



Prevalence and risk factors of ecto- and endoparasites of animals in Osun State University Zoological Garden, Osun State, Nigeria

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Abstract

Zoological gardens worldwide face threats from parasitic infections due to animal confinement, mixed-species housing, stress-related immunosuppression, environmental contamination, vectors, and parasite introduction through animal movement. This study examined the prevalence and risk factors of ecto- and endoparasites among animals in the Osun State University Zoological Garden. Thirty captive animals from ten (10) species, including *Cavia porcellus*, *Anser albifrons*, *Pavo cristatus*, *Oryctolagus cuniculus*, *Anas platyrhynchos*, *Leptoptilos crumenifer*, *Geochelone elegans*, *Erythrocebus patas*, *Anser anser*, and *Centrochelys sulcata*, were investigated. Faecal samples collected were analysed using centrifugal floatation and sedimentation techniques, while skin examinations were conducted for ectoparasites. Identified parasites included *Trichuris* spp., *Ascaris* spp., *Capillaria* spp., *Coccidia*, *Strongylus* spp., *Cryptosporidium* spp., and *Spirorchis* spp. *Ornithobius* and *Ixodidae* were found on the skin. A significant association ($p < 0.05$) was observed between parasitic load and housing, feed type, and management. These findings provide information of parasitic infections and infestations in zoological animals and establish the health status of the zoological animals as an essential component of wildlife conservation efforts

Keywords: Conservation, Parasitic infections, Risk factors, Sustainability, Zoological animals

Introduction

Parasitic infections are widely recognized as a significant health concern in animals, including those in zoological gardens (Ajibade *et al.*, 2010; Opara *et al.*, 2010; Dawet *et al.*, 2013; Otegbade & Morenikeji, 2014; Thawait *et al.*, 2014). Zoological gardens house a diverse range of wild animals, including mammals, birds, reptiles, amphibians, and fish, for aesthetic, educational, recreation and conservation purposes (Mir *et al.*, 2016). However, parasitic diseases remain one of the major health challenges in these facilities, often leading to illness and mortality among captive animals (Adetunji, 2014; Sam-Wobo *et al.*, 2017; Akinnubi & Morenikeji, 2020).

Captive animals serve as hosts to various endoparasites and ectoparasites. The most prevalent endoparasites include *Ascaridia* spp., *Capillaria* spp., *Strongyloides* spp., *Trichuris* spp., *Raillietina* spp., and *Moniezia* spp. (Ajibade *et al.*, 2010; Opara *et al.*, 2010; Adetunji, 2014; Sam-Wobo *et al.*, 2017; Akinnubi & Morenikeji, 2020). Major ectoparasites affecting these animals include the ticks of the genus *Hyalomma* and *Rhipicephalus* (Hard-bodied ticks), fleas of the genus *Notoedres cati* and mite of the genus *Psoroptes cuniculi*, *Sarcoptes scabiei*, *Leporacarus gibbus* Myiasis fly of the genus *Cuterebra cuniculi* and lice of the genus *Haemodipsus ventricosus*, *Pedicinus* spp.) (Mark, 2010; Ramzan *et al.*, 2020). These parasitic infections can significantly impact animal health, leading to reduced population sizes and increased mortality rates (Nath *et al.*, 2012; Mir *et al.*, 2016).

Parasites are introduced into zoological facilities through various means, including contaminated food (fruits, vegetables, meat, fish, etc.), intermediate and paratenic hosts (snails, ants, cockroaches, worms, rodents, etc.), newly acquired animals, staff, and visitors (Adetunji, 2014; Thawait *et al.*, 2014). While wild animals in their natural habitats experience lower parasite loads due to reduced exposure (Gracenea *et al.*, 2002), captivity often exacerbates parasitic infestations, posing a serious threat, particularly to endangered species. In the wild, animals maintain a natural balance with parasites, rarely experiencing severe infections unless stressed (Thawait *et al.*, 2014). However, the persistent stress of captivity weakens immune responses, making animals more susceptible to parasitic infections (Gracenea *et al.*, 2002).

