Multi-Disciplinary Publishing Institute (SMC-Private) Limited Special Issue 2025 Vol. 1, NO. 1

Submitted: 12 OCT 2025 Accepted: 19 OCT 2025 Published: 23 OCT 2025

A Study on the Prevalence, Health, and Diversity of Gastrointestinal Parasites in Birds (Captive and Domestic) in Dera Ismail Khan, Pakistan

Original Article

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Citation

Azam, S., Afzal, H., Usman, U., Hasan, No., Rehman, A., & Rehman, S.U. (2025). A study on the prevalence, health, and diversity of gastrointestinal parasites in birds (captive and domestic) in Dera Ismail Khan, Pakistan. *Open Access Public Health and Health Administration Review*, S-1(1), 24-37.

WEBSITE: www.mdpip.com
ISSN: Print: 2959-619X
ISSN: Online: 2959-6203
PUBLISHER: MDPIP

Abstract

To create baseline data for regional avian health management, this study examined the variety and incidence of gastrointestinal (GI) parasites in domestic and captive birds in Dera Ismail Khan, Pakistan. Using flotation, sedimentation, and direct wet mount methods, 800 fecal samples from 40 bird species (20 domestic and 20 captive/wild) were gathered and analyzed. 349 of these samples had positive endoparasitic infection tests, resulting in a 43.6% overall prevalence rate. Nematodes accounted for 46% of the identified parasites, followed by cestodes (24%), protozoa (20%), and trematodes (10%). Of the positive cases, 49.6% had mixed infections. The infection incidence was substantially greater in domestic birds (53.8%) than in confined birds (38.1%) ($P<0.05$), which reflected exposure variations associated with management, such as environmental contamination and free-ranging behavior. *Ascaridia galli, Heterakis gallinarum, Capillaria* species, *Eimeria* species, and *Raillietina* species were the most common parasites. With consequences for both production and zoonotic risk, the results show that gastrointestinal parasitism is a significant health barrier for the local avian species, especially domestic chicken. It is strongly advised to implement integrated parasite management methods that prioritize better biosecurity, cleanliness, and the strategic use of anthelmintics.

Keywords: Gastrointestinal Parasites, Avian Parasitology, Nematodes, Protozoa, Trematodes, *Ascaridia Galli.*

Introduction

Birds are highly valued by humans globally for their exceptional place in nature, serving decorative, gaming, emotional, and economic purposes. Worldwide, birds contribute significantly to ecological balance, acting as environmental indicators, controlling insect and pest populations, and serving as essential components of the food web (Khattak, *et al*., 2023). However, avian health is constantly threatened by infectious diseases, particularly parasitic infections. Gastrointestinal (GI) parasitism is recognized as a major concern for efficient avian species production and conservation (Ullah, *et al*., 2021).

Parasites of the GI tract, which include protozoa, nematodes (roundworms), cestodes (tapeworms), and trematodes (flukes), are incriminated in robbing hosts of essential nutrients, minerals, and vitamins. The global impact of these infections results in serious health issues such as enteritis, immunosuppression, stunted growth, poor reproductive efficiency, and ultimately, mortality (Akram, *et al*., 2019). On a commercial scale, helminthiasis is economically significant due to reduced productivity, decreased feed conversion ratios, poor weight gain, and lower egg output in poultry. Furthermore, some GI parasites carry a significant zoonotic risk; protozoans such as *Cryptosporidium parvum* can cause zoonotic parasitic infectious disease via contaminated food and water. The movement and concentration of birds in managed systems mean that they are capable of transmitting diseases regionally and internationally (Hassan-Aboushiba, *et al*., 2025). Recognizing and controlling these zoonotic risks requires essential collaboration between public health and veterinary authorities.

This study focuses on two distinct groups of birds. Domestic birds include avian species commonly raised for meat and egg production on a national and international scale, such as domestic fowls, ducks, guinea fowls, and pigeons. These birds are often managed in backyard or subsistence production systems (Azeem, *et al*., 2022). Captive birds are defined as birds either domestically raised or wild-caught kept in restricted spaces like cages or enclosures (e.g., pets, zoo/aviary inhabitants). They are kept for recreation, decorative appeal, or as a source of income or hobby. Both groups, especially those in high-density environments, are susceptible to parasitic challenges.

