

# HANDBOOK OF POULTRY PARASITES

Editor:  
**Tanmoy Rana**

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# **Handbook of Poultry Parasites**

Edited by

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## FOREWORD

Poultry production is one of the most significant sectors in the global agricultural economy, providing an essential source of protein through meat and eggs. As the demand for poultry products continues to grow, so does the need to understand and address the challenges that threaten the health and productivity of poultry flocks. Among these challenges, parasitic infections stand out as a persistent and pervasive problem that affects poultry worldwide, with substantial impacts on animal welfare, food safety, and economic sustainability.

The “Handbook of Poultry Parasites” is an indispensable resource that addresses this critical issue with clarity, depth, and scientific rigor. This book provides comprehensive insights into the various parasites that infect poultry, including their biology, epidemiology, diagnosis, control, and management. It covers a wide range of parasites, from protozoa and helminths to ectoparasites, each of which poses unique threats to poultry health.

What sets this handbook apart is its balanced approach, combining foundational knowledge with practical applications. It serves not only as a reference for veterinarians, poultry health specialists, and researchers but also as a practical guide for poultry producers and farm managers. The book emphasizes integrated pest management strategies, highlighting the importance of prevention, monitoring, and judicious use of treatments to minimize the impact of parasites while reducing the risk of resistance.

In an era marked by increasing concerns over antimicrobial resistance, food safety, and sustainable agriculture, this handbook is timely and relevant. It provides the tools and knowledge needed to develop effective, sustainable, and science-based strategies for managing parasites in poultry, ensuring that poultry production remains both profitable and responsible.

I commend the authors and contributors for their dedication to this project and for their valuable contributions to the field of poultry health. This handbook is a testament to their expertise and commitment to advancing our understanding of parasitic infections in poultry and their management.

I am confident that this book will become a vital reference for all those involved in poultry health and production. It will undoubtedly contribute to improving poultry welfare, enhancing productivity, and ensuring the sustainability of poultry farming around the world.

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## PREFACE

POULTRY generally suffers from many parasitic diseases, and the object of this book is to present to poultry-keepers the information about life histories of these pests, so that protection may be successfully ensured. Poultry products are valuable protein sources throughout the globe and the poultry commercial industry, especially Commercial Production Systems (CPS) gained continuous growth during 20-30 years. On the other hand, the traditional scavenging rural systems are also exploited with low growth and serious nutritional, management, and constraints of diseases. The parasite can cause harm in poultry developing countries with the declined productivity of backyard poultry. The handbook describes useful updated information on the pathogenic parasites of economic consequences and also elaborately describes the procedure as well as techniques for the epidemiological study, diagnosis, treatment, and control. The book is structured interestingly for routine application in research institutes, field laboratories, and universities. The book describes the characteristics and habits of the parasites in relation to the occurrence of many diseases. The book guides poultry-breeders, and fanciers in distinguishing and coping with poultry parasites that can cause them serious loss. As most of the birds are grown in more concentrated/confinement areas, new disease problems may appear and old ones sometimes reoccur simultaneously. Proper treatment, management, and sanitation can reduce disease or parasite problems at an early stage. The book is an invaluable resource for both veterinarians in training and in practice for gathering knowledge about the parasitic diseases of poultry. The contributors are well-specialized in their knowledge for writing the individual chapter. This book is especially intended for farmers, industry specialists, practitioners, academics, researchers, veterinarians, and DVM graduate students engaged with a special interest in poultry health, and management. It is assumed that a wide circulation of the handbook can accelerate the standardization and enhancement of diagnostic capacity, treatment, and effective disease control programmes. I hope that this book serves as a new paradigm for the stimulus to further research in clarifying the pathomechanisms, diagnosis, and treatment of parasitic diseases of poultry. I expect that the reader will observe this book interestingly with updated information about the diseases. The book can utilize the knowledge in research and teaching to the new generation. I always welcome constructive feedback and encouragement from my veterinarian colleagues all over the world.

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**CHAPTER 1**

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**Introduction**

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**Abstract:** Poultry now constitutes 30% of global meat consumption, with a rising demand observed worldwide. However, parasites pose a significant challenge in both large-scale commercial poultry operations and small backyard flocks, leading to considerable economic losses. Nematode and cestode worm infections in chickens can result in decreased egg production, weight loss, growth impediments, and weakness. Parasitic infestations in poultry are widespread, regardless of the rearing method used, and can severely affect production outcomes. In confinement systems, parasites have short life cycles and routes of direct transmission, such as *Heterakis gallinarum*, *Ascaridia galli*, *Eimeria* spp., and *Capillaria* spp. thrive more easily. On the other hand, free-range or backyard rearing creates opportunities for parasites that depend on intermediate hosts to complete their life cycles. It is important to understand that parasitism in poultry impacts the entire flock, and the health of an individual bird is of less economic significance compared to the overall impact on flock productivity.

**Keywords:** Diseases, Infection, Infestation, Parasites, Parasitism, Poultry.

**INTRODUCTION**

Various factors, including infectious agents, toxins, and nutritional deficiencies, significantly influence farm performance, thereby affecting the local poultry industry [1]. In addition, poultry is vulnerable to a variety of common diseases, including endoparasites, ectoparasites, infectious bronchitis, Marek's disease, fowl cholera, salmonellosis, infectious coryza, fowl pox, avian encephalomyelitis, among others. These health challenges can significantly impact poultry production and the sustainability of the industry. Controlling infectious diseases is essential for preserving poultry health, and diagnostic methods are critical for identifying disease causes and evaluating the effects of pathogens on the host [2].

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Although the core principles of disease diagnostics remain consistent, the landscape of poultry diseases is continually evolving, with new pathogens being discovered and deeper insights gained into epidemiology and disease mechanisms. At the same time, innovative technologies have emerged to detect and characterize infectious agents [3]. However, traditional methods, such as pathogen isolation and characterization through functional assays and studies, remain essential in the diagnostic process. These classical approaches complement new technologies, providing a more complete understanding of poultry health and disease management.

In poultry medicine, the diagnostic approach has shifted from focusing on individual birds to evaluating the health of entire flocks [4]. Flocks are considered “healthy” when they perform according to their genetic potential and show no clinical signs of disease [4]. On-farm diagnostic activities involve regular sampling and investigations as part of health control programs, often aligned with national or international efforts targeting specific parasitic diseases. Samples collected on-site may be tested immediately using rapid antigen tests or sent to laboratories for further analysis, including ELISA and PCR. Field veterinarians play a key role in diagnostic surveillance, and gathering epidemiological data to support flock management. Routine sample collection, such as feces, serum, and mucosal swabs, focuses on confirming flock health status and monitoring vaccine effectiveness [5]. The data generated through these diagnostic processes enable informed decision-making to optimize both flock health and production outcomes.

In field settings, diagnostic procedures are initiated promptly when flock health is compromised, typically indicated by rising morbidity or mortality rates. Investigations begin with the collection of a detailed case history, including relevant information about the flock, management practices, and the characteristics of the infection or disease [6]. This involves recording details such as the type and origin of the birds, their age, routine medications, vaccination protocols, history of diseases, husbandry practices, and standard operating procedures for feeding, watering, ventilation, and lighting systems. Additionally, hygiene and biosecurity measures are documented [7]. In addition, production parameters, morbidity and mortality statistics, the duration of observed signs or problems, and any epidemiological links to other production sites are carefully documented. This comprehensive information serves as the basis for the next diagnostic steps, enabling a systematic approach to identifying and resolving flock health issues [8].

On the farm, diagnostic procedures begin with the clinical examination of both flocks and individual birds at various disease stages, as well as their products, such as feces and eggs. These assessments are carried out by experienced poultry

workers and veterinarians who have a deep knowledge of what defines a healthy flock and environment. While clinical evaluations are thorough, they can be time-consuming and labor-intensive. Unfortunately, they may not always identify diseases, particularly subclinical infections, which can be difficult to diagnose accurately [9]. The manifestation of infectious diseases can vary greatly, ranging from subtle subclinical symptoms to severe clinical illness. This variability is influenced by factors such as the causative agent, host characteristics, and environmental conditions, making diagnosis more challenging. Common clinical signs often include non-specific indicators like apathy, ruffled feathers, and decreased appetite, which can be associated with a wide array of diseases [10]. Specific signs may also be present, indicating particular disorders, such as enteric, respiratory, or neurologic issues. In certain cases, signs may be pathognomonic, serving as unique indicators of a specific disease, such as those observed in histomonosis [11].

Post-mortem investigations, whether performed on the farm or in a laboratory, are essential diagnostic procedures designed to identify gross pathological changes in organs and tissues. These investigations assist in determining a tentative cause of impaired performance and clinical signs. By integrating a detailed case history, a comprehensive assessment of clinical signs, and careful post-mortem examinations, the range of presumptive diagnoses can be narrowed. This process lays the groundwork for selecting suitable laboratory methods to further confirm and refine the diagnosis [12].

### Protozoa

The primary protozoa are predominantly from the phylum Apicomplexa, encompassing genera such as *Eimeria* spp., *Leucocytozoon* spp., *Haemoproteus* spp., *Toxoplasma* spp., *Sarcocystis* spp., and *Cryptosporidium* spp. Additionally, flagellates like *Histomonas* spp., *Trypanosoma* spp., *Trichomonas* spp., *Chilomastix* spp., and *Hexamita* spp., as well as amoeba including *Entamoeba* spp. and *Endolimax* spp., are commonly found. Recently, a microsporidian known as *Encephalitozoon cuniculi* has also been reported in chickens [13].

### Coccidiosis

Coccidia unquestionably stands out as the most significant parasite affecting poultry, with widespread distribution, high frequency of occurrence, and substantial economic repercussions [14]. Although mortality from coccidiosis is effectively managed with anticoccidial medications, the poultry industry continues to face significant losses due to reduced weight gain, decreased feed efficiency, and treatment costs. To highlight the economic sensitivity of the industry, even a slight improvement in feed efficiency, such as a reduction of 0.01



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**CHAPTER 2**

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**Seasonal Dynamics in Parasitic Diseases**

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**Abstract:** Seasonal dynamics play a crucial role in the epidemiology and prevalence of parasitic diseases in poultry, influencing transmission patterns, host susceptibility, and environmental conditions. This abstract provides an overview of the seasonal variation observed in parasitic diseases affecting poultry populations and highlights the implications for disease management and control strategies. Seasonal factors, including temperature, humidity, rainfall, and photoperiod, can influence the survival, development, and transmission of parasitic pathogens, such as helminths, protozoa, and ectoparasites. Additionally, seasonal changes in host behavior, immune function, and reproductive status may impact susceptibility to parasitic infections and disease outcomes. Understanding the seasonal dynamics of parasitic diseases in poultry is essential for implementing targeted preventive measures, such as strategic deworming, parasite monitoring, and environmental management practices, to mitigate the risk of disease outbreaks and minimize production losses. Furthermore, seasonal variation in parasite populations underscores the importance of integrated approaches to disease control, including vaccination, biosecurity, and sustainable management practices, tailored to the specific epidemiological context and environmental conditions. By considering seasonal factors in disease management strategies, poultry producers can optimize health outcomes, improve welfare standards, and enhance the overall productivity and profitability of poultry production systems.

**Keywords:** Disease management, Environmental factors, Epidemiology, Parasitic diseases, Poultry, Seasonal dynamics.

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## INTRODUCTION

Poultry serves as the primary source of animal protein globally [1]. According to data from the USDA, chicken meat production reached 102.9 million tons in January 2020, marking a 3.9% increase from the previous year [2]. This upward trend in production is significant, especially considering projections that the global population will reach approximately nine billion by 2050, emphasizing the urgent need for sustainable and safe protein production. In intensive poultry farming systems, where birds are kept in close proximity and at high stocking densities, stress levels, and disease prevalence tend to be elevated. As a result, any disease that compromises the efficiency of such production systems poses a potential threat to the global food supply chain [3].

Seasonal dynamics in parasitic diseases of poultry encompass a broad spectrum of interactions between environmental factors, parasite life cycles, host physiology, and management practices [4]. A good understanding of these dynamics is important for effective disease prevention, control, and management in poultry production systems. Parasitic diseases represent an important obstacle in the poultry industry, exerting profound effects on health, welfare, and productivity on a global scale. These diseases, caused by different kinds of parasites, pose multifaceted challenges to poultry producers, impacting both economic viability and animal well-being. Parasites, ubiquitous in the environment, have a remarkable ability to adapt and proliferate, exploiting diverse ecological niches to perpetuate their life cycles [5]. However, their prevalence and intensity are not static but undergo dynamic fluctuations influenced by a multitude of factors, prominently including seasonal variations in environmental conditions. Seasonal changes, encompassing shifts in temperature, humidity, precipitation, and other environmental parameters, play a pivotal role in shaping the epidemiology of parasitic diseases in poultry. These environmental factors directly impact parasite survival, development, and transmission dynamics, exerting a profound influence on disease prevalence and severity [6]. For instance, warmer temperatures may accelerate the growth and multiplication of parasites, promoting their transmission within poultry flocks. Conversely, colder temperatures may hinder parasite development but facilitate their persistence in environmental reservoirs, perpetuating the risk of infection. Likewise, humidity levels significantly influence the viability of parasite stages outside the host, with higher humidity favoring survival and transmission. Precipitation patterns, by altering environmental moisture levels, can create conducive breeding grounds for parasite vectors, exacerbating the risk of transmission to poultry [7].

Moreover, host-related factors such as immune status, age, and management practices further modulate susceptibility to parasitic infections. Immune function,

influenced by genetics, nutrition, and prior exposure, plays a critical role in determining the host's ability to resist parasite invasion and mount an effective immune response. Age-related differences in immune competence and physiological susceptibility can render certain poultry populations more vulnerable to parasitic diseases, particularly young or immune-compromised individuals. Furthermore, management practices, including housing conditions, sanitation protocols, and biosecurity measures, profoundly impact the risk of parasite exposure and transmission within poultry flocks [8].