A lack of data on parasitic contamination and associated risk factors among zoological animals

remains a major barrier to effective disease control in zoological gardens. Accurate identification of parasitic species is crucial for understanding their prevalence, geographical distribution, taxonomy, and biology (Rao & Acharjyo, 1984; Yang & Gong, 1998). Additionally, zoonotic parasites pose significant public health risks and can affect the economic sustainability of zoological gardens. Studies have linked the occurrence of parasitic diseases in zoological facilities to poor management practices, particularly inadequate feeding regimens due to insufficient funding (Avcioglu & Burgu, 2008; Nath *et al.*, 2012; Kolapo & Jegede, 2017). Furthermore, factors such as global warming, human population growth, deforestation, globalization, wildlife trade, and pollution contribute to the prevalence and spread of parasitic infections in captive animals (Ngongeh & Chiejina, 2014).

Assessing the health status of zoological gardens is an essential component of wildlife conservation efforts (Singh *et al.*, 2006; Smith *et al.*, 2009). Regular monitoring and surveillance of parasites in zoological gardens worldwide can help develop effective control measures, ultimately improving the health and well-being of captive animals. Establishing a comprehensive profile of parasitic infections and infestations in zoological animals will provide valuable data for public health research and the sustainable development of zoological gardens.

This study aims to determine the prevalence of parasitic infections, infestations and associated risk factors among animals in the Zoological Garden of Osun State University, Osogbo, Osun State, Nigeria. The findings of this research could serve as a foundation for improving parasitic infection management strategies and promoting sustainable zoological practices.

Materials and Methods

Study site and animals

The study was conducted at the Zoological Garden of Osun State University (N7.757820 °and E4.605927°) (Figure 1). Osun State University's Zoological Garden is located within the university's Osogbo campus. The University is located in the southwest region of Nigeria. The garden was established in 2015 but officially opened in 2017. The geology of the study area comprises an alluvial sedimentary basin and a basement complex. Thick mangrove forests, bamboo trees, and light rainforests are the major vegetation

