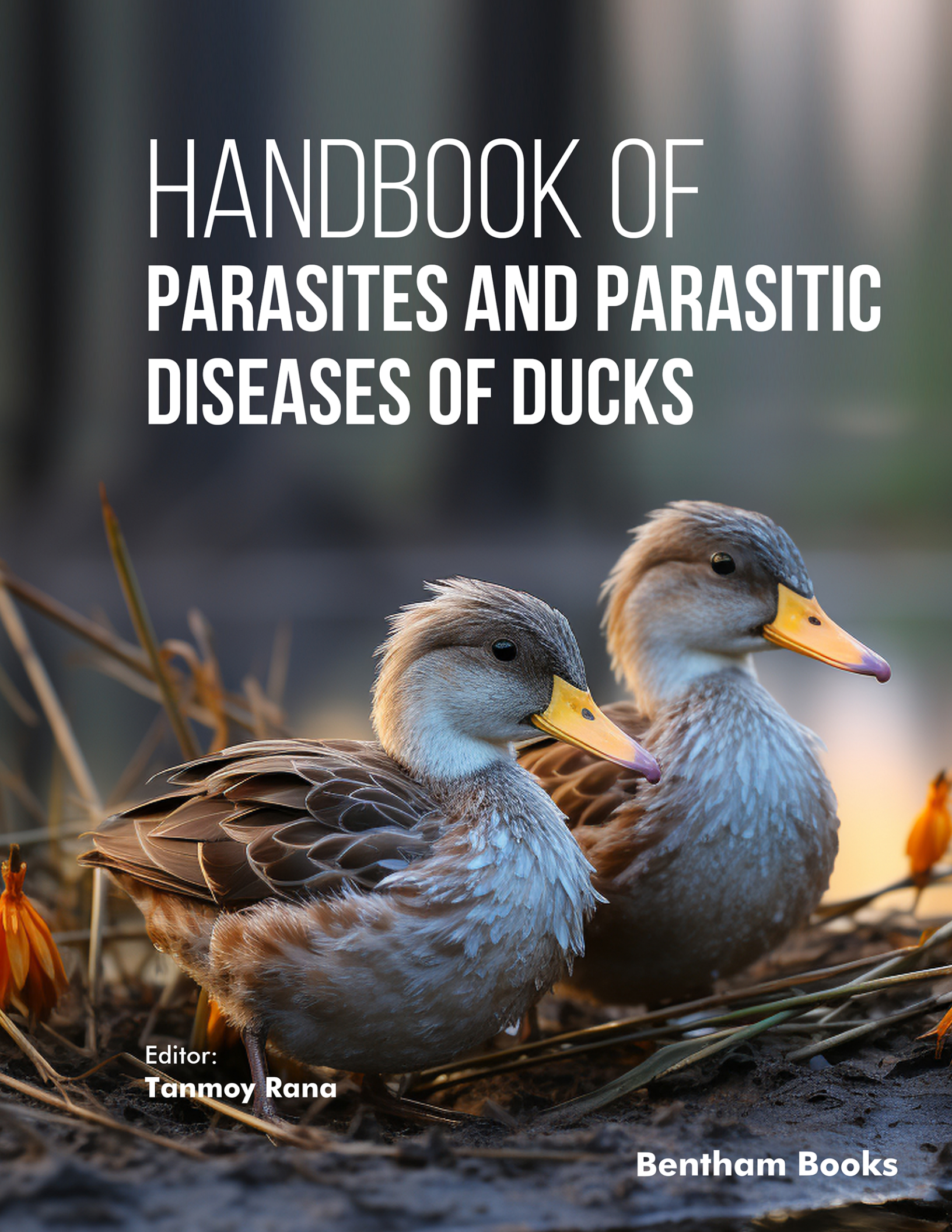
HANDBOOK OF PARASITES AND PARASITIC DISEASES OF DUCKS



Editor:
Tanmoy Rana

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Handbook of Parasites and Parasitic Diseases of Ducks

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FOREWORD

The book titled 'Handbook of Parasites and Parasitic Diseases of Ducks' is one of the books expected to meet the needs of students and scholars of Veterinary Medicine, Animal Science, and Zoology. The book is written because there is a lack of detailed literature on the parasites infecting both domestic and wild ducks.

The book comprises twenty-two chapters with comprehensive and detailed explanations not only of the parasites or disease entities but also of their economic, social, and public health importance. It covers most aspects of parasite morphology, pathophysiology, immune response to infection, economic impact, diagnosis, treatment, control, and the zoonotic importance of the parasites of ducks. It also offers useful and appropriate suggestions based on sound epidemiological considerations. I commend the authors of the various chapters for this wonderful account of this important and somewhat neglected subject.

I personally recommend the book to all categories of students at universities, colleges, and research institutes, particularly those in departments such as Zoology, Veterinary Science, Medical Science, and Animal Science with an interest in parasitology. Prospective readers who have majored in all branches of parasitology will certainly find the book interesting and highly educative.

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Preface

Ducks, whether in captivity or free-living, are hosts to a wide variety of internal and external parasites. The pathogenicity of a parasite may differ in various species of birds as well as different populations of the same species. Treatment and preventive measures are very difficult in free-ranging ducks. However, excellent sanitation can help in combating many parasites in captive situations. The first edition of the book provided comprehensive, up-t--date information on the most important parasites of ducks, as well as their diagnosis, treatment, and preventive measures. In addition, climate change and global impacts can create opportunities for parasites to thrive across various systems in ducks. Parasitic diseases can reduce economic income and also cause difficulties in designing and implementing health control programs. This book consists of 22 chapters arranged sequentially. This book is intended in a colorful format that is easy to read and comprehend. The book is a good source for understanding the topics easily. The contributors are well-versed in their respective fields and have written their individual chapters with utmost care. This book is especially useful for DVM graduate students, postgraduates, farmers, farm managers, industry specialists, practitioners, academicians, researchers, veterinarians, and those with a special interest in duck health, production, and management. I always welcome constructive feedback and encouragement from my veterinarian colleagues around the world.

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CHAPTER 1

Introduction to Parasitology in Ducks

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Abstract: Ducks occupy a distinctive niche in global agricultural systems, contributing substantially to meat, egg, and feather production while functioning as natural biocontrol agents in integrated farming operations. Whether wild or domesticated, duck populations are spread unevenly across different regions, with some parts of the world raising far more than others. Duck farming, traditionally practiced by smallholder and marginal farmers, has a long-standing cultural and agricultural foundation. Asia accounts for the largest share of global duck meat and egg production, with China contributing substantially to overall output. In contrast, in countries such as India, duck farming is still largely confined to small-scale or semi-intensive systems. Even though duck production has the potential to strengthen rural livelihoods, enhance income stability, and improve household nutrition, it remains less commercially prominent than other poultry sectors. Integrated systems, such as rice-duck farming, showcase sustainable agricultural practices. However, parasitic infestations continue to pose a serious challenge to the duck industry. Parasites compromise health status, reduce growth rates, increase mortality, and negatively affect meat and egg quality. In many cases, subclinical infections persist unnoticed, leading to gradual declines in productivity and economic returns. Such impacts ultimately influence the long-term viability of duck enterprises. A clear understanding of duck parasitology is therefore essential for effective health management. Comprehensive parasite control strategies that combine environmental management, sound biosecurity practices, and appropriate veterinary intervention are necessary to minimize production losses. Strengthening parasite surveillance and integrating modern disease management tools with traditional farming knowledge will be critical for improving the sustainability and productivity of duck farming systems.

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Keywords: Duck production systems, Duck parasitology, Egg production, Epidemiology, Helminths, Integrated parasite control, Meat production, Protozoa, Rural economy.

INTRODUCTION

The global duck population is difficult to calculate exactly due to variations in wild and domestic populations and differences in reporting methods across countries; therefore, it is challenging to estimate the precise population. According to FAO estimates, the global domestic duck population was approximately 1.15 billion birds in 2017, with more than 88 percent found in Asia [1 - 4]. Ducks are widely distributed in both wild and domestic settings; wild ducks exist in diverse habitats worldwide, including wetlands, rivers, lakes, coastal areas, and agricultural landscapes. The species include various species of ducks, such as mallards, teal, pintails, wood ducks, and many others. Ecologically, wild ducks contribute to seed dispersal, the regulation of aquatic insect populations, and the maintenance of wetland ecological balance. Because of their sensitivity to habitat degradation and pollution, they are frequently regarded as biological indicators of wetland health [5 - 8]. In addition, they support social and economic value through recreational birdwatching and hunting. The domestic population is also substantial and is raised for various purposes, including meat, eggs, feathers, ornamental ducks, and as pets. China is the largest producer of domestic ducks worldwide, followed by Vietnam, Indonesia, Bangladesh, and India [7]. Selective breeding programs have focused on improving traits such as rapid growth, enhanced egg yield, climatic adaptability, and resistance to common diseases. To put things in perspective, global estimates indicate approximately 33.09 billion chickens, 1.15 billion ducks, about 450 million turkeys, and roughly 364 million geese, highlighting the significant but comparatively smaller share represented by ducks within the global poultry sector [7]. From an economic standpoint, the global duck meat market was valued at approximately US$1.9 billion in 2022 and is projected to reach around US$2.3 billion by 2030, reflecting steady but moderate growth [9 - 11]. These figures emphasize both the economic importance and the untapped potential of the duck industry in many developing regions. According to figures from the Food and Agriculture Organization, between 2004 and 2020, the output of duck meat grew by 54.30%, from 3.1 million tonnes to 4.8 million tonnes. [1] Regarding duck eggs, the top producer was the People's Republic of China (77.63%), while the Netherlands accounted for the largest share of the global duck egg export market, with a value of US$85.2 million, representing 53.09% of total exports. With 21.09% of all imports worldwide, Spain was the top importer of duck eggs [2].

In India, 138.38 billion eggs are produced annually. An annual average of 101 eggs is available per person, *i.e.*, per capita availability (2022-23). Andhra Pradesh (20.13%), Tamil Nadu (15.58%), Telangana (12.77%), West Bengal (9.93%), and Karnataka (6.51%) are the top 5 egg-producing States. They account for 64.93% of the nation's total egg production. The global population of ducks was reported to be 1.15 billion in the year 2020, which decreased from 1.19 billion recorded in the previous year, 2019 [3]. The number of ducks in India is 33.51 million, or 4.00% of all poultry, according to the 2019 livestock census. Eastern (64.50%), North Eastern (16.02%), and Southern (12.60%) states of India have the highest duck populations (20th L.S. Census, 2019). The species-wise egg contribution in India showed that 0.74% and 0.12% of total eggs were laid by *Desi* or indigenous duck breeds and improved duck breeds, respectively [4]. Ducks are an indigenous species of poultry in India, where they have historically been raised by impoverished farmers as a source of income. It is vital to keep in mind that, unlike chicken farming, duck farming has not yet been industrialized or commercialized; nonetheless, because duck farming is one of the more promising species for the future, it is still growing slowly and steadily [5].

DUCK FARMING: A GLOBAL PERSPECTIVE

Duck farming is widespread, nomadic, and seasonal, and it is still overseen by small-scale farmers, marginal farmers, and nomadic tribes (Fig. **1**). Duck farming has its roots in the past when humans used to harvest ducks for their flesh and eggs. Duck breeds have evolved to meet specific needs, leading to a variety of duck-farming techniques employed by different cultures. Ducks raised for meat production may be kept in extensive, free-range, or intensive production systems depending on local practices and market demands [6, 7]. The customary wisdom that farmers have passed down over the years serves as the foundation for managing the populations of ducks and eggs. Integrated rice-duck farming, in which ducks are let to wander freely across rice paddies, is one of the most prominent methods in Asian countries. Not only does this technique manage weeds and insects as pests, but their droppings also help enrich the soil. Combining agricultural production and animal husbandry is a great example of sustainable agriculture. India has a largely nomadic system for duck production, with small-scale farmers raising the majority of the birds. Most of the time, the ducks forage in the communal ponds that are present in many settlements. During the day, they forage outdoors in search of food, and at night, they are lured inside by placing extra food within the shelter. Most duck farmers maintain a separate duck habitat close to their residences [8].

CHAPTER 2

Overview of Parasitology, Parasitism, and Their Significance in Waterfowl Health

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Abstract: Whether in the wild or in captivity, waterfowl frequently carry a variety of internal and external parasites. Because mixed infections, which involve multiple parasite species, are far more common than single-species infections, the true impact of these infections is typically still unknown. Therefore, it is necessary to take into account the effects of any one parasite species in relation to other parasites, illnesses, or stressors, such as malnutrition, that may also be affecting the host. Furthermore, the pathogenicity of a parasite can differ not only between bird species but also between populations of the same species. Several of the hundreds of parasite species that infect waterfowl have been linked to diseases and even death in both wild and captive varieties. The trematode Sphaeridiotrema globulus, several nematodes, Leucocytozoon simondi, cestodes from the genus Gastrotaenia, some acanthocephalans, and some coccidia species are among them. Conventional diagnostic techniques like blood smears and fecal flotation can detect a variety of parasitic infections. Finding parasites, however, does not always mean that a disease is present. There are few options for treatment and control, especially for waterfowl that are allowed to roam freely. Nonetheless, keeping a high standard of cleanliness in captivity can help lower parasite burdens.

Keywords: Ectoparasites, Internal parasites, Parasitology, Pathogenicity, Waterfowl.

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INTRODUCTION

Ducks, geese, and swans are among the waterfowl of the Anseriformes order, which are highly prized for their superior meat, eggs, and protein. Of these, ducks are the most frequently raised [1]. Ducks, however, are susceptible to several illnesses brought on by helminths, arthropods, bacteria, and protozoa [2]. Many researchers from all over the world have stressed the importance of helminth infections in ducks [3]. It is also acknowledged that ectoparasites play a significant role in the growth retardation, diminished vitality, and general ill health of birds [4]. Because of their scavenging habits and preference for damp settings, ducks are particularly vulnerable to gastrointestinal helminth parasites. Ducks, like chickens, eat a variety of foods, such as fruits, grains, insects, crustaceans, small amphibians, and even trash [5]. Like other infectious diseases, the effects of the majority of parasites that affect Anseriformes (ducks, geese, and swans) are still mostly unknown, particularly those that may affect waterfowl's essential physiological processes without directly killing them. Overcrowding causes food or water to become heavily contaminated with pathogens, which is frequently linked to clinical problems or die-offs. Inadequate management techniques may exacerbate these outbreaks in captive flocks.

ECTOPARASITES

Ectoparasites are one factor contributing to hybrid ducks' or ducklings' poor egg production. These parasites reside in the outer layers of the skin or on the exterior of the host's body. Ectoparasites can have a direct effect on duck health by causing dermatitis, allergic reactions, toxicosis, irritation, tissue damage, and blood loss. Both the quantity and quality of meat and eggs produced may decrease as a result of these effects [6]. The body temperature of the host, the surrounding environment, and the density and structure of the host's feathers are some of the variables that affect the spread of ectoparasites. In unclean cages and unsanitary environments, these parasites have a tendency to flourish and multiply quickly.

A variety of ectoparasitic arthropods, including lice, mites, ticks, and biting insects, live inside waterfowl. The main ways these parasites affect birds are by making those already ill worse and by serving as intermediate hosts or vectors for infectious diseases. For example, on sick birds, lice populations can increase rapidly, and the irritation of infestations can make the birds feel weaker overall. A biting louse serves as the intermediate host for the heartworm *Sarconema eurycerca*, which infects swans, and all avian hematozoa are spread by blood-feeding insects. Newly hatched wild ducklings have also been known to contract fatal myiasis. It has been noted that larvae of the flesh fly (*Wohlfahrtia opaca*) enter newly hatched birds through the umbilicus and burrow into the abdominal

subcutaneous tissues [7]. Myiasis in waterfowl is thought to be frequently disregarded, which means that the full scope of its effects is still mostly unknown.

Ducks are known to be infested by a variety of lice species. Among them are *H. leucoxanthum*, *H. maxbeibeieri*, *H. transvalence*, and *Holomenopon fatemae*. While Anatoecus dentatus usually inhabits the edges of the head and beak, Trinoton querquedulae and Anaticola crassicornis are usually found on the wings. Ducks are also parasitized by another species, *Anatoecus icterodes*. *Trinoton anserinum* is another noteworthy species, and *Menopon gallinae* is frequently found on the duck's ventral side. Certain ticks can infest ducks in addition to lice [8]. In a study by Musa *et al.* [7], a sample of 20 ducks had a 100% prevalence of *Goniocotes hologaster* lice. According to research conducted in the South Indian region by Narayanaperumal *et al.* [8], Anatoecus dentatus exhibits a preference for the head and beak edges. Anaticola species are mostly found on the wings of ducks, whereas *Menopon gallinae* are most frequently found on the ventral side (Fatimatussyahro, 2012). *Dermanyssus gallinae* is the most prevalent tick species in poultry, usually infesting the abdomen, wings, and tail. The abdomen and regions under the wings are preferred by Argas persicus and Argas robertsi, which are also present. Knemidocoptes mutans is the most common mite and typically affects the legs. *Ornithonyssus bursa* and *Knemidocoptes gallinae* are typically found close to the cloaca and are linked to decreased productivity in domestic chickens. These mites can cause death in chicks younger than one month [5].