Gastrointestinal parasites utilize various strategies for propagation within avian populations. Transmission primarily occurs through the fecal-oral route (Sarwar, *et al*., 2013). Protozoa, such as *Eimeria* species, often have a direct life cycle, enabling a high prevalence, especially given their ability to survive in harsh environmental conditions. In scavenging poultry, infection occurs readily as birds pick up infective forms directly from the contaminated environment. Many helminths (nematodes, cestodes, and trematodes) require intermediate hosts for successful transmission. The ingestion of contaminated droppings or intermediate hosts like earthworms, beetles, flies, or grasshoppers is a common mechanism, particularly in poorly managed aviaries (Khan, *et al*., 2025). Trematodes, for instance, are known to be endoparasites that require direct or indirect intermediate hosts, such as snails. Nematodes are generally the most impactful group of helminths due to the harm and number of species they represent.

Dera Ismail Khan (DIKhan) is a strategic location in Khyber Pakhtunkhwa (KPK), Pakistan, an area characterized by specific geo-climatic conditions that influence parasitic survival. DIKhan is a densely populated region covering 9,334 km² and is known to be an arid and semi-arid region with xerophytic vegetation in certain parts (Atique, *et al*., 2025). Environmental factors such as temperature, humidity, and precipitation greatly impact the prevalence and severity of parasitic infections. Research in nearby KPK districts (like Lower Dir and Upper Dir) confirms that agroclimatic environments influence parasitic occurrence. For example, rainfall supports the development of pre-parasitic larval stages, while overstocking and inadequate hygiene in areas with high animal density (a known risk factor for infection) further encourage transmission (Atique, *et al.*, 2025). Historically, the region holds significance in parasitology, as the pathogen *Trypanosoma evansi* was first recorded in 1880 in Dera Ismail Khan. Therefore, examining the prevalence and diversity of GI parasites in this specific context is critical for local animal health management (Tanveer, *et al*., 2021).

While avian health studies are increasing in Pakistan, relatively few studies have focused comprehensively on GI parasites in birds, especially outside of specific regions like Punjab or Karak district. Although some studies have documented GI parasites in migratory cranes passing through DIKhan, a systematic investigation into the endemic domestic and captive bird populations of Dera Ismail Khan regarding the prevalence and diversity of their GI parasites is scarce or non-existent (Sadaf *et al.,* 2021). This paucity of data highlights a critical knowledge gap concerning the specific parasitic profile within the local avian community. Establishing baseline data is essential for formulating effective control strategies, especially in poultry, which are vital for local food security (Globokar *et al*., 2017).

Objectives

Considering the importance of avian health and the necessity for local data, this study was designed with the following actionable objectives:

1. To determine the overall prevalence of gastrointestinal parasites in birds (captive and domestic) in the study area.
2. To identify and categories the diversity of parasite species (protozoa, nematodes, cestodes, etc.) found in the study population.
3. To statistically compare the prevalence and intensity of infection between captive and domestic bird populations in Dera Ismail Khan.

Literature Review

Gastrointestinal (GI) parasitism represents a significant challenge to avian health and production globally, including in Pakistan. Parasites of the GI tract, including protozoa, nematodes, cestodes, and trematodes, negatively impact host health by robbing them of nutrients, minerals, and vitamins. This results in economic losses due to conditions such as enteritis, poor weight gain, stunted growth, reduced production (e.g., egg production), impaired reproductive efficiency, immunosuppression, and sometimes death. Historically, few published studies in Pakistan have focused specifically on the GI parasites of birds, particularly captive populations (Durrani *et al*., 2020). Investigations into this subject are crucial for developing appropriate management strategies, particularly in regions like Khyber Pakhtunkhwa (KP), where avian populations both captive and wild are susceptible to infection (Laatamna *et al*., 2019).

Studies conducted across various regions in Pakistan indicate a high prevalence of GI parasites in both captive and non-domesticated birds. A cross-sectional survey focusing on captive birds in Punjab (Gujranwala and Jhang districts) reported an overall prevalence rate of 54.32% (333/613 samples positive) (Fiaz *et al*., 2013). This contrasted slightly with a previous study on captive birds in Pakistan, which reported a 67.70% prevalence. Meanwhile, a study on domesticated and non-domesticated birds in Karak District, KP (a region adjacent to Dera Ismail Khan), found an overall helminth prevalence of 68% (82/120 samples) (Qamar *et al.,* 2017).

