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A Cross-sectional Study of Prevalence of Gastrointestinal Parasites in Captive Wild Animals in Pakistan Zoological Gardens

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ABSTRACT

The animals held captive in zoos often face health and well-being issues. Parasitic infections can lead to health problems in wildlife animals by affecting their gastrointestinal tract. Therefore, the present study aimed to identify and evaluate the population of the various Gastrointestinal (GIT) parasites of wild animals enclosed in different zoological gardens in Pakistan. The fresh fecal samples (n = 960) of 20 captive wildlife animals were collected from Marghzar Zoo, Islamabad (n = 340), Ayub National Park, Rawalpindi (n = 221), Lohi Bher Wildlife Park, Rawalpindi (n = 296), and Bansra Galli Wildlife Park, Rawalpindi (n = 103). The samples were obtained from wildlife mammals, including urial (n = 95), blue bull (n = 106), chinkara gazelle (n = 77), zebra (n = 77), hog deer (n = 75), spotted deer (n = 43), blackbuck (n = 58), barking deer (n = 52), red deer (n = 104), yak (n = 44), grey goral (n = 40), lion (n = 37), mouflon sheep (n = 46), red fox (n = 12), bear (n = 37), grey wolf (n = 12), jackal (n = 12), vervet monkey (n = 12), rhesus monkey (n = 12), and langoor (n = 12). Various methods, such as direct smear examination, standard sedimentation, and floatation techniques were applied to detect and identify the endoparasites in the fecal sample. The detailed routine parasitological analysis identified approximately 52 endoparasites in the fecal samples, including *Haemonchus contortus*, *Eimeria bovis*, *Ostertagia curcumcincta*, *Strongyloides papillosus*, *Strogylus equinus*, *Oxyuris equi*, *Chabertia ovina*, *Protostrongylus*, and *Trichostrongylus vitrines*. The obtained results indicated that Lohi Bher Wildlife Park (46.35%) had a higher prevalence of GIT parasites, compared to Marghzar Zoo (33.23%), Bansra Galli Wildlife Park (33.02%), and Ayub National Park (19.45%). The study reports mild to moderate parasitic infection in captive wild animals and that could affect the survivability of the animals in captivity. The findings of the study can be used to formulate a proper health protocol and sanitation management in captive wild animals to control parasitic infections.

Keywords: Captive wild animal, Gastrointestinal infection, Parasite, Zoological Garden

INTRODUCTION

Parasitic infections are a major concern of wildlife units in Pakistan and worldwide (Khan et al., 2021). In zoological gardens, animals are mainly held captive in enclosures where the environment does not resemble their natural habitat (Da Silva Barbosa et al., 2019). The physiology of animals is changed when they are kept in their enclosures, as they are suddenly exposed to unpleasant and distressing environments. This physiological alteration renders the captive animals more susceptible to numerous infectious diseases, such as viral, bacterial, fungal, and parasitic. Gastrointestinal (GI) parasitic infections are most commonly found in captive wild animals (Dev Moudgil et al., 2015; Carrera- Játiva et al., 2018). In natural habitats, animals are innately resistant to parasitic infections as there is an ecological balance between animals and their parasites. Moreover, wild animals are less exposed to parasitic infections since they freely roam in open lands with low animal density (Thawait et al., 2014; Da Silva Barbosa et al., 2019). Nevertheless, parasitic infections have negative effects on the status, behavior, reproduction, and mortality rate of wild animals (Thawait et al., 2014; Kvapil et al., 2017). The host's survival and reproduction behavior could be affected by parasitic infection through pathological effects, causing tissue damage, blood loss, spontaneous abortion, and mortality, or indirectly by declining the immune response (Thawait et al., 2014).

In recent years, A study has been conducted on wildlife pathogens to investigate the prevalence of parasitic infections with zoonotic tendencies. However, this has led researchers to overlook the ecological factors surrounding parasites while it has also damaged the efforts to manage them (Sengar et al., 2017). Extensive studies investigated identifying GIT diseases and infections among wildlife animals. Ferdous et al. (2023) noticed the occurrence of GIT infections in Bangladesh Zoo. Khan et al. (2021) identified the GIT parasitic infections among cows and buffalo in various farms located in Khyber Pakhtunkhwa province of Pakistan, and Ruhoollah et al. (2023) noted GIT parasite impacts in lower Dir region animals. However, research concerning the health of wildlife animals in Islamabad and

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Rawalpindi is still scarce and requires more data. Hence, the present study aimed to identify the various GIT parasites of wild animals in zoological gardens located in Islamabad and Rawalpindi region.