INTERNAL PARASITES

Protozoa

Coccidia

There are many different species of coccidia, a broad category of protozoan parasites, many of which do not exhibit obvious clinical symptoms. Usually host-specific, these parasites cause the infected host to become partially immune to further infections. Given the high level of host specificity and the self-limiting nature of the majority of infections, coccidiosis is usually not regarded as a serious health concern in free-ranging waterfowl. However, the pathogenic potential of coccidial parasites can be increased by bird crowding, whether as a result of habitat loss or captivity. While young birds or those under stress are more likely to develop obvious clinical disease, adults generally have a tendency to have subclinical infections. Coccidial infections in waterfowl are generally classified according to the site of infection: some species infect the kidneys and associated structures, while others target the intestinal tract. Swans, geese, and ducks have all been reported to have enteric coccidia. Only a small number of the

CHAPTER 3

Helminth Parasites of Ducks: Classification, Life Cycle, and Impact

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Abstract: Helminth parasites are a serious and often overlooked threat to duck health, impacting both small backyard flocks and large commercial operations, as well as wild duck populations. Ducks are especially vulnerable to these internal worms because of their close association with ponds, wetlands, and other water sources, which naturally harbor snails, insects, and other small aquatic creatures that serve as intermediate hosts for many parasites. This review brings together current knowledge about the major worm parasites affecting ducks, grouping them into three main categories: roundworms (nematodes), flukes (trematodes), and tapeworms (cestodes). Common roundworm infections include gizzard worms (*Amidostomum* spp.), hairworms (*Capillaria* spp.), gapeworms (*Syngamus trachea*), and stomach worms (*Tetrameres* spp.). Important fluke parasites include intestinal flukes (Echinostoma spp.) and the damaging oviduct fluke (*Prosthogonimus* spp.), while tapeworms such as *Hymenolepis* spp. and *Drepanidotaenia lanceolata* frequently infect the intestinal tract. These parasites follow different life cycles—some spread directly through contaminated feed and water, while others require intermediate hosts to complete their development. Once inside the duck, they cause real damage: eroding the gizzard lining, inflaming the intestines, blocking airways, and even destroying reproductive tissues. The consequences for farmers are substantial. Infected birds grow poorly, convert feed less efficiently, and produce fewer eggs. In severe cases, particularly among young ducklings, death rates can climb as high as 30 percent. Beyond the farm gate, some of these parasites, particularly Echinostoma flukes, can infect people who eat raw or undercooked snails, frogs, or aquatic plants, a real concern in communities where such foods are traditional. The growing problem of drug resistance means we can no longer rely on dewormers alone. Effective control now demands an integrated approach combining targeted medication, smart environmental management (like rotating pastures and controlling snail populations), and good farm hygiene. Understanding how these parasites live, how they harm, and how they spread is essential for anyone raising ducks, whether for market or for conservation. This knowledge directly translates to healthier birds, better production outcomes, and reduced public health risks.

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Keywords: Cestodes, Ducks, Helminth parasites, Nematodes, Parasite control, Trematodes, Zoonotic risks.

INTRODUCTION

Helminth infections in ducks are widespread and often underestimated, affecting both domestic and wild avian populations. Ducks are particularly susceptible to helminth parasites because their natural feeding behavior involves dabbling and foraging in aquatic environments where many parasites and their intermediate hosts occur. During feeding, ducks frequently ingest infective stages of parasites or intermediate hosts such as freshwater snails, aquatic insects, and other invertebrates. This ecological exposure significantly increases the likelihood of infection and facilitates the maintenance and transmission of helminth parasites within duck populations [1, 2]. As a result, helminthiasis represents an important health constraint in duck production systems, contributing to reduced productivity, compromised welfare, and potential economic losses.

Helminths infecting ducks are broadly classified into three major groups: nematodes (roundworms), cestodes (tapeworms), and trematodes (flukes). These parasites primarily inhabit the gastrointestinal tract, although some species may affect other organs such as the liver or respiratory system [3, 4]. Among the nematodes, species such as Ascaridia galli, Heterakis gallinarum, and Capillaria spp. are commonly reported in poultry and may also infect ducks. Cestodes frequently encountered in ducks include species of Hymenolepis and Raillietina, while trematodes such as *Echinostoma* spp. and *Notocotylus* spp. are recognized parasites of waterfowl. Trematode infections are closely associated with aquatic environments because many of these parasites require freshwater snails or other aquatic organisms as intermediate hosts to complete their life cycles [5, 6]. The life cycles of helminths vary considerably among parasite groups. Most nematodes have a direct life cycle in which infective eggs or larvae are shed in the feces of infected birds and subsequently ingested by susceptible hosts through contaminated feed, water, or soil. In contrast, many cestodes and trematodes follow indirect life cycles that involve one or more intermediate hosts, typically arthropods or mollusks. Ducks acquire these infections when they consume infected intermediate hosts during routine foraging activities [7, 8]. Helminthiasis in ducks may produce a wide range of clinical and subclinical effects depending on parasite species, infection intensity, age of the birds, and overall health status. Common consequences include poor weight gain, reduced feed efficiency, decreased egg production, intestinal inflammation, and general deterioration of body condition. Heavy infections may lead to anemia, diarrhea, intestinal obstruction, or mortality, particularly in young or immunocompromised birds. Chronic helminth infections can also impair immune function, thereby increasing

susceptibility to secondary bacterial or viral diseases [3, 4]. Some helminths associated with waterfowl are zoonotic. For instance, certain species of Echinostoma are capable of infecting humans, typically through the consumption of raw or undercooked freshwater snails, fish, or other aquatic organisms that contain infective stages of the parasite. Although human infection is relatively uncommon in many regions, it remains a public health concern in areas where the consumption of raw aquatic food products is practiced [9]. A clear understanding of the taxonomy, epidemiology, life cycles, and pathogenic mechanisms of helminth parasites in ducks is essential for developing effective control strategies. Improved management practices, environmental sanitation, routine parasitological monitoring, and strategic use of anthelmintics can significantly reduce infection pressure and support sustainable duck production systems.

CLASSIFICATION AND TYPES OF HELMINTHS IN DUCKS

Helminths affecting ducks belong to three major phyla:

- Nematoda (Roundworms)
- Trematoda (Flukes)
- Cestoda (Tapeworms)

Each group exhibits distinct biological features and clinical manifestations. The diversity and prevalence of these parasites depend on host behavior, environment, and geographical distribution.

Nematodes of Ducks

Nematodes, commonly referred to as roundworms, are cylindrical, unsegmented helminths belonging to the phylum Nematoda and represent some of the most widespread and pathogenic parasitic organisms affecting ducks (Fig. **1**). Morphologically, they are characterized by elongated, tubular bodies covered by a resilient, multilayered cuticle that protects them from environmental stressors and host digestive enzymes. This structural adaptation contributes significantly to their survival and persistence within the host environment. In ducks, nematode infections predominantly involve the gastrointestinal and respiratory systems, although severe or chronic infestations may extend to additional organ systems depending on the species involved and the intensity of infection (Fig. **2**). Gastrointestinal nematodes typically inhabit the esophagus, proventriculus, gizzard, small intestine, or ceca, where they interfere with digestion, nutrient absorption, and mucosal integrity. Respiratory nematodes, on the other hand, colonize the trachea or airways and can impair normal respiratory function. The pathological impact of nematode infections varies widely and is largely

CHAPTER 4

Trematodes of Ducks: Flukes of Major Pathological Significance

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Abstract: Ducks are infected with endoparasitic infections like fluke infections caused by parasitic flatworms, which can affect various parts of the duck's body, depending on the species of fluke involved. The most common flukes that infect ducks include liver flukes and intestinal flukes. The common symptoms include lethargy, malnutrition, weight loss, and watery stools, especially with intestinal flukes, as well as blood loss leading to pale mucosa. Fluke infections can cause significant morbidity in ducks, especially in heavy infestations. While mild infections may go unnoticed, severe cases can lead to impaired growth, poor egg production, and even death. Verminous hemorrhagic ulcerative enteritis is a condition caused by intestinal Sphaeridiotrema globulus. The flukes have a complex life cycle that involves intermediate hosts, typically snails. Ducks can become infected by ingesting metacercariae that encyst on aquatic vegetation or other surfaces. Anthelmintics like praziquantel or albendazole are commonly used to treat fluke infections in ducks. Reducing snail populations in water bodies where ducks feed can help lower the risk of infection by managing vegetation or applying molluscicides.

Keywords: Enteritis, Echinostomes, Endoparasitic infections, Sphaeridiotrema globulus, Snail.

INTRODUCTION

Fluke infections in waterfowl like ducks are caused by parasitic flatworms, known as trematodes, that infect the birds primarily through contaminated water sources. These parasites can cause a range of health problems, depending on the species of fluke and the severity of the infection. Common flukes that affect ducks include strigeid trematodes (Sphaeridiotrema species), which infect the intestinal tract of birds. Heavy infections can cause inflammation, hemorrhage, and severe tissue

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damage, leading to death. Echinostomes affect the intestines of waterfowl, causing weight loss, anemia, and organ damage. Liver flukes like Ophisthorchis infect the liver and bile ducts of birds, causing liver damage, which can affect digestion and lead to lethargy and death in severe cases. Outbreaks of fluke infections can lead to significant mortality in duck populations, particularly in areas with high concentrations of birds and intermediate hosts [1]. Wetland habitats are particularly vulnerable to these outbreaks, especially if they contain high populations of infected snails. Habitat management, monitoring bird health, and limiting water contamination are a few steps that can be undertaken to contain the fluke infection.

OPISTHORCHIS SPP.

Opisthorchiosis is a neglected tropical disease caused by the Asian liver fluke *Opisthorchis viverrini*, which primarily affects the hepatobiliary system. The life cycle of *O. viverrini* involves freshwater snails (Bithynia snails) and cyprinid fish as intermediate hosts, with the host becoming infected by consuming raw or undercooked fish. This parasitic disease is associated with cholangiocarcinoma, a type of liver cancer. A host infected with this liver fluke may develop conditions such as suppurative cholangitis, gallstones (cholelithiasis), and bile duct cancer (cholangiocarcinoma).

Due to their habitat in freshwater environments, domestic ducks often consume small freshwater fish, which may be heavily infected with fishborne zoonotic trematodes. A high prevalence and intensity of infection in ducks suggest that large quantities of parasite eggs are being introduced into freshwater bodies, where ducks scavenge. These eggs can spread over vast areas due to water flow from streams and irrigation systems and due to the seasonal flooding of crop fields and rivers. During the dry season, as streams and rice fields dry up, ducks tend to scavenge more along rivers, where fish carrying the highest intensity of *O. viverrini* infection are present. Ducks raised for egg production are particularly vulnerable because they are exposed to infection for up to two years, compared to ducks raised for meat, which are typically sold at around three months of age and have less exposure to the parasite. [2, 3]. Although the morphological and genetic traits of duck isolates differ slightly from those of human isolates in endemic areas, aquatic birds may serve as reservoir hosts for this zoonotic parasite.

AMPHIMERUS SPP.

Amphimerus (*Amphimerus anatis*, *Amphimerus lancea*, and *Amphimerus caudalitestis*) is a genus of parasitic liver flukes that belongs to the Opisthorchiidae family, affecting the duck population. The adult flukes live in the bile ducts of their definitive hosts. Infection with liver flukes from this family

occurs through the consumption of raw or undercooked freshwater fish containing metacercariae.

Pathological examination revealed that infected livers were often slightly atrophied, smaller, and with wrinkled or shrunken liver capsules. The liver edges are sharp, with small white necrotic spots. Desquamation of the bile duct epithelium is common, while hyperplasia of the bile duct epithelium is not very common. [1,4[. The liver fluke *Amphimerus anatis* can destroy most of the functional liver tissue in the ducks, severely damaging all liver structures and leading to fibrosis and cirrhosis. Acute obstruction outside the liver is found, marked with significant bile duct hyperplasia and fibrosis in severe cases. In the liver, there is Kupffer cell hyperplasia and cholestasis, along with extensive portal fibrosis and sclerosing cholangitis. The affected bile ducts are completely replaced by fibrous tissue and surrounded by dense collagenous connective tissue, accompanied by significant eosinophil infiltration, areas of coagulation necrosis, and the presence of other leukocytes. The kidneys exhibited necrotic changes in the parenchyma, with severe congestion and hemorrhages in both the cortex and medulla. [5, 6].

ECHINOSTOMA SPP.

The body of the parasite is dorsoventrally flattened, elongated, and leaf-like, measuring 6–9 mm in length. The anterior end exhibits typical echinostome characteristics, including an oral sucker and a prominent head collar. The oral sucker is small, while the well-developed head collar bears 37 spines arranged in two alternating rows. The genital atrium and pore are centrally located, just behind the intestinal bifurcation, receiving both male and female ducts. The uterus is long, slender, with many transverse coils between the ventral sucker and ovary, containing numerous eggs. Two irregularly lobed testes are in tandem, and the Y-shaped excretory vesicle bifurcates behind the posterior testis. The numerous yellowish, oval, and immature eggs are operculate, with a small operculum and wrinkling or thickening at the abopercular end [2, 7].

E. miyagawai was first identified in ducks in Japan. Freshwater snails of the genera Planorbis, Radix, Galba, Gyraulus, and Anisus serve as the primary intermediate hosts. The secondary intermediate hosts include lymnaeid snails. Infection occurs when aquatic second intermediate hosts, such as freshwater snails, fish, and tadpoles, are ingested. Severe echinostome infections, particularly from *E. revolutum*, can lead to emaciation, catarrhal enteritis, and even death in young or unhealthy ducks. Poultry and birds act as key reservoirs of these infections [10]. High prevalence of zoonotic echinostomes like *E. revolutum*, *E. recurvatum*, and *H. conoideum* has been observed in domestic ducks in

CHAPTER 5

Cestodes in Ducks: Identification, Pathology, and Treatment of Tapeworm Infections

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Abstract: Ducks make up the bulk of the poultry produced worldwide. Very little is known about the population of ducks in various nations. Like other vertebrate families found in freshwater or marine environments, the Anatidae are most likely home to a variety of metazoan parasites. Among them, tapeworms (Cestoda) are the most common and extensive. Typically, the life cycle is indirect. Among the intermediary hosts they prey on are ants, earthworms, termites, houseflies, beetles, grasshoppers, mini-wisps, and snails. The majority of tapeworms do not cause any physical injury to the intestinal wall, but they are still harmful to the bird's health because they deprive it of nutrients, increasing the bird's risk of infection and sickness, stunted growth, and weight loss. The main goal of this book chapter is to ascertain the global prevalence of infections brought on by duck cestodes. The thorough data produced by this research will help policymakers create preventative and control measures.

Keywords: Duck, Disease, Lifecycle, Poultry cestode, Prevalence.

INTRODUCTION

Ducks are raised throughout the world, either in backyards or in industrial production systems. It provides vital protein sources like eggs and meat, as well as revenue and organic manure for high fertility [1, 2]. The poultry industry is extremely concerned about sanitation due to the expanding demand for free-range poultry products and the increased exposure of these animals to gastrointestinal parasites [3, 4]. Due to their frequent interaction with stagnant water and scavenging behaviours, free-range ducks are more susceptible to intestinal para-

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sitism than chickens and turkeys. In particular, in backyard free-range rearing, the tapeworm poses a serious threat to the production of poultry and results in significant financial losses. The word" parasite" comes from the Greek word "para," which means beside or close to where the grain or other living food is stored.

Cestodes have a flat, tape-like body that is elongate and lacks an alimentary canal. Strobila is made up of several proglottid segments that are divided by a transverse constriction. However, each segment has one or two sets of reproductive organs. The male reproductive organs in tapeworms mature first [5, 6]. The embryonated eggs have three pairs of hooks and an oncosphere with a spherical or oval body. Various intermediary hosts, such as oribatid mites, gastropod mollusks, psocids, beetles, ants, fleas, earthworms, lice, flies, *etc.*, are involved in the life cycle. All cestodes—aside from *Hymenolepis nana*—have an indirect life cycle. The majority of tapeworms are seen in birds raised naturally. The intestinal tapeworm parasite weakens and incapacitates the infected birds [7, 8]. Clinical signs include decreased output, stunted growth, weight loss, ruffled feathers, weakness, and diarrhoea, among others. As a result, the gastrointestinal system of the host is affected to varying degrees by pathogenic activity, which causes farmers to suffer significant financial losses. The elimination of intermediate hosts, cleaning and disinfection of litter and buildings, and pharmacological therapy with anthelminthics and anticoccidials are the major methods of control. More research and parasitological assays must be prioritised on duck farms to regularly monitor the animals' gastrointestinal parasite flora and improve their management strategies. The use of herbal extracts, yeast-derived enzymes, and predatory fungi, which have recently been advocated for the production of poultry, should be considered a novel solution [9, 10].

IMPORTANT CESTODE OF THE DUCK

More than 4,000 species of cestode parasites infect animals, including 1,400 species in infected birds belonging to the families Hymenolepididae, Dilepididae, and Davainidae, all of which are quite significant [2, 11]. Regularly, domestic ducks and geese become infected with a variety of tapeworms that are transmitted by wild ducks and geese (Table **1**).

Table 1. List of different cestodes along with their intermediate host and organ infected in ducks (Rzayev *et al.*) [2].

Tapeworm	Intermediate Host	Organ Infected
Amoebotaenia cuneata	Earthworm	Small intestine
Choanotaenia infundibulum	Insects	Jejunum

(Table 1) cont.....

