

Avian Coccidiosis: A Major Parasitic Disease of Poultry Industry

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How to cite this paper

Pal, M., Rebuma, T., & Tolosa, T. (2024). Avian Coccidiosis: A Major Parasitic Disease of Poultry Industry. *International Journal of Livestock Research*, 14 (1), 1-7.

Received : Jan 04, 2024
Accepted : Jan 25, 2024
Published : Jan 31, 2024

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Abstract

Avian coccidiosis is a serious parasitic disease that affects chickens and is caused by the intracellular apicomplexan protozoa Eimeria. The disease is fatal and targets the intestinal tract. Seven species of Eimeria are found in chickens, including the most prevalent, Eimeria acervulina, Eimeria maxima, and Eimeria tenella. These bacteria infiltrate the intestinal epithelial cells in a particular location of the gut and cause variable degrees of tissue damage and morbidity. The intricate life cycle of Eimeria consists of both intracellular and extracellular stages that trigger a strong inflammatory response. This response leads to tissue damage brought on by lipid peroxidation and oxidative stress, diarrheal bleeding, stunted growth, increased susceptibility to other disease agents, and, in extreme cases, death. The severity of coccidian infection depends on the age of the birds, Eimeria species, number of sporulated oocysts ingested, immune status of the bird, and environmental management. Coccidiosis in chickens is characterized by dysentery, enteritis, emaciation, drooping wings, poor growth, and low production, with a high rate of mortality and morbidity. Anticoccidials are drugs used for the prevention and control of coccidian infections. They can either be coccidiocidal or coccidiostatic. The most commonly used drugs are sulphonamides, amprolium, and toltrazuril. Today, the prevention and control of coccidiosis are based on chemotherapy, using anticoccidial drugs or vaccines, along with hygienic measures and improved farm management. This current review highlights the prevention and control of avian coccidiosis.

Keywords: Avian coccidiosis, Control, Diagnosis, Eimeria, Prevention, Poultry Industry.

Introduction

Avian coccidiosis is a common, widespread disease associated with considerable economic losses to poultry farmers worldwide. It can affect birds raised in any production system and for any production purposes. The parasites that cause coccidiosis in poultry consist of a wide range of single-celled protozoans of the genus *Eimeria*. Seven species of *Eimeria* (*Eimeria acervulina*, *Eimeria brunetti*, *Eimeria maxima*, *Eimeria mitis*, *Eimeria necatrix*, *Eimeria praecox*, and *Eimeria tenella*) are recognized as affecting chickens (Conway, 2007). Coccidiosis can be best diagnosed in birds sacrificed for immediate necropsy. The diagnosis was based on the zone of the intestine parasitized, the gross appearance of the lesion, oocyst morphology, and the location of the parasite in the host intestinal epithelium (Conway, 2007).

Diagnostic characteristics of value include the clusters of the large schizonts of *Eimeria necatrix* and *Eimeria tenella*, the small round oocysts of *Eimeria mitis*, or the large gametocytes of *Eimeria maxima*. The presence of clusters of large schizonts in the midgut area is pathognomonic for *Eimeria necatrix*, and similar findings in the ceca indicate *Eimeria tenella*. Oocysts associated with lesions in the duodenum are *Eimeria acervulina*, *Eimeria mivati*, or *Eimeria praecox*, and oocysts associated with lesions in the lower gut are *Eimeria mitis*, *Eimeria mivati*, or *Eimeria brunetti* (Saif *et al.*, 2008).

The control of avian coccidiosis is a challenge in veterinary parasitology. The efforts to prevent this disease have been focused on developing vaccines and drugs with coccidiostatic and coccidicidal activity (Tewari, 2011). So far, genomic studies have revealed the wide antigenic variability of species such as *Eimeria tenella*, one of the most pathogenic parasites in chickens, leading to rapidly developing vaccine resistance (Blake *et al.*, 2015). The main problem with coccidiosis treatment is that resistance to anticoccidial drugs can evolve rapidly, leading to a continuing need to develop novel and effective therapies (Reid *et al.*, 2014). The present mini-review delineates avian coccidiosis as an important disease of the poultry industry with a major emphasis on the prevention and control of the disease.

Literature Review on Avian Coccidiosis

Avian Coccidiosis

Coccidiosis is an economically devastating parasitic disease of the poultry industry caused by the development and reproduction of several species of *Eimeria* protozoan within the intestine, resulting in an estimated cost of \$3 billion annually worldwide. The chicken is host to seven species of *Eimeria*, including the most common *Eimeria acervulina*, *Eimeria maxima*, and *Eimeria tenella*, each of which infects a specific area of the gut and invades the intestinal epithelial cells, resulting in varying levels of tissue damage and morbidity (McDonald & Shirley, 2009).