The objective of the current study was to identify the various GIT parasites of wild animals and to evaluate the percentages of prevalent GIT parasites in wildlife mammals.

MATERIALS AND METHODS

Ethical approval

Formal permission was obtained from the respective parks and zoo administration for doing research while ensuring the animals' safety. The ethical approval committee was obtained from the Department of Life Sciences Abasyn University, Islamabad Campus, and National Veterinary Laboratories Park Road Chak Shahzad Islamabad, Pakistan.

Study design

The study followed a cross-sectional study design to conduct a study on wildlife mammals in the parks and zoos in Rawalpindi and Islamabad, Pakistan.

Study method

The study chose a quantitative research method to descriptively analyze the fecal samples of the captive animals to explore GIT parasites in them.

Sample selection

To determine the sample size of the study, epitool was used to estimate 960 items as the appropriate size of the sample. Hence, 960 fresh fecal samples from 20 captive wildlife animals were collected.

Study area and time

The research was conducted from August 2020 to July 2021 in the four chosen facilities, including Marghzar Zoo, Islamabad, Lohi Bher Wildlife Park, Rawalpindi, Bansra Galli Wildlife Park, Rawalpindi, and Ayub National Park, Rawalpindi. Islamabad–Rawalpindi metropolitan area is situated in the north of Punjab, in the Potohar Plateau, against the backdrop of the Margalla Hills, and constitutes the twin cities of Islamabad and Rawalpindi, Pakistan. In Rawalpindi and Islamabad, the mean annual temperature is recorded as 21.5°C (70 °F), and June is the hottest month with an average temperature exceeding 38°C (100.4 °F). The average annual rainfall is 1,346.8 millimeters, especially during monsoon season. The average humidity is 45% whereas the average wind speed is 16 kph (10 mph).

Health and hygiene management in zoological gardens

The zoo workers followed a strict feeding and sanitary protocol to ensure the health and hygiene of the animals. The animals were well kept in warm, closed enclosures with proper access to food and water. Every six months the animals were dewormed using anthelmintic drugs, as well other measures were adopted to prevent different infections and diseases, including proper vaccination. Zoo workers most commonly used 40 grams/100 lbs dosage of Fenbendazole and Moxidectin (Symans Pharmaceuticals, Pakistan) for deworming. The enclosures were regularly cleaned and maintained in the early morning. Additionally, a weekly cleanliness routine was implemented using the necessary antibiotics, mainly phenyl prophylaxis.

Study population

Fresh fecal samples (n = 960) were collected from Marghzar Zoo, Islamabad (n = 340), Ayub National Park, Rawalpindi (n = 221), Lohi Bher Wildlife Park, Rawalpindi (n = 296), and Bansra Galli Wildlife Park (n = 103), Rawalpindi. The samples were obtained from wildlife mammals (n = 960), including urial (n = 95), blue bull (n = 106), chinkara gazelle (n = 77), zebra (n = 77), hog deer (n = 75), spotted deer (n = 43), blackbuck (n = 58), barking deer (n = 52), red deer (n = 104), yak (n = 44), grey goral (n = 40), lion (n = 37), mouflon sheep (n = 46), red fox (n = 12), bear (n = 37), grey wolf (n = 12), jackal (n = 12), vervet monkey (n = 12), rhesus monkey (n = 12), and langoor (n = 12).

Collection and preservation of fecal sample

A total of 960 samples were collected from individually caged healthy mammals with no history of any illness. The fecal samples (10 gr each) were collected in the early morning before routine cleaning and maintenance of the cages. To avoid contamination, all samples were taken from the ground with a sanitized polystyrene spatula (Rahman et al. 2023) and samples were swiftly delivered to the National Veterinary Laboratory, Islamabad. Each sample was placed in a plastic container containing 10% formalin. The containers were kept in plastic biohazard bags to transport the samples. According to species, the samples were labeled with a marker, and the opening edge of the bag was tightly closed.

Examination of the sample

The fecal samples were analyzed through detailed routine parasitological to experiment with the presence of parasitic eggs/oocysts by direct smear examination, standard sedimentation (Rao et al., 2017), and floatation techniques (Soulsby, 1982; Qi et al., 2023). The prepared smear was placed on microscopic slides, sealed with a glass cover, and later it was inspected under a light microscope (Leica Microsystems, Germany) for parasitic eggs and larvae.