Tapeworm	Intermediate Host	Organ Infected
Platyscolexciliata	*Simocephalusexspinosus, Daphnia pulex, Moinarectirostris*	Small intestine
Aploparaksisfurcigera	*Lumbriculus variegates, Limnodrilus sp*	Small intestine, large intestine, caeca
Aploparaksisfilum	*Limnodrilusnewaensis*	Small intestine, ceca
Cladogyniaphoeniconaiadis	Unknown	Intestine
Cloacotaenia megalops	*Cypris pubera*	Cloaca Large intestine
Dicranotaenia coronula	*Ostracoda*	Small intestine Ceca
Diorchis buldose	Unknown	Small intestine
Diorchis donis	Unknown	Intestine
Diorchis elisae	*Cypridopsis vidua, Cyclocypris leavis, Diaptomus vulgaris, Dolerocypris fasciata, Notodromas onacha, Eucypris virens*	Small intestine
Diorchis formosensis	Unknown	Ceca, Small intestine – duodenum
Diorchis inflate	*Cypridopsis vidua, Cyclocypris laevis, Diantomus vulgaris*	Small intestine
Diorchis longiovum	Unknown	Small intestine
Diorchis markewitschi	Unknown	Small intestine
Diorchis nyrocae	*Cypridopsis vidua, Cyclocypris laevis(Ostracoda)*	Ceca, small intestine –middle region, large intestine
Diorchis ransomi	*Cyclocypris laevis, C. ovum, Cypridopsis vidua, Dolerocypris fasciata, Notodromas monacha, Diaptomus caeruleus*	Small intestine –middle region
Diorchis spinata	Unknown	Intestine
Diorchis sobolevi	Unknown	Small intestine
Diorchis stefanski	*Cypridopsis vidua, C. ovum, Macrocyclops fuscus, Dolerocypris fasciata, Notodromas monacha*	Small intestine – posterior region, large intestine
Diploposthe laevis	*Acanthocyclops viridis, Macrocyclops albidus, M. fuscus, Mesocyclops leuckartii, Cypridopsis vidua, Heterocypris incongruens*	Small intestine
Echinocotyle anatine	*Cyprinotus incongruens, Cypris ophthalmica, C. pubera*	Small intestine – posterior portion, large intestine

CHAPTER 6

Nematodes in Ducks: Roundworms and Their Impact

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Abstract: The sixth chapter of this book provides a detailed description of nematode parasites that inhabit the gastrointestinal system of ducks. Generally, the ducks are highly susceptible to various pathogens, including nematode parasites, due to their aquatic feeding behavior and their easy accessibility to intermediate hosts. Nematode parasites were reported in the mouth, crop, proventriculus, gizzard, small intestine, and large intestine of ducks. For each parasite, predilection site, parasite class, superfamily, gross description, microscopic description, final hosts, intermediate hosts, geographical distribution, life cycle, pathogenesis, clinical signs, diagnosis, pathology, epidemiology, treatment, and control are discussed in detail. This chapter provides updated insights into the common nematode parasites affecting ducks, comprehensively addressing the needs of students, field veterinarians, and academics.

Keywords: Ducks, Nematodes, Parasites, Parasitic diseases.

INTRODUCTION

Ducks contribute significantly to the supply of animal protein worldwide in the form of meat and eggs. Being aquatic in nature, they thrive best in regions with abundant water resources. Although ducks are reared throughout the country, they are predominantly found in the Eastern, North-Eastern, and Southern states of India. Ducks are an indigenous poultry species that have traditionally been raised by small, marginal, and nomadic farmers in India as a source of livelihood [1]. In recent years, depending on economic conditions, many organized duck farms have been established, particularly by unemployed youths, as a means of generating income. Farmers practice open-range, semi-intensive, and intensive duck-rearing systems. However, despite these efforts, the duck industry still fails to meet the growing consumer demand for eggs and meat in the country.

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One of the major constraints is the prevalence of parasitic infections, which cause severe economic losses to farmers due to poor growth rate, low feed conversion efficiency, reduced egg and meat production, and increased mortality. The agro-climatic conditions of India, with adequate rainfall, temperature, humidity, and diverse land topography, also provide a favorable microclimate for the growth and propagation of parasites [2]. Free-range ducks are in constant contact with soil, water, and vegetation, which serve as important sources of transmission for parasite eggs and larval stages.

Additionally, ducks feed on various aquatic organisms such as snails, fish, earthworms, and water cyclops, many of which act as intermediate hosts, thereby exposing ducks to parasitic infections. Nematodes isolated from the proventriculus and gizzards of ducks have been reported to include 21 species from six families: Amidostomatidae, Acuariidae, Tetrameridae, Dioctophymatidae, Ascarididae, and Anisakidae. Among these, nematodes of the genus *Amidostomoides* are the most prevalent, with *A. monodon* being the dominant species reported in Poland. This chapter provides an updated overview of common nematode parasites affecting ducks, intended for the benefit of students, field veterinarians, and academicians [3].

Porrocaecum crassum

- **Predilection site:** Found in the small intestine.
- **Parasite class:** Belongs to the phylum Nematoda.
- **Super family:** Classified under Ascaridoidea.
- **Gross description:** Worms are reddish-white in color; males measure 12–30 mm, while females range from 40–55 mm in length.
- **Microscopic description:** Eggs are ellipsoidal in shape and measure about 110 × 85 µm.
- **Hosts:** Occurs in both domestic and wild ducks.
- **Life cycle:** Follows the general pattern of other ascarid nematodes.
- **Distribution:** Occurs worldwide.
- **Pathogenesis:** Generally regarded as non-pathogenic.

Contracaecum spiculigerum

- **Predilection site:** Inhabits the small intestine.
- **Parasite class:** Falls under Nematoda.
- **Superfamily:** Member of the Ascaridoidea.
- **Gross description:** Male worms measure 32–45 mm, whereas females range between 24–64 mm in length.
- **Microscopic description:** Characterized by a club-shaped oesophagus; eggs are nearly spherical and measure 50–52 µm in diameter.

- **Hosts:** Found in ducks, geese, swans, and other waterfowl.
- **Life cycle:** Comparable to that of other ascarid worms.
- **Distribution:** Cosmopolitan in occurrence.
- **Pathogenesis:** Considered to be of little or no pathogenic significance.

Ascaridia galli

- **Preferred site:** Small intestine
- **Taxonomic class:** Nematoda
- **Super family:** Ascaridoidea

Macroscopic description: These worms are thick-bodied; females attain a length of up to 12 cm. It represents the largest nematode parasitizing poultry (Fig. **1**).

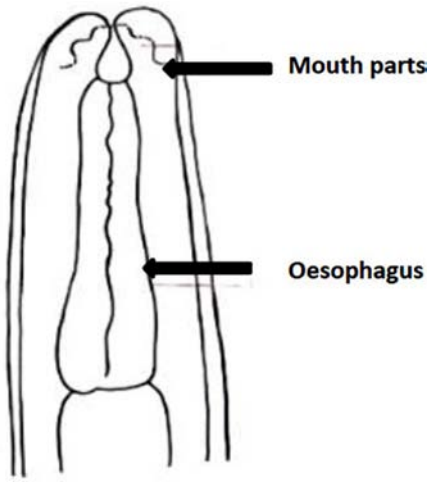


Fig. (1). Head end of *Ascaridia galli*.

Microscopic description: The anterior end is equipped with three prominent lips, and the oesophagus is club-shaped, lacking a posterior bulb. In males, the tail bears small caudal alae with 10 pairs of sessile papillae. A circular precloacal sucker with a thick cuticular margin is present. The spicules are nearly equal in size. Eggs are oval to elliptical with a smooth outer shell (Figs. **2**, **3**).

Hosts: Chicken, goose, turkey, duck, and guinea fowl.

Life cycle: The parasite has a direct life cycle. Eggs are excreted in droppings and, depending on temperature and humidity, develop into the infective stage (L2) in about 10 days or longer. Chickens acquire infection by ingesting eggs containing L2 larvae through contaminated food or water. Once ingested, the eggs are carried mechanically to the duodenum. Hatching occurs in the small intestine,

CHAPTER 7

Common Protozoan Infections and Their Effects on Duck Populations

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Abstract: Duck with endoparasitic infection presents retarded growth, lower egg production, loss of weight, and reduced haemoglobin. Amongst the endoparasites, protozoa, especially intestinal protozoa and haemoparasites, infect the ducks. Coccidian parasites are more prevalent, and *Eimeria* spp. and *Cryptosporidium* spp. are the most prominent. The common protozoan parasites of ducks include Leucocytozoon and Haemoproteus. Although protozoan parasites are believed to cause mild infections without serious effects, there is a need to implement better management practices and biosecurity measures to prevent their spread to other birds, animals, and humans.

Keywords: Coccidiosis, Cryptosporidium, Haemoprotozoa, Leucocytozoon, Protozoan infections.

INTRODUCTION

Domestic ducks (Anas platyrhynchos) are common domestic birds that play a major role in the rural economy through meat and egg production. Also, other products from ducks that can be sold include liver, feathers, and down. Parasites affect the growth and production traits of ducks, leading to economic losses [1]. Although tropical climatic conditions and waterlogging areas are suitable conditions for duck rearing, they also favour the development, survival, and dissemination of parasites. These fowls are mostly infected because they are reared in unhygienic conditions, with poor management practices and a lack of veterinary assistance in remote areas, predisposing them to parasitism [2].

Despite helminth parasites being more prevalent in ducks, intestinal protozoan parasites like coccidian species are also responsible for causing disease in different organs and tissues. Villous atrophy and catarrhal enteritis occur due to

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these protozoan parasites. Ducks are in continuous contact with cultivated lands and irrigation canals, and, due to overcrowding, they can become infected through food, water, and environmental contamination by oocysts [3].

INTESTINAL PROTOZOA IN DUCKS

Coccidia

Coccidia is a gastrointestinal apicomplexan protozoon causing diarrhoea and blood in faeces.

Eimeria sp.

Eimeria sp is the most prominent coccidian protozoan. The different coccidian parasites infecting ducks are Eimeria abramovi, Eimeria anatis, Eimeria battakhi, Eimeria boschadis, Eimeria danailovi, Eimeria schachdagica, Eimeria nottion, Eimeria saitamae, Isospora mandari, and Eimeria mulardi.

E. somateniae has been found in long-tailed ducks [4] in Canada, leading to rectal coccidiosis with irregular pale mottling on the surface of the kidneys. E. somateniae is pathogenic for the long-tailed duck. Eimeria aythyae has been reported from ducks, having broadly elliptical sporulated oocysts without polar granules or oocystic residuum. Each sporocyst has two large sporozoites and a compact mass of residual material. [5].

Tyzzeria sp. oocysts measure 10.8-13.5 by 9.4-11.6 microns, with a shape usually subspherical to ellipsoidal and smooth walls lacking a micropyle. The sporulated oocyst has eight sporozoites and a large, compact residual body. *T. perniciosa* has been reported from the domestic duck [5]. In ducklings less than 7 weeks old, *protozoa* are pathogenic, leading to hemorrhagic enteritis [6].

In Nigeria, the intestinal protozoan parasites found were *Eimeria* sp., with a prevalence of more than 30%, followed by *Tyzzeria* sp. and *Cryptosporidium* sp., with a prevalence of 15% [7,8]. Prevalence of *Eimeria* and *Cryptosporidium bailey* was documented from Northern Iran [9], while *Wenionella philiplevinei*, *Tyzerria* spp., and *Isospora mandarin* were reported from Southern Iran [10].

In Iraq, a survey on duck parasites and protozoan infections includes two species: *Eimeria* sp. and *Wenyonella philiplevinei*. *Wenyonella philiplevinei* oocysts have been isolated from the intestinal contents of ducks and consist of three-layered walls: the outer wall is blue, the middle walls are yellowish, and the inner wall is green [11].

Most species causing duck coccidiosis are non-pathogenic, but some species, like *E. danailovi* and *Isospora mandari,* can infect geese. In ducks, the subclinical or mild infection can confer protective immunity against subsequent infections, so it is recommended that the coccidian parasite be monitored and controlled, rather than eradicated.

Cryptosporidium

Cryptosporidiosis is a common coccidian protozoan found in the intestine, trachea, and the bursa of Fabricius of birds, causing diarrhea and unthriftiness. In infected ducks, epithelial hyperplasia and dilated mucous glands were observed in the trachea. In the bursa of Fabricius, it causes hypertrophy of the epithelium and infiltration with mononuclear cells. *Cryptosporidium spp* infecting the birds are C. *baileyi*, C. *meleagridis,* and *C. galli* [12]. Their presence in ducks has been documented in various countries of the world, and infected birds usually do not show clinical signs, with mild infection observed [13]. Free-ranging and domestic birds can be a significant source of oocysts for human infections, as they can mechanically spread Cryptosporidium oocysts [14].

Cochlosomiasis

Cochlosomiasis is caused by Cochlosoma *anatis*, a flagellated protozoan that causes limited pathological changes in the gut of ducks, culminating in diarrhoea. *Cochlosoma anatis* has a pyriform body with a characteristic adhesive disc on the ventral side [15].

Haemoprotozoa in Ducks

Haemoparasites like Leucocytozoon*, Haemoproteus, Eperythrozoon,* and *Aegyptinella* have been reported in ducks from Bangladesh, Iran, Nigeria, Iraq, and Kenya [16].

Leucocytozoon

These protozoa are round and intracellular, causing marked enlargement and distortion of the infected erythrocytes; they can cause microcytic normochromic anaemia and leucocytosis. *Leucocytozoon simondi,* infecting young ducks, causes weakness, anemia, dyspnea, anorexia, leukocytosis, and, at times, death within one day. During post-mortem, splenomegaly and liver degeneration were encountered. In the spleen and heart of ducks, extensive tissue damage was observed, with megaloschizonts of the protozoa. *L. simondi* and *L. caulleryi* are detected in lymphocytes of ducks. In case of *L. simondi* infection, the gametocytes are found in a leucocyte, elongated with a nucleus forming a very long, thin, dark

CHAPTER 8

Ectoparasites in Ducks: Tick Infestation and Its Impact on Duck Health

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Abstract: Ducks have gained considerable attention in veterinary science owing to their dual importance in commercial poultry production and natural ecosystems. As both domesticated livestock and free-ranging avian species, ducks play a vital role in food security, rural livelihoods, and ecological sustainability. Effective health management is therefore essential to ensure optimal productivity, welfare, and disease prevention. Among the various health constraints affecting ducks, ectoparasitic infestations, particularly ticks, represent an important yet often underrecognized concern with implications for both flock performance and disease ecology. Tick infestation in ducks can adversely affect growth, feed efficiency, and overall health status, thereby contributing to economic losses in poultry systems. Ticks belonging primarily to the genera Ixodes and Rhipicephalus are commonly associated with avian hosts. The prevalence and severity of infestation are influenced by environmental conditions, such as temperature and humidity, and by farm management practices, including housing hygiene and biosecurity measures. Clinically, infested ducks may exhibit anemia, reduced weight gain, lethargy, and increased susceptibility to secondary infections due to stress and blood loss. Beyond direct damage, ticks may also serve as vectors for various pathogens, further complicating disease dynamics. Given their four-stage life cycle—egg, larva, nymph, and adult—effective control requires integrated pest management strategies targeting multiple developmental stages. Sustainable prevention depends on environmental management, regular monitoring, and strategic acaricide use to safeguard duck health and maintain productivity.

Keywords: Acaricides, Duck health, Ducks, Ectoparasites, Tick infestation.

INTRODUCTION

Several tick species from different genera are known to parasitize ducks. Ticks are small, obligate hematophagous arthropods belonging to the order Ixodida [1]. As

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ectoparasites, they reside on the external surface of their hosts and obtain nutrition exclusively through blood feeding. Taxonomically, ticks are divided into two principal families: Ixodidae (hard ticks) and Argasidae (soft ticks). Both groups include species capable of infesting avian hosts, including domestic and wild ducks. Ticks are arachnids and are closely related to spiders and mites. They parasitize a wide range of vertebrates such as mammals, birds, reptiles, and occasionally amphibians. Their parasitic behavior involves attachment to the host's skin using specialized mouthparts (capitulum), which penetrate the epidermis to access blood vessels. During attachment, ticks secrete adhesive substances that anchor them firmly to the host, enabling prolonged feeding that may last from several hours to multiple days, depending on the species and developmental stage [2]. While feeding, ticks can transmit a variety of pathogens, including bacteria, protozoa, and viruses, thereby playing a significant role in disease epidemiology. In ducks, both hard and soft ticks have been reported, and understanding their biology, life cycle, and ecological interactions is essential for effective control and prevention strategies in avian health management.

TYPES OF TICKS

Hard Ticks

Hard ticks, classified under the family Ixodidae, are obligate blood-feeding ectoparasites of major veterinary and public health importance. They are characterized by a rigid dorsal shield (scutum) and well-developed mouthparts adapted for firm attachment and prolonged feeding. Their life cycle typically includes four stages—egg, larva, nymph, and adult—and may span one to three years depending on the species and environmental conditions.

Several hard tick species parasitize birds, livestock, companion animals, and wildlife. For example, Ixodes scapularis (black-legged or deer tick) is widely recognized as a vector of Lyme disease, while Dermacentor variabilis (American dog tick) transmits pathogens responsible for Rocky Mountain spotted fever. Beyond bacterial infections, hard ticks also transmit protozoan pathogens such as Babesia spp. and Anaplasma spp., which can cause significant morbidity and mortality in livestock and poultry. Additionally, certain species may induce tick paralysis due to neurotoxins present in their saliva.

Ecologically, hard ticks influence host population dynamics and contribute to pathogen maintenance within ecosystems. Their distribution and abundance are closely linked to climatic conditions, vegetation, and host availability, making them useful indicators of environmental change.

