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Clinical Diagnosis and Management of Diseases in Semi-Captive Bonobos (*Pan paniscus*) at Lola Ya Bonobo Sanctuary, Kinshasa, DRC

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ABSTRACT

The bonobo (*Pan paniscus*) is an endemic great ape of the Democratic Republic of Congo and is increasingly threatened by habitat loss, illegal hunting, and diseases. Veterinary surveillance in sanctuaries is therefore essential for conservation. This retrospective study describes the main clinical conditions diagnosed and managed in semi-captive bonobos at the Lola Ya Bonobo Sanctuary (Kinshasa, DRC) between 2020 and 2023. Clinical records from the sanctuary veterinary service were reviewed, and disease frequencies were analyzed by year and age class. A total of 358 clinical cases were recorded. Gastrointestinal disorders, particularly diarrhea, predominated in 2020 and 2022, whereas respiratory conditions, mainly cough, were most frequent in 2021 and 2023. Juveniles (0-8 years) were consistently the most affected age group. Treatments relied primarily on human pharmaceutical products adapted for veterinary use, and all affected bonobos recovered, with no mortality recorded during the study period. These findings highlight the importance of continuous clinical monitoring and appropriate therapeutic management for the health and conservation of bonobos, such

INTRODUCTION

The Congo Basin harbors one of the richest biodiversity worldwide, and the Democratic Republic of Congo (DRC) alone contains a remarkable diversity of primate species, including three great apes: *Gorilla beringei*, *Pan troglodytes*, and *Pan paniscus* (Oates, 2013; Fruth & Hohmann, 2006). The bonobo (*Pan paniscus*) is endemic to the DRC and restricted to forested areas south of the Congo River (Fruth & Hohmann, 2006). Despite legal protection at national and international levels, bonobo populations continue to decline due to habitat destruction, poaching, armed conflicts, and emerging infectious diseases (Hohmann & Fruth, 2003; Leendertz *et al.*, 2006; Daszak *et al.*, 2000). Infectious diseases are increasingly recognized as major drivers of population decline in great apes, sometimes acting synergistically with habitat loss and hunting pressure (Köndgen *et al.*, 2008; Leendertz *et al.*, 2016; Goldberg *et al.*, 2008). Human-wildlife interfaces, particularly in regions where bushmeat hunting and habitat encroachment occur, facilitate the emergence and transmission of zoonotic pathogens (Wolfe *et al.*, 2005; Cleaveland *et al.*, 2001; Karesh *et al.*, 2012).

Sanctuaries play a crucial role in great ape conservation by rescuing and rehabilitating confiscated individuals; however, they also present unique epidemiological challenges due to close contact between animals, humans, and the environment (Woodford *et al.*, 2002; Sleeman *et al.*, 2010; Wolf *et al.*, 2014). Previous studies have documented gastrointestinal and respiratory infections in both captive and free-ranging primates, often linked to anthroponotic transmission (Graczyk *et al.*, 2002;

Nizeyi *et al.*, 2002; Chapman *et al.*, 2006). Veterinary surveillance and clinical management are therefore essential components of conservation medicine and One Health approaches (WHO, 2017; Pedersen & Fenton, 2007; Ryan *et al.*, 2013). This study presents a four-year retrospective analysis of clinical conditions diagnosed and managed in semi-free-ranging bonobos at Lola Ya Bonobo Sanctuary, to contribute to improved disease surveillance, veterinary care, and conservation strategies for this endangered species.

MATERIAL AND METHODS

Study Area

The study was conducted at the Lola Ya Bonobo Sanctuary, located in Mont-Ngafula, Kinshasa, DRC. Founded in 1994, the sanctuary is the only facility worldwide dedicated exclusively to the rescue and rehabilitation of orphaned bonobos confiscated from illegal wildlife trade. Bonobos live in socially structured groups under semi-captive conditions within forested enclosures.

Study Design and Data Collection

A retrospective study design was adopted. Clinical records from January 2020 to December 2023 were reviewed. Data were extracted from individual medical files, veterinary treatment registers, and semi-structured interviews with veterinary staff. Recorded variables included year of diagnosis, type of pathology, age class (juvenile: 0-8 years; subadult: 9-14 years; adult: ≥ 15 years), sex, and treatment administered.