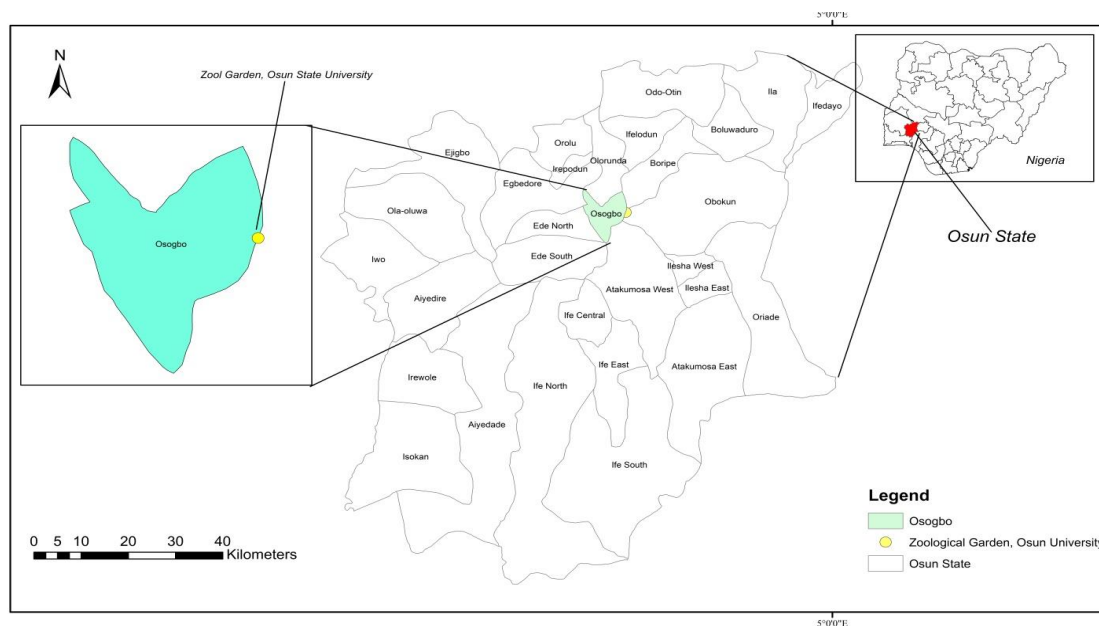


Figure 1: Map of Nigeria showing Osogbo Local Government Area of Osun State

types. The study area experiences heavy rainfall that results in waterlogging of part of the area. It experiences an average rainfall of 2,500 cm³ and a temperature range of 28–30°C annually, which supports the rainforest type of vegetation. The climate at the study site was characterised by both dry and wet seasons and relatively high humidity. There are three classes of animals belonging to different species in the zoological garden. The animals were caged in 10 different cages/sections for proper management. The list of animals in the garden includes tortoise, monkey, goose, peacock, duck, pigeon, marabou stock, rabbit, and guinea pig (Table 1). Some of the animal cages were unenclosed, while others were housed in cemented cages, which were cleaned on a daily basis. Each species of the different groups of animals was kept separately in a large area which is structured in ways that mimic their natural environment and allow for free movement. The zoological garden of Osun State University is not fenced, which sometimes allows passersby without

Ethical approval

The study was approved by the Ethical Committee of the College of Science, Engineering, and Technology, Osun State University, which approved the use of experimental animals (ZOO/CSET/ZG/0012/04). Permission was also obtained from the Management of the Zoological Garden of Osun State University, Osogbo, Osun State. In addition, a letter of introduction was obtained from the Department of

Zoology, Osun State University, for permission to collect samples from zoological animals at the Zoological Garden. The letter was approved by the Chairman of the Zoological Garden Committee before conducting the study.

Management procedures of the Zoological Garden animals

The Osun State University Zoological Garden adopted two housing patterns in an intensive system comprising rectangular iron mesh cages (4 cm aperture) with a concrete floor. The other cages contained sandy floors. The cages had stocking densities of 1.5 kg- 5 kg. Animals were classified into herbivores and carnivores. The herbivores were fed grains and vegetables, whereas the carnivores were fed locally sourced herring fish. The carnivores were fed once a day, while food was left in the cages of herbivores throughout the day and changed to fresh food the following day. Water containers were cleaned up and refilled daily with water sourced from the garden well.

Sample collection

A variety of zoological animals from different taxonomic classes were sampled for both endoparasites (gastrointestinal parasites) and ectoparasites at the Zoological Garden of Osun State University. Table 1 presents the classes and numbers of animals examined, their associated parasites, prevalence rates, and housing system types. All

Table 1: Classes, numbers of animals, associated parasites, and prevalence according to animals in the Zoological Garden of Uniosun

N/S	Class of Animals	Specimen	Types of cages	No.	Parasites Identified	Prevalence [%]	Intensity [EPG]
1	Mammalia (Herbivore)	Guinea pig (<i>Cavia porcelles</i>)	Iron with cemented floor	5	<i>Trichuris</i> spp.	16.7 (5/30)	5
2	Aves (Herbivore)	Pigeon (<i>Columba livia domestica</i>)	Iron with un-cemented floor	5	<i>Ascaridia</i> spp.	13.3 (4/30)	1.8
3	Aves (Herbivore)	Peacock (<i>Pavo cristatus</i>)	Iron with un-cemented floor	2	<i>Ornithobius</i> spp.	10.0 (3/30)	9.6
4	Mammalia (Herbivore)	Rabbit (<i>Oryctolagus cuniculus</i>)	Iron with cemented floor	3	<i>Coccidia</i>	6.7 (2/30)	21.5
5	Aves (Herbivore)	Duck (<i>Anas platyrhynchos</i>)	Iron with an un-cemented floor	2	<i>Strongylus</i>	10.0 (3/30)	6.6
6	Aves (Carnivore)	Marabou stock (<i>Leptoptilos crumenifer</i>)	Iron with cemented floor	1	<i>Trichuris</i> spp.	6.7 (2/30)	7.6
7	Reptile (Herbivore)	Tortoise (<i>Geochelone elegans</i>)	Iron with cemented floor	2	<i>Cryptosporidium</i>	3.3 (1/30)	10.8
8	Mammalia (Herbivore)	Patas monkey (<i>Erythrocebus patas</i>)	Iron with cemented floor	3	<i>Capillaria</i>	6.7 [2/30]	3.8
9	Aves (Herbivore)	Geese (<i>Anser albifrons</i>)	Iron with cemented floor	3	<i>Trichuris</i> spp.	6.7 (2/30)	4.6
10	Reptile (Herbivore)	Turtle	Iron with cemented floor	4	<i>Ixodidae</i> .	10.0 (3/30)	4.3
	Total			30	(Ectoparasite)	3.3 (1/30)	8.6
					<i>Ornithobius</i> spp.	10.0 (3/30)	6.6
					(Ectoparasite)		
					<i>Spirorchis parvus</i>	10.0 (3/30)	1.5
						25 (83.33)	