Given their medical and veterinary relevance, effective management of hard ticks requires integrated strategies, including habitat modification, acaricide application, surveillance, and public awareness. Continued research into their biology, vector competence, and resistance mechanisms remains essential for sustainable tick control and disease prevention [3].

Soft Ticks

Soft ticks, belong to the family Argasidae and represent an important group of ectoparasites affecting a wide range of vertebrate hosts, particularly birds and certain mammals. In contrast to hard ticks, soft ticks lack a rigid dorsal scutum and possess a leathery, flexible exoskeleton with a more rounded body form. Their mouthparts are located on the ventral surface and are not visible from above, which distinguishes them morphologically from members of the family Ixodidae.

Soft ticks exhibit distinct feeding behavior. Unlike hard ticks, which remain attached for prolonged periods, soft ticks typically feed rapidly and intermittently, often for short durations. They are commonly associated with nests, burrows, and sheltered habitats, where they parasitize avian hosts such as ducks and other ground-nesting birds. Because of their nidicolous (nest-dwelling) habits, infestations are frequently linked to housing conditions and environmental hygiene.

The life cycle of soft ticks includes egg, larval, multiple nymphal, and adult stages. Developmental duration is highly variable and depends on environmental temperature, humidity, and host availability. Notably, soft ticks are capable of surviving extended periods without feeding, thereby enhancing their persistence in nesting sites.

Ecologically, soft ticks influence host health and behavior, including nesting success and reproductive performance in birds. Their population dynamics may also reflect habitat quality and wildlife distribution, making them useful indicators in ecological monitoring and environmental health assessments [4].

LIFE CYCLE

Ticks exhibit a complex life cycle consisting of four distinct developmental stages (Fig. **1**). Completion of the life cycle may require one to three years, depending on species, host availability, and environmental conditions such as temperature and humidity. Most tick species require a blood meal at each active stage to progress to the next developmental phase.

CHAPTER 9

Ectoparasites Affecting Ducks: Mite Infestation and Its Impact on Duck Health

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Abstract: Parasites like mites can frequently cause problems for poultry livestock, such as ducks. Mites are microscopic organisms that resemble spiders and inhabit the skin and feathers of ducks. Infestations can result in significant discomfort, irritation, and disease. Ducks are infected with several mites, which cause disease. Around the world, mites continue to pose a serious threat to the production of duck meat and eggs. While some types of mites feed on blood and live off the host, others burrow beneath the skin of the bird. These mites cause welfare problems and productivity losses in poultry production systems in terms of bird growth, egg quality, and egg quantity, regardless of feeding strategy. Moreover, several species have the capacity to spread diseases, resulting in secondary infections that impair the growth and survival of birds. These minuscule mites consume bird droppings and blood. The selection of an absolute treatment programme depends on accurate mite identification. As a result, the primary species of duck mites, their importance, and their present and future management are the key topics of this book chapter.

Keywords: Duck, Diagnosis, Mites, Production loss, Treatment.

INTRODUCTION

Mite infestations are common in wild and abandoned domestic ducks. Mites, an ectoparasite (a parasite that lives on the external surface of its host), are found within the feathers of birds. They are more common in younger, weaker, or injured birds. Ducks contract the mites when they come into direct contact with an

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affected host. According to Walter and Proctor [1], blood-sucking mites are common ectoparasites found on birds worldwide. According to Burtt *et al.* 2], these mites reside on the host and in the nesting material, where they infect and feed on the chicks (Fig. **1**). Blood feeder mites belong to the genera *Dermanyssus* and *Ornithonyssus*. Due to their life cycle, the population of these mites can become very high on birds, which can pose a problem for producers both directly through reduced weight gain, egg production (Fig. **2**), or sperm production in roosters, and indirectly through their presence as nuisance pests to workers, especially those who handle hens and eggs [3 - 5].

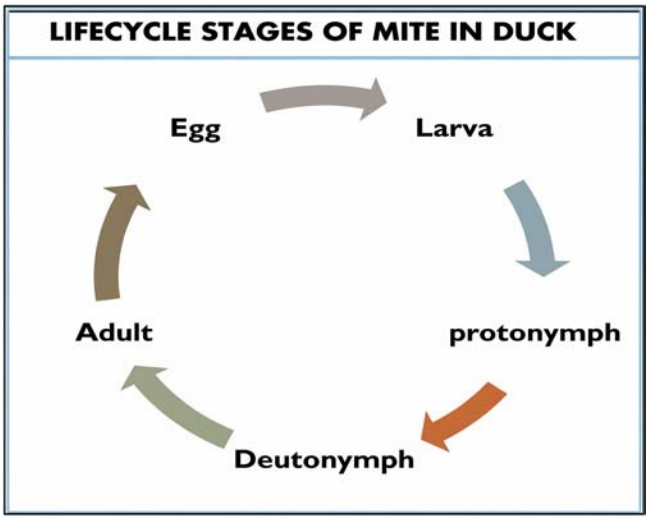


Fig. (1). Lifecycle stages of mites in ducks.

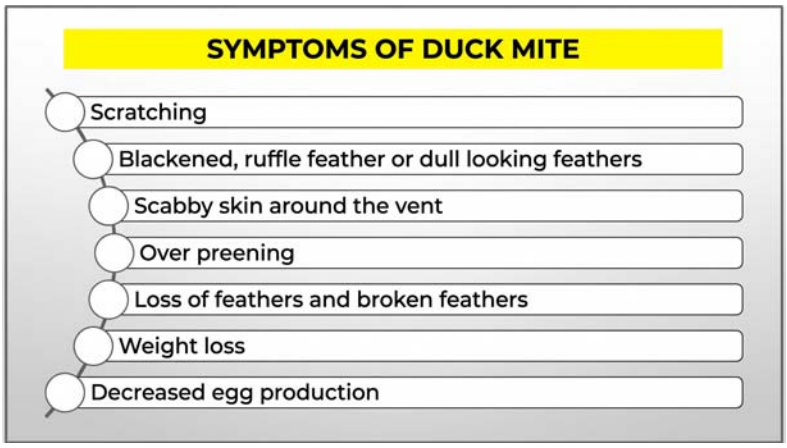


Fig. (2). Most common clinical symptoms associated with skin mites in ducks.

Accurate and timely diagnosis is fundamental for effective management of duck mite infestations (Fig. **2**). Given the elusive nature of these ectoparasites, diagnosis often proves challenging. However, advancements in diagnostic tools and techniques have enhanced our ability to detect duck mites at various stages of their life cycle. Microscopic examination of skin scrapings, feather samples, or debris collected from duck housing facilities remains a cornerstone in the diagnosis of duck mite infestations. Additionally, molecular techniques, such as polymerase chain reaction (PCR), offer high sensitivity and specificity, enabling the identification of mite species and the assessment of infestation intensity (Fig. **3**). The arsenal of treatment modalities for duck mite infestations has expanded with advancements in veterinary medicine. Traditional methods, including acaricides and insecticides, remain crucial components of treatment regimens (6,70. However, the emergence of resistance in some mite populations emphasizes the need for a diversified approach. Integrated pest management (IPM) strategies that incorporate biological control agents have gained prominence as sustainable alternatives. Predatory mites and beneficial insects play a pivotal role in controlling duck mite populations without the adverse effects associated with chemical interventions. Understanding the life cycles and ecologies of both target and beneficial organisms is essential for the successful implementation of IPM strategies.

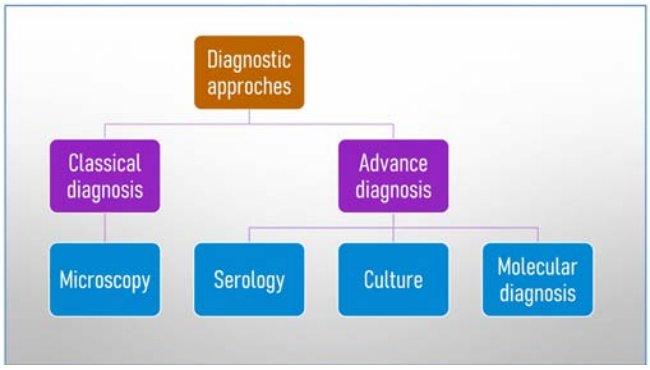


Fig. (3). Different methods for diagnosing mite infestation in ducks.

FACTORS AFFECTING THE PREVALENCE OF DUCK MITE

1. New Ducks: Introducing fresh ducks from unidentified sources. Mites can travel on human bodies. Before introducing new ducks, always treat and quarantine them.
2. Wild Birds: Allowing ducks to interact with wild birds can expose them to mites. Do not interact too much with untamed birds.
3. Inadequate Cleaning: Not enough time is spent cleaning bedding, coops, and nest boxes. In accumulated trash and dirt, mites flourish.

CHAPTER 10

Ectoparasites Affecting Ducks: Flea Infestation and Its Impact on Duck Health

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Abstract: Ducks are cosmopolitan birds found all over the globe except Antarctica. It ranks second to chicken in its contribution to egg and meat production. Due to numerous benefits over chicken production, duck rearing is increasing continuously. The ducks can be reared in extensive, semi-extensive, and intensive systems. The duck-fish, duck-rice, and duck-rice-fish are the three important integrated agricultural systems of duck rearing. Parasitism is a limiting factor in these duck rearing systems. There are several ecto- and endo-parasites affecting the duck industry. Duck fleas are an important ectoparasite of the duck industry that adversely affects the general health and production of ducks. Despite a few species of duck fleas, their importance is increasing due to their direct and indirect effects on their hosts. Flea bite allergies, along with blood-sucking, tissue fluid-sucking, irritation, and hair loss, are some important primary effects. While the primary secondary effect of flea infestation in ducks is pathogen transmission, as well as acting as a vector for important diseases. This chapter describes the different species of fleas affecting ducks worldwide, their life cycles, pathogenesis, clinical signs, diagnosis, treatment, and control.

Keywords: *Ceratophyllus garei*, *Ceratophyllus gallinae*, Duck, Flea infestation.

INTRODUCTION

Domestic ducks belong to the genus Anas and Cairina and act as an important food source in rural areas of Asia, especially in Southeast Asia [1 - 3]. Duck industries have a major advantage over the poultry industry, particularly in terms of disease tolerance. In that country where rice is grown in paddy fields, synergies

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may be found between duck and rice production. Ducks also act as natural predators of insects, some molluscs, and slugs; they also play a role as producers of natural fertilizer, leaving manure on rice fields, which contributes to higher yields [4 - 7]. The duck flea is a holometabolous blood-sucking organism that acts as a vector for various parasitic diseases. Considering how well-adapted fleas are to their hosts, different host species will have different biology and behaviour [8, 9]. According to the FAO, there are more than 1.15 billion ducks (Anas spp.) worldwide, with 1.0 billion (88%) living in Asia. China, Vietnam, Bangladesh, and Indonesia have the largest duck populations (Fig. **1**).



Fig. (1). *Anas poecilorhyncha* (Duck).

Fleas are categorized in the class Insecta, order Siphonaptera, which is derived from the Greek words siphon+apteron, which means the sucking wingless insects [10]. There are about 2500 described species present on earth, of which most are present on mammals and a few are found on birds [11, 12]. These are temporary wingless laterally compressed bodies with three pairs of legs. The third pair of legs is much larger than the others, which are adapted for leaping on and off their host. On the body, it has a rubber-like elastic protein, resilin, which helps the flea

jump from one place to another [13, 14]. A flea can jump vertically up to 18 cm and horizontally up to 33 cm. The body of the flea, head, and thorax regions bear several prominent spines called combs or ctenidia. On the head region, combs are called genal combs or genal ctenidium, while combs present on the posterior border of the first thoracic segment are called pronotal combs or pronotal ctenidium. These characteristic structures allow for rapid movement through the host's hairs and also serve to resist removal from the host hairs. Fleas also have a large number of strong setae, which help them withstand the effects of host grooming. The male and female sexes are found separately, and during feeding, the maxillary laciniae cut and pierce the host's skin. The epipharynx is elongate and enters a blood vessel. Saliva, which is released by the laciniae, does not enter the blood vessels. After the female consumes blood meal, she lays eggs on the host's body. Mainly, up to 20 eggs are laid at a time over a couple of months to six months, but sometimes several hundred eggs may be laid, which usually fall to the ground within a few hours after drying. Within a few days, the egg hatches, but depending on environmental conditions, it may take up to 3 weeks. Hatching phenomena depend on humidity and temperature [15 - 18].

After hatching, a maggot-like larva (instar) emerges and feeds on decaying material, such as vegetation and epithelial cells, present on the ground. Larval stages may last up to 2 weeks, but in adverse conditions they may persist for 6-7 months, or longer, in some species. Larval stages seek out areas with appropriate humidity in their surroundings, which helps them grow to the next stage, pupa [19]. Pupa develops in a pupal case, like silk larvae, and takes about one week; however, at low temperatures, it may take up to 1 year. After the development of the adult stage, a flea can live for a long time without feeding. They search for their suitable host by odours, and they are cued by light, shadow, and temperature. As part of disease transmission, they can host the tapeworm cysticercoid stage and the bubonic plague [20, 21]. Several representative species of flea infect mammals as well as poultry, like the genus *Ceratophyllus* species (on duck/poultry), *Ceratophyllus garei* (duck), *Ceratophyllus gallinae* (duck), *Echidnophaga gallinacea* (Poultry), *Ctenocephalides felis* (cat flea), *Hoplopsyllus anomalus*, *Pulex simulans*, *Xenopsylla cheopis* (rat flea), *Ceratophyllus niger* (western chicken flea), *Diamanus montanus*, *Nosopsyllus fasciatus,* and *Tunga penetrans*.

There are two main patterns in flea life cycles (Fig. **2**). Many Ceratophyllidae groups have a straightforward link with the nest habitat that is typified by occasional and brief ties to the host and frequent adult mobility between hosts and nests. On the other hand, many Pulicidae species maintain ongoing adult associations with their hosts. However, there may be substantial variance even within these broad groups [22 - 27]. Only a few genera remain connected throughout adulthood. These are the 'stickfast' or burrowing fleas, whose females

CHAPTER 11

Ectoparasites Affecting Ducks: Lice Infestation and Its Impact on Duck Health

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Abstract: This book chapter describes the specifics of duck lice, their detrimental effects on production, and how to control them using various widely available insecticides in an effort to establish a baseline for further research in this area. The sparse information in the literature regarding various duck lice has led to this book chapter. Under flocks grown outside and under free-range conditions, lice are the most common ectoparasite. The six-legged, tiny, flat parasites are particular to their host. Lice can live their whole lives on ducks. They survive by eating shards of feather, skin, and blood. Lice infestations are more prone to cause issues. Moreover, moulting drastically lowers the population of lice. Across the world, a variety of chemicals and herbal remedies are utilised to treat chicken lice infestations. The phthiraptera group of parasites in poultry should be controlled using a combinatorial, rotating, and repeatable medicinal approach, in addition to management care, unlike ticks and other arthropods.

Keywords: Control, Duck, Ectoparasite, Infestation, Lice, Transmission.

INTRODUCTION

Duck is one of the indigenous poultry species, traditionally reared by poor farmers for their livelihoods worldwide [1]. The global poultry sector is largely comprised of ducks. The majority of small and marginal farmers still engage in substantial, itinerant, seasonal duck farming. According to FAO estimates from 2017, there are approximately 150 million ducks in the world. Duck farming holds significant scientific importance due to its multifaceted contributions to agriculture, ecology, and nutrition. Scientifically, ducks are considered efficient converters of feed into

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high-quality protein, making them a valuable asset for sustainable food production. One key aspect is their role in pest control. Ducks have a natural inclination to forage for insects, snails, and weeds in wetlands and agricultural fields. This behaviour not only helps control pests but also reduces the reliance on chemical pesticides, contributing to environmentally friendly farming practices [2]. Moreover, duck manure is a rich source of organic fertilizer. The nutrient content in duck droppings, including nitrogen, phosphorus, and potassium, enhances soil fertility and promotes better crop yields. This cycle of nutrient recycling establishes ducks as integral components of integrated farming systems, showcasing their scientific significance in sustainable agriculture. Ducks also play a crucial role in wetland ecosystems [3]. Their presence helps maintain the ecological balance by controlling the population of aquatic organisms and preventing the overgrowth of aquatic plants. This, in turn, supports biodiversity and ensures the health of aquatic ecosystems. From a nutritional perspective, duck meat and eggs are valuable sources of high-quality protein, essential amino acids, and micronutrients. Scientifically, incorporating duck products into diets contributes to improved nutrition and food security, particularly in regions where protein deficiencies are prevalent. There are enough water resources for ducks to wade in and eat fish and snails. But these materials also encourage the development of parasites in ducks. In terms of parasites, lice infestations have an impact on the growth and productivity of ducks because of the severe irritation they cause [4].