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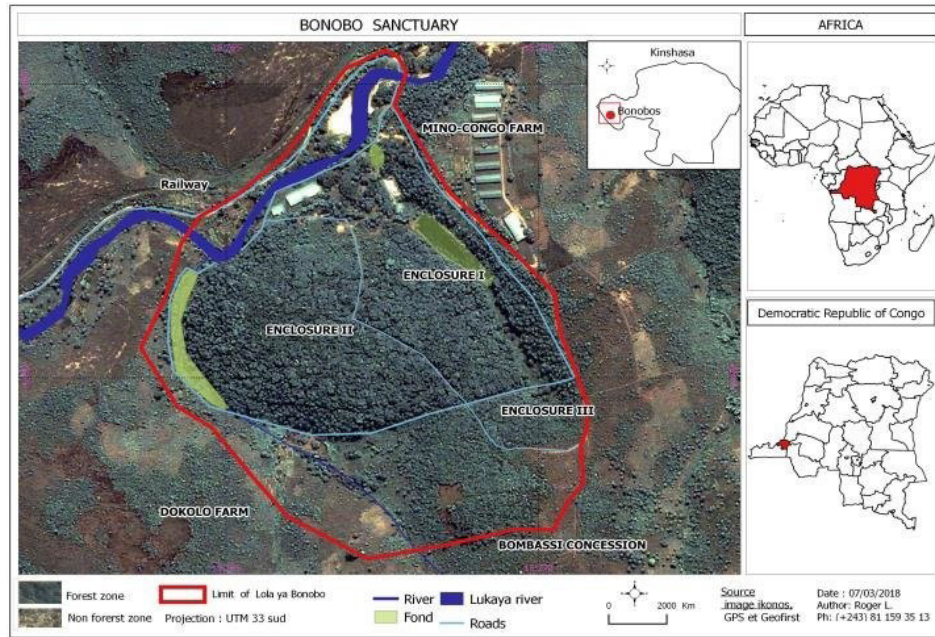


Figure 1: Lola ya bonobo sanctuary location

Data Analysis

Descriptive statistics were used to summarize disease occurrence by year and age class. Prevalence was calculated as the proportion of affected individuals relative to the total number examined and expressed as a percentage. Because of small and uneven sample sizes and the categorical nature of the data, inferential analyses were limited. Differences in the occurrence of dominant clinical conditions between age classes were assessed using Fisher’s exact test. Temporal trends in the distribution of major clinical conditions across years were evaluated using Spearman’s rank correlation test, with

year treated as an ordinal variable. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Annual Distribution of Clinical Cases

A total of 358 clinical cases were recorded at Lola Ya Bonobo Sanctuary between 2020 and 2023. The annual number of cases fluctuated over the study period, with 78 cases in 2020, 94 in 2021, 88 in 2022, and 98 in 2023. Despite this variability, the cumulative number of reported cases increased steadily throughout the study period, reaching 358 cases by 2023.

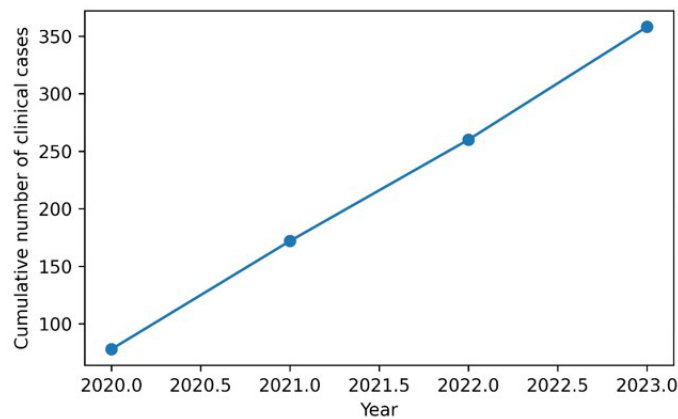


Figure 2: Cumulative trend of clinical cases in semi-captive bonobos (*Pan paniscus*) at Lola Ya Bonobo Sanctuary (2020-2023). The line graph illustrates the progressive accumulation of clinical cases over the four-year study period, with values representing the cumulative number of diagnosed cases annually.