Data analysis

The data was analyzed using IBM SPSS software version 20 and descriptive statistics was used for tabulating and summarizing the data. The percentages of prevalence of different parasites in the collected samples were calculated using the below-mentioned formula (Farooq et al., 2012):

Percent prevalence = [Positive sample/Total number of samples] x 100.

RESULTS

To see the prevalence of gastrointestinal parasites, an aggregate of 340 fecal samples was collected at the Zoological Garden (Marghzar Zoo, Islamabad), and out of 340 samples, 113 cases (33.23%) were indicated positive for various kinds of endoparasites (Table 1). At Bansra Galli Wildlife Park Rawalpindi, a sum of 103 fecal samples were obtained and just 36 cases (33.02%) were infected with parasites which is presented in Table 2. At Lohi Bher Wildlife Park, Rawalpindi a total of 296 fecal samples were collected and, 140 cases (46.35%) were found tainted for different sorts of parasites (Table 3). At Ayub National Park, Rawalpindi a sum of 221 waste samples was gathered and just 43 (19.45%) fecal examples were tested for various sorts of endo-parasites (Table 4). The higher predominance of parasites was documented at Lohi Bher Wildlife Park (46.35%) compared with Marghzar Zoo (33.23%), Bansra Galli Wildlife Park (33.02%), and the lowest commonness at Ayub National Park (19.45%).

Table 1. Prevalence of oocytes/eggs, larvae of parasites isolated from zoo animals between August 2020 to July 2021 from Marghzar Zoo, Islamabad, Pakistan

Mammals	Total Sample	Number of infected animals	(%)	Parasite's encountered
Blue Bull	45	26	57.8	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vistrinus, Ostertagia curcumcinta, Chabertia ovina*
Chinkara	28	16	57.1	*Haemonchus contortus, Trichostrongylus vistrinus, Ostertagia curcumcincta, Strongyloides papillosus, Nematodirus filicollis*
Urial	39	19	48.7	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vistrinus, Ostertagia curcumcincta, Strongyloides papillosus, Protostrongylus, Chabertia ovina, Dictayocaulus*
Zebra	23	13	39.4	*Eimeria bovis, Strongyloides papillosus, Nematodirus filicollis, Strogylus equinus, Oxyuris equi, Protostrongylus*
Hog Deer	22	4	18.2	*Eimeria ovis, Haemonchus contortus, Chabertia ovina*
Spotted Deer	20	7	35	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vitrines, Ostertagia curcumcincta, Chabertia ovina*
Red Deer	12	0	0	0
Grey Goral	18	2	11.1	*Eimeria bovis, Haemonchus contortus, Chabertia ovina*
Black Buck	13	12	92.3	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vitrines, Moniezia*
Barking Deer	12	3	25	*Eimeria bovis, Trichostrongylus vitrines, Ostertagia curcumcincta*
Mouflon sheep	12	1	8.3	*Trichostrongylus vitrinus, Strongyloides papillosus*
Rhesus monkey	12	0	0	0
Vervet Monkey	12	0	0	0
Langoor	12	0	0	0
Brown Bear	12	8	66.66	*Trichuis vulpis, Toxoc1ra canis*
Grey Wolf	12	3	25	*Trichuris vulpis, Toxocara canis, Muell1rius capillaris*
Red Fox	12	2	16.66	*Toxocara canis, Muel1erius capillaris*
Jackal	12	2	16.66	*Trichuris vulpis, Toxo1ara canis*
Lion	12	2	16.66	*Toxocara canis, Dipyl1dium caninum*
Total	340	113	33.2	

As can be seen in Table 1, the maximum numbers of ungulates were found positive for gastrointestinal parasites compared to Carnivores and only one species (Brown bear) from Omnivores was found positive for gastrointestinal parasites. *Eimeria bovis* was the most prevalent (15.4%) parasite followed by *Haemonchus contortus* (10.2%), *Trichostrongylus vitrinus* (7.7%), *Strongyloides papillosus* (5.1%), *Protostrongylus* (3.7%) and *Ostertagia curcumsincta* (2.5%). A total of 45 samples were obtained from blue bull and 19 samples were infected. *Trichostrongylus vitrinus* and *Haemonchus contortus*, were most prevalent (13.3%) followed by *Eimeria bovis* (8.88%), *Haemonchus contortus* (4.4 %), and *Chabertia ovina* (2.2%). A total of 28 samples were obtained from Chinkara out of which, 15 samples were infected with endoparasites. *Ostertagia curcumsincta* was the most prevalent parasite (17.85%) along with *Trichostrongylus vitrinus* and *Fasciola hepatica* (each 7.1%), *Strongyloides papillosus* and *Nematodirus filicollis* (each 3.6%).