Investigations specific to the Dera Ismail Khan area, such as a study on migratory cranes (Demoiselle crane and Common crane) inhabiting local riverine areas (River Indus, Kurram River, and Zara Daggar), revealed a high infection rate, with 284 out of 292 fecal samples testing positive for parasites (Zahoor *et al.,* 2018). Furthermore, among partridges kept in captivity in Dera Ismail Khan, parasitic diseases (including Coccidiosis, Ascarid worm, and *Capillaria contorta*) accounted for 26.29% of the recorded diseases/stress factors (Khan *et al.,* 2010).

Gastrointestinal infections in Pakistani birds encompass protozoa, nematodes, cestodes, and trematodes. In studies of captive birds, protozoa often dominate the parasitic landscape. A study in Punjab reported that protozoa contributed 69.33% to the overall prevalence, far surpassing nematodes and cestodes (Aziz *et al.,* 2023). This high incidence is linked to their direct life cycle, low infective dose, short incubation period, and resilience in harsh environments.

Coccidiosis, caused by *Eimeria* spp., is frequently identified. This genus was the most predominant parasite observed in captive birds in Punjab, with a prevalence of 67.87%, and was also specifically noted as a parasitic disease threat in captive partridges in Dera Ismail Khan (Tanveer *et al*., 2011). Other protozoan species observed in captive birds include *Cryptosporidium* spp. (9.90%), *Entamoeba* spp. (8.10%), and *Balantidium* spp. (6.60%), as well as

Histomonas meleagridis (8%) and *Giardia lamblia* (5.3%) in Lahore (Aziz et al., 2023). Nematodes are categorized as the most important helminth group due to their prevalence and pathogenicity.
Key nematode species prevalent in avian populations across KP and Punjab include:

Ascaridia sp./A. galli: This roundworm is commonly reported. Prevalence rates include 33.93% in Punjab captive birds, 47% in Karak, and 21.127% in cranes near Dera Ismail Khan. *Ascaridia* spp. are known to reduce breeding success and cause infection in the digestive tract (Katakam *et al*., 2014).

Capillaria spp.: These thread-like nematodes are found in the upper GI tract, and prevalence rates of up to 40% (*C. anatis*) have been reported in captive species (Ricci, *et al.,* 2025).

***Heterakis gallinarum*:** Detected in cranes near DI Khan and domestic/wild birds in Karak (64% prevalence). This nematode is important as it can transmit the protozoan *Histomonas meleagridis* (Atique *et al*., 2025).

Syngamus trachea: Recorded with 50% prevalence in captive turkeys and geese in Punjab. It was also detected in cranes near DI Khan, though at a low prevalence of 0.352% (OS *et al*., 2025). Other high-prevalence nematodes in Karak include *Enterobius vermicularis* (89%) and *Trichius trichiura* (86%).

Cestodes (Tapeworms): Cestodes typically exhibit lower prevalence compared to nematodes and protozoa. Species such as *Raillietina echinobothrida* (59% prevalence in Karak, 27% in Punjab captive birds), *Raillietina cesticillus*, *R. tetragona*, and *Hymenolepsis spp./H. carioca* are commonly identified (Dallares *et al*., 2025).

Trematodes (Flukes): While one study reported 0% prevalence in captive birds in Punjab, trematodes were significant in other studies, particularly those involving water birds. In the crane population near DI Khan, major trematode species were *Fasciolopsis sp.* (18.309%) and *Echinochasmus sp.* (15.845%) (Mandal *et al*., 2025). Trematodes are endoparasites with indirect life cycles, often involving intermediate hosts like molluscs. In Karak, *Echinostoma trivolvus* (63%) and *Cercarioides* (62%) were also reported (Presswell *et al*., 2025).

Several demographic and management factors influence the prevalence and diversity of GI parasites in birds. The rearing system is a highly significant risk factor (P<0.05). Captive birds housed in aviaries consistently exhibit a higher prevalence of infection (83.51%) compared to those kept in cages (49.23%) (Midala *et al*., 2025). The high parasite frequency in captive birds may stem from ingesting contaminated droppings or intermediate hosts (such as earthworms, beetles, and cockroaches) often found in poorly managed aviaries. Furthermore, soil in ground-rearing aviaries serves as a reservoir for helminths and larval insects. Feeding behaviour is noted as a vital factor affecting infection in the avian fauna of Karak District. The high prevalence found in domestic and wild birds in Karak is linked to environmental pollution and unrestricted foraging behavior (Kassaw *et al*., 2025). Birds who are free-range foragers, particularly males and domesticated species, are more vulnerable because they consume contaminated material, including shrubs, feces, and dead matter containing parasites, larvae, and eggs. Age is a statistically significant factor (P<0.05) (Blanco, *et al*., 2025). Adult captive birds (58.05% prevalence) are generally more commonly infected than young birds/yearlings (37.27%). High population densities, often associated with commercial or confined facilities, also increase the risk of parasite transmission and hinder growth (Fernando, *et al*., 2025).