Table 1: Proportion of clinical diagnoses among bonobos at Lola Ya Bonobo Sanctuary according to age group and sex in 2020

Clinical diagnoses	Total n (%)	Juveniles (0-8 yrs) n (%)	Subadults (9-14 yrs) n (%)	Adults (≥15 yrs) n (%)	Males n (%)	Females n (%)
Cough	19 (24.4)	4 (21.1)	14 (73.7)	1 (5.3)	10 (52.6)	9 (47.4)

Common cold	5 (6.4)	0 (0)	4 (80.0)	1 (20.0)	3 (60.0)	2 (40.0)
Flu	3 (3.8)	3 (100)	0 (0)	0 (0)	1 (33.3)	2 (66.7)
Diarrhoea	21 (26.9)	14 (66.7)	5 (23.8)	2 (9.5)	11 (52.4)	10 (47.6)
Balantidium coli	1 (1.3)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)
Ankylostoma sp.	1 (1.3)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)
Conjunctivitis	6 (7.7)	2 (33.3)	4 (66.7)	0 (0)	3 (50.0)	3 (50.0)
Hyperthermia	4 (5.1)	0 (0)	4 (100)	0 (0)	0 (0)	4 (100)
Skin allergy	11 (14.1)	3 (27.3)	6 (54.5)	2 (18.2)	7 (63.6)	4 (36.4)
Deep wounds	1 (1.3)	0 (0)	0 (0)	1 (100)	1 (100)	0 (0)
Superficial wounds	3 (3.8)	1 (33.3)	0 (0)	2 (66.7)	3 (100)	0 (0)
Ringworm	2 (2.6)	0 (0)	0 (0)	2 (100)	2 (100)	0 (0)
Abscess	1 (1.3)	0 (0)	1 (100)	0 (0)	1 (100)	0 (0)
Total	78 (100)	27 (34.6)	38 (48.7)	13 (16.7)	42 (53.8)	36 (46.2)

Distribution of Clinical Conditions Sixteen distinct main clinical conditions were identified during the study period. Gastrointestinal disorders, particularly diarrhea, represented the most frequent conditions in 2020 and 2022, accounting for 26.9% and 32.1% of cases, respectively. In contrast, respiratory conditions, mainly cough, predominated in 2021 (28.7%) and 2023 (43.9%); respiratory conditions, mainly cough, predominated in 2021 (28.7%) and 2023 (43.9%); represented the most frequent conditions in 2020 Fig. 3).

Table 2: Proportion of clinical diagnoses among bonobos at Lola Ya Bonobo Sanctuary according to age group and sex in 2021

Clinical diagnoses	Total n (%)	Juveniles (0-8 yrs) n (%)	Subadults (9-14 yrs) n (%)	Adults (≥15 yrs) n (%)	Males n (%)	Females n (%)
Cough	27 (28.7)	6 (22.2)	16 (59.3)	5 (18.5)	12 (44.4)	15 (55.6)
Common cold	4 (4.3)	2 (50.0)	1 (25.0)	1 (25.0)	2 (50.0)	2 (50.0)
Flu	5 (5.3)	3 (60.0)	2 (40.0)	0 (0)	2 (40.0)	3 (60.0)
Diarrhea	22 (23.4)	14 (63.6)	5 (22.7)	3 (13.6)	12 (54.5)	10 (45.5)
Conjunctivitis	4 (4.3)	4 (100)	0 (0)	0 (0)	1 (25.0)	3 (75.0)
Skin allergy	13 (13.8)	4 (30.8)	8 (61.5)	1 (7.7)	5 (38.5)	8 (61.5)
Hyperthermia	6 (6.4)	2 (33.3)	4 (66.7)	0 (0)	2 (33.3)	4 (66.7)
Deep wounds	2 (2.1)	0 (0)	0 (0)	2 (100)	0 (0)	2 (100)
Superficial wounds	1 (1.1)	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)
Ringworm	5 (5.3)	0 (0)	3 (60.0)	2 (40.0)	4 (80.0)	1 (20.0)
Abscess	5 (5.3)	0 (0)	3 (60.0)	2 (40.0)	3 (60.0)	2 (40.0)
Total	94 (100)	36 (38.3)	42 (44.7)	16 (18.2)	44 (46.8)	50 (53.2)