## ENVIRONMENTAL FACTORS INFLUENCING SEASONAL DYNAMICS

Environmental factors play a crucial role in influencing the seasonal dynamics of poultry diseases. These factors encompass various elements of the environment, including temperature, humidity, precipitation, and other ecological parameters, which directly impact the survival, transmission, and prevalence of pathogens affecting poultry (Fig. 1) [9]. The various factors are explained;

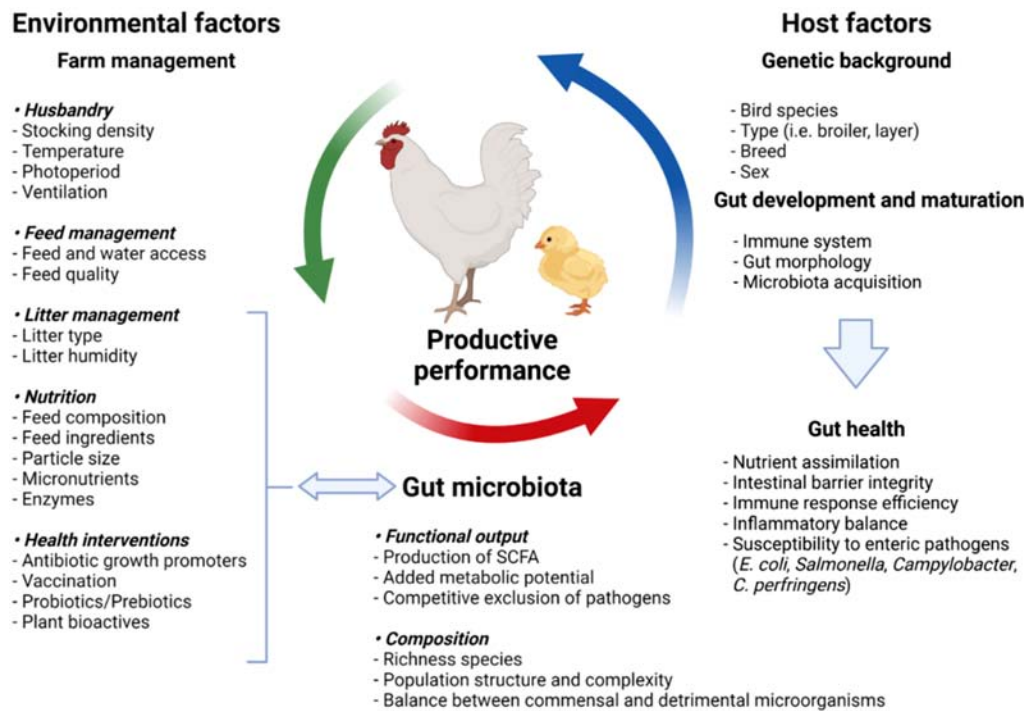


Fig. (1). Factors influencing parasite infection in poultry by Shehata *et al.* [15].

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**CHAPTER 3**

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**Principles of Parasitism in Parasitic Diseases**

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**Abstract:** “Principles of Parasitism in Parasitic Diseases of Poultry” discusses the fundamental aspects of parasitic diseases affecting poultry. It delves into the principles governing parasitism within this context, exploring the interactions between parasites and their avian hosts. The abstract highlights the significance of understanding these principles in the management and control of parasitic infections in poultry populations. By elucidating the mechanisms of parasite transmission, host-parasite interactions, and the impact of parasitic diseases on poultry health and productivity, the abstract underscores the importance of adopting comprehensive strategies for disease prevention and control. Furthermore, it emphasizes the role of integrated approaches involving parasite surveillance, biosecurity measures, and appropriate treatment protocols in mitigating the economic losses associated with parasitic infections in poultry farming. Overall, the abstract provides a concise overview of the central concepts and implications of parasitism in the context of poultry diseases, aiming to inform researchers, veterinarians, and poultry producers about the complexities of managing parasitic infections in avian populations.

**Keywords:** Biosecurity, Disease management, Host-parasite interactions, Parasitic diseases, Parasitism, Poultry.

## **INTRODUCTION**

Parasitic diseases pose significant challenges to poultry production worldwide, affecting bird health, welfare, and productivity [1]. The poultry industry has emerged as the primary provider of efficient and high-quality animal proteins on a global scale. Poultry meat and eggs offer numerous advantages over other sources of animal-based foods. Poultry meat stands out due to its favorable protein

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content, balanced amino acid profile, and rich supply of energy and micronutrients [2]. Moreover, when compared to mammalian meat, poultry meat, particularly when skinless, contains lower levels of fat, mainly attributed to the reduced presence of intramuscular fat in avian species, as highlighted [3]. Parasitism represents a type of ecological interaction wherein one organism, known as the parasite, derives benefits from utilizing resources obtained from another organism, referred to as the host. Over the course of evolution, species have coexisted alongside populations of parasites, which, along with various other ecological interactions, have played a role in regulating the sizes, population structures, and genetic compositions of these species. Parasites exert an influence on hosts akin to that of predators, competitors, and other natural adversaries. Indeed, the impact of a parasite on a host can extend to its response to competitors and mutualistic organisms, its reaction to environmental conditions, its overall health status, reproductive capabilities, resource acquisition abilities, and even its survival [4]. At the core of parasitism lies the intricate interaction between the parasite and its host. In essence, the crux of parasitism lies in the dynamics of the parasitic-host relationship, which constitutes a fundamental aspect of ecological studies examining the interplay between organisms and their surroundings. Yet, ecologically speaking, the relationship between parasite and host can be likened to a “double-edged sword”. This is because the ecology of the host organism can concurrently influence the life cycle of a parasite, with the host effectively serving as a habitat for the parasite. Numerous biotic and abiotic factors contribute to shaping the ecology of hosts, thereby exerting a corresponding impact on the parasites they harbor [5].

In ecological terms, interactions between hosts and parasites are characterized by the relative fitness, encompassing factors like survival and reproduction, of each participating organism. Typically, parasitic interactions confer benefits to the parasite while imposing detrimental fitness outcomes on the host. However, the degree to which hosts are adversely affected by parasites can vary widely, with certain host-parasite relationships exhibiting characteristics akin to commensalism, where one organism benefits without causing significant harm to the other. The extent of fitness costs incurred by hosts is also heavily influenced by environmental factors, whereby ideal ecological conditions may render parasites relatively benign to hosts, whereas exposure to stressors like extreme weather or food scarcity can lead to noticeable survival or reproductive costs for hosts [6]. Moreover, host-parasite interactions can be examined from a physiological standpoint, focusing on the molecular and cellular interplay occurring when parasites come into contact with host tissues. In some instances, these interactions directly lead to host pathology, or negative fitness consequences, through mechanisms such as parasite-induced tissue damage, exploitation of host resources, or suppression of host immune responses by the

parasite. Conversely, in other scenarios, the adverse fitness impacts of parasites on hosts predominantly stem from host-mediated responses to parasitism, such as immunopathology or alterations in host behavior that may impede reproductive success [7].

## **BIOLOGY OF POULTRY PARASITES**

Poultry parasites encompass a diverse array of organisms, including protozoa, helminths, arthropods, and other pathogens, that exploit birds as hosts to complete their life cycles. These parasites can affect various systems within the bird's body, including the gastrointestinal tract, respiratory system, integumentary system, and reproductive organs. Parasitic infections can lead to clinical signs such as diarrhea, weight loss, respiratory distress, decreased egg production, and increased mortality rates, posing significant challenges to poultry producers worldwide [8].

## **CLASSIFICATION OF POULTRY PARASITES**

Poultry parasites are classified into different taxonomic groups based on their evolutionary relationships, morphology, and life cycle characteristics. Protozoan parasites include species such as *Eimeria*, *Giardia*, and *Cryptosporidium*, which infect the gastrointestinal tract of poultry. Helminth parasites encompass nematodes (roundworms), cestodes (tapeworms), and trematodes (flukes), which can infect various organs and tissues in poultry. Arthropod parasites include mites, lice, fleas, and ticks, which infest the skin, feathers, and respiratory tract of birds [9].

## **MORPHOLOGY AND LIFE CYCLES OF COMMON POULTRY PARASITES**

Poultry parasites display a wide array of morphological adaptations that are tailored to their parasitic lifestyle. These adaptations enable them to effectively exploit their avian hosts and complete their life cycles [10].

### **Protozoan Parasites**

Protozoan parasites are single-celled organisms that can infect various tissues and organs of poultry. They exhibit complex life cycles that typically involve multiple developmental stages, each adapted to survive in different environmental conditions and host tissues. For example, the life cycle of *Eimeria spp.*, a common protozoan parasite in poultry, includes stages such as sporozoites, merozoites, gametocytes, and oocysts. Sporozoites are the infective stage of *Eimeria* parasites, released from sporulated oocysts upon ingestion by the host. These motile forms

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**CHAPTER 4**

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**Pathological Significance of Parasitic Diseases****P.N. Bashetti<sup>1</sup> and Debolina Dattaray<sup>2,\*</sup>**<sup>1</sup> *Division of Veterinary Pathology, IVRI, Izatnagar, Uttar Pradesh, India*<sup>2</sup> *Department of Veterinary Pharmacology and Toxicology, Institute of Veterinary Science and Animal Husbandry, Siksha 'O' Anusandhan University, Bhubaneswar, Odisha, India*

**Abstract:** Parasitic diseases in poultry pose substantial pathological and economic challenges, affecting both commercial and backyard flocks. This chapter comprehensively overviews the most common parasitic infections, including coccidiosis, nematodiasis, cestodiasis, and ectoparasitic infestations like mites and lice. It explores the pathological changes caused by these parasites, such as tissue damage, immunosuppression, reduced feed conversion, and impaired growth rates. Special attention is given to the interaction between parasites and the host's immune system, leading to secondary infections and exacerbating other health conditions. The chapter also discusses the economic losses associated with reduced egg production, increased mortality, and the cost of treatment and prevention. Current strategies for diagnosis, treatment, and control, as well as emerging trends in parasite management, are also addressed, emphasizing the need for integrated approaches to safeguard poultry health.

**Keywords:** Cestodes, Ectoparasite, Nematodes, Pathological significance, Protozoal infection.

**INTRODUCTION**

The poultry industry in India is growing tremendously. It is one of the fastest growing industries in the world. India ranks third in egg production and sixth in meat production in the world. Human protein needs can be fulfilled by both poultry eggs and meat so this industry contributes to both the economic status of the country as well as the nutritional status of the health. Nonetheless, the economics of poultry farming are frequently marred by outbreaks due to poor management practices, which resulted in various infectious diseases such as bacterial, viral, and parasitic diseases [1]. Among these, parasitic diseases are a major concern in poultry production worldwide. These diseases can significantly impact the health, productivity, and economic viability of the poultry industry.

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Parasites in poultry can be broadly categorized into ectoparasites and endoparasites. Again ectoparasites contain various types of fleas, mites, lice, and ticks. Endoparasites can be classified as nematodes, cestodes, and protozoa. Each type has unique challenges and various pathological consequences [2]. This chapter explores the pathological significance of various parasitic diseases in poultry, including their effects on the health and productivity of affected birds, as well as the economic implications for the poultry industry (Table 1).

**Table 1. Classification of different poultry parasites with their common names.**

| Class of Parasite                                                       | Scientific Name                   | Common Name            | Description                                                                                            |
|-------------------------------------------------------------------------|-----------------------------------|------------------------|--------------------------------------------------------------------------------------------------------|
| Ectoparasite:<br>A) Mites                                               | 1. <i>Dermanyssus gallinae</i>    | Red Mite               | Red in color when fed, mostly fed at night.                                                            |
|                                                                         | 2. <i>Ornithonyssus sylvarum</i>  | Northern Fowl Mite     | Causes irritation, blood loss, and decreased egg production.                                           |
|                                                                         | 3. <i>Ornithonyssus bursa</i>     | Tropical fowl mite     | Colonize the vent feathers, and feed on blood.                                                         |
|                                                                         | 4. <i>Cnemidocoptes mutans</i>    | Scaly leg mite         | Burrows under the scales of legs and feet, causing thickening and crusting.                            |
|                                                                         | 5. <i>Cnemidocoptes gallinae</i>  | Depluming mite         | Causing severe itching and feather plucking.                                                           |
| B) Lice                                                                 | 1. <i>Menacanthus stramineus</i>  | Chicken body louse     | Feeds on skin scales, feathers, and blood, leading to irritation and decreased productivity.           |
|                                                                         | 2. <i>Menopon gallinae</i>        | Shaft louse            | Lives on feathers causing feather damage and irritation.                                               |
| C) Fleas                                                                | 1. <i>Echidnophaga gallinacea</i> | Sticktight flea        | Attaches firmly to the skin, particularly around the eyes and comb, causing irritation and anemia.     |
| D) Ticks                                                                | 1. <i>Argas persicus</i>          | Fowl tick (blue bug)   | Feeds on blood at night and hides in cracks during the day, causing weakness and disease transmission. |
| Endoparasites which affect the Gastrointestinal portion<br>A) Nematodes | 1. <i>Ascaridia galli</i>         | Large roundworm        | Found in the small intestine, causing weight loss and intestinal blockage.                             |
|                                                                         | 2. <i>Heterakis gallinarum</i>    | Cecal worm             | Found in the ceca, can transmit <i>Histomonas meleagridis</i> (blackhead disease).                     |
|                                                                         | 3. <i>Capillaria spp.</i>         | Hairworm or threadworm | Affects the crop and intestine, leading to weight loss and diarrhea.                                   |
| B) Cestodes                                                             | 1. <i>Raillietina spp.</i>        | Tapeworm               | Causes weight loss, diarrhea, and intestinal damage.                                                   |
|                                                                         | 2. <i>Davainea proglottina</i>    | Tapeworm               | Causes nodular lesions in the intestine.                                                               |



(Table 1) cont.....

| Class of Parasite | Scientific Name                  | Common Name                | Description                                                                                                                                                                                                                  |
|-------------------|----------------------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C) Protozoa       | 1. <i>Eimeria</i> spp.           | Coccidia                   | Causes coccidiosis, characterized by diarrhea, weight loss, and sometimes death. Different species affect different parts of the intestine (e.g., <i>Eimeria tenella</i> in the ceca, <i>Eimeria maxima</i> in the mid-gut). |
|                   | 2. <i>Histomonas meleagridis</i> | Blackhead disease agent    | Causes blackhead disease, primarily affecting turkeys but can also affect chickens, leading to liver and cecal lesions.                                                                                                      |
|                   | 3. <i>Trichomonas gallinae</i>   | Avian trichomoniasis agent | Causes lesions in the upper digestive tract.                                                                                                                                                                                 |
| Other parasites   |                                  |                            |                                                                                                                                                                                                                              |
| Helminths         | <i>Syngamus trachea</i>          | Gapeworm                   | Resides in the trachea, causing respiratory distress and gaping in affected birds.                                                                                                                                           |

## PROTOZOAL INFECTION

There are three major groups of protozoa in the birds which include phylum Apicomplexa, phylum Parabasalia, and the less important Microspora group. The first phyla Apicomplexa (coccidia) are mostly intracellular parasites. In this group, the major parasites include *Eimeria*, *Isospora*, *Plasmodium*, and *Cryptosporidium*. Phylum Parabasalia has mostly flagellates and amoebas like *Histomonas*, *Entamoeba*, *Trypanosoma*, and *Cochlosoma*. The third group contains *Encephalitozoon cuniculi*, which has lesser importance in the poultry industry. The parasites that have shorter and more direct life cycles can affect modern and commercial poultry through diseases like coccidiosis. The only exception to this is the Blackhead Disease (histomoniasis) which spreads easily in turkeys despite having a complex lifecycle [3].