animals in the garden, including *Cavia porcelles* (Guinea pig) (Sophie, 2015); *Anser albifrons* (White goose) (Vrezec, 2023); *Pavo cristatus* (Blue peacock) (Linnaeus, 1758); *Oryctolagus cuniculus* (Domestic rabbit) (David, 2010); *Anas platyrhynchos* (Wild duck) (Drilling *et al.*, 2020); *Leptoptilos crumenifer* (Marabou stork) (Elliot *et al.*, 2021); *Geochelone elegans* (Tortoise) (Schoepff, 1795); *Erythrocebus patas* (Patas monkey) (Shafiu *et al.*, 2021); *Anser anser* (Greylag goose) Carboneras & Kirwan, 2020) and *Centrochelys sulcata* (African spurred tortoise) (Fabio *et al.*, 2020) were used in the study, and samples were collected between the hours of 6.00 am and 7.00 am (Mekete *et al.*, 2012).

The samples comprised stool samples from 30 animals (11 males and 19 females). The same animals were used for the wet and the dry seasons. Faecal samples were collected from the 30 animals during the wet season. 2 of the animals in this garden died after the wet season sampling. Only 28 animals were therefore available for sampling during the dry season. Data on the sex of the animals and the season

in which the samples were collected were also recorded.

Sample processing and parasite identification

Freshly passed stool samples were collected from the animals between 6:00 am and 7:00 am, as previously described (Mekete *et al.*, 2012). Samples were collected in specimen cups from individual animals, tightly covered with lids to prevent contamination, and transported to the Postgraduate Laboratory of the Department of Zoology, Osun State University, for evaluation within 24 h of collection based on the methodology described by Yang & Gong (1998). The stool samples were processed using the concentration method (sedimentation and flotation techniques) (Soulsby, 1982). Zoological animals host a wide range of parasites (nematodes, trematodes, cestodes, protozoa), so a single method is not enough; using both techniques increases sensitivity, ensuring detection of both heavy and light eggs. Sedimentation was used to detect parasites with heavier eggs and larvae (e.g., trematodes), which

settle at the bottom after centrifugation, while the flotation technique was used to detect lighter eggs and protozoan cysts, such as *Ascaris*, *Trichuris*, *Cryptosporidium* and *Coccidia*, since the eggs of these parasites float on the surface when mixed with a high-density solution. Salt solution was used as the flotation fluid in this study. Parasite identification in the faeces of the animals was performed using the identification key described by Cassandra *et al.* (2016). For the sedimentation technique, 5 g of each faecal sample was emulsified thoroughly in 15 mL of clean tap water using a glass rod in a beaker. The resulting suspension was strained through a fine mesh sieve into a clean centrifuge tube to remove large debris. The filtrate was then centrifuged at 1,500 rpm for 5 minutes. After centrifugation, the supernatant was carefully decanted without disturbing the sediment. The sediment was resuspended in clean water, and the centrifugation process was repeated twice to ensure adequate washing and concentration of parasitic elements. Following the final centrifugation, the supernatant was discarded, and a drop of the sediment was placed on a clean glass microscope slide. The preparation was covered with a coverslip and examined microscopically under $\times 10$ and $\times 40$ objective lenses for the presence of helminth eggs and larvae.