The obtained results indicated that 59 faecal samples of Red deer (*Cervus elaphus*) were infected with *Haemonchus contortus* (14.0%) followed by *Ostertagia curcumcincta* (12.3%), *Trichostrongylus vistrinus* (10.5%), *Eimeria bovis* (7.0%), and *Strongyloides papillosus* (1.7%). A total of 44 fecal samples from Yak (*Bos grunniens*) shown to be infected with *Ostertagia curcumcincta* (10%), *Haemonchus contortus* (7.5%), *Eimeria bovis* and *Oesophagostomum columbianum* (each 2.5%), and 12 fecal samples were obtained from Siberia tiger (*Panthera tigris altaica*) and one sample was positive for *Taxocara canis* (8.3%).

Table 2. Prevalence of oocytes/eggs, larvae of parasites isolated from zoo animals between August 2020 to July 2021 from Bansra Galli Wildlife Park, Rawalpindi, Pakistan

Mammals	Total sample	Number of infected animals	(%)	Parasite's encounter
Yak	44	9	22.5	*Eimeria bovis, Haemonchus contortus, Ostertagia curcumcincta, Oesophagostomum columbianum*
Red Deer	59	26	45.61	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vitrines, Ostertagia curcumcincta, Strongyloides papillosus*
Total	103	36	36.08	

Table 3. Prevalence of oocytes/eggs, larvae of parasites isolated from zoo animals between August 2020 to July 2021 Lohi Bher Wildlife Park, Rawalpindi, Pakistan

Mammals	Total sample	Number of infected animals	(%)	Parasite's encounter
Blue Bull	43	24	55.8	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vitrines, Ostertagia curcumcincta, Strongyloides papillosus, Fasciola hepatica, Chabertia ovina*
Urial	29	11	37.9	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vitrines, Ostertagia curcumcincta, Strongyloides papillosus, Protostrongylus, Chabertia ovina*
Chinkara	31	11	35.4	*Trichostrongylus vitrines, Ostertagia curcumcincta, Strongyloides papillosus, Fasciola hepatica*
Black Buck	27	24	88.8	*Eimeria bovis, Trichostrongylus vitrines, Ostertagia curcumcincta, Strongyloides papillosus, Nematodirus filicollis*
Barking Deer	22	5	41.6	*Eimeria bovis, Chabertia ovina*
Mouflan Sheep	16	6	37.5	*Eimeria bovis, Ostertagia curcumcincta, Protostrongylus*
Grey Goral	22	0	0	0
Zebra	27	14	51.8	*Strongyloides papillosus, Strogylus equinus, Oxyuris equi, Protostrongylus*
Red Deer	33	1	7.6	*Ostertagia curcumcincta*
Hog Deer	26	17	65.3	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vitrines, Ostertagia curcumcincta, Strongyloides papillosus, Nematodirus filicollis, Fasciola hepatica, Protostrongylus, Moniezia*
Spotted Deer	23	5	26.3	*Haemonchus contortus, Trichostrongylus vitrines, Strongyloides papillosus*
Total	296	118	46.27	

Table 3 reveals that Ungulate species had the greatest range of gastrointestinal parasites eggs/ova and hatchlings compared to Carnivores. Out of 29 samples of Urial, *Eimeria bovis* and *Chabertia ovina* eggs were more prevalent (10.34%), whereas *Trichostrongylus vitrinus* was most prevalent (19.35%) in Chinkara (*Gazella bennettii*). Other detected endoparasites included *Haemonchus contortus*, *Trichostrongylus vitrinus*, *Ostertagia curcumcincta, Strongyloides papillosus*, and *Protostrongylus*, however, these parasites had low prevalence.

