by staff biosecurity training (Kvapil et al., 2017; Martin et al., 2017; AZA Secure Zoo Strategy, 2019; NASPHV, 2023; Nyokabi et al., 2024).

# CONCLUSION

This study, conducted at the JACK Sanctuary in Lubumbashi, documented the prevalence and diversity of gastrointestinal parasites among 241 captive primates. Among the five species identified, Balantidium coli and Strongyloides stercoralis were the most frequent, with prevalences of 17% and 11%, respectively.

These results highlight the importance of protozoa in the parasitofauna of captive primates and underline the need to:

• Strengthen hygiene and biosecurity measures;

• Implement regular veterinary monitoring; and

• Adopt rational antiparasitic use to limit transmission and prevent resistance.

Continuous surveillance and improved health management practices remain priorities to safeguard primate health and reduce zoonotic risks.

Ethics approval and consent to participate

Approved by JACK Sanctuary authorities. All procedures complied with animal welfare regulations.

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