### ***EIMERIA* SPP.**

There are almost 1700 species of the genus *Eimeria*, which are monoxenous parasites that affect specific domestic mammals and birds. The *Eimeria* has seven species that infect the poultry industry, each having a different pathogenicity. All these *Eimeria* species have different invasion sites within the intestine. Along with this, they also produce different lesions and severity. *E. acervulina*, *E. maxima*, and *E. tenella* are responsible for having a major impact on gut health in both young and older birds. Whereas *E. mitis* and *E. praecox* cause subclinical coccidiosis, which leads to reduced broiler growth. *E. brunetti* and *E. necatrix* primarily affect long-living birds, such as laying-hens and breeders, causing

## CHAPTER 5

## Immuno-pathological Purview of Parasitic Infection

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**Abstract:** Parasitic infections pose a major challenge in poultry farming, affecting both the health and productivity of birds. Immunopathology plays a key role in determining the severity of these infections and the host's ability to resist them. The immunopathological processes in poultry parasitic infections involve a complex interplay between the host's immune response and the parasite's tactics to evade or alter immunity. Parasites stimulate immune responses, leading to the activation of immune cells, the release of cytokines, and the recruitment of inflammatory mediators to the infection site. However, if these responses become dysregulated, they can cause tissue damage, inflammation, and pathological changes in the affected organs. An overactive immune response can result in immunopathology marked by excessive inflammation and tissue damage. On the other hand, parasites may suppress the host's immune response, allowing them to survive and spread within the host.

**Keywords:** Disease management, Host-parasite interactions, Immune response, Parasitic infections, Poultry, Immunopathology.

### INTRODUCTION

Immunopathology refers to the study of abnormal immune responses that result in tissue damage, inflammation, and disease. Immunopathology represents a medical discipline concerned with immune responses linked to various diseases. Immunopathology encompasses a spectrum of pathological conditions arising from dysregulated or aberrant immune responses. These responses may be triggered by infectious agents, environmental factors, genetic predispositions, or autoimmune processes, leading to tissue damage, inflammation, and disease. Within biology, it denotes harm inflicted upon an organism due to its immune system's response, often occurring as a consequence of infection [1]. Parasitic infections present substantial challenges to poultry health and production globally,

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causing economic losses and raising welfare concerns. Understanding the immunopathology of these infections is crucial for developing effective control and management strategies. Poultry have a complex immune system, consisting of diverse organs, cells, and molecules that work together to protect against pathogens, including parasites. While their immune system shares core features with that of mammals, poultry also displays unique immune adaptations suited to their distinct physiological and ecological needs [1].

## **Mechanisms**

Immunopathological mechanisms involve a complex interaction among various immune system components, including immune cells like lymphocytes, macrophages, and neutrophils, along with signaling molecules such as cytokines, chemokines, and other inflammatory mediators. Together, these elements coordinate to generate immune responses against invading pathogens or foreign substances. When immune responses become dysregulated, however, this can lead to abnormal outcomes. Overactivation of the immune system may result in excessive inflammation and tissue damage, whereas immunodeficiency arises when the immune system cannot adequately respond to pathogens, leaving the host susceptible to infections. Autoimmunity, another consequence of immune dysregulation, occurs when the immune system mistakenly attacks the body's own cells and tissues, potentially leading to chronic inflammation and tissue damage. Hypersensitivity reactions, characterized by exaggerated immune responses to harmless substances, trigger inflammatory responses that can damage surrounding tissues. These reactions are classified into four types (Type I to Type IV) based on their immunological mechanisms [2].

## **INNATE IMMUNITY**

### **Poultry Innate Immune Mechanisms: The First Line of Defense**

In the complex fight between poultry and pathogens, innate immune mechanisms serve as the first line of defense, rapidly activating to combat invading microorganisms. This section explores the key components of the innate immune system in poultry, emphasizing their roles in detecting and eliminating pathogens [3, 4].

### **Physical Barriers**

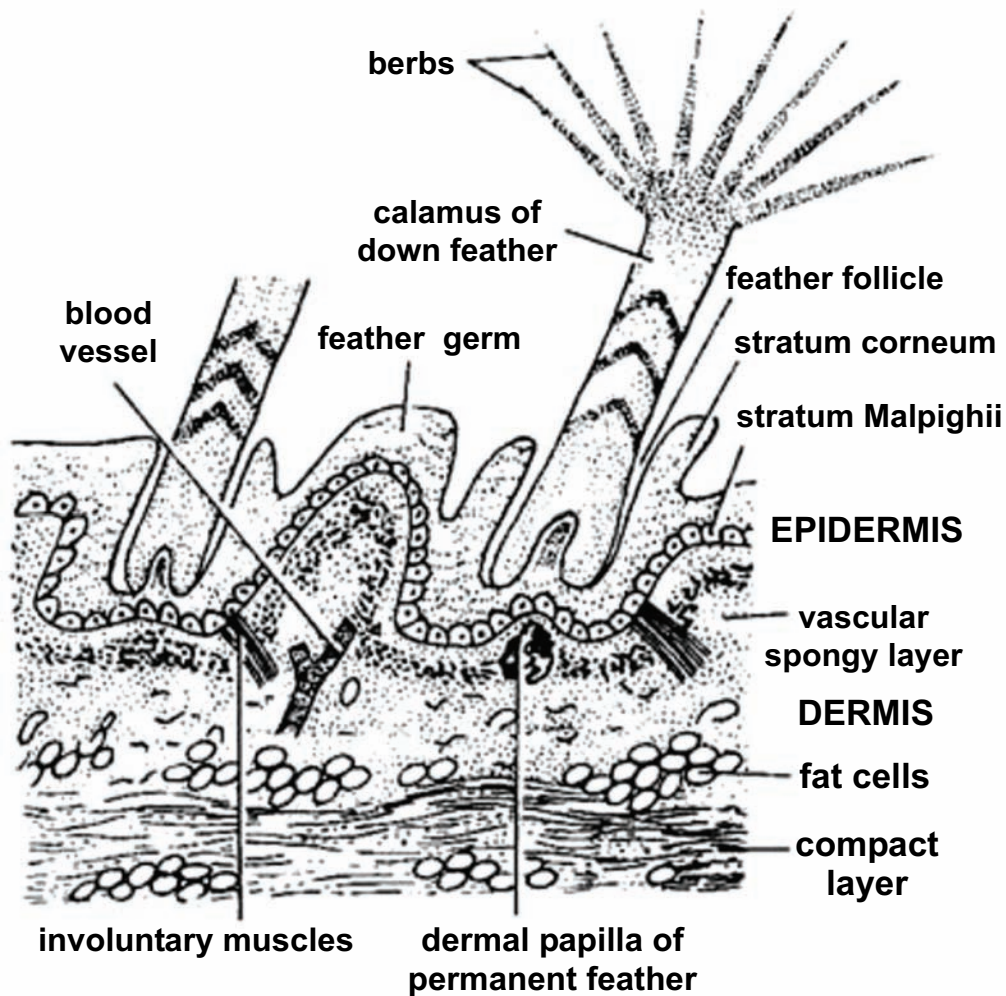
#### ***Skin***

The skin acts as the primary defense against external pathogens in poultry, forming a formidable barrier that prevents microbial invasion and protects the

body from infections.

### ***Structure of the Avian Skin***

The avian skin is a multifunctional organ composed of several layers, each with distinct structural and functional characteristics. The anatomy of the skin of the birds is crucial for appreciating its role as a physical barrier against pathogens (Fig. 1).



**Fig. (1).** Structure of the Avian skin.

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**CHAPTER 6**

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**Diagnostic Methods of Parasitic Diseases of Poultry**

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**Abstract:** The use of diagnostic methods for the diagnosis of parasitic diseases in poultry has been almost constant over the past few decades. Since the introduction of PCR, few major advances have been adopted in clinical diagnostic tests. Many diagnostic tests that form the backbone of the “modern” microbiology laboratories rely on very old and labour-intensive technologies such as microscopy for the diagnosis of parasites including helminths, protozoans, arthropods, and haemoprotozoans. Urgent needs include more rapid tests without compromising the sensitivity, value-added tests, and point-of-care tests for both high- and low-resource settings. In recent years, research has been focused on alternative methods to improve the diagnosis of parasitic diseases. These include molecular technique-based approaches, immunoassays and proteomics using mass spectrometry platforms technology. This chapter discusses the progress of several approaches in parasite diagnosis and some of their silent characteristics.

**Keywords:** ELISA, Microscopic examination, McMaster chamber, PCR, Poultry parasites.

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## INTRODUCTION

The poultry industry is one of the leading and fast-growing sectors that support protein nutrition globally. The consumption of chicken is becoming more popular across the world due to consumer perceptions of its health benefits, low price, ease of preparation, and lack of religious constraints [1 - 4]. Approximately, 90 million tons of broiler meat is produced annually from 21 billion broiler chicks worldwide, accounting for 89% of total meat production in the world. It has been predicted that the world's meat consumption will rise exponentially from 330 to 455 million tons annually by 2050 due to increased consumer demand for meat products and the accelerated growth of the world's human population (present 7.6 billion population predicted to reach 9.8 billion by 2050). Meanwhile, 40% of the increased demand will be covered by broiler chicken meat [5 - 7]. In addition to the production costs in the present and strategic future of the poultry industry, the health of birds is a vital factor that influences the growth and global competition of the poultry industry. Accordingly, infectious diseases brought on by a variety of pathogens, including bacteria, viruses, parasites, and fungus, either by themselves or in conjunction with other microorganisms, can have a detrimental impact on the productivity and well-being of the poultry sector, leading to a rise in mortality [6, 8]. Parasitic diseases are one of the proven factors that cause the most detrimental effects in poultry, causing high mortality, impaired growth, reduced feed efficacy, and anemia compared to other bacterial or viral diseases [9, 10]. Parasitic infections result in huge economic losses in terms of mechanical injuries, the effects of toxic compounds, nutritional deficiencies, and immunosuppression of the host [11]. The better housing management and hygiene and the prevalence of parasitic infection in poultry seem to have decreased significantly in indoor production systems as compared to deep litter/ free-range and backyard farming systems. However, parasitic infections are still a major concern in both commercial deep litter and free-range systems. These traditional systems of poultry rearing around the world are infected with several parasites, which contribute significantly to reduced productivity. The commonly reported parasites in poultry are *Eimeria* spp., *Ascaridia galli*, *Heterakis gallinarum*, *Raillietina* spp, *Echidnophaga gallinacea*, *Dermanyssus gallinae*, *Histomonas meleagridis*, *Plasmodium* sp., *Leucocytozoon* sp. and *Haemoproteus* sp. etc. An early and accurate diagnosis of the causative agents is a crucial step for the prevention and control of any diseases. This chapter discusses the different approaches to parasite diagnosis with its salient features (Table 1).

All the parasites of poultry are divided into three major groups with subgroups. These groups include Endoparasites, Ectoparasites, and Haemoparasites. A list of the most common pathogenic and economically important parasites that affect poultry is tabulated in the given Table 1, 2 & 3 [12]. For a comprehensive list of

poultry parasites please refer to the book *Helminths, arthropods and Protozoa of Domesticated Animals* by E.J.L. Soulsby [13] or other books as mentioned under the reference section (Tables 2 and 3).

**Table 1. Some important endoparasites of poultry.**

| Parasite                                 | Hosts                                                              | Site of Predilections                      |
|------------------------------------------|--------------------------------------------------------------------|--------------------------------------------|
| <b>Trematodes:</b>                       |                                                                    |                                            |
| <i>Prosthogonimus</i> spp.               | Fowls, ducks, geese                                                | Bursa fabricius, oviduct, cloaca, rectum   |
| <i>Echinostoma revolutum</i>             | Duck, geese                                                        | Caeca, rectum                              |
| <b>Cestodes:</b>                         |                                                                    |                                            |
|                                          | -                                                                  | -                                          |
| <i>Davainea proglottina</i>              | Fowls, pigeons                                                     | Small intestine                            |
| <i>Raillietina</i> spp.                  | Chicken, guinea fowl, turkey, pigeons                              | Small intestine                            |
| <i>Cotugnia</i> spp.                     | Fowls, duck                                                        | Small intestine                            |
| <i>Choanotaenia infundibulum</i>         | Fowls, turkeys                                                     | Small intestine                            |
| <i>Amoebotaenia sphenoides</i>           | Fowls                                                              | Small intestine                            |
| <i>Hymenolepis carioca</i>               | Fowls                                                              | Small intestine                            |
| <b>Nematodes:</b>                        |                                                                    |                                            |
|                                          | -                                                                  | -                                          |
| <i>Heterakis gallinarum</i>              | Chickens, guinea fowl, turkey, duck, goose, pea fowl               | Caeca                                      |
| <i>Ascaridia galli</i>                   | Chickens, guinea fowl, turkey, goose                               | Small intestine                            |
| <i>Subulura brumpti</i>                  | Chickens, turkey, guineafowl                                       | Caeca                                      |
| <i>Oxyuris mansoni</i>                   | Chickens, turkey, guineafowls, pea fowls                           | Nictitating membrane of eye, lacrimal duct |
| <i>Syngamus trachea</i>                  | Chickens, turkeys, guineafowls, pea fowls, geese, quails           | Trachea, lungs                             |
| <i>Dispharynx spiralis</i>               | Chickens, turkeys, pigeons, guinea fowl, pheasant                  | Wall of proventriculus and esophagus       |
| <i>Hartertia gallinarum</i>              | Fowl, wild bustards                                                | Small intestine                            |
| <i>Ornithostrongylus quardriradiatus</i> | Pigeon                                                             | Crop, proventriculus, and small intestine  |
| <i>Gongylonema ingluvicola</i>           | Chickens, turkey, quails, pheasant                                 | Crop                                       |
| <i>Cheilospirura (Acuaria) hamulosa</i>  | Chickens, turkey, guinea fowl, pheasant, grouse, quails            | Gizzard                                    |
| <i>Tetrameres americana</i>              | Chickens, turkey, duck, geese, guinea fowl, pigeon, grouse, quails | Proventriculus                             |
| <i>Capillaria</i> spp.                   | Chicken, turkey, guinea fowl, geese, quail, pigeon                 | Intestine                                  |

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**CHAPTER 7**

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# **Anthelmintic Drug Resistance and One Health Approach**

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**Abstract:** Anthelmintic resistance (AR) is a significant global concern in both human and veterinary medicine. Understanding the types of AR resistance is crucial for designing effective parasite control strategies to preserve the efficacy of available anthelmintics as well as to minimize the risk of resistance development. The development of anthelmintic resistance is an interdisciplinary process influenced by factors such as host, parasite, anthelmintic type, management practices, and environmental conditions. Diagnosis of AR is possible by both *in vivo* and *in vitro* methods and early detection of resistance allows for timely intervention strategies. The research and surveillance programs are important for its prevention and management. The promotion of good hygiene practices, education, and awareness can reduce the spread of AR. AR issue requires coordinated efforts at local, national, and international levels. Implementation of policies and regulations to control the use of anthelmintic drugs in both human and veterinary medicine is necessary by adopting the one health approach.