Lice (Insecta: *Phthiraptera*) are lifelong parasites of their hosts, meaning they spend their whole life cycle on a single host [5]. According to Clayton *et al.,* [5], brooding and feeding of chicks are the primary vertical transmission times for feather lice in birds. However, chewing lice are among the least specialized of all avian lice [6], parasitizing ducks, geese, and swans (Aves: Anseriformes) worldwide. It is yet unknown whether these parasites are generalists as a result of the recent host radiation, the behaviour and ecology of their hosts, or the biology of the lice (*i.e.*, their enhanced dispersal capacities. According to their host ecology, which states that many waterfowl species migrate to areas where they form mixed-species flocks, these lice can spread to a wide range of hosts. In addition, other species that co-occur in bodies of water provide additional opportunities for host transfer [7]. The relatively frequent hybridization of waterfowl species also presents additional opportunities for the transmission of lice from one host species to another. Typically, lice pose more of a bother than a hazard to their hosts. The common duck, *Anas platyrhynchos domesticus (L.),* serves as a host for seven species of lice throughout the world, *viz*. *Anaticola crassicornis* (Scopoli), *Anatoecus dentatus* (Scopoli), *Holomenopon leucoxanthum* (Burmeister), along with *Anatoecus icteroides* (Nitzsch), *Holomenopon maxbeieri* Eichler, *Holomenopon transvaalense* (Bedford), and

Trinoton querquedulae (L.) [1, 8]. Lice infestations can negatively impact the overall health and well-being of ducks. The parasites feed on feathers, skin debris, and blood, causing irritation, feather damage, and potential blood loss. In severe cases, lice infestations can lead to weight loss, reduced egg production in females, and reduced overall fitness in affected ducks. The prevalence of lice in ducks is a dynamic, multifaceted phenomenon influenced by various ecological factors. Understanding the life cycle and transmission mechanisms of duck lice is crucial for implementing effective control measures and promoting the health and welfare of duck populations in both natural and domestic environments.

FACTORS AFFECTING THE PREVALENCE OF DUCK LICE

The prevalence of duck lice is influenced by complex interactions among environmental, host-related, and management factors. A holistic approach that considers these factors is essential for effective control and prevention strategies in both natural and farm settings (Fig. **1**).

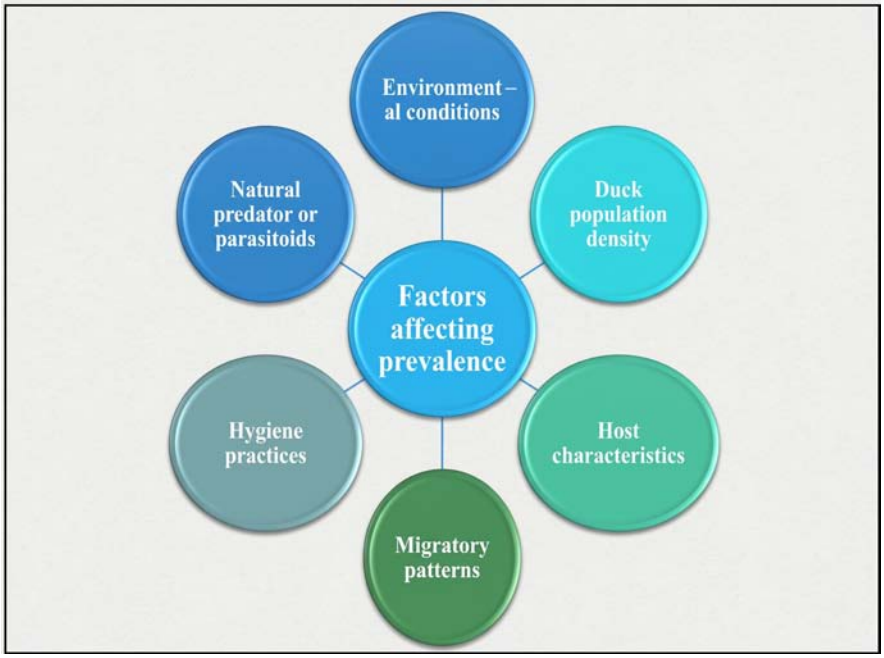


Fig. (1). Factors affecting the prevalence of duck lice.

Environmental Conditions

Water Quality: Duck lice prevalence is significantly influenced by the water quality in which they live. Clean and well-oxygenated water reduces the likelihood of lice infestations, as lice thrive in stagnant or dirty water.

CHAPTER 12

Parasitic Zoonoses from Ducks to Humans: Risks and Transmission

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Abstract: Parasitic zoonoses transmitted from ducks to humans represent a significant and often overlooked public health concern, particularly in regions where waterfowl farming intersects with human populations and where waterborne infections are prevalent. Ducks (Anas platyrhynchos domesticus and wild species) serve as important reservoirs for diverse parasites, including trematodes, cestodes, nematodes, and protozoa. Their aquatic lifestyle and feeding behaviors facilitate both acquisition and transmission of these pathogens through contaminated water, direct contact, or consumption of undercooked duck products and infected intermediate hosts such as fish, snails, and amphibians. This comprehensive review examines major parasitic zoonoses associated with ducks, including echinostomiasis, fascioliasis, heterophyiasis, diphyllobothriasis, hymenolepiasis, capillariasis, baylisascariasis, giardiasis, and cryptosporidiosis. Each parasite's life cycle, clinical manifestations, geographic distribution, and transmission dynamics are detailed, with emphasis on the critical role ducks play in maintaining environmental contamination. Clinical outcomes in humans range from mild gastrointestinal disturbances to severe complications, including hepatobiliary damage, neural larva migrans, protein-losing enteropathy, and potentially fatal outcomes in immunocompromised individuals. Geographic distribution patterns correlate strongly with regions where raw or undercooked fish consumption, inadequate sanitation, and close human–duck interactions are common. Prevention strategies emphasize proper food handling, water treatment, sanitation improvements, and public health education. A One Health approach integrating medical, veterinary, and environmental surveillance is essential for effective control of these emerging and re-emerging zoonotic threats.

Keywords: Control, Ducks, One Health approach, Prevention, Parasitic zoonoses, Reservoirs, Trematode infections.

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INTRODUCTION

Parasitic zoonoses are infections caused by parasites that are naturally transmitted from animals to humans through multiple pathways, including direct contact with infected hosts, ingestion of contaminated animal products, or exposure to environmental sources such as contaminated water, vectors, or intermediate hosts [1, 2]. Ducks,both domestic (*Anas platyrhynchos domesticus*) and wild, serve as important reservoirs for a wide range of parasites with zoonotic potential. These parasites may infect humans either directly or indirectly through intermediate hosts or contaminated aquatic environments. Consequently, parasitic zoonoses associated with ducks represent a significant public health concern, particularly in regions where duck production systems operate in close proximity to human settlements or in environments where water-borne parasitic infections are common.

The spectrum of parasitic infections reported in ducks is extensive and includes trematodes (digenean flukes), cestodes (tapeworms), nematodes (roundworms), protozoan parasites, and certain arthropods that may act as vectors or intermediate hosts. These parasite groups collectively contribute to the zoonotic disease burden associated with duck populations. The ecological and behavioral characteristics of ducks further increase their susceptibility to parasitic infections. Their aquatic habitat, combined with foraging behaviors such as dabbling, grazing on aquatic vegetation, and ingesting invertebrates from potentially contaminated water bodies, facilitates frequent exposure to infective parasite stages. As a result, ducks often function as amplifying or reservoir hosts for numerous zoonotic parasites circulating in aquatic ecosystems [3, 4].

MAJOR PARASITIC ZOONOSES FROM DUCKS TO HUMANS

Trematode (Fluke) Infections

Echinostomiasis

Echinostomiasis is a food-borne parasitic disease caused by intestinal trematodes belonging primarily to the genus *Echinostoma*, as well as related genera such as *Himasthla* and *Echinochasmus*. The infection represents an important zoonotic public health concern in several regions of the world, particularly in areas where sanitation infrastructure is inadequate and freshwater ecosystems support abundant populations of intermediate hosts such as aquatic snails, fish, and amphibians. Members of the family *Echinostomatidae* possess complex heteroxenous life cycles involving multiple hosts and free-living developmental stages, which facilitate environmental persistence and zoonotic transmission [6].

These trematodes are commonly maintained in natural transmission cycles involving aquatic birds, especially ducks and other waterfowl, which serve as definitive hosts. Humans become accidental definitive hosts when they ingest infective stages through contaminated aquatic food sources. Consequently, the disease is closely associated with aquatic environments, traditional dietary practices involving raw or undercooked freshwater foods, and the ecological interactions among waterfowl, mollusks, and aquatic vertebrates.

Causative Agents

The principal etiological agents of echinostomiasis are trematodes belonging to the genus *Echinostoma*, including *Echinostoma revolutum*, *Echinostoma ilocanum*, and *Echinostoma caproni*. In addition, species within related genera, such as *Himasthla* and *Echinochasmus,* have been implicated in human infections. These parasites belong to the family Echinostomatidae, which is morphologically characterized by the presence of a distinctive cephalic collar armed with spines surrounding the oral sucker. This collar of spines facilitates the firm attachment of adult flukes to the mucosa of the small intestine and represents a key taxonomic feature for species identification.

- ***Echinostoma* spp.:** *Echinostoma revolutum* and *Echinostoma ilocanum* are among the most frequently reported species infecting humans. These parasites are widely distributed in Southeast Asia, China, and the Indian subcontinent, although sporadic occurrences have also been documented in Europe and the Americas.
- ***Himasthla* spp.:** Species within the genus *Himasthla* are also members of the family Echinostomatidae and occur primarily in aquatic bird hosts. Although human infections are relatively uncommon, they have been reported in some regions of Europe and the Mediterranean basin.
- ***Echinochasmus* spp.:** Members of this genus are smaller echinostomatid trematodes that may also infect humans. They are commonly associated with freshwater ecosystems where snail populations and aquatic birds coexist.

These parasites demonstrate low host specificity, allowing them to infect a wide range of vertebrate hosts during different stages of their life cycle. Ducks and other waterfowl serve as important definitive hosts, maintaining the parasite within aquatic ecosystems and contributing to environmental contamination through the shedding of eggs in feces.

CHAPTER 13

Diagnosis of Parasitic Diseases in Ducks: Techniques and Tools for Diagnosing Parasitic Diseases

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Abstract: Precise detection and monitoring of parasitic infections in ducks are critical for the welfare of waterfowl species and the habitat they live in. Ducks, both migratory and resident species, are vulnerable to a range of parasitic diseases, including those caused by protozoa, helminths, and arthropods. Parasitic infections in ducks can have substantial negative impacts on their health and ecosystems. Protozoan parasites, such as Tyzzeria and Tetratrichomonas, cause intestinal irritation leading to reduced weight gain and reproductive competence. Helminth infections result in tissue damage, weakness, and decreased feed intake. Ectoparasites such as lice and mites can cause skin irritation. Correct identification is essential for efficiently dealing with parasites in duck populations. Techniques such as faecal examination, serology, and molecular assays enable parasite species identification and evaluation of the intensity of parasitic infection and treatment efficacy. Appropriate detection and management of parasitic infections in ducks involve various diagnostic methods and techniques. These include examining faeces (both macro- and microscopic), carrying out blood tests for hemoparasites, examining feathers, taking crop swabs and their fluid, performing necropsies, examining tissues, conducting serology tests, and using molecular techniques. These diagnostic procedures are imperative for safeguarding the overall health of ducks.

Keywords: Conservation, Epidemiology, Parasitic infections.

INTRODUCTION

Parasitic infections pose a considerable risk to the health and productivity of domestic and wild duck populations around the world. Ducks, semi-aquatic animals raised, in part, in open environments, can be affected by a range of endo-

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parasites (trematodes, cestodes, nematodes, protozoans) and ectoparasites (mites, lice, ticks) [1]. Parasitic infections in ducks can lead to subclinical or severe disease, with clinical presentation ranging from weight loss and reduced egg production to poor feed conversion efficiencies and, in some cases, death. Parasitic infestations may predispose infected ducks to secondary bacterial or viral infections, with concomitant impacts on economic viability and health in the duck industry. Accurate and timely diagnosis of parasitic infections is vital to effective management and control of the disease process; however, diagnosing parasitic infections poses some challenges, such as the presentation of non-specific clinical signs, often intermittent shedding of parasite life stages, and the numerous parasitic species capable of co-infecting a host. Consequently, a definitive diagnosis incorporates clinical observation, parasitological examination, and increasingly molecular diagnostic methodologies. The overall intention of this chapter is to provide a detailed description of the diagnostic procedures for parasitic infections in ducks [2].

FAECAL EXAMINATION

Investigating excretory-secretory discharges, such as faecal, cloacal, nasal, and lachrymal, is essential for identifying the type of parasitic infection. Sometimes, the symptoms remain atypical while helminths and coccidia persist in the gut; in such cases, diagnosis of these parasites is mainly based on the presence of eggs/oocysts in faecal samples.

Collection of Faecal Samples

To collect faecal samples, it is important to use sterile, leak-proof containers with tight-fitting lids. The timing and location are also crucial, and it's best to collect samples in the morning when ducks are active. To prevent contamination, gloves or containers should be used. It's important to minimize disturbance during the collection process. Collecting multiple samples from different birds within a population is preferred, and fresh specimens are best. Proper labeling is crucial and should include the date, location, and species. During transportation to the laboratory, it's important to handle the samples carefully to avoid contamination. In the laboratory, various techniques such as flotation or sedimentation are used to isolate and identify parasite eggs and oocysts.

Storage and Shipment of Faecal Samples

If there is a delay in analysing collected faecal samples within a few hours, it is recommended to store the samples in the refrigerator at 2-8°C. Freezing should be avoided as it can distort parasitic eggs. However, for molecular analyses, freezing at -20°C or lower is recommended to preserve nucleic acids until further testing.

When sending samples by post, a container with a capacity of 20 ml is used. The container is filled to 1/9th to 1/8th of its capacity with fecal samples. Preservatives such as 10% formalin are used to stop the growth of helminthic ova, 2.5% potassium dichromate to provide nascent oxygen for the sporulation of protozoan oocysts, and polyvinyl alcohol for trophozoites. It is recommended to use an anaerobic storage system in an airtight container containing tap water to minimize development and hatching. If the sample is aged, parasite eggs may hatch, and trophozoites may disintegrate, leading to misdiagnosis, as routine diagnostic tests are incompatible with the detection of larvae. To prevent contamination, the container must be tightly sealed with paraffin film. Additionally, the samples must be clearly labelled with species information, sample type, collection date, and any necessary identifiers for tracking. If the samples require refrigeration or freezing, appropriate cooling packs are used during shipment to maintain the desired temperature (Fig. **1**).

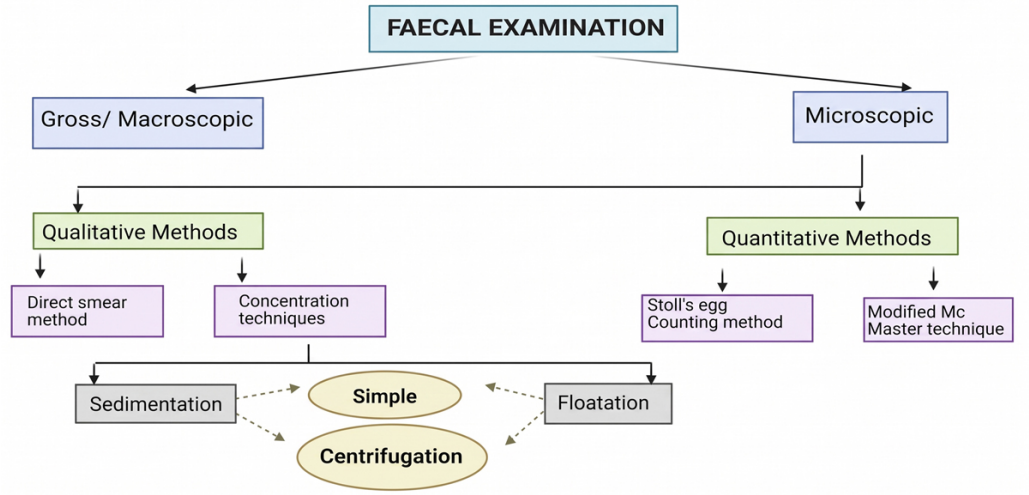


Fig. (1). Schematic depiction of diverse fecal analysis tests (Created at biorender.com).

Gross Examination of Faeces

The information provided before the microscopic examination of duck faecal samples includes the following:

Consistency: The fecal consistency should be noted, especially if it is soft and watery or contains mucus, which may indicate the presence of intestinal parasites.

Colour: Greenish or bloody droppings indicate *Tyzzeria perniciosa* or *Eimeria spp* infection.

CHAPTER 14

Pathophysiology of Duck Parasitic Diseases: A Marker for Detecting Diseases

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Abstract: The pathophysiology of parasitic diseases in duck populations is a highly complex subject, encompassing a variety of infections causatively linked to protozoa, helminths, and ectoparasites. A variety of protozoal infections, comprehensively including coccidiosis, trichomoniasis, and cryptosporidiosis, primarily target the gastrointestinal and respiratory systems, directly leading to severe diarrhoea, systemic dehydration, and subsequent mortality. Furthermore, hemoprotozoal diseases, specifically avian malaria caused by *Plasmodium* spp., result in massive red blood cell destruction and profound clinical anaemia. Extensive helminthic infections involving nematodes, cestodes, and trematodes are documented to cause severe mucosal inflammation, gross ulceration, and systemic malnutrition. The structural damage to the intestines and hepatobiliary systems, particularly chronic hepatic fibrosis induced by *Dicrocoelium* spp., could be attributed to the continuous parasitic competition for essential nutrients and localized tissue invasion. However, even the integumentary system is significantly affected by ectoparasites and severe tick infestations, actively triggering intense pruritus, massive feather loss, and profound systemic weakness. This compromised underlying immune function frequently increases the inherent susceptibility of the avian host to opportunistic secondary bacterial infections. The present overview, therefore, was aimed at elucidating the intricate life cycles and complex pathophysiological mechanisms of these diverse parasites. A comprehensive understanding is systematically considered crucial for the rigorous development of effective diagnostic, therapeutic, and preventive veterinary strategies, in accordance with established environmental sanitation and vector management protocols, thereby successfully safeguarding vulnerable duck populations and continuously ensuring optimal agricultural productivity.