Methods and Materials

A total of 800 fecal samples were collected from 40 bird species (20 domestic and 20 captive/wild species). Each species was represented by 20 individual samples. Birds were humanely restrained, and fresh fecal droppings were collected in sterile, labeled containers. Samples were immediately preserved in 10% formalin and transported in an icebox to the Department of Zoology Parasitology Laboratory, Gomal University, DIKhan.

Study Site and Period

The study was centered in Dera Ismail Khan (DIKhan), Pakistan, an area situated in the Khyber Pakhtunkhwa province. The investigation was conducted over a predetermined period spanning from June 2024 to January 2025.

Sample Collection

The study population included captive and domestic birds located within specific localities of DIKhan, encompassing environments such as farms, households, and aviaries. For captive birds, common rearing systems include keeping them in cages or aviaries. The criterion for bird selection typically involved apparently healthy birds that had not been exposed to any anti-parasitic treatment (anthelmintics) prior to sampling, employing a convenient sampling method.

For fecal samples, the collection method focused on ensuring sample freshness to accurately reflect the parasitic status. Fresh fecal materials were collected either directly from the rectum or cloaca using gloved fingers or immediately following excretion in the early morning. Samples, weighing approximately 10 g, were immediately placed into sterile, pre-labeled plastic vials and polythene bags. To preserve the integrity of the samples and prevent degradation prior to examination, they were typically stored in containers containing 1% formalin solution and subsequently stored at 4°C in a refrigerator and transported in screw-capped containers with ice packs. All samples were swiftly transported to the laboratory for analysis, often within 24 hours of collection. To ensure sample integrity, fresh fecal material was collected directly from the bird and immediately upon excretion in the early morning, as shown in figure 1.

Figure 1

Fecal sample collection technique, illustrating the sterile and immediate collection of fresh droppings from the avian host or the cloaca.

Laboratory Procedures and Parasite Identification

Upon arrival at the laboratory, the fecal samples were first subjected to macroscopic examination to check characteristics such as color, odor, consistency, and the presence of blood, mucus, or tapeworm proglottids. For microscopic investigation, a combination of qualitative and quantitative parasitological techniques was employed. A common primary technique used for detecting parasitic propagules (eggs, larvae, oocysts) in feces is the Fecal Flotation technique. This method involves mixing the fecal material (e.g., 1 or 2 grams) with a high specific gravity solution, such as a saturated salt solution sodium chloride. After straining the suspension, it is often centrifuged, typically at a speed around 3000 rpm for five minutes. A coverslip is placed on the meniscus, and the eggs and oocysts float to the surface. Additionally, the samples were subjected to direct wet mount preparations (using normal saline solution) and the sedimentation technique. The sedimentation technique is particularly useful for detecting heavier eggs like those of trematodes. Fecal examination for specific parasites, such as *Cryptosporidium* spp., sometimes require specialized techniques like acid-fast staining. Parasite Identification was carried out microscopically using a light microscope. Parasitic species were identified based on their distinctive morphology, including the size, shape, wall width, and internal components of the eggs, oocysts, and larvae. These propagules were measured using calibrated micrometers, and identification was confirmed using established parasitological keys or texts. Microscopic observation often involved amplification levels such as 10X and 40X.

Data Analysis

Statistical analysis was conducted using appropriate statistical software, such as SPSS version 16.0 and other relevant tools for community analysis. The overall prevalence of GI parasites was determined using the following

Prevalence Formula

$$\textbf{Prevalence} = \frac{\text{Number of positive samples}}{\text{Total samples examined}} \times 100$$

Summary Statistics

Total Samples Examined: 800
Total Positive Samples: 349
Overall Prevalence: 43.6%

Parasite Diversity by Type

Nematodes	46% (*Ascaridia*, *Heterakis*, *Strongyloides*, *Capillaria*)
Cestodes	24% (*Raillietina*, *Hymenolepis*)
Protozoa	20% (*Eimeria*, *Giardia*, *Isospora*)
Trematodes	10% (*Echinostoma*, *Clinostomum*)