**Keywords:** Anthelmintic resistance, Livestock, One health, Stewardship.

## **INTRODUCTION**

Anthelmintics are crucial in managing parasitic infections in livestock. Liver flukes, lungworms and gastrointestinal nematodes are the helminths that parasitize livestock. These infections are among the most significant worldwide production-limiting illnesses and they have the potential to cause serious illness and decrease productivity in every category of animals [1].

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Anthelmintic drug resistance refers to the phenomenon where parasites, particularly helminths, develop reduced susceptibility or complete resistance to anthelmintic drugs used to treat or control them. The development of anthelmintic drug resistance is a significant concern in both human and veterinary medicine, as it can lead to treatment failure, decreased productivity, increased disease transmission, and economic losses in agriculture. Anthelmintic resistance (AR) has been reported in various animal species including livestock (cattle, sheep, goats, and pigs), horses, pets (dogs and cats) and wildlife. This resistance can occur in various types of parasites, including roundworms, lungworms and liver flukes and poses a significant challenge in the control and management of parasitic infections in animals. The most common parasites associated with anthelmintic resistance in veterinary medicine include *Haemonchus contortus* (barber's pole worm), *Trichostrongylus* spp., *Cooperia* spp. and *Ostertagia* spp.

### COMMON ANTHELMINTHICS

Three kinds of anthelmintics are most widely used among livestock.

**Benzimidazoles (BZs):** This class includes drugs like albendazole and fenbendazole. They act by disrupting the parasite's ability to maintain cellular integrity, leading to paralysis and death. Resistance to BZs has become widespread due to their long history of use and the development of resistance mechanisms by parasites [2].

**Macrocyclic lactones (MLs):** MLs such as ivermectin and doramectin exert their anthelmintic effects by interfering with nerve transmission in parasites, ultimately causing paralysis and death. While resistance to MLs was initially less common, it has been increasingly reported, particularly in gastrointestinal nematodes.

**Cholinergic agonists:** Levamisole acts by stimulating nicotinic acetylcholine receptors in the parasite, leading to paralysis and expulsion. Resistance to levamisole has also been documented, although it tends to be less prevalent compared to BZs and MLs.

### GLOBAL PREVALENCE

The development of anthelmintic resistance is a global phenomenon affecting various helminths across multiple animal species and affecting both developed and developing countries. The key points for the widespread nature of AR are diverse helminth species, multiple anthelmintic classes, diverse environments and management practices, wide animal range as host, and easy global distribution.

It has been reported in various regions and across different livestock production systems. The prevalence of anthelmintic resistance varies depending on factors such as the type of parasite, geographical location, drug usage patterns, and farming practices. Some regions, such as parts of Europe, Australia, and the Americas, have reported significant levels of anthelmintic resistance in livestock, particularly in sheep and cattle. Anthelmintic resistance is indeed a concern in Asia, particularly in countries where there's extensive use of anthelmintic drugs in agriculture and animal husbandry. While specific data on the prevalence of anthelmintic resistance in Asia may vary by country and region, there have been reports of resistance emerging in various livestock species, including cattle, sheep, and goats [3].

## **TYPES OF RESISTANCE**

Cross-resistance, side resistance and multiple resistance are three different types of anthelmintic resistance. These types of anthelmintic resistance underscore the complex interactions between parasites and anthelmintics, as well as the adaptability of parasites to develop resistance mechanisms. Understanding these types of resistance is crucial for designing effective parasite control strategies that minimize the risk of resistance development and preserve the efficacy of available anthelmintics.

**Cross Resistance:** In cross-resistance, a parasite strain develops tolerance to therapeutic doses of anthelmintics that are chemically unrelated or have different mechanisms of action. This means that resistance to one type of anthelmintic confers resistance to others, even if they belong to different classes. For example, a parasite strain resistant to benzimidazoles may also exhibit resistance to macrocyclic lactones or cholinergic agonists. Cross-resistance highlights the ability of parasites to develop broad resistance mechanisms that affect multiple drug classes.

**Side Resistance:** Side resistance occurs when resistance to one anthelmintic is conferred by the selection pressure exerted by another anthelmintic having an analogous mode of functioning. In other words, exposure to one anthelmintic results in the emergence of resistance to another anthelmintic with a comparable mode of action. An example of side resistance is seen among benzimidazole anthelmintics, where strains resistant to one benzimidazole may also show resistance to another benzimidazole due to shared mechanisms of action.

**Multiple Resistance:** Multiple resistance refers to the development of resistance to two or more anthelmintics, either belonging to the same class or different classes, due to independent selection pressures or side resistance mechanisms. This type of resistance represents a significant challenge in parasite control

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**CHAPTER 8**

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**Vaccines and Vaccination of Parasitic Diseases**

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**Abstract:** The poultry industry is one of the largest sources of meat and eggs for human consumption throughout the globe. For this, vaccination is needed due to the complexity of parasites and their life cycles. In addition, viral outbreaks in farmed stock are a very common occurrence and also a major source of concern for the industry. Mortality as well as morbidity in the flock during an outbreak can cause economic losses with a subsequent detrimental impact on the global food chain. Mass vaccination program is one of the main strategies to control viral infection in poultry. It can reduce husbandry costs. The vaccination protocol is essential to counteract emerging and re-emerging viral infectious diseases in poultry. Potential antigens for recombinant vaccines have also been incorporated for the viral infection. The book chapter describes viral vaccines and vaccination regimens available for common poultry viral infections.

**Keywords:** Poultry diseases, Production, Vaccine, Vaccination.

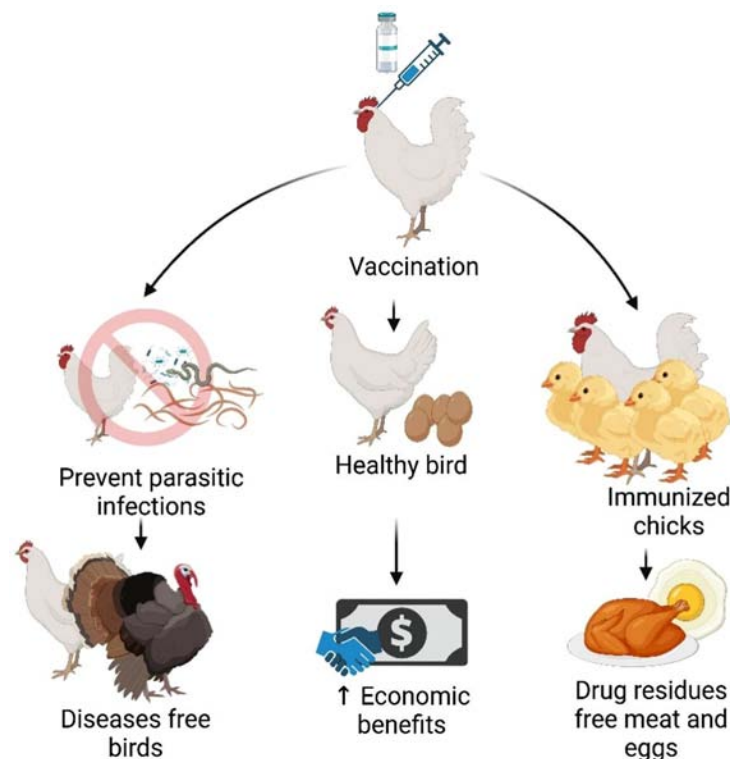
## **INTRODUCTION**

The production of meat and eggs from poultry farming is a crucial source of protein, making it a fundamental component of the global food business. The sector does, however, confront a number of difficulties, one of which is the risk of parasitic infections [1]. In chicken production, parasites are a major problem since they can cause lower output, higher mortality rates, and large financial losses. Numerous parasites, including helminths, ectoparasites, and protozoa, are responsible for these illnesses; each poses distinct difficulties for prevention and management [2]. Numerous types of protozoan parasites have the potential to

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spread disease, making them a serious threat to poultry farms. *Eimeria*, the protozoan parasite that causes coccidiosis, is one of the most prevalent infections that affect poultry. A serious illness called coccidiosis can cause severe intestinal damage or even death in certain situations. The chicken industry makes extensive use of coccidiosis vaccines that have been produced. Usually administered as live attenuated or subunit vaccines, these shots offer defense against certain *Eimeria* species [3]. *Histomonas meleagridis*, another significant protozoan parasite, is the causative agent of histomoniasis, also referred to as blackhead sickness. In poultry, particularly in turkeys, histomoniasis can be a fatal condition with significant fatality rates. It is possible to prevent chickens from the disease histomoniasis by administering vaccines against it. Usually, these vaccinations are whole-cell vaccines that are killed or attenuated from live viruses to protect against *H. meleagridis*. Another protozoan disease that can afflict poultry is cryptosporidiosis. It is caused by *Cryptosporidium* spp. and affected birds may have diarrhea and weight loss. Research is currently concentrating on identifying appropriate antigens for vaccine development, as the development of vaccines against cryptosporidiosis is still in its early phases (Fig. 1) [4].



**Fig. (1).** Beneficial effects of vaccination in poultry.

Similarly, helminthic parasites, such as cestodes, nematodes, and trematodes, can severely increase the morbidity and mortality rate in chickens. In poultry, *Ascaridia galli* is the common helminth that causes ascaridiosis. Ascaridiosis vaccines have been developed and are used to protect poultry from the parasites. Usually, the recombinant antigens used in these vaccinations offer defense against *A. galli*. *Heterakis gallinarum* is the source of heteroakiasis, another significant helminthic infection in poultry. Heterakiasis vaccines have been developed and are used to protect birds from this parasite. Usually, the recombinant antigens used in these vaccines offer protection against *H. gallinarum* (Pleidrup *et al.*, [4]). Similarly, ectoparasites like fleas, lice, and mites are common in chickens and can lead to decreased egg production, skin irritation, and feather damage. *Dermanyssus gallinae*-caused mite infestations are a major problem in chicken husbandry. *D. gallinae* vaccines have been created and are used to keep poultry safe from this ectoparasite. Usually, recombinant antigens used in these vaccinations offer defense against *D. gallinae*. In chicken production, lice infestations brought on by *Menacanthus* and *Goniocotes* species are also a problem. In order to protect against these ectoparasites, recombinant antigens are demonstrating potential as a vaccine against lice infestations [5].

## TYPES OF POULTRY VACCINES

Vaccination is a vital part of managing flock health and preventing disease in poultry. Poultry are protected against a variety of bacterial, viral, and parasite infections using a variety of vaccines. These vaccinations are carefully chosen according to the particular needs of the poultry operation, the type of disease, and the age of the birds. Developing vaccination programs that effectively protect the health and welfare of chicken flocks requires an understanding of the various vaccine types and how they work [6]. In the poultry enterprise, live attenuated vaccines are a commonly used vaccine type. The disease-causing organism is present in these vaccinations in weaker forms that can replicate within the host but do not cause diseases. A robust immunological response is triggered by this vaccine, which results in the formation of lifelong immunity. Live attenuated vaccines can be administered to flocks of chickens in large quantities since they can be given orally. The Marek's disease vaccine, which offers protection against the highly contagious viral disease that can cause tumors and neurological abnormalities in chickens, is one of the most often used live attenuated vaccines in poultry [7]. Another significant vaccination utilized in poultry is inactivated vaccines, sometimes referred to as killed vaccines. The microorganisms in these vaccines have been rendered inactive or killed by radiation, heat, or chemicals. Since inactivated vaccines can not reproduce within the host, it usually takes more than one dosage to elicit a protective immune response. These vaccinations, which are used to prevent infections, including avian influenza and infectious bursal

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**CHAPTER 9**

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**Therapeutics, Prevention, and Control of Parasitic Diseases**

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**Abstract:** Poultry disease prevention and control are more important in maintaining flock health than the therapy of the disease. Poultry products are a major global protein source, with commercial poultry production especially showing steady expansion over the last decade. The poultry business faces substantial managerial, nutritional, and disease constraints as a result of the high number of parasite infections and infestations, which cause a variety of diseases and significantly reduce chicken productivity and growth. Poultry parasites encompass helminths, protozoa, ectoparasites, and haemoparasites. Several of these parasites are recognized as highly pathogenic leading to substantial production losses and mortality in poultry. Parasitic illnesses spread from poultry to poultry, from human/ intermediate host to poultry, or *vice versa* via contact or ingestion of infective larvae or oocysts in polluted water, soil, and food or through chicken products. Parasites live inside or outside their hosts and consume host nourishment and blood, reducing productivity and resulting in financial losses owing to control, treatment, and mortality costs. Parasitic diseases can limit and restrict the economic benefits of poultry farming. Endemic parasites are a major cause of economic loss in animal husbandry, particularly in tropical regions and underdeveloped countries. Parasitic disease controls are the husbandry practices utilized by the individuals involved in poultry farms that prevent diseases of poultry. This chapter will be helpful and valuable to veterinarians and other poultry personnel to refresh and update their knowledge on parasite infection prevention and control.