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Keywords: Duck parasitic diseases, Helminths, Parasitic control measures, Protozoa, Trematodes.

INTRODUCTION

The pathophysiology of parasitic diseases in duck populations is defined as a complex and multifaceted issue, comprehensively encompassing a wide variety of parasitic infections primarily caused by protozoa, helminths, and ectoparasites [1]. It is observed that each specific parasite poses unique, profound challenges to the overall health and productivity of ducks, with significant implications for both the individual avian host and larger commercial populations. Furthermore, the life cycles of these parasites are considered highly intricate, typically involving the direct entry of infective stages into the susceptible host, subsequent migration through various biological tissues, and complex interactions with host immunological defences. Accordingly, these physiological interactions can result in a wide range of pathologies, including severe organ damage, systemic nutritional deficiencies, and, in certain documented cases, the facilitated transmission of other secondary pathogens. A comprehensive understanding of the precise molecular and physiological mechanisms by which these diverse parasites invade, actively replicate, and successfully evade host immune responses is critical for the rigorous development of effective diagnostic, therapeutic, and preventive strategies. Hence, these sustained scientific efforts are considered crucially essential to effectively mitigating the significant negative impact that parasitic diseases continually have on the baseline health and economic productivity of global duck populations [2].

PROTOZOAL DISEASES

Protozoal infections in ducks are systematically evaluated as a major veterinary concern. This could be attributed directly to their severe impact on various interconnected physiological systems, with each specific pathogen presenting distinct pathophysiological mechanisms.

Gastrointestinal Protozoal Infections

In the gastrointestinal system, coccidiosis, which is primarily caused by *Eimeria* species, is identified as one of the most significant protozoal diseases affecting duck populations. It is documented that these protozoa aggressively invade the intestinal mucosa, thereby leading to massive epithelial cell destruction, profound localized inflammation, and the subsequent biological formation of coccidial oocysts. Clinically, signs of active infection include severe bloody diarrhoea, systemic dehydration, and significantly reduced growth rates. Furthermore, this disease presents with a high potential for significant morbidity and mortality

within affected flocks. If left untreated, coccidiosis can result in severe economic losses, which could be attributed to poor feed conversion ratios and excessively high flock mortality rates [3].

Another protozoal infection that significantly affects the gastrointestinal system is intestinal trichomoniasis. This specific disease is caused by *Tetratrichomonas anatis*, which is identified as a common inhabitant of the lower digestive tract of ducks. It is observed that this parasite actively induces catarrhal to fibrino-necrotic enteritis, directly leading to severe clinical diarrhoea and mortality rates documented to be as high as 60 to 70 per cent in young ducklings. In adult ducks, *T. anatis* can systematically cause advanced salpingitis and yolk peritonitis, thereby further compounding the negative impact on breeding duck populations. Notably, there are also clinical reports of associated respiratory illnesses linked with trichomoniasis in ducks. These presentations are strictly characterised by clinical signs such as persistent coughing, frequent sneezing, marked swelling of the infraorbital sinuses, and concurrent diarrhoea [4].

Cryptosporidiosis is another significant protozoal infection that has been widely reported in duck populations globally. Affected ducks commonly present with severe diarrhoea and a generally poor overall physiological condition. *Cryptosporidium* spp. not only causes severe gastrointestinal disease but can also concurrently affect the respiratory system. This dual involvement leads to marked pathological changes, such as mucosal epithelial hyperplasia, widespread loss of cilia, and severely dilated mucous glands in the trachea of infected ducklings [5]. Hence, this dual-system involvement makes cryptosporidiosis particularly challenging to medically manage, as it can concurrently compromise both digestion and respiration, ultimately leading to high morbidity rates in affected flocks.

In addition, giardiasis, which is primarily caused by *Giardia* spp., possesses the capacity to severely alter the structural permeability of the gastrointestinal epithelium. This alteration triggers a robust inflammatory response that ultimately results in profound digestive and absorptive abnormalities. Accordingly, this pathophysiological state can lead to significantly decreased absorption of essential dietary nutrients, particularly crucial fats and vitamins, which can severely impact normal growth and baseline health in developing ducks. Furthermore, another notable protozoal pathogen, *Cochlosoma anatis*, is well known to cause severe enteric disease in various waterfowl. This specific infection is clinically characterised by watery diarrhoea, profound lethargy, severely depressed weight gain, and widespread morbidity within the actively affected flocks [6]. This specific infection is also closely associated with severe stunting and runting in

CHAPTER 15

Immunological Response to Parasitic Infections in Ducks

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Abstract: The immune system of ducks is a complex and highly efficient defence mechanism that safeguards these birds from a range of diseases and infections. Just as in other animals, including humans, the immune system of ducks plays a pivotal role in maintaining their overall health and well-being. The immune system in birds consists of two main branches: innate immunity and adaptive immunity. Innate immunity serves as the initial line of defence, encompassing physical and chemical barriers such as the skin and mucous membranes that deter pathogens from breaching the body. Furthermore, innate immune cells such as macrophages and heterophils play vital roles in phagocytosis, pathogen engulfment, and neutralization, as well as in the production of proinflammatory cytokines. Like mammals, adaptive immunity exists in birds and relies on specialized immune cells, mainly T and B lymphocytes. These cells are responsible for recognizing specific antigens and forming immunological memory. When a pathogen is encountered for the first time, the adaptive immune system learns to recognize it, enabling a more rapid and effective response upon subsequent exposure. They possess critical lymphoid organs like the bursa of Fabricius and the thymus. The bursa plays a key role in developing and maturing B cells responsible for generating antibodies. The thymus, on the other hand, is crucial for T cell development, which directly targets infected cells. Additionally, immunological memory develops after encountering a pathogen, resulting in a faster and more effective response upon subsequent exposure.

Keywords: Cell-mediated immunity, GALTs (gut-associated lymphoid tissues), Heterophils, Immunoglobulin, IgY.

INTRODUCTION

Parasitic infections in ducks negatively impact productivity and health, while also eliciting immune responses that can interact with the course and outcome of the disease in very complicated ways. It is important to understand the immunopa-

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thology of parasitic infections to untangle host-parasite interactions and develop prevention, control, and treatment strategies. Ducks exhibit unique immune responses due to their status as waterfowl, so, like all animals, they vary in their immune response to parasitic invasions depending on the type of parasite, the level of invasion, and the state of physiology the duck is in. Parasites have evolved robust mechanisms that evade or modulate the host immune system, enabling chronic infections that cause immune-mediated pathology. This can result in tissue damage and inflammatory responses or immune suppression, which then impacts disease severity. Simultaneously, the host immune system tries to recognize and eliminate the invader through processes that involve both innate and adaptive immunity, including macrophage activation and migration for cytotoxic actions, cytokine release, antibody production, and cellular immunity. This chapter aims to describe the immunopathological responses of ducks to parasitic infections, highlighting the balance between protective immune response and the pathological effects of infection. Knowing these intricacies is important not only for appropriate disease interpretation but also for paving the way for the development of parasite-specific vaccines, immunotherapies, and breeding programs aimed at enhancing disease resistance in duck populations.

IMMUNITY MECHANISMS IN DUCKS

Innate Immune Response

The nonspecific defence mechanisms of innate immunity refer to the broad and immediate protective responses the body employs against a wide range of pathogens, without specifically targeting any particular invader, such as the skin or respiratory mucosa [1]. Immunoglobulin A (IgA), in conjunction with the mucosal immune system and general non-specific natural defences (like the mucous cilia clearance system), constitutes the initial defence, acting as the primary barrier. IgA's significance lies in its role in immune exclusion against infectious parasites within the mucosal epithelium. Immune responses like lysozyme and acute-phase proteins act as immediate defences. Lysozyme targets bacteria by breaking down their cell walls, while acute-phase proteins, like ceruloplasmin, increase during infection [2]. The complement system, triggered by substances like endotoxins, generates C3 fragments, aiding in immunity by binding to pathogens and promoting immune cell activity.

Cellular Immune Response

Cellular immune response involves macrophages, heterophils, eosinophils, basophils, thrombocytes, NK cells, and mast cells, which serve as key sentinels within avian immune defences. When ducks encounter parasites like protozoans or helminths, these cells act as essential immune defenders. They employ various

mechanisms to counteract these invaders, including phagocytosis to engulf and digest parasites, releasing reactive oxygen species and enzymes to neutralize and destroy them. They also contribute to the regulation of the inflammatory response, helping eliminate parasitic threats [3].

Cell-Mediated Immunity

The cell-mediated immune (CMI) response directed at intracellular antigens primarily focuses on exogenous antigens that have entered cells through the endocytic pathway or endogenous antigens generated within cells. However, CMI involves both specific and non-specific antigen activation of T lymphocytes, macrophages, and natural killer cells.

Cytotoxic T cells (CD8+ T cells) recognize and eliminate cells infected with intracellular pathogens. They release cytotoxic molecules that induce apoptosis (cell death) in infected cells, thereby curbing the pathogen's spread. Another critical aspect is the involvement of T helper cells (CD4+ T cells), which regulate immune responses. They help activate other immune cells, such as macrophages and B cells, thereby enhancing their ability to eliminate internal parasites. The activation of T cells relies on the major histocompatibility complex (MHC) antigens. Cytotoxic T lymphocytes identify foreign antigens in conjunction with MHC class I molecules, while T helper cells recognize antigens in conjunction with MHC class II molecules. Throughout this process, co-stimulatory signals play a crucial role in achieving complete activation of T cells. Additionally, regulatory T cells (Tregs) contribute to immune regulation and prevent excessive immune responses that could lead to tissue damage. Ducks also possess T cells involved in delayed-type hypersensitivity responses, which trigger inflammatory reactions upon encountering specific antigens, thereby contributing to the immune system's ability to combat various pathogens [4].

Dendritic cells (DCs), also known as antigen-presenting cells, serve as a vital connection between innate and adaptive immunity. They have a distinctive capacity to induce both innate and acquired immunity, mainly through immune cell proliferation and cytokine production. APCs secrete lysosomal proteases that lyse the protein of the blocked antigen before presentation.

Interleukins like IL-1β act as significant cytokines in the early inflammatory response. IL-1β stimulates the production of chemokines, facilitating the recruitment of inflammatory cells to the site of inflammation. IL-18 plays a role in the secretion of IFN-γ. IL-2, a powerful growth factor, triggers the expansion of chicken T lymphocytes and activates NK cells. IL-6 plays a crucial role in the ultimate maturation of antibody-producing B cells and is primarily generated by endothelial cells, macrophages, and T cells. IL-10 is an anti-inflammatory

CHAPTER 16

Antiparasitic Treatments and Their Importance in Duck Health

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Abstract: The need for eggs, meat, and ornamental ducks—many local species are prized as attractive birds—makes duck farming a lucrative livestock enterprise. A significant portion of the community has made a living from duck farming for many years. Although farming communities have benefited greatly from duck farming, there have been years when disease outbreaks of various kinds have severely hampered the industry's efforts and viability. In general, bacterial, fungal, viral, and parasitic infections are the most significant illnesses that afflict ducks. Parasitic illnesses rank second in importance among them. The state of treatment for major parasitic infections worldwide is summarized in this book chapter.

Keywords: Control, Ducks, Economy, Parasitic disease, Therapeutics.

INTRODUCTION

Domestic ducks are among the most widespread domestic animals, with a total population of about 700 million. The role of ducks in both wild ecosystems and domesticated farming systems cannot be overstated. These birds are not only integral to natural water habitats as part of wetland biodiversity, but they also have significant economic importance in poultry farming across the globe [1, 2]. However, just like other animals, ducks are susceptible to a range of parasitic diseases that can have profound impacts on their health, productivity, and survival. Understanding the nature of these diseases, as well as the current and emerging therapeutic approaches, is vital for maintaining the health of duck popu-

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lations and ensuring sustainable farming practices. Humans keep ducks primarily for eggs and meat [1]. Other products from ducks that can be sold include down, feathers, and fattened livers [2]. Geographical location, subtropical climatic conditions, and waterlogged and low-lying areas of the country are suitable habitats for rearing ducks, but these factors also favour the growth, multiplication, development, survival, and spread of parasites [3]. Parasitic infestations cause disease in ducks and affect their productivity and growth. Domestic fowls are more often infected due to unhygienic management practices, malnutrition, lack of veterinary supervision, and the complicated life cycle of the parasites [4]. Gastrointestinal parasites are, however, the most prevalent and devastating parasites affecting duck productivity [5]. In the village, ducks are raised mainly under free-range (scavenging) conditions, with partial or no housing, which predisposes almost all ducks to parasitic diseases [6], such as helminthiasis [7 - 9]. Prevalence of gastrointestinal parasites is also affected by the route of drug administration [10]. Proper health management is essential for productivity in duck farming [11]. Management practices and the locations where they are reared can be considered important factors influencing the prevalence of gastrointestinal parasites. Veterinary health programmes, along with appropriate prevention and control strategies supported by both the government and the private sector, will be necessary to minimize duck parasite burdens [12].

THE IMPORTANCE OF PARASITIC DISEASE MANAGEMENT IN DUCKS

Parasitic diseases are a major concern in both wild and domesticated ducks, affecting their gastrointestinal system, respiratory tract, blood, and other tissues. The parasites that infect ducks belong to various groups, including helminths (worms), protozoa, and arthropods (such as lice and mites). These parasites can cause a range of symptoms, from mild discomfort to severe illness, including diarrhea, weight loss, anemia, reduced growth rates, and even death in severe cases. In a farming context, these infections can reduce productivity by affecting egg production, growth, and the overall health of the flock, leading to significant economic losses. In wild ducks, parasitic diseases can have broader ecological impacts. Ducks play a role as intermediate or definitive hosts in the life cycles of many parasites, and their infections can affect other species in the food web, including other birds, mammals, and even humans in the case of zoonotic parasites. Moreover, some parasitic diseases can lead to population declines, affecting biodiversity and wetland health.

COMMON PARASITIC DISEASES IN DUCKS

The variety of parasites that can infect ducks makes the management of these diseases particularly challenging. Some of the most common parasitic infections in ducks include:

- **Nematodes:** Nematodes, or roundworms, are among the most common helminths infecting ducks. Species such as *Ascaridia galli* and *Capillaria* spp. are frequently found in the gastrointestinal tract of ducks, causing malnutrition, reduced feed efficiency, and weight loss [13 - 16].
- **Cestodes:** Also known as tapeworms, cestodes like *Hymenolepis* spp. and *Fimbriaria fasciolaris* are common in ducks, especially those with access to water where intermediate hosts like snails are prevalent. Tapeworms can cause inflammation and irritation of the gut lining, leading to digestive issues and malabsorption of nutrients [17 - 20].
- **Trematodes:** Flukes, or trematodes, such as *Echinostoma* spp. and *Notocotylus attenuatus*, are frequently encountered in ducks, especially in waterfowl that have access to aquatic environments where intermediate hosts like snails are present. These parasites can cause severe damage to the liver, intestines, and other organs. [17 - 21].
- **Protozoa:** Ducks are susceptible to several protozoan infections, including *Eimeria* spp., which cause coccidiosis, a disease characterized by diarrhea, weight loss, and poor growth. Other protozoa, such as *Histomonas meleagridis*, can cause blackhead disease, a condition that leads to liver and cecal lesions.
- **Arthropods:** External parasites, such as mites and lice, are also common in ducks. *Cnemidocoptes mutans* (scaly leg mite) and *Dermanyssus gallinae* (red mite) can cause significant irritation, feather damage, and anemia due to blood loss [22 - 29].

THERAPEUTIC APPROACHES

Anthelmintics

Anthelmintics are drugs used to treat helminth (worm) infections in animals, including ducks. Ducks, both in wild and domestic settings, are susceptible to a variety of parasitic worm infections, including nematodes (roundworms), cestodes (tapeworms), and trematodes (flukes). Managing these parasitic infections is critical for the health and productivity of ducks, especially in farming environments where parasitic loads can significantly impact flock health, growth, and egg production (Fig. **1**).

CHAPTER 17

Strategies for Managing and Preventing Parasitic Infections in Duck Populations

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Abstract: Prevention and control of parasites, both internal and external, is an important aspect in maintaining the health, productivity, and overall welfare of ducks. Understanding the life cycles of these parasites is crucial for effective management and control. To effectively manage parasitic infestation in ducks, it is important to take a holistic approach. Appropriate treatment methods, biosecurity measures, proper disinfection, litter management, proper lighting, ventilation, and the isolation of sick birds are measures that need to be adopted to control parasites in ducks. Additionally, Integrated Pest Management (IPM) methods support a balanced approach that blends chemical treatments with natural controls and smart environmental practices, helping sustainably keep parasite levels in check. Recent advances, such as attenuated and non-attenuated live vaccines, are available for control of coccidiosis and other parasites. Ongoing research aims to develop more targeted vaccines against specific parasites affecting ducks, such as helminths and ectoparasites. This area is promising and may lead to more effective control measures in the future. The emergence of resistance to antiparasitic drugs has led to the introduction of phytochemicals, or natural plant extracts, as dietary supplements to stimulate the immune system against various parasites. Combining all available options and identifying new viable alternatives in the near future will reduce the incidence of parasites in ducks.

Keywords: Biosecurity, IPM, Phytochemicals, Parasites, Vaccines.