For the flotation technique, 5 g of faecal material was also emulsified in 15 mL of flotation solution (saturated sodium chloride) in a beaker using a glass rod until a uniform suspension was obtained. The suspension was strained through a fine mesh sieve into a clean centrifuge tube to remove coarse debris. The filtrate was centrifuged at 1,500 rpm for 5 minutes. After centrifugation, additional flotation solution was gently added to the tube until a convex meniscus formed at the rim. A clean coverslip was carefully placed on top of the tube, ensuring contact with the meniscus, and left undisturbed for 10 minutes to allow helminth eggs and larvae to float and adhere to the coverslip. Following the flotation period, the coverslip was carefully lifted vertically and placed on a clean glass microscope slide. The preparation was examined microscopically under $\times 10$ and $\times 40$ objective lenses for the presence of helminth eggs and larvae.

Skin scraping using sharp curve scissors, coat brushing, and hand picking were used to diagnose ectoparasite infestations in animals as described by Mark (2010).

The ecto-parasites recovered in this study were identified using identification keys by Soulsby (1982); Ramzan *et al.* (2020). The flotation fluid used in this

study was a saturated solution of sodium chloride (NaCl) salt prepared in the laboratory at 1.23 specific gravity (Cringoli *et al.*, 2010).

Statistical analysis

The raw data were cross-tabulated using Microsoft Office Excel 2011 to obtain the proportion and prevalence of infections. These were later imported into SPSS Statistical Software Version 22 for Logistic Regression Analysis using the dependent variable [e.g., parasite presence: Yes/No] against the independent variables (e.g., housing type, feed, management) to interpret the Odds Ratios (Exp(B)) and significance levels (p-values) to determine the strength of the association between the dependent and independent variables. The association is considered significant at $p < 0.05$.

Results

The overall prevalence of parasitic infections among the surveyed animals was 83.33% (25 out of 30 animals) (Table 1). Identified parasites included both endo- and ectoparasites. Endoparasites detected include *Trichuris* spp., *Ascaridia* spp., *Ascaris* spp., *Capillaria* spp., *Coccidia* parasite, *Strongylus* spp., *Cryptosporidium* spp., and flukes from faecal samples. Ectoparasites such as lice (*Ornithobius* spp.) and ticks of the Ixodidae family were collected from the skin (Table 1).

The general prevalence of ecto and endoparasites among the animals in the zoological garden was 83.33% representing 25 of a total number of 30 animals that were sampled. The prevalence varied by animal type. Nine animals, including *Columba livia domestica* (pigeon), *Erythrocebus patas* (patas monkey), and *Anser albifrons* (geese), were infected with ectoparasites (*Ornithobius* spp. and *Rhipicephalus* spp. (Ixodidae), corresponding to a prevalence rate of 30% (9/30). Endoparasitic infections were more common, with *Trichuris* spp., *Ascaridia* spp., *Coccidia*, *Strongylus*, *Cryptosporidium*, *Capillaria*, and a trematode, *Spirorchis parvus* being detected in 86.66% of the animals. *Cryptosporidium* had the lowest prevalence, detected in only one animal (3.33%), a marabou stork (Table 1).

Cases of multiple parasitic infections (both endo- and ectoparasites) were observed among mammals (*Cavia porcellus*—guinea pigs and patas monkeys) with a prevalence of 46.15% (6/30), involving *Ascaris*, *Coccidia*, and *Ornithobius* spp. Similarly, aves (geese) exhibited a 27.27% (3/30) prevalence of multi-parasitism (Table 2). The overall prevalence of multi-parasitism across all animals was 30% (9/30) (Table

2). Notably, reptiles had no cases of multi-parasitism, with 0% (0/6) prevalence. *Trichuris* spp. was found to be the predominant infectious agent among all species of parasites recovered.

The prevalence based on risk factors is presented in Table 3. The table details the prevalence according to the groups of sampled animals in the zoological garden, where mammals exhibited a higher prevalence (90.9% (10/13)) when compared to Aves (46.15% (6/13)) while reptiles showed no infection (0% (0/6)) (Table 2). Additionally, all recovered endoparasites, except for *Capillaria* spp., demonstrated a significant gender preference, with a higher prevalence in males (84.21% (16/30)) than in females (81.82% (14/30)). Similarly, ectoparasite

infections showed group preference, with reptiles exhibiting no ectoparasite infestation (0% (0/6)) (Table 3). Housing conditions also influenced infection rates, with animals kept in cages with uncemented floors recording an infection rate of 30% (9/30), while those in cemented-floor cages had a prevalence of 63.3% (19/30). *Trichuris* infections displayed minimal variation across different cages.