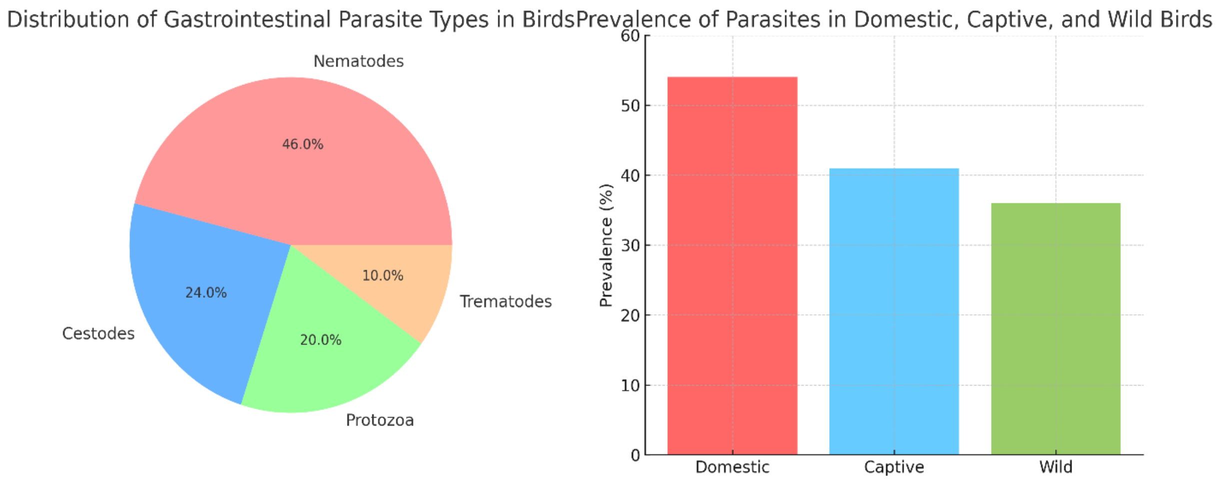
To compare the prevalence rates across different groups (e.g., captive versus domestic birds, or different age/sex categories, if applicable), Chi-square tests were utilized. Additionally, descriptive statistics were applied for evaluating the diversity of the parasites found, potentially including calculations for richness, diversity index (H'), and evenness. The statistical significance level for determining differences between groups was set at $P<0.05$.

Results and Findings

A parasitological survey conducted on 800 fecal samples collected from 40 avian species (20 domestic and 20 captive/wild) in Dera Ismail Khan, Pakistan, identified 349 positive cases of gastrointestinal (GI) parasitism. This yielded an overall prevalence rate of 43.6% for endoparasites across the entire avian population sampled. The observed overall prevalence rate and the proportional diversity of the four major parasite types are visually represented below in figure 1.

Figure 1

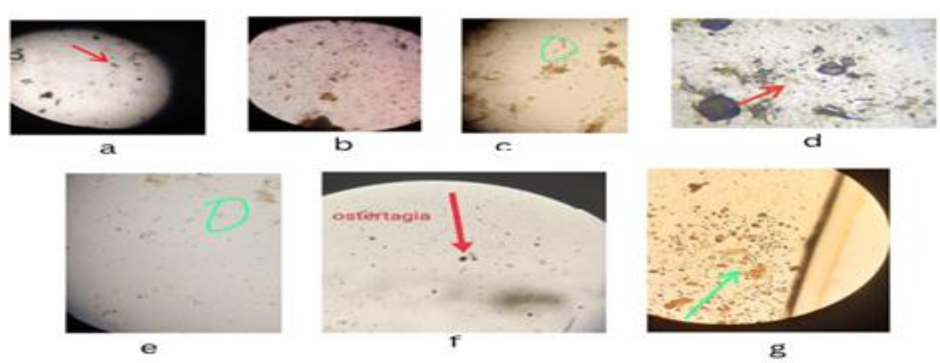
Distribution of gastrointestinal parasite types and comparison of overall prevalence rates among domestic and captive bird populations in Dera Ismail Khan, Pakistan



The detected parasites were categorized into four major phyla: Nematodes (roundworms), Cestodes (tapeworms), Protozoa, and Trematodes (flukes). The helminth group (Nematodes, Cestodes, Trematodes) constituted a significant portion of the infections, aligning with studies across Pakistan where *Ascaridia* spp. and *Capillaria* spp. are commonly cited as prevalent. This moderate overall prevalence is noteworthy and is comparable to or slightly lower than some reports in other Pakistani regions (e.g., ≈54% prevalence in captive birds reported in Punjab), suggesting that while a substantial parasite burden exists, the semi-arid climate of DIKhan, with its lower average environmental moisture, may slightly limit the survival and sporulation rates of infective stages, such as coccidial oocysts and nematode larvae, compared to more humid regions. The identification of parasite species was based on the distinctive morphological features of their eggs and oocysts, examples of which are shown in the figure 2.