In Zebra (*Equus quagga*), *Strongylus equines* (18.52%) had the highest prevalence rate compared to *Strongyloides papillosus, Oxyuris equi*, and *Protostrongylus* (14.81%, 11.11%, and 7.41%) respectively. In 26 samples of Hog deer (*Hyelaphus porcinus*) 9 different endo-parasitic species were isolated, and *Trichostrongylus vitrinus* was the most infecting parasitic species (15.38%). Other endo-parasites include *Eimeria bovis, Haemonchus contortus, Ostertagia curcumcincta, Strongyloides papillosus, Nematodirus filicollis, Fasciola hepatica, Protostrongylus*, and *Moniezia* species.

Table 4. Prevalence of oocytes/eggs, larvae of parasites isolated from zoo animals between August 2020 to July 2021 Ayub National Park, Rawalpindi, Pakistan

Mammals	Total Sample	Number of infected	(%)	Parasite's encounter
Urial	27	6	22.2	*Eimeria bovis, Haemonchus contortus, Trichostrongylus vitrines, Ostertagia curcumcincta, Chabertia ovina*
Blue Bull	18	3	16.6	*Protostrongylus, Moniezia, Dicyocaulus*
Chinkara	18	3	16.6	*Ostertagia curcumcincta, Strongyloides papillosus, Chabertia ovina*
Zebra	27	6	22.2	*Strongyloides papillosus, Strogylus equinus, Oxyuris equi*
Black Buck	18	5	27.7	*Haemonchus contortus, Ostertagia curcumcincta, Fasciola hepatica*
Mouflon Sheep	18	2	11.1	*Protostrongylus, Chabertia ovina*
Barking Deer	18	3	16.6	*Haemonchus contortus, Fasciola hepatica, Chabertia ovina*
Hog Deer	27	3	11.1	*Haemonchus contortus, Trichostrongylus vitrines, Protostrongylus*
Lion	25	3	12	*Baylisaascis procyonis, Toxocara canis, Alaria*
Bear	25	3	12	*Trichuris vulpis, Toxocara canis*
Total	221	37	16.75	

The data from blue bull (*Boselaphus tragocamelus*) obtained from 18 fecal samples, including *Protostrongylus spp.*, *Moniezia spp.*, and *Dictyocaulus spp.* were the most prevalent (each 5.5%). A total of 18 fecal samples from Chinkara gazelle (*Gazella bennettii*) were infected with *Ostertagia curcumcincta., Strongyloides, and chabertia* (each 5.5%). A total of 27 fecal samples were collected from Zebra (*Equus quagga*), *Strongylus equinis* were the most prevalent (11.1%) followed by *Oxyuris equi* (7.5%) followed by *Strongyloides* (3.7%). The most prevalent parasite isolated from black buck was *Haemonchus contortus* (16.6%) followed by *Ostertagia curcumcincta* and *Fasciola hepatica* (each 5.5%). A total of 18 fecal samples were collected from Mouflon sheep (*Antilope cervicapra*) and isolated *Protostronglus* and *Chabertia ovina* (each 5.5%). A total of 18 fecal samples of Barking deer (*Muntiacus muntjack)* were infected with *Haemonchus contortus*, *Fasciola hepatica* (each 5.5%). In 27 fecal samples of hog deer (*Hyelaphus porcinus*), *Trichostrongylus vitrinus* was the most prevalent (7.4%) parasite followed by *Haemonchus* and *Protostrongylus* species (each 3.7%). The collected 25 samples from Lion (*Panthera leo*) were infected with *Baylisascaris procyonis* and *Alaria* (each 4%), and Bear (*Ursus americanus*) was found infected with *Trichuris vulpis* and *Taxocara canis* (each 4%).

Figures 1-4 present microscopic images of endoparasites, namely *Dictyocaulus* species, *Trichuris* species, *Strongyloides* species, and *Taxocara* species. The direct smear method and Microscope image processing technique were used to get a detailed and magnified image of the parasites.

Figure 1. Larva of *Dictyocaulus* species extracted from Blue Bull in September 2020 from Ayub National Park, Rawalpindi, Pakistan. The image was obtained using 40x power of magnification.

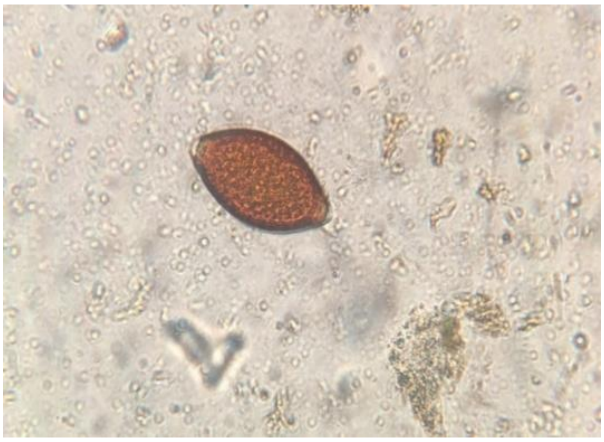

Figure 2. Ova of *Trichuris* species from Brown Bear in September 2020 from Marghzar Zoo, Islamabad, Pakistan. The image was obtained using 10x power of magnification.