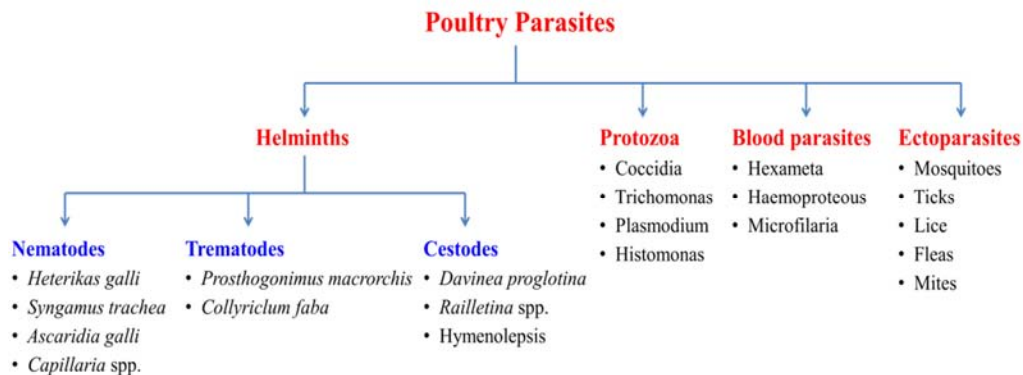
**Keywords:** Blood parasites, Coccidia, Control, Deworming, Ectoparasites, Flies, General principles, Helminths, Parasitic control, Parasitic disease, Poultry, Prevention.

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## INTRODUCTION

Poultry encompasses domestic birds raised for human consumption *i.e.* eggs and meat, comprising chickens, pigeons, turkeys, geese, ostriches, ducks, guinea fowl, and doves. Poultry parasites range from single-celled protozoans that develop either intracellularly or extracellularly to multicellular helminths (nematodes, trematodes, and cestodes), blood parasites, and ectoparasites as depicted in Fig. (1). Mostly seen parasitic infestation in poultry includes nematodes, cestodes, and coccidia, which can lead to significant harm and economic losses within the industry. Parasitic infestations result in malnutrition, reduced weight loss, feed conversion ratios, egg production, and fatalities among birds [1, 2]. Moreover, parasitic infections reduce the ability of the flock to fight against diseases and worsen existing health conditions [3, 4]. Parasitic life cycles may be direct or complex indirect cycles requiring various arthropod or animal hosts. Some species of parasites can infect nearly every organ system, although individual genera will affect specific organs or tissues (Fig. 1) [5].



**Fig. (1).** Common poultry parasites.

Poultry diseases like coccidiosis and helminth infections lead to economic losses due to bird deaths, lower body weight, and increased expenses for prevention and treatment. These issues are common in modern poultry farming, especially in confined spaces [6, 7]. Parasitic infections can interfere with bird metabolism, causing poor feed use, slow growth, and delayed maturity. When multiple parasites affect birds, especially those in the gut, they increase the risk of chick deaths and reduce productivity in adults [8]. Treating these infections strategically with anthelmintics can help poultry owners minimize losses and boost productivity in backyard farming setups [4]. There are many parasites causing infections and infestation in poultry in various farms and different rearing systems.

## CONTROL AND PREVENTION OF POULTRY PARASITES

In commercial indoor production systems, the extent of parasitism is largely influenced by management practices. For instance, the adoption of total enclosure principles, enhancements in cleaning and disinfection procedures, and the implementation of production based on the “all in- all out” principle seem to have diminished the significance of parasitism. The ban on battery cages in several countries has led to the emergence of new intensive free-range systems. However, preventing parasitic infections in these systems has proven challenging. The utilization of outdoor areas, where parasite eggs can endure in the environment for extended periods, has heightened the risk of infections [7].

### GENERAL PRINCIPLES OF PARASITIC CONTROL

The main goal of a parasite control strategy is to minimize parasitic challenges in young birds, preventing symptoms and reducing production losses. Complete eradication of most parasites is uncertain due to the large number of eggs released, their environmental persistence, and transmission *via* feces. Before starting a control program, it is crucial to understand the parasitic infections in the population, including species present, prevalence, and transmission patterns, which may vary by region. If this knowledge is limited, an investigation should be conducted first before starting any control program.

Backyard poultry can host all parasite species, but commercial free-range systems often eliminate parasites requiring intermediate hosts. Most helminths with indirect life cycles are nearly eradicated, except *Raillietina* spp., transmitted by flies as production shifts from backyard to commercial systems, parasites with direct life cycles, such as *Ascaridia*, *Heterakis*, *Capillaria*, and *Eimeria* spp. tend to decrease. The best way to control poultry parasites is by improving flock management and hygiene. This can eliminate some parasites and reduce others to acceptable levels. Complete eradication through routine treatment is impossible, so control programs typically combine management improvements with antiparasitic drugs.

### Density of Birds

Maintaining an appropriate density of birds in any poultry production system is crucial. The density of birds (stocking rate) is crucial in any poultry production system. Excessive stocking can cause birds to come into closer contact with feces, increasing the risk of ingesting more infective parasitic eggs.



## Fluke Parasites in Poultry

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**Abstract:** Although rarely in commercial settings, flea infections in poultry present serious health hazards in backyard and free-range habitats, particularly among warmer, wetter areas. The three main fluke species that plague poultry are investigated in this chapter: *Collyriclum faba* (subcutaneous cysts), *Philophthalmus gralli* (eye fluke) and *Prosthogonimus macrorchis* (oviduct fluke). Insects and snails are the intermediate hosts that these parasites need. Clinical symptoms include cysts, decreased egg production, weight loss, and eye problems. Since adult flukes are usually seen at lesion sites, diagnosing fluke infections is difficult since eggs are not always present in feces. Since few and frequently poor treatment options exist, such as praziquantel and fenbendazole, preventive efforts concentrate on environmental control to avoid intermediate hosts. Keeping chickens in areas free of flukes is essential for their well-being and output.

**Keywords:** Diseases, Fluke, Infection, Infestation, Poultry parasites.

### INTRODUCTION

Over the past few decades, there has been a significant increase in the number of widely and intensively housed chickens due to the growing demand for poultry products for human consumption [1, 2]. While rare in commercial poultry operations, fluke diseases pose a serious health issue in backyard and free-range environments, especially in warmer, wetter regions. The fluke life cycle, which needs intermediate hosts like snails and insects like mayflies and dragonflies, is aided by these habitats. Poultry raised in backyards and on farms have a higher chance of coming into touch with these hosts, which increases the risk of

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infection. In the fields of veterinary medicine and poultry farming, parasites and parasitic illnesses pose a serious threat. These illnesses not only harm the well-being and output of chickens but also provide significant financial difficulties for the sector. It is essential to comprehend the biology, life cycles, and epidemiology of these parasites to develop management and control plans that are effective. A variety of parasite illnesses can affect poultry, which includes chickens, turkeys, ducks, and other birds kept for meat, eggs, or breeding. It is known that poultry can contract oviduct flukes from over 24 species across two genera. Three species have been identified in chickens: *Prosthogonimus ovatus*, *P. macrorchis*, and *P. pellucidus* [3].

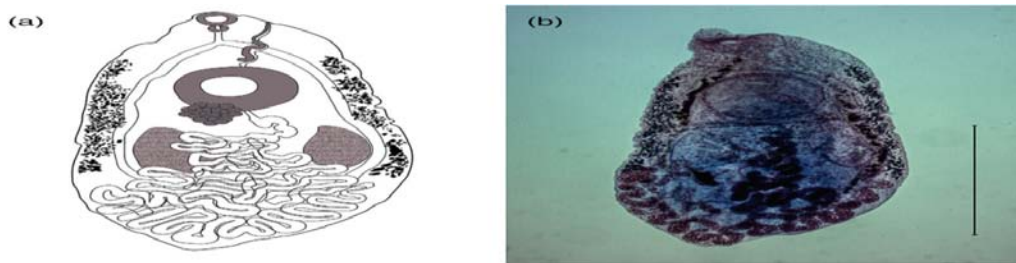
*Collyriclum faba*, *Philophthalmus gralli*, and *Prosthogonimus macrorchis* are the three primary fluke species that infect poultry. The oviduct fluke, *Prosthogonimus macrorchis*, is especially dangerous since it can seriously impair a bird's ability to reproduce. The symptoms of infection in birds include cloacal discharge, decreased egg production, and weight loss. These flukes can induce lesions that range in severity from minor oviduct rupture to severe inflammation. Conversely, birds who have *Philophthalmus gralli* in their eyes may go blind as a result of this infection. This impairs the bird's capacity to forage and makes it more vulnerable to environmental dangers and predators [4].

Subcutaneous cysts caused by *Collyriclum faba* have the potential to cause subsequent bacterial infections. These cysts, which are frequently located close to the vent, can make heavily afflicted birds unable to move and unappetizing.

Reducing poultry contact with intermediate hosts is key to preventing fluke infections. This can be accomplished by preventing chickens from entering regions with water and places where aquatic insects and snails are common. However, there aren't many choices for treatment after the infection has set in. Although some medications, such as fenbendazole and praziquantel, have had some effectiveness, there are currently no approved medicines that are consistently beneficial for use in poultry. Furthermore, a number of parasite illnesses are zoonotic, which means that humans may contract them from chickens and hence be in danger to public health. This book chapter explores the several parasites that impact poultry, looking at their life cycles, means of transmission, symptoms, and techniques for diagnosis. Additionally, it examines new and existing methods for treating, managing, and preventing parasite infections in chickens (poultry), while highlighting the significance of integrated management practices. Poultry producers, veterinarians and researchers can improve poultry health and productivity by safeguarding poultry chicks against parasite illnesses by thoroughly comprehending these factors [5].

## TYPES OF FLUKE PARASITES IN POULTRY

In poultry farming, parasitic infections are a serious problem that has a big impact on the health and welfare of the birds as well as the operations' ability to make money. *Prosthogonimus* is a genus of trematodes belonging to the family *Prosthogonimidae* and includes several species. These flatworms infect the bursa Fabricius, the oviduct, and the posterior intestine of various poultry and wild bird species, including chicken, ducks, geese, and other birds. The genus *Prosthogonimus* is widespread and has been reported in many regions worldwide, including Africa, Asia, Europe, North and South America [6]. The prevalence of helminth infections can be influenced by many factors such as the climatic conditions and agro-ecological zones, the accumulation of infective stages of larvae or eggs in the environment, the presence of intermediate hosts, and the individual susceptibility of the final host [7]. These illnesses, which can result in significant financial losses and jeopardize the safety and quality of chicken products, are brought on by a diverse range of endoparasites (such as nematodes, cestodes, trematodes, and protozoa) and ectoparasites (such as mites, lice, and fleas) (Fig 1) [8].



**Fig. (1).** *Prosthogonimus cuneatus* was recovered in *Erithacus rubecula*. They were drawn with Adobe Illustrator 2020 (a) and coloured with Semichon's carmine (b) Bar: 1000  $\mu$ m [6].

### *Prosthogonimus macrorchis*

*Prosthogonimus macrorchis*, commonly known as the oviduct fluke, primarily infects poultry through the ingestion of metacercariae found in dragonflies, which serve as the secondary host. This fluke localizes in the oviduct of birds, causing significant reproductive issues. Symptoms of infection include inappetence, droopiness, weight loss, and decreased egg production, often leading to an increase in the number of soft-shelled eggs. Severe cases can result in lesions ranging from mild inflammation to oviduct distention or rupture, potentially leading to the bird's death. Due to the specific nature of its lifecycle, involving both snail and dragonfly hosts, controlling the environment to limit bird exposure to these intermediates is crucial for prevention (Figs. 2 and 3).

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CHAPTER 11

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## Round Worm Infection

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**Abstract:** Diseases caused by nematode infestations pose a significant challenge to poultry production, impacting economic viability and overall bird health. Over 50 nematode species, including large roundworms (*Ascaris* sp.), small roundworms (*Capillaria* sp.), and cecal worms (*Heterakis gallinarum*), inflict pathological harm on poultry, waterfowl, and wild birds. The resulting economic losses include malnutrition, reduced feed conversion, weight loss, diminished egg production, and increased mortality in young birds. Concurrent infestations with multiple gastrointestinal-preferring parasites contribute to early chick mortality and productivity losses in adult birds. Nematode infestations extend beyond direct losses, increasing susceptibility to other diseases and worsening existing health conditions. Efficient and prompt diagnosis is crucial for controlling parasitic infections. Diagnosis methods include fecal sample analysis through flotation techniques, necropsy examination, ELISA technique, and a loop-mediated isothermal amplification assay with lateral flow dipstick for visual detection of parasitic eggs. The preferred drug for treating roundworms is piperazine, though recent medications like albendazole and levamisole have shown high success rates. Flubendazole, pyrantel tartrate, and ivermectin are also effective treatments. Poultry commonly harbors six species of *Capillaria* sp., necessitating specific diagnosis and treatment approaches. Preventive measures include rigorous cleanliness, optimal ventilation, moisture control, and avoiding overcrowding. Regular deworming, age-specific bird separation, and litter replacement are essential for controlling parasitic infections. The use of insecticides to eliminate intermediate hosts is discouraged due to environmental concerns. A comprehensive and proactive approach is vital for sustaining the health and productivity of poultry in the face of nematode challenges.

**Keywords:** *Ascaridia galli*, *Capillaria*, *Heterakis gallinarum*, *Oxyuris mansoni*, Poultry Nematodes, Roundworms, *Subulura brumpti*, *Syngamus trachea*, *Tetrameres* sp.

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## INTRODUCTION

The disease poses a significant challenge to poultry production, with nematodes emerging as the predominant and crucial helminth species affecting poultry, waterfowl, and wild birds. There are over 50 identified nematode species impacting poultry, including large roundworms (*Ascaris* sp. or ascarids), small roundworms (*Capillaria* sp. or capillary/threadworms), and cecal worms (*Heterakis gallinarum*). These nematodes, particularly the majority among them, inflict pathological harm on the host, resulting in substantial economic losses for the poultry industry. The damage caused includes malnutrition, reduced feed conversion ratio, weight loss, diminished egg production, and mortality in young birds [1]. Additionally, parasitic infestations can increase the susceptibility of poultry to other diseases and worsen existing health conditions [2, 3].