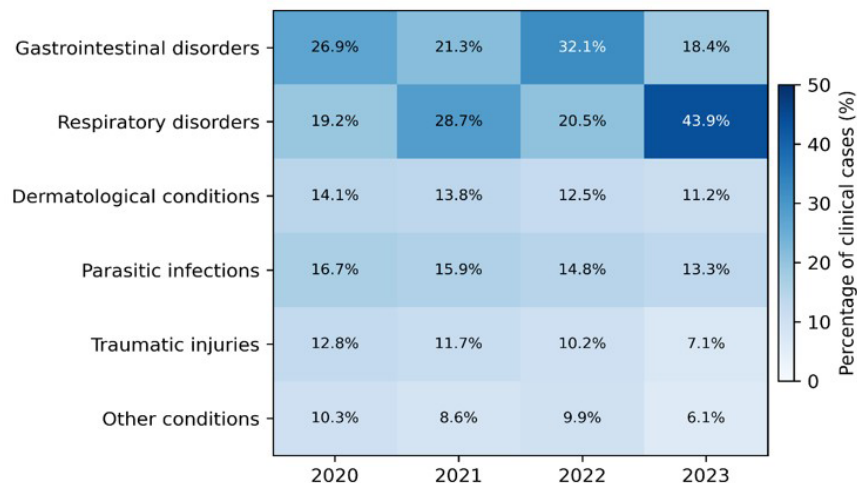


Figure 3: Heatmap showing the temporal distribution of major clinical conditions diagnosed in semi-captive bonobos at Lola Ya Bonobo Sanctuary between 2020 and 2023

Color intensity represents the percentage of main clinical cases recorded per year for each condition, with darker shading indicating higher proportions. Temporal trends in clinical conditions were assessed using Spearman's rank correlation test. A significant increasing trend was observed for respiratory disorders

over the study period ($p < 0.05$), whereas traumatic injuries showed a significant decreasing trend across years ($p < 0.05$). No statistically significant temporal trends were detected for gastrointestinal disorders, dermatological conditions, parasitic infections, or other clinical conditions ($p > 0.05$).

Table 3: Proportion of clinical diagnoses among bonobos at Lola Ya Bonobo Sanctuary according to age group and sex in 2022

Clinical diagnoses	Total n (%)	Juveniles (0-8 yrs) n (%)	Subadults (9-14 yrs) n (%)	Adults (≥ 15 yrs) n (%)	Males n (%)	Females n (%)
Cough	17 (19.3)	11 (64.7)	5 (29.4)	1 (5.9)	5 (29.4)	12 (70.6)
Common cold	2 (2.3)	1 (50.0)	1 (50.0)	0 (0)	1 (50.0)	1 (50.0)
Flu	3 (3.4)	3 (100)	0 (0)	0 (0)	1 (33.3)	2 (66.7)
Diarrhea	29 (32.1)	19 (65.5)	6 (20.7)	4 (13.8)	13 (44.8)	16 (55.2)
Balantidium coli	1 (1.1)	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)
Conjunctivitis	2 (2.3)	2 (100)	0 (0)	0 (0)	2 (100)	0 (0)
Hyperthermia	4 (4.5)	3 (75.0)	1 (25.0)	0 (0)	1 (25.0)	3 (75.0)
Skin allergy	2 (2.3)	0 (0)	2 (100)	0 (0)	0 (0)	2 (100)
Scabies	3 (3.4)	3 (100)	0 (0)	0 (0)	2 (66.7)	1 (33.3)
Deep wounds	6 (6.8)	0 (0)	2 (33.3)	4 (66.7)	4 (66.7)	2 (33.3)
Superficial wounds	4 (4.5)	0 (0)	0 (0)	4 (100)	3 (75.0)	1 (25.0)
Ascaris sp.	1 (1.1)	0 (0)	1 (100)	0 (0)	0 (0)	1 (100)
Ringworm	13 (14.8)	1 (7.7)	3 (23.1)	9 (69.2)	7 (53.8)	6 (46.2)
Abscess	1 (1.1)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)
Total	88 (100)	44 (50.0)	21 (23.9)	23 (26.1)	40 (45.5)	48 (54.5)

Age-Related Distribution of Diseases

Clinical conditions were unevenly distributed among age classes. Juvenile bonobos (0-8 years) consistently accounted for the highest proportion of cases across all

years, followed by subadults (9-14 years) and adults (≥ 15 years). Differences in disease occurrence between age classes were statistically significant for dominant clinical conditions (Fisher's exact test, $p < 0.05$).