INTRODUCTION

Parasitic diseases, including both internal and external parasites, have serious implications in poultry production, including ducks (Fig. **1**). Parasite-associated economic losses are due to morbidity, mortality, reduced FCR, reduced weight

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gain, retarded growth, decreased fertility, and the cost of treatment [1, 2] and also have some indirect effects, including transmission of other pathogens. These parasites include different species of helminths, arthropods, and protozoa. The incidence of these parasites depends on various factors, including age, season, housing system, nutritional status, hygiene, and management. For the control of these parasites, so far, the use of chemical anthelmintics is widely practised.



Fig. (1). Integrated farming system of ducks.

Modern-day rearing practices focus on integrated parasite management, *i.e.*, a combination of available control measures [3, 4]. So far, many approaches have been developed to find alternatives to chemical control measures, as drug resistance in livestock and poultry parasites has developed and increased public concern about chemical residue-free animal products [5, 6]. Development of an effective vaccine against parasites may facilitate effective control, but despite many efforts, limited success has been achieved so far, and no such vaccines are available, particularly for helminths of poultry, including ducks. On the other hand, few commercial vaccines are available for helminths, arthropods, and protozoa of livestock and poultry, such as Coccivac for poultry coccidiosis, GAVAC and TickGard for *Boophilus microplus* tick, and Barbervax for *Haemonchus contortus* in sheep [7]. Herbal formulations may be a suitable

alternative to chemical compounds in the future and are now mostly preferred over them, as they have no side effects and do not develop resistance.

COMMON HELMINTH PARASITES OF DUCK

Cestodes

Mostly inhabit the small intestines of their host for absorption of ready-made nutrients as they lack a digestive system. Common tapeworms of ducks are *Hymenolepis* spp., *Raillietina* spp., and *Fimbriaria fasciolaris*. These tapeworms are transmitted by intermediate hosts.

Trematodes

Commonly encountered ones include *Echinostoma revolutum*, *Hypoderaeum conoideum*, *Echinoparyphium recurvatum,* and *Notocotylus attenuatus,* as well as *Prosthogonimus* sp. These digenetic trematodes are transmitted by snails and other intermediate hosts.

Nematodes

They include *Amidostomum anseris*, *Capillaria contorta*, *Ascaridia galli, Tetrameres* spp., *Allodapa suctoria*, *Heterakis gallinarum, Syngamus trachea, etc*.

Acanthocephala (Thorny-headed worms)

They include*Polymorphus* spp. and *Filicollis anatis*.

Pathogenic Significance

The intestinal tract is the most common site of predilection of helminths, and they are a major cause for concern to health and productivity [8], though some of them may be present elsewhere in the body. Pathogenicity of helminthoses is due to the structures and activities of these parasites. Spines on the tegument and suckers of trematodes and spines and hooks in the suckers and rostellum of cestodes inflict injuries during attachment. Moreover, activities such as feeding can cause blood loss and nutrient deficiencies. Other activities include increased peristaltic movement of oviduct-by-oviduct fluke, which may result in the production of a deformed egg, like a soft, soft-shelled, or shell-less egg. Characteristic hepato-pulmonary migration of helminth parasites may sometimes result in peritonitis and intestinal perforation [8]. Injuries to the intestinal wall caused by parasites such as *Ascaridia galli*, Heterakis gallinarum, and Capillaria spp. result from penetration of the intestinal mucosa, leading to hemorrhage, and the return of the mature worm to the lumen reduces weight gain and productivity [9, 10].

CHAPTER 18

Differences in Parasitic Diseases in Wild *vs.* Domesticated Ducks

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Abstract: Ducks (Anas platyrhynchas Linnaeus, 1758) are vital to the rural economy because they produce meat and eggs. Ducks are vulnerable to a wide variety of intestinal helminth infections. They serve as intermediate and final hosts for a variety of helminth and protozoan parasites. In addition to having detrimental health effects, these parasites cause financial losses by reducing body weight, decreasing egg production, and increasing vulnerability to infectious diseases. Young birds frequently exhibit stunted growth, emaciation, and death. During the infection, mature ducks may show no symptoms. However, in breeding management, parasitic infections in ducks are often overlooked. Nematodes (roundworms), trematodes (flukes), and cestodes (tapeworms) are common helminths that infect ducks. Direct ingestion of eggs or larvae from the final host's feces causes the nematodal infection. In contrast, digenean trematodes and tapeworms require at least one intermediate host to finish their life cycle. In order to develop into an infectious stage, the intermediate host consumes the eggs and larvae that are expelled by the final host. The cycle is completed when the final hosts consume the intermediate hosts. Rainfall, humidity, soil and water temperatures, and the availability of intermediate and final hosts are some of the variables that impact helminth transmission and persistence. Due to their high level of activity and ability to forage in a variety of habitats, wild ducks are more likely to be exposed to a wide range of parasites. They come into contact with domestic species because they have unrestricted access to backyards, which makes it easier for parasites to spread between them. At the individual, population, and community levels, parasites can impact their hosts. On an individual level, parasites can cause a range of illnesses and even lead to the host's death. Heavy infections are frequently found in dying and deceased people, and the effects are typically density-dependent.

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Keywords: Climate, Domesticated Ducks, Habitat, Parasitic infections, Wild Ducks.

INTRODUCTION

Around the world, ducks can be found in a wide range of aquatic environments. They are frequently housed in zoological and decorative collections and are the ancestors of commercially raised duck breeds used in agriculture [1]. According to Bi *et al.* [2], habituated ducks, a significant poultry species, are considered natural reservoirs for certain pathogens and are responsible for their evolution, maintenance, and spread. Many diseases can be spread from one country to another and from one region to another by the majority of these domestic and wild reservoirs [3]. To safeguard the public's health, it is crucial to identify and assess potentially harmful microorganisms in duck flocks [2]. Standard hygienic exercises and planned health management are rarely used in backyard duck farms, and contact with farm animals, pets, and wild birds is common [4]. As a result, such flocks typically have poor health. Numerous parasites can infect a waterfowl's digestive tract [5]. The helminthic parasites of the duck's digestive system include Acuaria species (Fig. **1**), Amidostomum species (Fig. **2**), Hetarakis species (Fig. **3**), Hymenolepis species (Fig. **4**), and others [1].

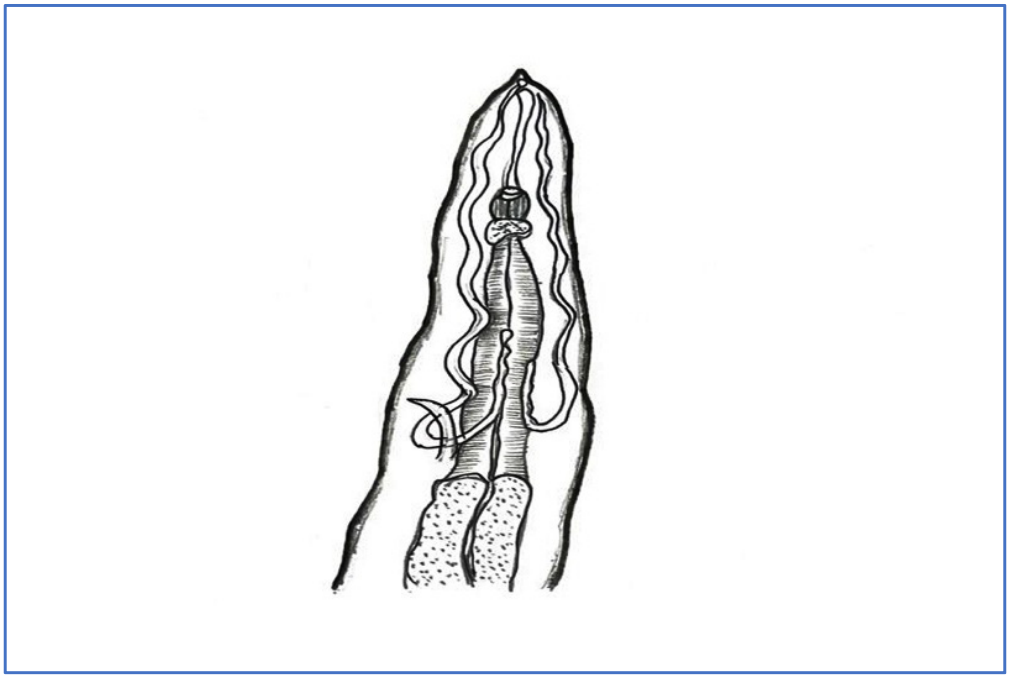


Fig. (1). Anterior end of *Acuaria spiralis*.

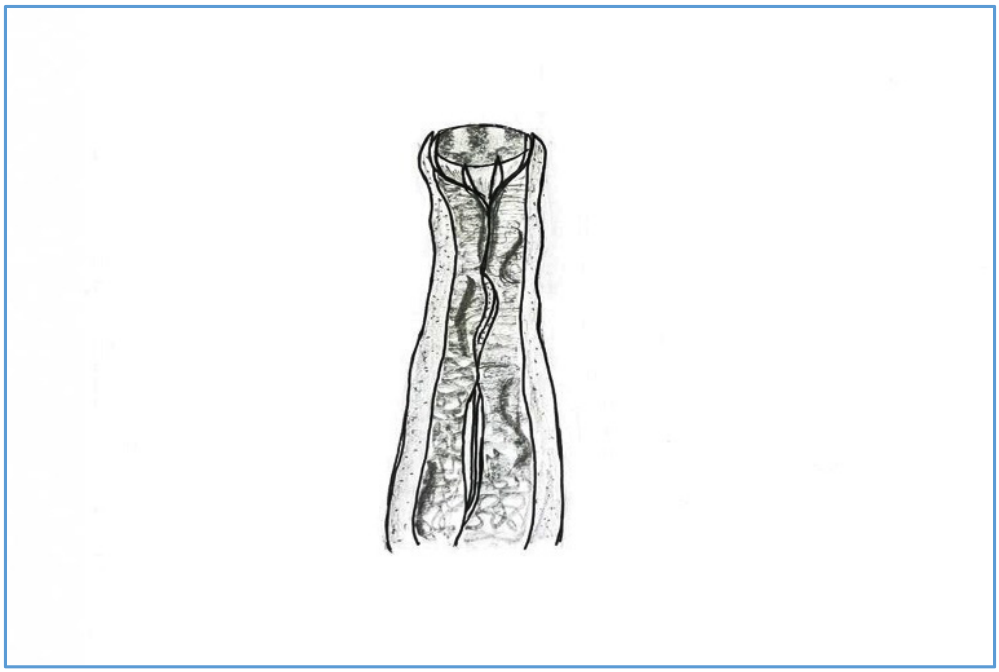


Fig. (2). Anterior end of *Amidostomum anseris*.

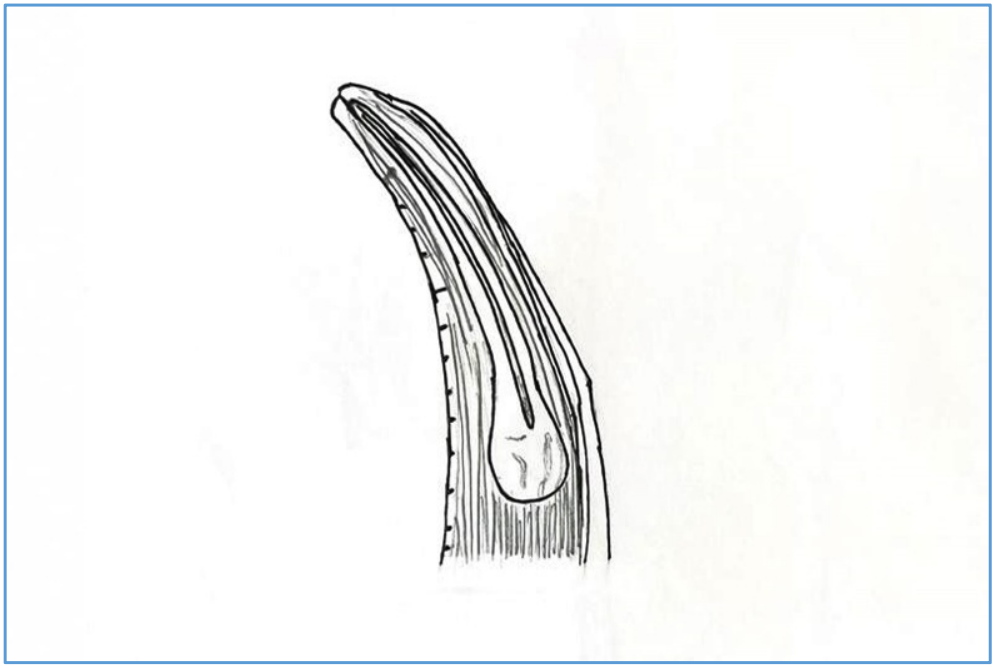


Fig. (3). Anterior end of *Heterakis gallinarum*.

CHAPTER 19

Economic Impact of Parasitic Diseases in Duck Farming: How Parasitic Infestations Affect Duck Farming and Production

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Abstract: Duck production plays a crucial role in the agricultural economy. The economics of duck farming are significantly influenced by parasitic diseases, affecting both productivity and profitability. Ducks are prone to a range of internal and external parasites, leading to direct and indirect economic losses. Direct economic losses include mortality, reduced productivity due to retarded growth, reduced feed efficiency, and decreased egg production. Indirect economic losses include poor reproductive performance, increased labor requirements for disease management, deterioration in flock health, and the risk of secondary infections. This loss affects both the individual farmer and the poultry industry, where duck farming is a vital livelihood. Understanding the consequences of parasitic infection, one needs to take mitigation measures like regular deworming, hygienic environment, integrated pest management strategies, and improved biosecurity measures. These measures promote increased productivity and contribute to the global economy.

Keywords: Biosecurity, Duck farming, Economic impact, Parasitic diseases, Productivity.

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INTRODUCTION

Ducks belong to the order Anseriformes and family Anatidae and are waterfowl closely related to geese and swans. They have peculiar broad bills, webbed feet, and are adaptable to various aquatic habitats. Ducks mostly breed in freshwater environments such as marshes, shallow lakes, and swampy areas. Most domestic ducks are descended from the wild Mallard, while a few are descended from the Muscovy duck. The precise time of duck domestication remains unclear, but historical evidence suggests that ancient Egyptians used ducks for sacrificial purposes around 1353- 1336 B.C. and likely bred them for food [1, 2].

Ducks, in comparison to chickens, are more adaptable to various environmental conditions. They are hardy, resistant to many diseases, and can scavenge for food without human assistance. Duck breeds have shown faster growth rates, better feed conversion, and higher meat quality through breeding and selection. Well-known duck breeds such as Pekin, Khaki Campbell, Muscovy, Indian Runner, and mule ducks are commonly raised for meat and eggs, which are good sources of protein and iron [3 - 5]. Ducks are also reared for decorative purposes, for clothing, to control snails in rice fields, and hunted as game animals [6, 7].

IMPORTANCE OF DUCK FARMING IN THE GLOBAL ECONOMY

Duck farming plays a crucial role in the global agricultural economy, contributing substantially to food security and generating employment and trade. Duck meat and egg are excellent sources of high protein, essential amino acids, iron, and omega-3 fatty acids. Globally, demand for duck products is gradually increasing, especially in countries such as China, Vietnam, and France, which are leading producers and consumers of duck eggs and meat [8].

Duck meat, eggs, and by-products like feathers used for bedding materials and textiles contribute substantially towards international trade and foreign exchange earnings. The duck meat market was valued at approximately $6.5 billion in 2020 due to increased demand for high-quality poultry products [9, 10].

Duck farming generates employment opportunities in rural areas by involving youth in duck breeding, production, processing, and distribution.

PARASITIC INFECTIONS AS A CHALLENGE IN DUCK FARMING

Parasitic infections in duck farming have a great impact on health, productivity, and economic viability (Fig. **1**). Ducks are susceptible to both internal and external parasites, which affect ducks' growth, reproduction, and overall health, leading to reduced egg and meat production. Internal parasites such as trematodes

and cestodes are commonly found in ducks reared in free-range and semi-intensive systems through contaminated food, water, and intermediate hosts like snails and insects. External parasites such as ticks, mites, and lice cause skin irritation and feather loss. They also lead to reduced feed intake, stress, and decreased productivity. Ducks kept under unhygienic and overcrowded conditions are prone to these infestations [11].



Fig. (1). Ducks are overcrowded, which leads to parasitic infection.

So, economic losses are faced due to the inclusion of treatment costs, reduced growth, and low market value of infected birds. Mitigation measures include regular deworming, maintaining hygiene, and promoting biosecurity measures to reduce duck parasitic infections [12].

TYPES OF DUCK PARASITES

Ducks are hosts to various internal and external parasites that can compromise their health and productivity. Internal parasites include nematodes such as *Ascaridia spp.* and *Capillaria spp.*, which infest the intestines and respiratory tract, causing nutrient competition and tissue damage [13, 14]. Trematodes like *Echinostoma spp.* and *Prosthogonimus spp.* can damage the liver, intestines, and reproductive organs [15]. Cestodes such as *Hymenolepis spp.* [16] and protozoa like *Eimeria spp.* [17] lead to malabsorption and intestinal damage, while blood parasites like *Leucocytozoon spp.* result in anaemia and systemic stress [18]. External parasites such as mites (*Dermanyssus gallinae*) and lice (*Menacanthus spp.*) infest skin and feathers, causing irritation and feather loss. Ticks (*Argas*

CHAPTER 20

Parasitic Vaccines and Their Importance in the Control of Parasitic Diseases in Ducks

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Abstract: Parasitic infections represent a major constraint to duck and poultry health, adversely affecting productivity and resulting in substantial economic losses within the agricultural industry. This review examines the progress made in the design and utilization of vaccines targeting parasitic diseases as an effective control measure. Immunization provides a preventive strategy by stimulating protective immune responses in birds against key parasites, including coccidia, gastrointestinal nematodes, and various ectoparasites. Lowering infection rates through vaccination contributes to improved flock performance, enhanced weight gain, and increased egg yield, while simultaneously decreasing dependence on chemotherapeutic agents and limiting the emergence of drug-resistant parasite populations. Despite these advantages, several obstacles persist, such as inconsistent immune reactions among birds and the requirement for parasite- and host-specific vaccine formulations. Continued research efforts and coordinated collaboration among researchers, veterinarians, and poultry producers are vital to refine vaccine development and ensure effective field application. Overall, parasitic vaccines hold considerable promise for advancing poultry health management and supporting more sustainable and resilient production systems.