Concurrent infestations with multiple parasites, especially those with a gastrointestinal preference, play a significant role in early chick mortality and contribute to productivity losses in adult birds [4]. The overall impact of nematode infestations extends beyond direct losses, affecting the overall health and productivity of poultry in the industry. Nematodes, belonging to the phylum Nematelminthes and the class Nematoda, are parasitic worms affecting poultry. These worms are unsegmented and typically display a cylindrical and elongated shape. The cuticle of nematodes may exhibit various features such as circular annulations, smooth surfaces, longitudinal striations, or ornamentations like cuticular plaques or spines. All nematodes possess an alimentary tract, and they exhibit separate sexes. The life cycle of these worms can be either direct or indirect, involving an intermediate host [5]. Furthermore, mechanical transmission by earthworms or cockroaches is noteworthy [6]. It is important to emphasize that there is no development of the larval stage within these carriers (Table 1).

**Table 1. Common roundworms of poultry.**

| Roundworm                     | Definitive host                                                  | Intermediate host  | Site of predilection |
|-------------------------------|------------------------------------------------------------------|--------------------|----------------------|
| <i>Capillaria annulata</i>    | Fowl, turkey                                                     | earthworms         | Esophagus and crop   |
| <i>Capillaria caudinflata</i> | Fowl, pigeons, wild birds                                        | earthworms         | Duodenum and Ileum   |
| <i>Capillaria. obsignata</i>  | Chickens, turkeys, partridges, pigeons, guinea fowl, and quail   | Direct             | Small intestine      |
| <i>Capillaria anatis</i>      | Fowl, anatine birds                                              | Direct             | Caeca                |
| <i>Ascaridiagalli</i>         | Fowl, guinea fowl, turkey, goose, wild birds                     | Direct             | Small intestine      |
| <i>Subulura brumpti</i>       | Chickens, turkeys, guineafowls, ducks, pheasants, grouse, quails | Beetles, cockroach | Caeca                |

(Table 1) cont....

| Roundworm                     | Definitive host                            | Intermediate host         | Site of predilection                           |
|-------------------------------|--------------------------------------------|---------------------------|------------------------------------------------|
| <i>Oxyspirura mansoni</i>     | Fowl, turkey                               | cockroaches               | Eye (nictitating membrane)                     |
| <i>Syngamus trachea</i>       | Chickens, pheasants, turkeys, and peacocks | Direct                    | trachea and lungs                              |
| <i>Tetrameres americana</i>   | Fowl, Turkey, duck, pigeon                 | Grasshoppers, cockroaches | Proventriculus                                 |
| <i>Heterakis gallinarum</i>   | Chickens, Turkey, duck, game birds         | Direct                    | Caeca                                          |
| <i>Cheilospirura hamulosa</i> | Goose, chickens, turkeys                   | Beetles, grasshoppers     | Gizzard                                        |
| <i>Dispharynx spiralis</i>    | Turkeys, pigeon, guinea fowl, pheasants    | Beetles, grasshoppers     | Proventriculus and Oesophagus                  |
| <i>Amidostomum</i>            | Waterfowl, wild geese, ducks, parakeets.   | Direct                    | Gizzard sometimes proventriculus and esophagus |

***Ascaridia galli*****Order:** Ascaridida**Super family:** Ascaridoidea**Family:** Ascarididae**Genus:** *Ascaridia*

*Ascaridia galli*, the roundworm species, is highly prevalent and pathogenic, particularly in domestic fowl such as *Gallus domesticus*. This species is known for its widespread occurrence and significant impact on domestic poultry [7]. It can also infest other species of poultry, including turkeys, geese, and wild birds. The parasitic nature of *Ascaridia galli* makes it a notable concern in various poultry populations, causing potential harm and health issues in affected birds (Fig. 1).

The largest nematode, *Ascaridia galli* is a semitransparent, creamy-white, cylindrical-bodied nematode. At its anterior end lies a distinctive mouth surrounded by three prominent tri-lobed lips, with the dorsal lip wider than the subventral ones. The lip edges are furnished with teeth-like denticles (Fig. 2) [8]. The entire body is enveloped in a robust proteinaceous cuticle, exhibiting transverse striations and featuring a pair of faintly developed cuticular alae. Notably, two conspicuous papillae are present on the dorsal lip, and each subventral lip hosts one. The esophagus lacks a posterior bulb, and these papillae

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CHAPTER 12

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## Tapeworm (Taeniasis) Infection

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**Abstract:** The chapter “Tapeworm (Taeniasis) Infection” highlights the critical role of poultry farming, encompassing species such as chickens, turkeys, swans, and quails, in providing essential protein and economic benefits globally. However, tapeworms present a significant threat to poultry health, especially in free-range systems. These parasites have complex life cycles involving intermediate hosts like earthworms and beetles and can infect the intestines of poultry, disrupting nutrient absorption and reducing feed conversion efficiency. Common tapeworm species affecting poultry include *Raillietina*, *Davainea proglottina*, *Amoebotaenia cuneata*, *Choanotaenia infundibulum*, *Hymenolepis cantaniana*, and *Hymenolepis carioca*. Infected birds experience impaired nutrient absorption, slower growth rates, and increased production costs, alongside heightened susceptibility to other diseases. Effective management requires precise identification of tapeworm species, control of intermediate host populations, and strict biosecurity measures. Understanding the life cycles of these parasites and implementing targeted interventions are crucial for mitigating their impact on poultry health and productivity. Key strategies include reducing intermediate host populations, preventing poultry from ingesting these hosts, maintaining hygiene, managing waste, and using insecticides. A comprehensive understanding of tapeworm life cycles is vital for developing effective treatments and improving the overall health and productivity of poultry flocks.

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**Keywords:** *Amoebotaenia cuneata*, Chicken, *Choanotaenia infundibulum*, Duck, *Davainea proglottina*, Diagnosis, Epidemiology, Geese, *Hymenolepis cantaniana*, *Hymenolepis carioca*, Life cycle, *Raillietina* spp, Turkey.

## INTRODUCTION

In the diverse and vibrant world of poultry, a variety of bird species can be found, from chickens and turkeys to swans and quails. These birds are integral to both backyard settings and commercial production systems globally. Poultry not only provides a rich source of protein through its meat and eggs but also serves as a means of generating income. Additionally, the organic manure produced by poultry is highly fertile, making it valuable in agriculture [1]. Endoparasites, particularly tapeworms, pose a significant threat to poultry production, especially in free-range or backyard systems. The presence of these parasites can lead to substantial economic losses by reducing the efficiency with which chickens convert their feed into energy, delaying their growth and development, and increasing medication and production costs [2].

## TAPEWORMS: LIFE CYCLE AND IMPACT

Tapeworms have a complex life cycle involving various intermediate hosts such as earthworms, snails, slugs, beetles, ants, and houseflies, depending on the species. These parasites infiltrate the intestines of chickens, depleting vital nutrients and disrupting nutrient absorption. This parasitic invasion leads to a decrease in feed conversion efficiency, requiring more feed to produce the same amount of meat or eggs [3]. Infected birds often face delayed growth and development, resulting in lower market value and decreased turnover rates. Additionally, the presence of tapeworms necessitates increased medication and production costs, further burdening poultry farmers. Heavy parasitic infections can also diminish the chickens' resistance to other infections, compounding the health issues within the flock [4].

## COMMON TAPEWORM SPECIES IN POULTRY

Tapeworms are responsible for causing cestodiasis in both domestic and wild birds worldwide, with over 1400 species identified. Some common species that infect the small intestine of chickens include:

- *Raillietina echinobothrida*
- *Raillietina tetragona*
- *Raillietina cesticillus*
- *Davainea proglottina*
- *Choanotaenia infundibulum*



- *Amoebotaenia cuneata*
- *Hymenolepis cantaniana*
- *Hymenolepis carioca*

## ANATOMY AND IDENTIFICATION

Tapeworms are elongated, segmented, and ribbon-like, typically white in appearance. The front part of a tapeworm called the scolex or head, is equipped with four suckers that help it attach to the lining of the small intestine. These suckers are primarily attachment organs and do not consume food. Tapeworms lack a mouth or alimentary canal and absorb nutrients through their body wall, known as the cuticle [3].

The scolex may feature a specialized organ called the rostellum, resembling an anchor, which aids in securing the tapeworm to the intestinal mucosa. This rostellum may have hooks that further assist in anchoring. The neck, located just behind the scolex, is the growth region from which the rest of the tapeworm's body, known as the strobila, develops. The strobila comprises many segments or proglottids, categorized into immature, mature, and gravid based on their proximity to the head and neck [5].

Gravid proglottids contain reproductive organs that have degenerated, leaving behind only a uterus filled with eggs. These eggs consist of an oncosphere, a striated shell, and a delicate membrane. Tapeworms are hermaphroditic, with each proglottid containing both male and female reproductive organs, allowing for both cross-fertilization and self-fertilization [4].

## DIAGNOSIS AND CONTROL

Precise identification of tapeworm species is crucial for developing effective prevention and control strategies, as different species can vary significantly in their pathogenicity. Diagnosticians often rely on examining the scolex, eggs, or individual proglottids of recently shed, live specimens. Differential staining can reveal internal organs of mature proglottids, aiding in species identification [5].

In poultry, tapeworms are more frequently found in warmer seasons when intermediate hosts are abundant. Many species of tapeworms are now considered rare in intensive poultry-rearing regions due to the lack of contact with intermediate hosts. However, beetles and houseflies inhabiting poultry houses can still act as intermediate hosts for some large chicken tapeworms, such as *Raillietina cesticillus* and *Choanotaenia infundibulum* [3].

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**CHAPTER 13**

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**Protozoan Parasitic Infection**

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**Abstract:** Poultry has protozoa that are classified into multiple taxonomic groupings. In poultry, two types of parasites are significant: the coccidia and the mastigophora (flagellates). Some parasites, which cause coccidiosis, have short, direct life cycles and are therefore preferred, while other parasites that involve intermediate hosts typically do not pose a threat to commercial poultry. A significant exception is blackhead disease (histomoniasis), which has a complex life cycle involving intermediate hosts, but relies on chickens as reservoir hosts and spreads easily among turkeys within a flock. Most coccidia found in poultry belong to the genus *Eimeria*, however, there are also some species of *Isospora* and *Cryptosporidium*. The most well-known are the *Eimeria*, of which seven significant species have been identified in chickens and several more in turkeys. Anywhere chickens are raised, whether in huge commercial operations or tiny backyard flocks, parasites are an issue that can result in severe financial losses. This chapter will provide a quick overview of the main poultry protozoan parasitic species, along with some pathophysiology.

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**Keywords:** *Ascaridia galli*, *Capillaria*, *Coccidia*, *Cryptosporidium*, *Haemoprotozoa*, *Heterakis gallinarum*, *Oxyspirura mansoni*, *Poultry Nematodes*, *Poultry parasites*, *Protozoa*, *Round worms*, *Subulura brumpti*, *Syngamus trachea*, *Tetrameres* sp.

## INTRODUCTION

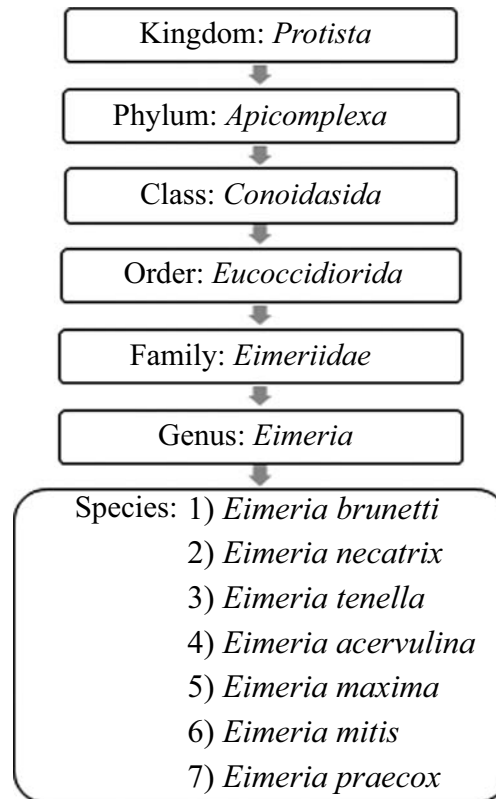
Protozoan parasites of poultry usually inhabit the lumen of the intestinal tract, present within the cells of many tissues or extracellularly in their blood and other body fluids. Some protozoa are host-specific, while others can infect a wide range of poultry species. Sometimes protozoa, which are relatively non-pathogenic may cause severe clinical disease in birds that are stressed or immune-compromised or have co-morbidities. Protozoan parasites that infect poultry come from various taxonomic groups, with many belonging to the phylum Apicomplexa [1 - 4]. This group includes intracellular protozoa distinguished by the presence of an apical complex during the sporozoite stage. The genera in this group include *Eimeria*, *Tyzzeria*, *Wenyonella*, *Plasmodium*, *Haemoproteus*, *Leucocytozoon*, *Toxoplasma*, *Sarcocystis*, and *Cryptosporidium*. Flagellates such as *Trypanosoma*, *Histomonas*, *Chilomastix*, *Spirotrichus*, *Cochlosoma*, and amoebas from the genera *Entamoeba* and *Endolimax* also infect poultry. The microsporidian, *Encephalitozoon cuniculi* has recently been found in chickens [2 - 5].

## POULTRY COCCIDIOSIS

Poultry coccidiosis is caused by apicomplexan protozoa from three genera: *Eimeria*, *Tyzzeria* and *Wenyonella*. It affects virtually all domestic and wild birds, causing enteric disease, which is marked by symptoms such as pallor, diarrhoea (with or without blood), poor feed conversion, weight loss, and occasionally mortality [7 - 10]. Coccidiosis mainly caused by various *Eimeria* spp., is the most significant parasitic disease in the global poultry industry, leading to substantial economic losses due to the costs associated with preventing and controlling both sub-clinical and clinical disease [11 - 13]. Coccidiosis alone represents 30% of total expenditures on pharmacological control for all potential poultry diseases [14 - 18]. The disease typically affects immunologically naïve birds or those that are stressed or overcrowded, leading to severe infections. In general, clinical parasitic disease is less of a concern in backyard poultry compared to commercially raised birds for two reasons: 1) Parasite replication is self-limiting due to a fixed number of asexual cycles, and 2) Hosts develop protective immunity following infection [19 - 22].