Etiology

Avian coccidiosis is an economically important disease in chickens caused by the intracellular protozoa parasite of *Eimeria* species in the genus *Eimeria*, family *Eimeridae*, order *Eucoccidiorida*, and phylum. Seven species of *Eimeria* (*Eimeria acervulina*, *Eimeria brunetti*, *Eimeria maxima*, *Eimeria mitis*, *Eimeria necatrix*, *Eimeria praecox*, and *Eimeria tenella*) although coccidiosis have been known for many years, it is still considered the most economically important parasitic condition affecting poultry production worldwide (Taylor, 2015).

Morphology

The morphology of coccidia oocysts is similar for most *Eimeria* species. They are ellipsoidal or circular-shaped, with a thick cell wall and sporocysts. The majority of *Eimeria* oocysts have an ovoid shape. *Eimeria maxima* (30.5 x 20.7µm) is the largest, while *Eimeria mivati* (15.6 x 13.4µm) and *Eimeria mitis* (15.6 x 14.2µm) are the smallest as compared to other species of *Eimeria*. *Eimeria tennella*, *Eimeria maxima*, *Eimeria acervulina*, *Eimeria hagani*, and *Eimeria burnetti* are ovoid, while *Eimeria necatrix* is oblong (Clark *et al.*, 2012).

Eimeria Life Cycle

Birds become infected through the ingestion of sporulated *Eimeria* oocysts from contaminated feed, water, or litter

(Li *et al.*, 2012). The oocyst wall is crushed by the gizzard, releasing the sporocysts. Once the sporocysts are broken down with the aid of trypsin and bile in the duodenum, sporozoites are released. The sporozoites then invade the intestinal epithelial cells, where they develop into schizonts containing many offspring called merozoites. This developmental stage is capable of breaking out of the epithelial cells, invading other cells, and asexually replicating further. Due to this cyclic reproduction, many of the epithelial cells are destroyed. Once asexual reproduction ceases, the later-generation merozoites develop into sexual male and female gametocytes, identified as microgametes and macrogametes, respectively. The microgamete subsequently fertilizes the macrogamete to produce a zygote. The zygote matures into an oocyst, ruptures the intestinal cell, and is passed with the feces (Blake, 2014). Once outside the host, the oocysts will sporulate when environmental conditions such as temperature, humidity, and oxygen become conducive to growth and once again become infective (Williams, 2002). The entire lifecycle, from ingestion to release, may take 4-6 days to complete (Allen and Fetterer, 2002).

Clinical Signs

The severity of coccidian infection depends on the age of the birds, *Eimeria* species, number of sporulated oocysts ingested, immune status of the bird, and environmental management (Hafez, 2008). Coccidiosis in chickens is characterized by dysentery, enteritis, emaciation, drooping wings, poor growth, and low production, with a high rate of mortality and morbidity (Awais *et al.*, 2012).

Diagnosis

Coccidiosis can be best diagnosed in birds sacrificed for immediate necropsy. The diagnosis was based on the zone of the intestine parasitized, the gross appearance of the lesion, oocyst morphology, and the location of the parasite in the host intestinal epithelium (Conway, 2007).

a. Microscopic Examination

Diagnostic characteristics that are of value include the clusters of the large schizonts of *Eimeria necatrix* and *Eimeria tenella*, the small round oocysts of *Eimeria mitis*, or the large gametocytes of *Eimeria maxima*. The presence of clusters of large schizonts in the midgut area is pathognomonic for *Eimeria necatrix*, and similar findings in the ceca indicate *Eimeria tenella*. Oocysts associated with lesions in the duodenum are *Eimeria acervulina*, *Eimeria mivati*, or *Eimeria praecox*, and oocysts associated with lesions in the lower gut are *Eimeria mitis*, *Eimeria mivati*, or *Eimeria brunetti* (Saif *et al.*, 2008). The dropping score may be used in the same manner as the lesion score for a rapid and fairly reliable rating of the infection. The species identification of coccidians is based on morphological characteristics. Polymerase chain reaction was also used for the detection of coccidial infections and species identification (Haug *et al.*, 2008).

b. Gross Lesions

The entire length of the external serosal surface of the digestive tract, from the gizzard to the lower rectum, needs to be examined under strong light. In examining the serosal surface, a search should be made for whitish plaques or petechiae. Whitish streaks or rounded colonies of oocysts in the duodenal area often indicate *Eimeria acervulina* or *Eimeria mivati*. In the mid-gut area on both sides of the yolk sac diverticulum, whitish plaques may be produced by colonies of *Eimeria necatrix* Schizonts (Conway, 2007). While cutting, watch for thickened areas indicating parasitic invasion of the mucosa or sub-mucosa. The presence of mucus, blood, casts, or cores and the presence of cheesy coagulation necrosis should be noted. The presence of blood in the caeca suggests a diagnosis of *Eimeria tenella*. But bleeding may originate from the more anterior zones of the intestine, and moving to the cecum may lead to misdiagnosis in the case of the *Eimeria necatrix* and *Eimeria tenella* infection. The lesion produced by *Eimeria tenella* is found mostly in the caeca. Lesion scoring is a technique developed to provide a numerical ranking of gross lesions caused by coccidians, as cited by (Conway, 2007). The entire gastrointestinal tract is removed unbroken from the bird. The gizzard and the rectum are left attached for orientation to locate the lesion observed in various parts of the intestine. The lesions are scored 1-4 based on the key identification characteristics discussed by (Conway, 2007).