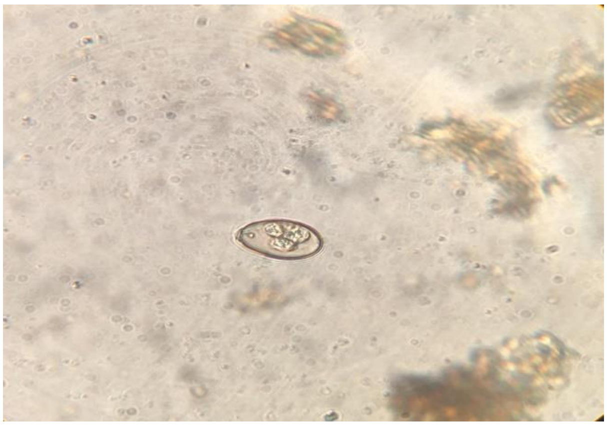

Figure 3. Ova of *Strongyloides* species from Urial in September 2020 from Lohi Bher Wildlife Park, Rawalpindi, Pakistan. The image was obtained using 10x power of magnification.

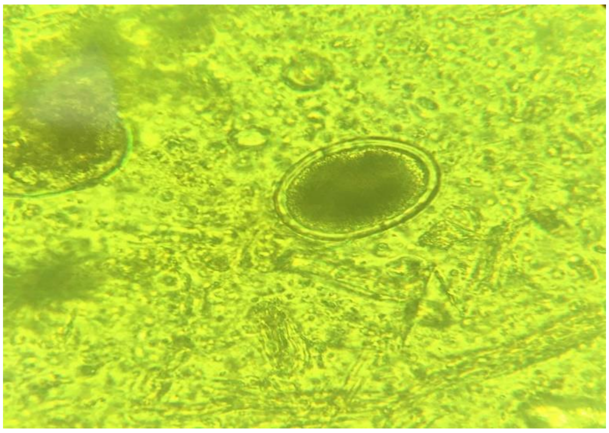

Figure 4. Ova of *Taxocara* species isolated from Siberian tiger in September 2020 from Bansra Galli Wildlife Park, Rawalpindi, Pakistan. The image was obtained using 40x power of magnification.

DISCUSSION

The present study showed that 31.14% of the wild animals were positive for nematodes, cestodes, and trematodes parasites in twin cities' parks and zoos, indicating a mild to moderate prevalence of parasitic infections. The results aligned with Khattak et al. (2023) which showed a high prevalence of GIT parasites among wild and domestic animals in Golden Life Safari Park Khyber Pakhtunkhwa and Mardan district. They attributed the high prevalence to poor settlement, body conditions, anthelminthic medications, and management systems in zoos and parks. The hygiene and cleanliness conditions in the chosen locations of the present study were also compromised, leading to poor animals' health. Moreover, the present study recognized that captive wildlife animals in Pakistan are vulnerable to GIT parasitic infections, especially ungulates including deer, chinkaras, and urials. The high prevalence of GIT infections in these animals was also depicted by Mir et al. (2016), who reported a higher prevalence of parasites from Bir Moti Bagh Mini Zoo, Patiala, Punjab, and found that Blue bull (100%), Spotted deer (50%), Hog deer, Blackbuck (75%), and Barking deer (100%) were infected with GIT parasites. Similarly, Farooq et al. (2012) isolated helminths from domesticated and wild ruminants, including cattle, goats, sheep, camels, chinkara, and blackbuck in the Cholistan desert in Pakistan. The study recorded a high prevalence of helminths in cattle (44.7%) followed by sheep (43%), goats (39%), chinkara (27%), and black buck (20%). The present study reported moderate to high prevalence of GIT parasites in Zebra (22.2%, 39.4%, and 51.8%). However, obtained results of the study from Etosha National Park, Namibia by Turner and Getz (2010) contradicted the findings of the present research, in which a low prevalence of endo-parasites in Zebra, Springbok Blue wild beast, and Gemsbok was reported. The difference in the prevalence of endo-parasites might be due to the difference in management conditions, as in Etosha National Park, animals were dewormed and vaccinated at regular intervals. The findings of the current study are supported by the majority of literature, which emphasizes the susceptibility of both wild and domestic animals to gastrointestinal and parasitic infections.