### Etiology and Life Cycle

Poultry coccidiosis is a parasitic disease caused by protozoa from the phylum Apicomplexa, specifically the genus *Eimeria*. These are obligate intracellular protozoan parasites that infect and replicate within the intestinal epithelial cells of birds. In domestic chicken (*Gallus gallus domesticus*), although nine species of *Eimeria* have been identified, only seven are widely accepted (Fig. 1). The species responsible for hemorrhagic disease are *E. brunetti*, *E. necatrix*, and *E. tenella*. *E. acervulina*, *E. maxima*, *E. mitis*, and *E. praecox* are considered mildly pathogenic and are associated with malabsorptive disease [22]. Concurrent infections with two or more species of *Eimeria* are common. However, each species develops in a specific site of the small intestine (upper, middle, lower, rectum, and caeca) and leads to distinct, recognizable diseases that are independent of the other species of *Eimeria* infecting that poultry species.



**Fig. (1).** Taxonomy of *Eimeria* spp. in chickens (Adapted from Conway and McKenzie [18]).

Naïve chickens of all ages and breeds are vulnerable to infection. However, immunity develops after mild infections, which helps limit future infections.

## Ectoparasites: Tick Infestation

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**Abstract:** Most of the domesticated birds are susceptible to a wide range of ectoparasites like flies, fleas, lice, ticks, and mites. Ectoparasites besides causing direct injuries with skin-associated lesions, irritation, and anemia act as vectors with a significant impact on the transmission of a variety of pathogens. Among ectoparasites, ticks are notorious vectors and second in line next to mosquitoes and they belong to the suborder Ixodida within the order Parasitiformes. This suborder comprises three families: hard ticks (Ixodidae), soft ticks (Argasidae), and the monotypic family Nuttalliellidae; while the family Argasidae encompasses 198 species of “soft ticks” (without scutum). *Argas persicus* popularly known as ‘fowl tick’ parasitizes domestic poultry, including chickens, ducks, and geese, and is found throughout the dry climatic zones of the world. Heavy tick infestation may lead to anemia and eventually death. Additionally, they play a role in transmitting various parasitic, bacterial, and viral diseases including leucocytozoonosis, aegyptianellosis, pasteurellosis, avian encephalomyelitis, fowl spirochaetosis, and fowl cholera.

**Keywords:** *Argas persicus*, Fowl spirochaetosis, Fowl tick, Hard ticks, Soft ticks, Tick paralysis, Tick toxicosis, Ticks.

### INTRODUCTION

Among the blood-sucking arthropods, ticks are of major public health concern as being vectors for numerous pathogens [1]. The first documented case of cattle fever (caused by *Babesia bigemina*) transmitted through the vector *Rhipicephalus microplus*, marked the beginning of a new era in the discovery of the role of ticks in transmitting some of the life-threatening diseases. Ticks are second in line next to mosquitoes in the transmission of a variety of pathogenic organism viz.,

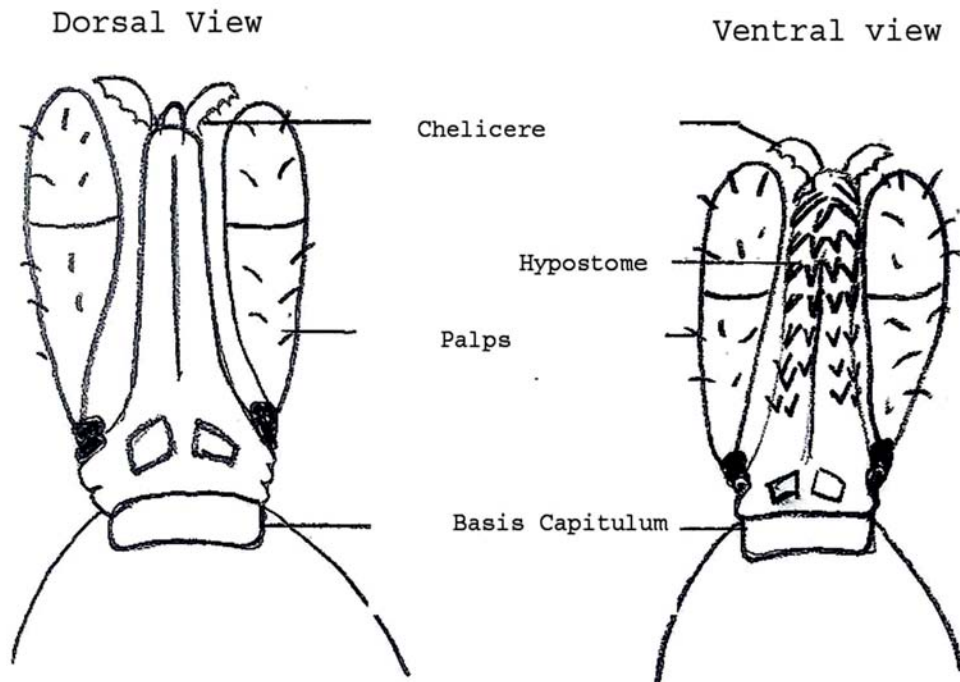
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bacteria, viruses, rickettsia, and protozoa to humans, animals, and birds. In addition to their vector potentiality, ticks are important as pests causing tick paralysis, toxicosis, irritation, bite allergies, immune responses, and economic losses due to blood loss. Additionally, they can cause serious illnesses in the host by injecting proteins (Lipocalins) along with their saliva. Meanwhile, the major economic detriment to the poultry industry is ancillary effects by ectoparasite infestations with ticks, lice, and mites [1]. Heavy tick infestation may lead to anemia and eventually death. Additionally, they are known to transmit diseases such as leucocytozoonosis, Aegyptianellosis, avian encephalomyelitis, fowl cholera, and paralysis in different domestic birds [2].

*In toto*, ticks are obligate blood-sucking arthropods and nearly 850 species are known worldwide. The suborder Ixodida comprises three families: Ixodidae, Argasidae, and the monotypic family Nuttalliellidae. The family Ixodidae comprises “hard ticks,” which have a protective scutum on their dorsal side. This family contains 14 genera, with *Ixodes* being the largest tick genus, estimated to include around 200 species followed by *Haemophysalis* (155 species); *Amblyomma* (102 species); *Rhipicephalus* (75 species); *Dermacentor* (30 species); *Hyalomma* (30 species) and *Boophilus* (5 species). However, the family Argasidae encompasses 198 species of “soft ticks” (without scutum) distributed among five genera of significance. Of these, the genus: *Ornithodoros* comprises 101 species followed by *Argas* (61 species); *Antricola* (10 species); *Otobius* (2 species), and the monospecific genus *Nothoaspis*. *Argas persicus*, first recorded by Lorenz Oken in 1818 in Mianeh, Persia initially named the parasite *Rhynchoprion persicum* which predominantly parasitizes domestic fowl such as chickens, ducks, and geese.

## GENERAL MORPHOLOGY OF TICKS

Typically body comprises the *capitulum* (Gnathosoma) and *idiosoma*. Gnathosoma has a basic capitulum on which the rostrum is lodged. The rostrum comprises four segmented paired palps, two segmented paired chelicera, and a hypostome with recurved teeth (Fig. 1). The chelicerae cut through host tissues thus facilitating the attachment. The body without mouthparts *viz.*, idiosoma is further divided into two regions: the anterior part, which contains the legs and the genital pore, is termed the podosoma, while the posterior section is called the opisthosoma. In hard ticks belonging to the family Ixodidae, mouth parts are visible dorsally and are typically characterized by the presence of a chitinous shield or plate called ‘Scutum’. However, in the family Argasidae scutum is absent hence the name soft ticks and capitulum/mouthparts are not visible dorsally due to hood-like expansion. In the soft ticks, the body is leathery and mamillated [3].



**Fig. (1).** Line diagram of gnathosoma or capitulum of ticks with dorsal and ventral views (image source: Dr. V. Gnani Charitha).

The legs are articulated with the body and consist of six segments: the coxa, trochanter, femur, patella (genu), tibia, and tarsus. Variations in the structure and arrangement of the first coxa help to distinguish several genera. Further, studying the first coxa contributes to the knowledge of tick biology, ecology, and taxonomy, which is essential for controlling tick-borne diseases and understanding their role in ecosystems. Tick larvae are easily identified by the presence of only three pairs of legs, while nymphs and adults possessing four pairs of legs. A pair of claws and a pad-like pulvillus are present on each tarsus of most hard tick species and it is absent in argasid nymphs and adults. The differences between hard ticks and soft ticks are represented in Table 1.

The internal organs of a tick are bathed in a colorless fluid known as hemolymph. A simple heart located mid-dorsally, filters and circulates this vital body fluid. Ticks respire through paired spiracles that connect internally to the ramified tracheal system. The digestive system facilitates the complete expansion of the midgut when filled with blood. Mouthparts are internally connected to a pair of salivary glands that resemble a bund of grapes. Tick saliva contains a complex mixture of biologically active compounds that serve various functions during the

## Ectoparasites: Fleas Infestation

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**Abstract:** The most overlooked ectoparasites in the Siphonaptera order are poultry fleas. An estimated USD 2.8 billion is lost economically each year in America alone as a result of flea infestations in various animal species. These are ectoparasites with hopping legs that have been laterally flattened. The main reason fleas bother their hosts is because they itch, which prompts the host to attempt to get rid of the pest by biting, pecking, or scratching. At the location of each bite, a slightly elevated, swollen, and itchy nodule with a single puncture point in the center, resembling a mosquito bite, forms on the epidermis. This can result in flea allergic dermatitis, an eczematous, itchy skin condition that affects numerous host species, including poultry. The bites might itch and become inflamed for a few weeks after they occur, and they frequently occur in groups or rows of two bites. In severe circumstances, they might also result in anemia. The fully mature flea has a thin and flat body that enables it to fit through the feathers of its host. It is usually brown in color and grows to a length of 3 millimeters (1/8 inch). The wings are absent and their posterior legs are mainly adapted for jumping. Their claws keep them immobile, while their mouthparts are intended for piercing flesh and drawing blood. The present chapter discusses the different fleas of poultry life cycle and control measures.

**Keywords:** *Ceratophyllus*, *Echidnophaga*, Ectoparasite, Flea, Poultry, Siphonaptera.

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## **INTRODUCTION**

The flea is a special pest of poultry, as well as other birds and mammals. In case of poultry, these fleas are seen in groups around the comb, eyes, wattles, and other exposed areas. On the basis of external morphology, they have their heads embedded in the host's body and cannot be removed by any object. In the poultry industry, chickens are known as naturally resilient and generally free from diseases [1 - 4]. Once the birds are attacked by fleas, they become inactive, which decreases production in poultry farms. Fleas are categorized as the class Insecta, order Siphonaptera, which is derived from the Greek word Siphon apteron, which means the sucking wingless insects. There are so many species present on earth, most of them are present in mammals and few are found in poultry [5 - 7]. These are temporary parasites that are wingless, laterally compressed bodies and have three pairs of legs. They have three pairs of legs; the third pair is designed for jumping on and off of its host. Resilin, a rubber-like elastic protein found on the body, aids in the flea's ability to leap from one location to another. A flea can jump up to 18 cm vertically and 33 cm horizontally [8 - 10].

## **MORPHOLOGY**

The flea's head and thorax area have numerous protruding spines known as combs or ctenidia. Genal combs, which are also known as genal ctenidium, are found on the head region, whereas pronotal combs, which are also known as pronotal ctenidium, are found on the posterior boundary of the first thoracic segment. These unique features both facilitate quick passage through the host's hairs and prevent detachment from the host hairs. Additionally, fleas have a large number of robust setae that shield them from the impacts of host grooming [12 - 14]. The sexes, male and female, are found apart, and when feeding, the maxillary laciniae pierce and cut the host's skin. The elongated epipharynx enters the blood vessel. The laciniae release saliva, yet this saliva does not enter the blood vessel. Only adults have sucking mouth parts. Mouthparts form short proboscis and are modified for piercing and sucking the body fluids of their hosts. The abdomen has ten segments [15, 16]. The ninth abdominal segment of both sexes has a dorsal sensory plate on its tergum, which is called sensillum or pygidium covered with sensory setae like that of a pin cushion. The function of this body part is still unknown. In males, the tergum of the ninth segment is modified to form the claspers that hold the female during copulation. The chitinous penis, which is also known as aedeagus, projects between the claspers and the sternum of the ninth segment.

## LIFE CYCLE

Once the female has finished her blood meal, she lays her eggs on the host's body. The female flea generally lays about 3 to 18 eggs at a time and usually, between two and six months, up to twenty eggs can be laid at a time; however, occasionally, hundreds of eggs can be laid; most of which fall to the ground a few hours after drying. The eggs are oval about 5 mm long, white and glistening, and rounded at the ends [18 - 20]. The egg hatches in a few days, but it could take up to three weeks depending on the environmental conditions. Both temperature and humidity affect the hatching phenomenon. The larvae may hatch in 2-16 days after laying of the eggs. The young larvae are active, without legs, yellowish-white, elongate, slender, maggot-like, and hiding from light [21 - 24]. Larvae consist of three thoracic and ten abdominal segments, each of which bears a few long hairs. The last abdominal segment bear two hooked processes called the anal struts, which are used for holding on the substrate or for locomotion. The head is more strongly chitinised than the rest of the body. It bears two short antennae; each of which consists of two segments.

Mouth parts of larvae are masticatory types with a pair of mandibles, a pair of first maxillae, and a labium formed by the second pair of maxillae. The larvae eat little food like organic matter, dry blood, and parts of faeces [25]. The fully developed larvae need moderate moisture. About seven to ten days or sometimes more in unfavorable conditions, the larvae grow and molt two times and become opaque white. Now it converts into mature maggots and the size becomes about 6 mm long. After a few days, it becomes quiescent and spins a whitish cocoon of about 4 mm x 2 mm inside which it pupates [26]. The cocoon is loosely spun and the free pupa can be seen inside it very easily. The pupal stage runs for a variable period from ten days to about one year as per condition which is present externally. In favorable conditions, the whole life cycle takes place in about 20 days. Once an adult flea develops, it may survive for a very long time without food. They use scents to find the right host, and light, shadow, and temperature cues help them find it. They are able to harbor both the bubonic plague and the tapeworm cysticercoids stage of the disease [27].