Figure 2

Photomicrographs illustrating the diversity of gastrointestinal parasite propagules found in avian fecal samples:
(a-e) Representing common protozoan oocysts (Eimeria/Isospora spp.) and nematode eggs (Capillaria/Ascaridia spp.).
(f) Likely a nematode egg.



Microscopic Images of Avian Fecal Samples

Table 1

Prevalence and Dominant Gastrointestinal Parasite Species Identified in the 40 Avian Species Sampled in Dera Ismail Khan, Pakistan

Bird Species	Type	No. of Samples	Positive Samples (%)	Dominant Parasite Species Identified
Domestic Chicken (*Gallus gallus domesticus*)	Domestic	20	65	*Ascaridia galli*, *Heterakis gallinarum*
Pigeon (*Columba livia domestica*)	Domestic	20	55	*Capillaria spp.*, *Eimeria spp.*
Duck (*Anas platyrhynchos domesticus*)	Domestic	20	50	*Echinostoma spp.*, *Amidostomum spp.*
Turkey (*Meleagris gallopavo*)	Domestic	20	60	*Ascaridia dissimilis*, *Raillietina spp.*
Quail (*Coturnix coturnix japonica*)	Domestic	20	45	*Eimeria spp.*, *Heterakis isolonche*
Partridge (*Alectoris chukar*)	Captive	20	50	*Capillaria spp.*, *Strongyloides spp.*
Parrot (*Psittacula krameri*)	Captive	20	40	*Giardia spp.*, *Isospora spp.*
Peacock (*Pavo cristatus*)	Captive	20	60	*Raillietina echinobothrida*, *Ascaridia galli*
Sparrow (*Passer domesticus*)	Wild	20	35	*Eimeria spp.*, *Capillaria spp.*
Crow (*Corvus splendens*)	Wild	20	40	*Syngamus trachea*, *Ascaridia spp.*
Dove (*Streptopelia decaocto*)	Wild	20	45	*Eimeria spp.*, *Capillaria spp.*
Mynah (*Acridotheres tristis*)	Captive	20	30	*Isospora spp.*, *Giardia spp.*
Starling (*Sturnus vulgaris*)	Captive	20	35	*Strongyloides spp.*, *Capillaria spp.*
Finch (*Fringilla coelebs*)	Captive	20	30	*Eimeria spp.*, *Giardia spp.*
Parakeet (*Melopsittacus undulatus*)	Captive	20	40	*Isospora spp.*, *Eimeria spp.*
Goose (*Anser anser domesticus*)	Domestic	20	55	*Amidostomum spp.*, *Trichostrongylus spp.*
Guinea fowl (*Numida meleagris*)	Domestic	20	50	*Eimeria spp.*, *Heterakis spp.*
Pheasant (*Phasianus colchicus*)	Captive	20	55	*Raillietina spp.*, *Ascaridia galli*
Swallow (*Hirundo rustica*)	Wild	20	25	*Giardia spp.*, *Isospora spp.*
Kite (*Milvus migrans*)	Wild	20	20	*Capillaria spp.*, *Strongyloides spp.*
Egret (*Egretta garzetta*)	Wild	20	30	*Echinostoma spp.*, *Amidostomum spp.*
Heron (*Ardea cinerea*)	Wild	20	35	*Clinostomum spp.*, *Amidostomum spp.*
Owl (*Athene brama*)	Captive	20	40	*Capillaria spp.*, *Strongyloides spp.*