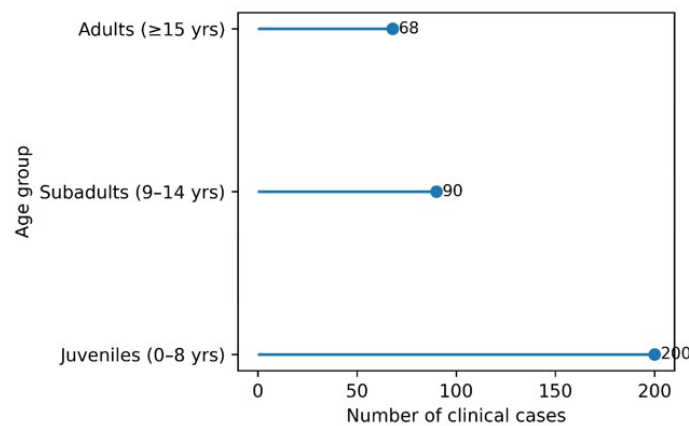


Figure 4: Distribution of clinical cases among age groups of semi-captive bonobos at Lola Ya Bonobo Sanctuary

Dots represent the number of recorded clinical cases per age group, with horizontal lines indicating the magnitude of cases in juveniles (0-8 years), subadults (9-14 years), and adults (≥ 15 years). The distribution of clinical cases differed significantly across age groups (Fisher's exact test, $p < 0.05$), with juveniles (0-8 years) more affected than subadults (9-14 years) and adults

(≥ 15 years). The significant association between age group and clinical case occurrence indicates that disease burden is unevenly distributed across age classes. Juveniles were disproportionately affected, suggesting increased vulnerability during early life stages, likely related to immunological immaturity and behavioral exposure.

Table 4: Proportion of clinical diagnoses among bonobos at Lola Ya Bonobo Sanctuary according to age group and sex in 2023

Clinical diagnoses	Total n (%)	Juveniles (0-8 yrs) n (%)	Subadults (9-14 yrs) n (%)	Adults (≥15 yrs) n (%)	Males n (%)	Females n (%)
Cough	43 (44.9)	22 (51.2)	10 (23.3)	11 (25.6)	18 (41.9)	25 (58.1)
Common cold	10 (10.2)	8 (80.0)	2 (20.0)	0 (0)	4 (40.0)	6 (60.0)
Flu	4 (4.1)	3 (75.0)	1 (25.0)	0 (0)	3 (75.0)	1 (25.0)
Diarrhoea	19 (19.4)	15 (78.9)	0 (0)	4 (21.1)	8 (42.1)	11 (57.9)
Troglodytella sp.	2 (2.0)	2 (100)	0 (0)	0 (0)	0 (0)	2 (100)
Conjunctivitis	2 (2.0)	2 (100)	0 (0)	0 (0)	1 (50.0)	1 (50.0)
Hyperthermia	10 (10.2)	9 (90.0)	1 (10.0)	0 (0)	3 (30.0)	7 (70.0)
Deep wounds	4 (4.1)	1 (25.0)	0 (0)	3 (75.0)	4 (100)	0 (0)
Superficial wounds	1 (1.0)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)
Ringworm	1 (1.0)	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)
Torticollis	1 (1.0)	1 (100)	0 (0)	0 (0)	0 (0)	1 (100)
Abscess	1 (1.0)	0 (0)	1 (100)	0 (0)	0 (0)	1 (100)
Total	98 (100)	64 (65.3)	15 (15.5)	19 (19.4)	42 (43.3)	56 (57.1)

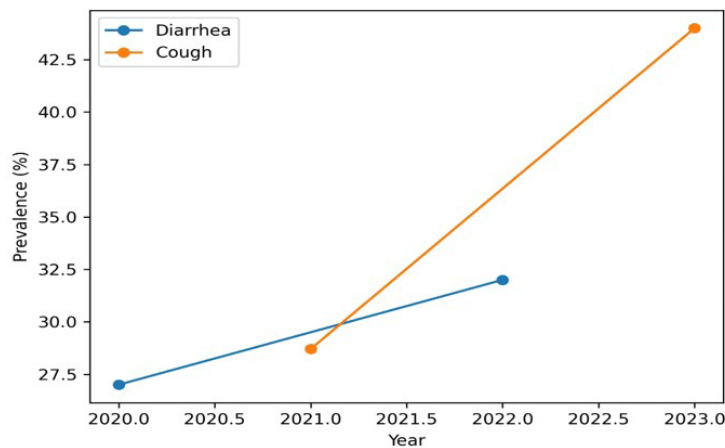


Figure 5: Temporal variation in the prevalence of diarrhea and cough in semi-captive bonobos (2020-2023)

The line graph illustrates annual changes in the prevalence (%) of diarrhea and cough, the two most frequently diagnosed clinical conditions during the study period.