The findings of this study established a clear association between parasite prevalence and factors such as housing pattern, diet, seasonality, and environmental management (Table 3). Analysis based on diet revealed that carnivorous animals, consuming

Table 2: Prevalence of parasites in relation to the group of animals and site of infections among the zoological animals surveyed in Uniosun Zoological Garden

Group of species and Composition	Site of infection		Multiple infection (Ecto + Endo parasites)
	Ectoparasites (%)	Endoparasites (%)	
Mammals (11)	3 (27.27)	10 (90.91)	3 (27.27)
Aves (13)	6 (46.15)	10 (76.92)	6 (46.15)
Reptiles (6)	0 (0)	5 (83.33)	0 (0)
Total (30)	9 (30.00)	25 (83.33)	9 (30.00)

Table 3: Risk factors associated with the distribution of parasites in zoological animals

Risk factors	No of animals sampled	No of Positives	Prevalence (%)	P-value
Group of animals				<0.059
Mammals	11	10	90.91	
Aves	13	10	76.92	
Reptiles	6	5	83.33	
Sex				<0.0261
Male	11	09	81.82	
Female	19	16	84.21	
Total	30	25	83.33	
Settlement				<0.041
Cage built with iron with a cemented floor	21	19	90.46	
Cage built with iron with sandy floor	09	09	100.0	
Season				<0.011
Rainy	30	25	83.33	
Dry	28	25	65.78	
Feed Type				<0.001
Millet/corn	26	21	80.77	
Insects/fish/meat	01	01	100.0	
Banana/pawpaw/sweet	03	23	66.6	
Total	30	25	83.33	
Management system*				<0.037
Poor	09	06	66.67	
Moderate	18	16	88.89	
Good	03	0	0(0)	
Overall	30	25	83.3	

meat and fish had the lowest prevalence (3.3% (1/30)) compared to other animals in the garden that feed on giran. Seasonal variations significantly influenced the prevalence and mean intensity of both endo- and ectoparasites, with markedly higher rates ($p < 0.05$) recorded during the rainy season compared to the dry season.

Though the logistic regression did not converge properly, likely due to a small sample size and high conventional significance level of 0.05, there is statistical evidence to suggest a significant association between risk factors and parasitic infection prevalence. However, there could still be a meaningful trend that might be more apparent with a larger sample size. Logistic regression analysis indicated that the presence or absence of parasites was significantly influenced by housing pattern, diet, and management level. Housing conditions and management level notably increased parasite risk (Chi-square value (χ^2) = 23.08), while diet was observed to either reduce or influence parasite risk. All variables assessed in this study were statistically significant ($P < 0.05$) (Table 3).

Discussion

The overall prevalence of parasites among the sampled animals in the Zoological Garden was 25 (83.33%). The intensive husbandry of wild animals in zoological parks or gardens may be one of the reasons for the higher infection rate, as high animal density in enclosures and their proximity to other species of animals provide opportunities for transmission of parasites (Elena *et al.*, 2011). The confinement of wild animals in the zoological garden has also been attributed to high parasitic infections despite proper attention to feeding, water, and maintenance of hygiene in captivity (Elena *et al.*, 2011). Multiple parasite infections occur frequently in some of the zoological animals sampled, but there were fewer hosts with multiple infections than with a single infection. This could be attributed to environmental and host-dependent factors that can influence the structure and dynamics of the parasite communities that make up these multiple infections. (Adegbulu *et al.*, 2015; Mir *et al.*, 2016) has also attributed this to possible synergistic and competitive interactions between parasite species, which can influence the likelihood of their successful transmission to other hosts and increase or decrease their overall pathogenic impact. Nematodes and some coccidian parasites have a direct life cycle, that is, they do not involve any intermediate host and are transmitted via a faeco-oral route through contaminated feed, water,