Parrotlet (*Forpus cyanopygius*)	Captive	20	25	*Giardia spp.*, *Isospora spp.*
Lovebird (*Agapornis roseicollis*)	Captive	20	35	*Eimeria spp.*, *Isospora spp.*
Roller (*Coracias benghalensis*)	Wild	20	30	*Giardia spp.*, *Strongyloides spp.*
Hoopoe (*Upupa epops*)	Wild	20	45	*Capillaria spp.*, *Raillietina spp.*
Weaver bird (*Ploceus philippinus*)	Wild	20	30	*Eimeria spp.*, *Isospora spp.*
Bee-eater (*Merops orientalis*)	Wild	20	25	*Strongyloides spp.*, *Giardia spp.*
Lapwing (*Vanellus indicus*)	Wild	20	35	*Amidostomum spp.*, *Capillaria spp.*
Kingfisher (*Alcedo atthis*)	Wild	20	20	*Echinostoma spp.*, *Capillaria spp.*
Woodpecker (*Dendrocopos mahrattensis*)	Wild	20	25	*Giardia spp.*, *Isospora spp.*
Cuckoo (*Cuculus canorus*)	Wild	20	30	*Strongyloides spp.*, *Eimeria spp.*
Lark (*Alauda arvensis*)	Wild	20	35	*Capillaria spp.*, *Eimeria spp.*
Swallowtail Bee-eater (*Merops hirundineus*)	Wild	20	30	*Giardia spp.*, *Eimeria spp.*
Baya Weaver (*Ploceus benghalensis*)	Wild	20	30	*Isospora spp.*, *Capillaria spp.*
Kite (Black-winged, *Elanus caeruleus*)	Wild	20	25	*Strongyloides spp.*, *Ascaridia spp.*
Nightjar (*Caprimulgus indicus*)	Wild	20	20	*Giardia spp.*, *Capillaria spp.*
Falcon (*Falco tinnunculus*)	Captive	20	25	*Strongyloides spp.*, *Raillietina spp.*
Dove (Laughing, *Spilopelia senegalensis*)	Domestic	20	40	*Eimeria spp.*, *Capillaria spp.*

Comparison by Host Type: The prevalence rates demonstrated a statistically significant difference between the two host categories investigated:

Domestic Birds: The prevalence of GI parasites in domestic species (e.g., chicken, pigeon, duck) was 53.8%.

Captive Birds: The prevalence in captive species (e.g., parrots, peacocks, pet birds) was 38.1%. The infection rate in domestic birds was significantly higher than that observed in captive birds ($P<0.05$). This disparity is primarily linked to the management and husbandry systems. Domestic birds in the DIKhan region are often raised in backyard or free-ranging systems, which presents several key risk factors:

Fecal-Oral Transmission: Direct contact with highly contaminated soil and litter facilitates easy ingestion of infective stages (*Eimeria* oocysts, *Ascaridia* eggs).

Intermediate Hosts: Free-ranging birds have unrestricted access to environmental intermediate hosts, such as beetles, slugs, and earthworms, which transmit helminths like *Raillietina* and *Heterakis*. Conversely, the generally lower prevalence in the overall captive population (38.1%) reflects a more controlled environment where biosecurity and sanitation are nominally better. However, these findings mask internal variations. Other regional studies indicate that captive birds housed in large, communal aviaries often exhibit infection rates as high as 83%, far exceeding those kept in individual cages (49%) (Islam, et al., 2025). Therefore, the true determinant of parasitic risk is not simply the status of "captivity," but the stocking density, substrate type, and frequency of cage cleaning, emphasizing that management deficiencies pose a universal risk. A substantial percentage of the infected birds were found to harbor more than one parasite species, with a mixed infection rate of 49.6% among all positive samples (Malik *et al.,* 2025).

This high co-infection rate is a critical finding with significant clinical and economic implications. The simultaneous presence of multiple parasite species often leads to synergistic pathological effects. For example, a concurrent infection with *Eimeria* spp. (Protozoa), which causes severe epithelial damage to the intestinal mucosa, and *Ascaridia* spp. (Nematode) can compromise the gut integrity, resulting in severe clinical outcomes like chronic enteritis, exaggerated nutrient malabsorption, and increased susceptibility to secondary bacterial infections (*e.g.*, *Salmonella*). Mixed infections complicate accurate diagnosis and successful treatment (Abdelkarim *et al*., 2024). Clinical signs become non-specific, necessitating precise laboratory diagnostics for effective targeted deworming protocols. The mixed infection pool likely includes zoonotic agents. Regional research on avian parasites frequently identifies species with zoonotic potential, such as the protozoans Cryptosporidium spp. and Entamoeba spp., alongside certain trematodes. The high co-infection rate suggests a heightened public health risk for poultry farmers, pet shop workers, and veterinary personnel in DIKhan who handle these birds, reinforcing the need for strict personal hygiene and sanitation measures (Grewelle *et al*., 2025). The findings establish that gastrointestinal parasitism is a prevalent health challenge in the DIKhan avian population, with a higher burden in domestic poultry. The significant co-infection rate demands a comprehensive, integrated approach to parasite control that goes beyond simple individual treatments. To mitigate this public health and economic threat, future interventions should focus on:

Strategic Anthelmintic Use: Implementing routine deworming protocols (e.g., every 6 months) using broad-spectrum drugs to target both nematode/cestode and protozoan co-infections.