Treatment Outcomes

All diagnosed cases were managed through appropriate veterinary interventions based on clinical assessment. Treatment protocols primarily involved pharmaceutical products of human origin adapted for veterinary use, including antibiotics, antiparasitic agents, antipyretics, and supportive therapies. Laboratory analyses were rarely used to confirm diagnoses, and clinical decision-making relied mainly on observed signs and symptoms. Despite this limitation, clinical response to treatment was favorable in all cases, with complete recovery observed and no mortality recorded during the study period.

Discussion

This study provides a four-year overview of clinical conditions affecting semi-free-ranging bonobos at Lola Ya Bonobo Sanctuary. The predominance of

gastrointestinal and respiratory disorders observed is consistent with findings from other studies conducted in great ape sanctuaries and free-ranging primate populations (Chapman *et al.*, 2006; Gillespie, 2006; Makouloutou *et al.*, 2014). Gastrointestinal parasites and enteric pathogens are among the most frequently reported health problems in non-human primates, particularly in environments with close human contact (Ashford & Crewe, 2003; Thompson, 2004). Respiratory diseases have been identified as a major threat to great apes, with several outbreaks linked to human respiratory viruses causing significant morbidity and mortality in wild populations (Köndgen *et al.*, 2010; Palacios *et al.*, 2011; Leendertz *et al.*, 2016). The temporal variation observed in this study, with alternating dominance of diarrhea and respiratory conditions, may reflect seasonal factors and fluctuations in pathogen circulation within surrounding human communities (McMichael, 2004; Altizer *et al.*, 2003). Juvenile bonobos were consistently the most affected age group, a pattern widely reported in primate health studies and attributed to immunological immaturity, behavioral

exposure, and nutritional transitions during early life stages (Gillespie & Chapman, 2008; Murray *et al.*, 2011). Similar age-related susceptibility has been documented in both captive and free-ranging primates (Terio *et al.*, 2011; Huffman, 2003).

The absence of mortality and the full recovery of all treated individuals highlight the effectiveness of the veterinary management protocols implemented at the sanctuary. Comparable outcomes have been reported in other well-managed great ape sanctuaries where early clinical intervention and appropriate treatment are applied (Sleeman *et al.*, 2010; Wolf *et al.*, 2014). The frequent use of pharmaceuticals of human origin is justified by the close genetic relationship between humans and bonobos; however, strengthening laboratory diagnostic capacity would further improve pathogen detection and long-term surveillance (Leendertz *et al.*, 2006; Calvignac-Spencer *et al.*, 2012). Overall, these findings underscore the importance of integrated veterinary care, continuous disease monitoring, and One Health approaches in the conservation of endangered primates (Hotez *et al.*, 2008; Salyer *et al.*, 2017; Haydon *et al.*, 2002).

CONCLUSION

This study provides a comprehensive overview of clinical conditions affecting semi-free-ranging bonobos at Lola Ya Bonobo Sanctuary over four years. Gastrointestinal and respiratory disorders were the most frequently diagnosed conditions, with juveniles being disproportionately affected. The absence of mortality and the consistent recovery of treated individuals highlight the effectiveness of the veterinary management strategies implemented at the sanctuary. Strengthening preventive health measures and diagnostic capacity will further improve disease surveillance and contribute to the long-term conservation of *Pan paniscus*.

Author Contributions Statement

Mungongo Mayama: Conceptualization, Methodology, Software, Data curation, Writing-Original draft preparation, Manuscript revision. Kiela Jenny: Data curation, Investigation, and Formal analysis. Diafuka Saila Ngita: Manuscript revision and Investigation. Bha Nsekene: Data curation, Manuscript revision, and Investigation. Mbiala Vodiasilua: Map Designed and Investigation. Pomme Francis: Investigation. Mukamba Jonas: Investigation. Tshilenge Mbuyi: Data curation, manuscript revision, and editing. Masuku Masky: Conceptualization and Investigation. Mulumba Mfumu-Kazadi: Conceptualization, Supervision, Manuscript revising, Editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval

Not applicable

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