and soil, and have the potential to accumulate in a captive environment (Elena *et al.*, 2011). The prevalence of infection observed in this study was consistent with that reported by various authors in Nigeria (Ajibade *et al.*, 2010; Dawet *et al.*, 2013; Opara *et al.*, 2010; Otegbade & Morenikeji, 2014). *Trichuris* spp., also known as whipworms, have the highest prevalence of infections, as recorded in this study, and have parasitised many domesticated species, causing enteritis, diarrhoea, and weight loss (Emikpe *et al.*, 2002). Most of the parasites recorded in this study have a direct life cycle and could survive in the environment; the high prevalence recorded in this study may be attributed to a high possibility of environmental contamination (Mir *et al.*, 2016). Environmental contamination can occur through contaminated water or fodder, roaming fowl, and even zoo workers have been reported to play a role in transmission by acting as vectors and transmitting parasites through their shoes, clothes, hands, food, or with working tools (Rao & Acharjyo, 1984). In the present study, finding revealed that there was no foot dip at the entrance of each cage/enclosure to disinfect the entrance of the zoological garden; therefore, there is a possibility of zoological garden workers contaminating the cages in the process of cleaning the cages which could act as a vehicle for the transmission of parasites, as the pathogens may be present in their bodies through contamination from the environment of the zoological garden. One of the parasites recorded in this study was a digenetic parasite and therefore required an intermediate host for effective transmission. The presence of swamps and other stagnant waters within the zoological garden may be good breeding grounds for intermediate hosts such as snails. The seasonal prevalence and mean intensity of both endo- and ectoparasites recorded in the study were significantly ($p < 0.05$) higher in the rainy seasons than the dry seasons. Intestinal parasitic infections are significantly associated with the rainy season, which may facilitate conditions and risk factors that predispose animals to intestinal parasitic infections. The sufficient moisture and temperature required by the eggs of intestinal parasites to embryonate and become infective, in addition to poor disposal of faecal waste swept from the animal houses, may have resulted in the high infection recorded for endoparasites during the rainy season. This is consistent with previous studies (Ajibade *et al.*, 2010; Dawet *et al.*, 2013; Thawait *et al.*, 2014). Findings from this study revealed that animals in cages with cemented floors had a higher prevalence of parasites

than animals in cages with uncemented floors. Generally, animals housed on uncemented floors have a higher prevalence of soil-transmitted parasites because soil-transmitted parasites have soil as a common medium for the development of immature eggs and the early stages of larvae. In addition, the soil provides conditions under which its development to the infection stage can occur. The soil can protect the infective stage for a period, during which it may be brought into contact with a susceptible animal by mouth or skin (Dawet *et al.*, 2013). The findings from this study contradict this general belief. The animals in cages with cemented floors had a higher prevalence of parasites than animals in cages with uncemented floors. This may be attributed to the lack of foot dip at the entrance of each cage/enclosure to disinfect the feet of the garden workers and visitors who may have used their contaminated legs to carry the infective stage of the parasites into the cages. The results of this study showed a clear relationship between parasites and level of management, housing pattern, feed type and seasonality. (Avcioglu & Burgu, 2008) indicated that the presence of endoparasites was directly related to poor sanitation and management. Other authors have found a relationship between the host, parasite, and environment (Thawait *et al.*, 2014; Adegbulu *et al.*, 2015; Kolapo & Jegede, 2017). The ectoparasites were mostly found on animals and in cages with poor management, indicating that ectoparasites can be used as a bio-indicator of environmental deterioration.

Endoparasites and ectoparasites pose significant health challenges in the zoological garden of Osun State University. The findings of this study reveal that, despite existing management practices, parasite infections remain prevalent among the animals. This underscores the need for enhanced husbandry practices, including routine deworming, the installation of foot dips at the entrance of all cages, and the implementation of strict policies to prevent visitor contact with zoological animals to safeguard both animal and public health.

Additionally, sand filling of waterlogged areas should be prioritised to eliminate potential breeding grounds for invertebrate hosts of digenetic parasites. To further mitigate parasite transmission, the garden should be securely fenced to prevent free-ranging fowls from grazing within the premises. This is particularly crucial as many of the parasites identified in the animals also infect fowls, increasing the risk of cross-species transmission.

Overall, endoparasite infections were more prevalent than ectoparasite infections, aligning with findings from previous studies (Yang & Gong, 1998; Sam-Wobo *et al.*, 2017).

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Conflict of Interest

The authors declare that there is no conflict of interest.

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