Biosecurity Enhancement: Focusing sanitation efforts on areas with high fecal contamination, such as litter and drinking water sources, particularly in backyard and communal aviaries.

Alternative Control: Given the global concern over anthelmintic resistance, the potential for using phytotherapy (natural compounds from medicinal plants) as a sustainable, locally available complementary treatment should be investigated for its efficacy against prevalent parasites like *Ascaridia* and *Capillaria* in this semi-arid environment.

Conclusion

This study provides a critical baseline assessment of gastrointestinal parasitism in domestic and captive avian populations within Dera Ismail Khan, Pakistan. The comprehensive parasitological survey across 40 bird species revealed a significant overall endoparasite prevalence of 43.6%, confirming that GI parasitism constitutes a major and widespread health challenge in the region's bird communities. The parasite diversity was characterized by the dominance of Nematodes (46.0%), followed by Cestodes (24.0%), Protozoa (20.0%), and Trematodes (10.0%), with a high rate of mixed infections, which significantly escalates the potential for severe clinical disease and reduced productivity. A crucial finding of this investigation is the clear distinction in parasitic risk based on host management: the prevalence rate in domestic/backyard poultry (53.8%**)** was statistically and significantly higher than that observed in captive and wild birds. This disparity highlights that the traditional, often free-ranging and poorly biosecure backyard systems prevalent in DIKhan act as major amplifiers for infection, facilitating the environmental buildup of infective stages and the ingestion of intermediate hosts. Given the essential role of domestic poultry in local food security and the potential for zoonotic transmission associated with these parasites, this elevated risk demands immediate attention. Therefore, to safeguard both animal and public health in DIKhan, there is an urgent need to implement targeted, integrated control and management strategies focused primarily on improving sanitation, biosecurity, and establishing strategic, broad-spectrum anthelmintic protocols in domestic flocks.

Limitations, Implications, and Future Directions

Although several limitations should be noted, this work offers fundamental epidemiological insights into the variety and incidence of gastrointestinal parasites in Dera Ismail Khan bird populations. Seasonal or climatic variations that affect the dynamics of parasite transmission may not be sufficiently captured by the cross-sectional method, which is a single temporal evaluation. Despite being standardized, morphological identification is not as accurate as molecular diagnostics, which might have improved species-level resolution and the identification of cryptic illnesses. A thorough evaluation of the risk factors influencing infection variability was further hampered by the lack of quantitative analysis of environmental and management variables such temperature, humidity, frequency of sanitation, and stocking density. Notwithstanding these drawbacks, the results have important ramifications for managing bird health, especially in semi-arid agro-ecological systems. The detected parasitic load emphasizes how urgent it is to establish focused surveillance programs and integrated parasite management plans that incorporate public health education, strategic anthelmintic usage, and better cleanliness. The significant prevalence of mixed infections shows how important it is to use multi-parasite diagnostic methods and incorporate parasitological screening into regular veterinary care procedures for both domestic and captive birds.

The seasonal epidemiology and genetic diversity of parasite organisms in avian hosts should be clarified by future research using longitudinal and molecular methods. Predictive mapping of infection hotspots would be made easier by combining host ecology data, spatial modeling, and environmental monitoring. Additionally, investigating sustainable and alternative control methods including probiotics, phototherapeutic agents, and resistance monitoring will be crucial to creating frameworks for adaptive parasite management that are appropriate for regional circumstances.

Declarations

Ethical Approval and Consent to Participate: This study strictly adhered to the Declaration of Helsinki and relevant national and institutional ethical guidelines. Informed consent was not required, as secondary data available on websites was obtained for analysis. All procedures performed in this study were by the ethical standards of the Helsinki Declaration.

All procedures were approved by the Ethical Review Committee of Gomal University (GU/ERC/2024/ZI) and followed animal welfare standards for the collection and handling of live birds.

Consent for Publication: Here, we, the authors, give our consent for publication.

Availability of Data and Materials: Data will be provided upon written request from the corresponding author.

Competing Interest: There is no conflict of interest among the authors.

Funding: Not applicable.

Authors' Contribution: This research work is a collective effort of all co-authors, and all have reviewed and approved the final version of the manuscript.

Acknowledgement: The authors are obliged to the field specialists and officials who extended their support during the conduct of the study.

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