There are several genera of flea that infect poultry as well as mammals which are as follows: *Echidnophaga gallinacea* (Fig. 1); *Ceratophyllus gallinae* (Fig. 2); *Ceratophyllus garei* (Fig. 3); *Ceratophyllus niger* (western chicken flea) found in poultry. *Ctenocephalides felis* (cat flea); *Ctenocephalides canis* (dog flea); *Hoplopsyllus anomalus*; *Pulex simulans*; *Xenopsylla cheopis* (rat flea); *Diamanus montanus*; *Nosopsyllus fasciatus* and *Tunga penetrans* are found in mammals. The simple connection between the nesting habitat and many Ceratophyllidae groups is exemplified by the adults' frequent movement between hosts and nests and their

## Ectoparasites: Mites Infestation

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**Abstract:** External parasites, particularly mites belonging to families such as Dermanyssidae, Macronyssidae, and Trombiculidae, pose a significant threat to poultry production worldwide. These pests, including the poultry red mite (PRM), northern fowl mite, tropical fowl mite, and turkey chigger, not only compromise the health and welfare of poultry but also lead to substantial economic losses in the industry. Understanding the biology, behavior, and effective control measures of these parasites is crucial for sustaining the productivity and profitability of poultry operations. The life cycle of poultry mites comprises five stages: larva, egg, protonymph, deutonymph, and adult, each presenting unique challenges for management. Repeated mite bites can cause hens to lose more than 3% of their blood resulting in sub-acute anemia. Additionally, *Dermanyssus gallinae*, besides causing direct injury, serves as a vector for various bacterial and viral diseases affecting birds. Chemical control strategies for mites involve the use of pesticides and essential oils, with careful consideration given to minimizing non-target effects and preventing resistance. Biological control methods utilizing entomo-pathogens like fungi and nematodes, as well as natural enemies such as *Androlaelaps casalis*, show promise but require further research for practical implementation in poultry houses.

**Keywords:** External parasites, Mites, Poultry, Production.

### INTRODUCTION

External parasites pose a significant threat to poultry production worldwide, especially mites from families such as *Dermanyssidae*, *Macronyssidae*, and *Trombiculidae* are among the most impacting economically. Mites are commonly spread to chickens from wild birds, as all types of birds can suffer from mites [1]. These parasites, including the poultry red mite, northern fowl mite, tropical fowl mite, and turkey chigger, not only affect the health and welfare of poultry but also

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inflict substantial financial losses on the industry. Understanding the biology, behavior, and control measures of these pests is crucial for maintaining the productivity and profitability of poultry operations (Table 1).

**Table 1. Name of the parasites and their host.**

| Name                            | Common name                       | Hosts                                                |
|---------------------------------|-----------------------------------|------------------------------------------------------|
| <i>Dermanyssus gallinae</i>     | Poultry Red Mite, Roost mite.     | Chickens, pigeons, turkeys, ducks and other birds.   |
| <i>Ornithonyssus sylviarum</i>  | The northern fowl mite (NFM).     | Fowl, turkey, and other birds.                       |
| <i>Ornithonyssus bursa</i>      | Tropical fowl mite.               | Chicken, sparrows, pigeons, turkey, and other birds. |
| <i>Cnemidocoptes gallinae</i>   | Depluming itch mite.              | Chickens, pigeons, parrots and pheasants.            |
| <i>Cnemidocoptes mutans</i>     | Scaly leg mite.                   | Chickens, turkeys, pheasants, and other birds.       |
| <i>Cnemidocoptes pilae</i>      | Scaly face mite.                  | Budgerigars, and other psittacine species.           |
| <i>Trombicula alfreddugesi</i>  | Common chigger, and Harvest mite. | Animals, birds, and humans.                          |
| <i>Neoschongastia americana</i> | Turkey chiggers.                  | Majorly turkey and other birds.                      |
| <i>Laminosioptes cysticola</i>  | Fowl cyst mite.                   | Chickens, turkeys, and pigeons.                      |

### ***Dermanyssus gallinae***

Kingdom: Animalia

Phylum: Arthropoda

Subphylum: Chelicerata

Class: Arachnida

Order: Acarina

Sub Order: Mesostigmata

Family: Dermanyssidae

Genus: *Dermanyssus*

**Synonyms:** Poultry Red Mite, Roost mite.

**Hosts:** Chickens, pigeons, turkeys, ducks, and other domestic and wild birds. Sometimes on humans.

**Morphology:** Adult *D. gallinae*, an obligatory hematophagous ectoparasite measuring 0.75–1 mm in length, often have greyish-white bodies that turn reddish-brown when they are engorged. They have segmented and flattened bodies, with eight well-organized legs. Their dorsal shield is truncated at the back margin and taper towards the back. The setae on the dorsal shield are smaller than those on the skin around the dorsal plate. The anus is on the posterior half of the anal plate. In both sexes, the anal plate has three pairs of setae [2]. Modified piercing-sucking mouthpart aids in the penetration of the host skin and makes blood intake easier.

**Predilection site:** Due to its nocturnal behaviour, *D. gallinae* is present on the host at night only and can be located anywhere on the skin. The mites hide throughout the day in a variety of inconspicuous places, including cardboard boxes, crevices, cracks, beneath cribs and roosts, and walls and floors. Using thigmokinesis, they usually group with larval stages in the middle, females outside, and males on top [3].

**Life Cycle:** The five life stages of this species are larva, egg, protonymph, deutonymph, and adult. During the 14 mins-1 hour mating process, which takes place off the host, the male transfers sperm in a specific sack. Females are reproductive for three weeks, and males can mate up to four times in four days [4].

Following mating, females lay 4-8 eggs per day while fasting for three days in between batches. After the third, fourth, and fifth blood meal, the majority of eggs are generated. The ideal temperature range for egg laying is between 20 and 25 °C with 70% humidity. Eggs remain viable but do not hatch at 5 °C; at 45 °C, they rapidly become dehydrated.

After 13-51 hours, eggs become larvae, which molt into protonymphs after a 24 hour fast. Before developing into deutonymphs, protonymphs consume blood; they then require another blood meal to mature into adults. The life cycle can last anywhere from 5.5 to 17 days, depending on the temperature, and the sex ratio is equal.

**Pathogenesis and Clinical Signs:** Every night, a hen that has been bitten by a mite multiple times may lose more than 3% of her blood volume leading to sub-acute anemia. Hens may potentially die from acute anemia in extreme circumstances of large infestations. In addition to causing direct injury, *Dermanyssus gallinae* acts as a vector for a number of bacterial and viral diseases that affect birds. These include *Salmonella gallinarum* and *S. enteritidis*, *Pasteurella multocida*, *Escherichia coli*, *Borrelia anserine*, *Equine encephalomyelitis viruses*, *Newcastle disease virus*, and *avian influenza A virus*.

## Ectoparasites: Lice Infestation

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**Abstract:** Avian lice, which belong to the order Phthiraptera, are permanent ectoparasites infesting a wide range of domesticated birds. The chewing lice/bird lice (Amblycera & Ischenocera) are wingless, flat-bodied insects characterized by biting and chewing mouthparts. They primarily feed on the skin, feathers, hair, or scales of their host animals, but sometimes they feed on blood, particularly in the Amblycera species. Lice undergo incomplete metamorphosis with the egg stage followed by three nymph instars, and the entire life cycle can take as little as 2 to 3 weeks, allowing populations to grow quickly if left untreated. Lice are primarily transmitted through close contact between hosts, such as grooming or shared bedding. Bird lice are highly host-specific and inhabit highly specialized host sites. *Menacanthus stramineus*, the chicken body louse, is considered as the most economically significant parasite of poultry farming. Less frequent infestations occur with the shaft louse (*Menopon gallinae*), the wing louse (*Lipeurus caponis*), the head louse (*Cuculotogaster heterographus*), the fluff louse (*Goniocotes gallinae*), the large chicken louse (*Goniodes gigas*), and the brown chicken louse (*Goniodes dissimilis*). Lousiness in infected birds often exhibits poor growth, weight loss, and reduced feed efficiency as their energy is diverted toward coping with the irritation and stress from lice. Bite wounds cause significant skin irritation, leading to scabs, sores, and inflammation that are further complicated by secondary infections. Chewing lice, particularly *Trinoton anserinum* act as an intermediate host for the filarial heartworm *Sarconema eurycerca* that parasitized waterfowls/ swans. Further, louse-borne diseases like fowl cholera and fowl spirochetes prevailed in flocks with heavy lice infestations. This overall view highlights the need for proper control of lice infection with the majority being still relied on chemical pesticides.

**Keywords:** Amblycera, Bird lice, Chewing lice, Control, Disease transmission, Hemimetabolous, Ischenocera.

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## INTRODUCTION

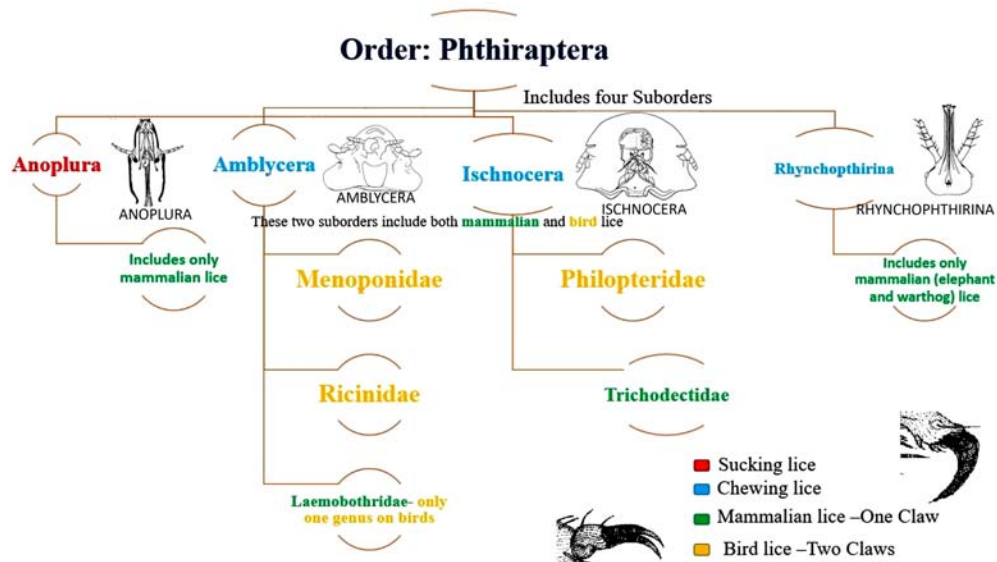
Domestic and wild birds are susceptible to various ectoparasites such as flies, fleas, lice, bugs, ticks, and mites. Based on the duration of existence on the host, external parasites are classified as either temporary or permanent. Temporary ectoparasites (flies, bugs, and ticks) only engage with their host during feeding or breeding periods. Conversely, permanent parasites (lice and mites) remain on their host throughout their lifecycle. Lice belong to the Phylum Arthropoda, Class Insecta, and Order Phthiraptera. Bird lice are a group of permanent ectoparasites that have remained under-focused for many years. To date, around 5,000 described species of lice have been documented parasitizing both mammals and birds. Of these more than 70% inhabited bird hosts, reflecting the close evolutionary relationship between birds and their lice [1]. In earlier classifications, lice were divided into two separate orders: Anoplura (In Greek: ‘anoplos’-unarmed; ‘ura’-tail) and Mallophaga (Greek: “Mallos” - lock of wool; Phagus-eating). This distinction has been revised, and all lice are now grouped under the single-order Phthiraptera with four suborders 1. Anoplura (sucking lice); 2. Amblycera; 3. Ischnocera, and 4. Rhynchophthirina (the latter three are popularly grouped as chewing lice or biting lice) [2]. Sucking lice (Suborder: Anoplura), exclusively inhabit mammals, feeding on their blood. These small, wingless insects possess retractable mouthparts adapted for piercing and sucking. Furthermore, the Rhynchophthirina includes lice that parasitize elephants and warthogs. Avian lice, which constitute the primary focus of the present study, fall under two suborders: Amblycera and Ischnocera.

Ectoparasites present a significant health risk and constitute major obstacles in poultry production worldwide. They prompt significant negative impacts on a bird's health, welfare, and productivity. Additionally, biting lice generally takes a toll on skin health, inducing intense itching, pruritus, and abrasions or wounds. Localized alopecia with hair or feather loss, especially around the vent, breast, and neck of the birds, is quite visible. Amblyceran lice target the quills of feathers, causing extensive feather damage, while the Ischenoceran members chew the feathers, causing partial damage. Moreover, they serve as mechanical or biological vectors, transmitting numerous pathogens [3]. However, they often receive less attention compared to endoparasites and infectious diseases. The substantial economic impact of these parasites warrants a comprehensive study that encompasses accurate disease information.

## CLASSIFICATION

Recent molecular phylogenetic analyses reveal that both sucking lice (Anoplura) and chewing lice (Mallophaga) are thought to have evolved from a common, free-

living ancestor within the Psocoptera (booklice and bark lice). However, few authors now acknowledge the order Psocodea, encompassing both parasitic lice and book/bark lice. Over time, as lice became more specialized for life on specific hosts, two distinct groups emerged (Anoplura and Mallophaga). This distinction has been again revised, and all lice are now grouped under the single order Phthiraptera with four suborders 1. Anoplura (sucking lice); 2. Amblycera; 3. Ischnocera, and 4. Rhynchophthirina (the latter three are popularly grouped as chewing lice or biting lice) (Fig. 1). Price *et al.* [4] identified thousand-odd species of chewing lice that primarily parasitize the birds (87.6%). *Amblycera Suborder* has six families (Boopidae; Gyropidae; Laemobothriidae; Menoponidae; Ricinidae and Trimenoponidae) [5].



**Fig. (1).** Classification of bird lice under the order: Phthiraptera (Source for Head and mouthparts Anoplura from, Ferris; 1931 Amblycera from, Bedford; 1932 Ischnocera from, Clay; 1938 Rhynchophthirina from Ferris, 1931).

*Ischnocera Suborder:* It comprises permanent, obligate ectoparasites with a cosmopolitan distribution with two main families (Trichodectidae and Philopteridae).

*Rhynchophthirina Suborder:* Only three known species are documented within the genus *Haematomyzus* (Family *Haematomyzidae*), which parasitize large mammals.



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