The present study sought to identify various parasites that lead to GIT infections in captive wildlife animals particularly ungulates in Pakistan. The role of various microorganisms in causing GIT infections, including *Haemonchus contortus*, *Trichostrongylus vitrinus*, *Strongyloides papillosus, Protostrongylus, Ostertagia curcumsincta, Trichostrongylus vitrinus*, *Haemonchus contortus, Eimeria bovis* (8.88%), *Haemonchus contortus*, and *Chabertia ovina* was found out. The results are also complementary to Ferdous et al. (2023) who examined wild animals at the safari parks in Bangladesh and reported a high prevalence of GIT parasitic infection, supporting the result of the present study. Beesley et al. (2018) and Frey et al. (2018) also isolated *Dictyocaulus viviperus*, *Ostertagia* spp., and *Fasciola hepatica* from wild ruminants, such as red, white-tailed, and fallow deers in New Zealand. Kvapil et al. (2017) noted that 45% of the samples were positive for endo-parasites from Ljubljana Zoo in Slovenia. They isolated various parasites, including *Eimeria* spp., *Trichuris* spp., *Ostertagia* spp., *Strongylidae* spp., *Strongyloides* spp., *Trichostrongylus* spp., *Capillaria* spp., *Eimeria* spp., and *Protostrongylidae* spp., from Ungulate species, *Ascaridida* spp., *Trichuris* spp., *Capillaria* spp. from Carnivores, and *Balantidium* spp., *Enterobius* spp., *Oxyuridae* spp., *Strongylidae* spp., and *Trichuris* spp. from primates, supporting the results of the present paper. According to Davidson et al. (2014), there was *Ostertagia leptospicularis* (83%), *Spiculopteragia spiculopter* (92%), and characteristics of *Capillaria* spp., *Moniezia* spp., *Oesophagostomum venulosum,* and *Chabertia* spp. parasites in the red deer. Hence, the obtained results of the present study are in line with the given literature on the types of parasites that result in GIT infections in captive wild animals.

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The study contributes to the literature concerning the veterinary health and well-being of wild animals and identifies a need for improved management of these animals. Thus, the findings of the study suggest inadequate deworming practices and administration at the zoos and parks in twin cities. Nehmat et al. (2015) emphasized the importance of adequate veterinary care and sanitary management of captive wildlife animals to minimize the risk and prevent the occurrence of parasitic infections. Accordingly, the present study recommends improving the health and hygiene conditions of captive wild animals. Moreover, ensuring the cleanliness of the landscape and effective administration providing high-quality food and deworming services can enhance the outcomes of the animals.

CONCLUSION

The study reported a mild to moderate level of parasitic infection in four different zoological parks across Islamabad and Rawalpindi, Pakistan, and identified that ungulates had a high prevalence of GIT parasitic infections and were mostly affected by various endoparasites. The study highlighted the adverse impacts of poor management and inadequate deworming protocols in Pakistani zoological gardens for captive wildlife animals. It warned about the worrisome situation which can endanger the lives of precious captive animals. Therefore, it is recommended that a proper deworming protocol should be developed and authorities should improve the sanitation and hygienic condition of these zoological parks. Future studies can explore the most effective strategies for managing these wild animals based on individual animal safety and health needs. Moreover, future studies can identify the type of environment and habitats to suit the health, and well-being of these animals ensure their immunity, and reduce vulnerability.

DECLARATIONS

Availability of data and materials

Due to privacy concerns of the corresponding author, the data is not openly available.

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Author's contributions

Kaleem Ahmed and Wahid Ullah collected fecal samples from premises that had captive wildlife animals. Qasim Ali and Shah Fahad analyzed the samples in the laboratory for parasitic contamination. Kaleem Ahmed and Muhammad Adeel helped in drafting the manuscript. All authors have read the final version of the manuscript for publishing in the present journal.

Competing interests

Authors have no competing interests.

Ethical considerations

All authors have checked the ethical concerns such as plagiarism, misconduct, fabricated or false data, consent to publish double publication and/or submission, and redundancy.

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