Keywords: Ducks, *Eimeria* spp., Parasitic vaccine, Poultry, Parasitic diseases.

INTRODUCTION

The poultry sector is a cornerstone of global agriculture, contributing substantially to food security, nutrition, and economic growth. It involves the production, management, and commercialization of different avian species, chiefly chickens, ducks, turkeys, and geese. Over recent decades, the industry has undergone remarkable transformation, shaped by innovations in technology, improved management practices, and shifting consumer preferences. Emphasis on higher

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productivity, biosecurity, and operational efficiency has enabled the sector to expand and adapt to the growing global demand for poultry meat and eggs [1, 2].

Parasitic infections represent a major challenge for the poultry industry, compromising the health, welfare, and performance of birds such as ducks and chickens. A diverse range of parasites, including protozoans, helminths, and external parasites, is responsible for these conditions, which may result in poor weight gain, lowered egg output, and higher mortality rates. Conventional control approaches, particularly the use of anthelmintic drugs and chemical treatments, have been extensively applied to manage these infections. However, such methods are not without drawbacks. Repeated and indiscriminate use can contribute to the emergence of drug-resistant parasite strains and may also pose risks to animal well-being and the surrounding environment [3, 4]. In recent years, considerable attention has been directed toward the development of vaccines targeting parasitic infections as an innovative approach to disease control in poultry. Immunization enables the bird's immune system to identify and respond effectively to specific parasites, thereby providing preventive protection instead of depending exclusively on post-infection treatments. Such an approach is designed not only to safeguard flock health and improve production performance but also to promote more sustainable poultry management. By decreasing dependence on chemical therapeutics, vaccination strategies can contribute to reduced drug usage, lower risk of resistance development, and environmentally responsible farming practices. [4, 5].

Although parasitic vaccines offer considerable promise, their development is accompanied by several scientific and practical challenges. The intricate interactions between host and parasite, along with differences in immune responsiveness among various poultry species, complicate the design of broadly effective vaccines. In addition, antigenic diversity and variations in parasite life cycles further complicate the development of long-lasting protective immunity. Even so, ongoing progress in immunology, molecular biology, and vaccine delivery systems is opening new avenues for the development of targeted and species-specific immunoprophylactic strategies, particularly for ducks and other economically important poultry species. These advancements provide a strong foundation for innovative disease control approaches tailored to the unique epidemiological and physiological characteristics of different avian species. This discussion emphasizes the importance of parasitic vaccines as a forward-looking tool in the control of parasitic diseases affecting ducks and poultry. As scientific efforts continue to advance, incorporating vaccination into integrated disease management programs is likely to strengthen flock resilience, improve productivity, and support more sustainable poultry production systems on a global scale [6, 7].

PARASITIC DISEASES IN DUCKS/POULTRY: SCOPE AND IMPACT

Parasitic infections represent a major challenge for the poultry and waterfowl sectors, as they contribute to substantial economic losses, diminished productivity, and, in severe cases, elevated mortality rates. Ducks and other domesticated avian species are especially susceptible to numerous parasitic agents because of their rearing conditions and frequent exposure to contaminated environments and biological vectors. The range of parasitic diseases affecting ducks and poultry is extensive, encompassing multiple parasite groups with diverse life cycles and transmission patterns. Their influence on bird health, welfare, and overall farm performance is profound, underscoring the significant burden these infections impose on poultry production systems [8 - 10].

SCOPE OF PARASITIC DISEASES

Parasitic infections in ducks and poultry are generally divided into two main groups: external parasites and internal parasites. Each category presents unique health challenges to affected birds. However, the distribution, intensity, and overall consequences of these infections are influenced by factors such as climate, housing conditions, hygiene standards, management systems, and regional epidemiological patterns.

EXTERNAL PARASITES

External parasitic infestations in ducks and poultry are primarily caused by arthropods, including mites, lice, fleas, and ticks. These ectoparasites cause irritation, discomfort, and stress to the birds, which can negatively affect feeding behavior and overall performance. Beyond their direct impact, they also serve as vectors for a range of infectious agents, thereby increasing the likelihood of secondary infections and more complex disease conditions within flocks [11, 12].

1. **Mites:** The northern fowl mite, *Ornithonyssus sylviarum*, is among the most prevalent ectoparasites of poultry. This parasite colonizes the skin and feather regions of birds, leading to severe pruritus, irritation, and blood loss that may progress to anemia. Prolonged or heavy infestations can markedly reduce egg yield, impair weight gain, and diminish the general health and productivity of affected flocks.
2. **Lice:** Poultry lice, including *Menacanthus stramineus*, are wingless ectoparasites that inhabit the feathers and skin of ducks and other poultry species. Their feeding activity leads to irritation, restlessness, feather damage, and, in severe cases, decreased egg production. Persistent infestations may also compromise the birds' immune competence, increasing their vulnerability to secondary infections and other health disorders.

CHAPTER 21

Drug Resistance in Duck Parasites: Strategies for Effective Management

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Abstract: Ducks play a vital role in the global poultry industry, but parasitic infections can cause severe diseases and reduce productivity. Anthelminthics are commonly used to control these parasites; however, the emergence of anthelminthic resistance (AR) is a major concern worldwide in both veterinary and human medicine. The development of AR is influenced by multiple factors, including the host, the parasite species, the type of anthelminthic, management practices, and environmental conditions. Designing effective parasite control strategies to preserve the efficacy of existing anthelminthics and reduce the risk of resistance requires a thorough understanding of the different mechanisms of AR. The spread of AR can be mitigated through increased awareness, education, and good hygiene practices. Research and surveillance programs are essential for monitoring and managing resistance. Addressing AR effectively requires coordinated efforts at the local, national, and international levels. Adopting a One Health approach also involves implementing regulations to ensure responsible use of anthelminthic drugs in both human and veterinary medicine.

Keywords: Anthelminthics, Drug resistance, Ducks, One Health, Stewardship.

INTRODUCTION

Ducks play an important role in the global poultry industry as a key source of animal protein. The Food and Agriculture Organization (FAO) estimates that there were 1.15 billion ducks (*Anas* spp.) in the world in 2020, with Asia accounting for 89-90% of the total population (1.24 billion). Duck farming is crucial to the development of sustainable food supplies, particularly in Asia's developing nations [1].

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Ducks are typically infected with three primary helminthes, *viz*., tapeworms, roundworms, and gapeworms. Roundworm infections are becoming more common as a result of intense free-range and backyard duck rearing, particularly in rural areas. The most common internal parasite is the large roundworm (*Ascaridia galli*), which should be controlled. The most common external parasites are body lice. They can result in severe disease and reduced productivity across all bird species. The control of helminth parasites is crucial to the sustainable production of ducks.

In order to control parasitic diseases in poultry, anthelminthics are essential. One major problem is the emergence of anthelminthic resistance (AR) because it may result in treatment failure, reduced output, a rise in the spread of parasitic diseases, and financial losses in the poultry industry. Anthelmintic resistance is defined as a significant increase in the ability of individuals within a strain of parasites to tolerate doses of a compound that would be lethal to the majority of individuals in a normal population of the same species. The phenomenon known as anthelminthic drug resistance occurs when parasites, especially helminths, become less susceptible to or completely resistant to the anthelminthic medications used to treat or manage them. Both the production and the health of the ducks are affected by these diseases, which may manifest both symptomatically and asymptotically [2].

The parasites most commonly associated with resistance to anthelminthic drugs in ducks include nematodes like *Ascaridia galli*, *Capillaria obsignata*, *Heterakis gallinarum*, *Syngamus trachea, and Strongyloides avium,* and cestodes such as *Raillietina cesticillus, Davainea proglottina,* and *Hymenolepis* species. Ducks can be infected with trematodes, also known as flukes, including *Prosthogonimusanatinus*, *Sphaeridiotrema globules*, *Diplostomum mergi*, *Echinostoma revolutum,* and *Zygocotyle lunata*. Liver flukes can cause severe disease in waterfowl, especially in diving ducks, swans, and coots. Ducks become infected by eating invasive faucet snails that harbor the parasite.

The commercial duck production industry could suffer significant financial losses due to anthelmintic-resistant parasites. In poultry, parasites can affect feed conversion, and eliminating resistant parasites can be expensive. The feed conversion of birds treated with anthelminthics for resistant parasite infections was found to be much lower than that of birds treated for susceptible parasite infections. Resistance of nematodes and trematodes to different classes of anthelminthics is a significant issue. Under field conditions, nematode resistance to anthelmintics has developed more slowly than antibiotic resistance in bacteria. However, due to the introduction of only a few chemically distinct anthelminthics over the past few decades, resistance is spreading. The majority of anthelminthics

fall into one of three chemical classes: macrocyclic lactones, imidazothiazoles, or benzimidazoles. All of these classes of drugs have constituent molecules exhibiting similar behavior. Therefore, resistance to other members of the group may coexist with resistance to a specific chemical. Only a small number of anthelminthic products are used to chemically control helminth infections in poultry. The two approved medications that can be used as water-administered anthelminthics in poultry are piperazine and levamisole. Ducks and other domesticated poultry, as well as many wild bird species, are impacted by fenbendazole and levamisole [3].

GLOBAL SCENARIO

Anthelminthic resistance (AR) is a worldwide issue that affects both developed and developing nations and a variety of helminths across many animal species. Many anthelminthic classes, a variety of helminth species, a diversity of locations and management techniques, a broad animal host range, and ease of worldwide dispersal are the main factors contributing to the pervasive nature of anthelminthic resistance. *A. galli* and *Capillaria* spp. are the kinds of helminth parasites that are often controlled with fenbendazole and levamisole, and these drugs have no negative effects on egg laying or hatching. Nematodes belonging to the *Ascarididae* family, *Ascaridia galli* and *Ascaridia dissimilis,* are among the most prevalent and economically significant nematode parasites of poultry, particularly free-range ducks. Anthelmintic resistance is a growing concern in Asia, especially in countries where anthelmintic drugs are widely used in agriculture and livestock production. The prevalence of anthelminthic resistance in Asian countries differs across regions. However, reports have shown that the AR has emerged in various poultry species, including ducks [3].

TYPES OF ANTHELMINTHIC RESISTANCE

There are three main types of anthelminthic resistance observed, viz., cross-resistance, side-resistance, and multiple resistance. The complex interactions between parasites and anthelminthic drugs, along with the parasites' ability to adapt and develop survival mechanisms, are reflected in these forms of resistance. Understanding these resistance patterns is essential for designing effective parasite control strategies that minimize the risk of resistance development and preserve the efficacy of available anthelminthics [4].

Cross-Resistance

Cross-resistance occurs when a parasite strain develops tolerance to therapeutic doses of anthelminthics that are chemically unrelated or have different modes of action. In such cases, resistance to one class of drug may confer resistance to

CHAPTER 22

Emerging Parasites in Ducks: Global Perspectives on New and Emerging Parasitic Threats

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Abstract: Numerous factors can contribute to emerging parasitic infections in ducks, such as previously unidentified infectious agents, previously recognized agents whose role in particular diseases has not been acknowledged, and the re-emergence of agents whose disease incidence had previously declined or disappeared and has since resurfaced. Emerging or reemerging diseases can affect duck production, duck well-being, and the health of entire ecosystems; thus, it is crucial to recognize them.

Keywords: Ducks, Diseases, Global impact, Infection, Parasites, Threats.

INTRODUCTION

Parasitic diseases represent significant neglected infectious diseases affecting domestic poultry, which are vital to the economic well-being of villagers [1 - 4]. These diseases lead to reduced growth, production, and overall efficiency in poultry operations [5, 6]. In rural areas, the most economically important domestic birds include chickens, ducks, turkeys, and quail. Today, ducks are mainly reared for their high-quality meat and eggs [7, 8]. Additionally, duck breeding in the industrial farming system was boosted economically by additional duck products, including down, feathers, and fattened livers [9 - 12]. Additionally, compared to broiler and layer, raising these birds is simpler and less costly. The number of ducks (*Anas spp.*) worldwide reached 1.24 trillion in 2016, with Asia (89%) accounting for 1 trillion of that total [13]. Outside their nests, ducks are well known for being good scavengers and resistant to many diseases, making them hardy animals. These rural birds, therefore, have a greater impact on risk

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factors than industrial species. This scavenger bird, however, can be thought of as the final or intermediate host of several helminths or protozoan parasites. The eggs of gastrointestinal parasites are primarily excreted through the feces and released into the environment, where they can infect humans and other animals.

Besides this, the intestinal parasite causes enteric disorders in ducks [14], which are clinically manifested by malnutrition, reduced feed conversion ratio, leading to weight loss, gradual loss of production, and even death of the birds [15, 16], and ultimately affecting the monthly income of the farmers.

BAYLISASCARIASIS

Cerebrospinal nematodiasis in North American animals is caused by nematodes of the *Baylisascaris* species. Among these, *Baylisascaris columnaris, Baylisascaris procyonis,* and *Baylisascaris melis* are the most important from a zoonotic point of view. In addition to humans, more than 130 species of birds and mammals can act as paratenic hosts, and the raccoon is the primary host [17, 18]. These big ascarid nematodes develop in the host's intestines. Millions of parasite eggs can be shed daily by infected raccoons. These eggs typically accumulate at common defecation sites and can survive for extended periods in this environment, as well as in polluted cages and enclosures. Ducks and other small animals serve as paratenic hosts. Ducks get infected when they come into contact with this environment while searching for food. When these eggs hatch, the larval nematodes will aggressively travel through the tissues of paratenic hosts, frequently causing neurologic damage and resulting in diseases of the central nervous system [19].

Clinicopathological Findings

Clinical indications, including loss of equilibrium, worsening ataxia, circling, torticollis, head tilts, visual abnormalities, and difficulty standing or walking, are common in central nervous system infections. Brain hemorrhage and malacia may be glaringly apparent, but absent or mild lesions are more frequent. There will be gliosis and perivascular lymphocyte and plasma cell proliferations along with a nonsuppurative inflammatory response histologically. In certain cases in which granulomas have been observed in the kidney, liver, and heart, it has been suspected [20].

Prevention

Cleaning the surroundings is crucial if cases of *Baylisascaris* encephalitis are found. Finding the locations of raccoon latrines is part of this. It is essential to remove any contaminated bedding or soil. Additionally, cages containing

raccoons, skunks, and badgers should be meticulously cleaned to get rid of any feces that might be the source of the nematode eggs [21].

SCHISTOSOMIASIS

Schistosomes are members of a broad trematode family found worldwide that uses snails as intermediate hosts. Both mammals and several bird species (such as ducks) are the definitive hosts. For instance, *Anserobilharzia* has been isolated only from geese, and the genus Allobilharzia has been isolated only from swans [4]. Twenty species of bird schistosomes now exist, belonging to at least eight genera: *Macrobilharzia*, *Trichobilharzia*, *Dendritobilharzia*, *Anserobilharzia*, *Austrobilharzia*, *Ornithobilharzia*, *Gigantobilharzia*, and *Allobilharzia* [5, 22].

Schistosomes have a two-host life cycle and are digenetic trematodes. They use a variety of snail families as their first intermediate hosts. The freshwater pulmonate snail families (*Physidae*, *Lymnaeidae*, and *Planorbidae*) are responsible for the transmission of the majority of schistosome species. The host's epithelial surface is penetrated by the cercarial stage, which spends its adult life within the vasculature. Based on the site of predilection, this parasite can be divided into two types: visceral and nasal [16]. It is believed that nasal species exhibit a neurotropic route of migration, while visceral species move through the viscera and gain entry into the mesenteric, renal, cloacal, and portal blood vessels [23]. *Trichobilharzia* develops and lays its eggs in the nasal mucosa veins of certain duck species. As infected ducks drink or feed, the miracidia that have hatched from eggs in the tissue leave the host [24, 25].

Clinicopathological Findings

Many of the *Trichobilharzia* species that infect visceral pathways will go to the intestinal portal veins, where hyperplastic endophlebitis, a condition marked by extreme myointimal hyperplasia that frequently obliterates the vascular lumen, may develop. The schistosome eggs will then move through the intestinal mucosa from this distance [26, 27]. The presence of viable adult schistosomes in the portal veins and nonviable schistosomes in the bile ducts in some ducks can result in portal fibroplasia in the liver [28]. In Atlantic Brant geese (*Branta bernicla hrota*), the primary symptoms of *Trichobilharzia brantae* infection include caudal mesenteric vein thrombosis due to adult schistosomes in serosal and mesenteric blood vessels, and eggs in the intestinal loop, leading to fibrinohemorrhagic colitis [29]. These deadly trematodes migrate through the intestinal vasculature, obstruct the intestinal and portal veins, and are clinically manifested as an emaciated duck followed by death [2, 30]. In migration through the central nervous system, the clinical signs include paralysis, sluggish movements, and behavioral changes, followed by death [31].

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