Prevention and Control

The control of avian coccidiosis is a challenge in veterinary parasitology. So far, any treatment, including anticoccidial drugs, vaccines, or natural alternatives, controls avian coccidiosis by itself. It proposed the use of a combination of different strategies to achieve effective control. In the past, it has been realized that eradication of coccidia is not realistic, and hygienic measures alone are not able to prevent infections. However, if an outbreak of coccidiosis occurs, treatment via drinking water should start as soon as possible. The most commonly used drugs are sulphonamides, amprolium, and toltrazuril. Today, the prevention and control of coccidiosis is based on chemotherapy, using anticoccidial drugs and vaccines, along with hygienic measures and improved farm management (Quiroz-Castañeda and Dantán-González, 2015).

c. Conventional Control Measures (With Application of Anticoccidials)

Anticoccidials are drugs used for the prevention and control of coccidian infections. They can either be coccidiocidal or coccidiostatic. The former kills the coccidial parasites, whereas the latter prevents replication and growth (Quiroz-Castañeda and Dantán-González, 2015). In general, coccidiocidals are more effective than coccidiostats because, when coccidiostatic medication is withdrawn, halted parasites may resume their life cycle and go on to contaminate the environment with infective oocysts (Saif *et al.*, 2008).

d. Alternative Strategies Control of Avian Coccidiosis

Cost-effective alternative strategies are being sought for more effective and safer control of avian coccidiosis.

Acids

Acids are known to have antibacterial, antifungal, and antiprotozoal activity, particularly at low PH. Many acids like formic acid, butyric acid, anacardic acid, acetic acid, and hydrochloric acid are found effective in controlling avian coccidiosis. Some strong acids, like hydrochloric acid, in low concentrations are also being used for the control and treatment of avian coccidiosis (Abbas *et al.*, 2012).

Non-Steroidal Anti-Inflammatory Drugs

The use of nonsteroidal anti-inflammatory drugs may be another effective approach for the control and treatment of avian coccidiosis, but so far, very limited work has been done on this aspect. Ibuprofen is a nonsteroidal anti-inflammatory drug that inhibits the biosynthesis of prostaglandins with pro-inflammatory and immunosuppressive properties and is therefore proposed as a candidate molecule for the treatment of coccidiosis in broiler chickens. Several trials were performed to find out the anticoccidial activity of Ibuprofen. In all experiments, Ibuprofen was administered via drinking water, and it was found that coccidial lesion scores and oocyst shedding were reduced when Ibuprofen was provided at a dose of 100 mg/kg body weight. However, at this dose, Ibuprofen did not show any significant effect on the degree of sporulation and infectivity of *Eimeria acervulina* oocysts (Vermeulen *et al.*, 2007).

e. Integrated Coccidiosis Control Program

Immuno-prophylaxis

Protective immunity in chickens can be induced by deliberate infection with low numbers of *Eimeria* parasites, and it is established that after two to three consecutive infections, the birds develop solid immunity. All commercially available coccidiosis vaccines are based on this principle. The two types of available vaccines for the immunization of chickens are attenuated and virulent vaccines (Chapman, 2014).

Live, Non-Attenuated Vaccines

This vaccine includes a variable number of wild-type strains. For broiler breeders, up to eight *Eimeria* species are included in these products (Coccivac D, Immucox C2), whereas for use in the broiler industry, the number is restricted to up to four species (Coccivac B, Immucox C1). The mode of application is with drinking water for all four live vaccines (Tewari and Maharana, 2011).

Live-Virulent Vaccines

These vaccines are prepared by attenuating live parasites (Lee *et al.*, 2007). Live-tolerant to ionophores vaccines: These vaccines comprise strains of different species of *Eimeria* that are relatively tolerant to ionophores. The advantage of these vaccines is that they allow the use of ionophores during the first 3-4 weeks when immunity is not complete (Vermeulen *et al.*, 2007).

f. Biosecurity and Management Practices

Generally, in animal production, biosecurity is a key program to prevent or minimize the number of organisms entering and spreading within the farm. Bio-security measures could be different depending on the production system but have three main components: isolation, traffic control, and sanitation. In avian coccidiosis prevention, bio-security programs and management practices also play an important role besides other prophylactic methods, including ionophores, chemical drugs, or vaccines. Many studies have indicated that the risk of coccidiosis and the severity of infection are attributable to environmental and management factors (Hafez, 2008).

Housing Design

High stock density increases the number of infective oocysts ingested by birds; thus, commercial farms have a higher risk of coccidiosis outbreaks than backyard, free-range, or organic systems. A typical commercial broiler production may contain between 20 and 50,000 chickens at a stocking density of one bird per 0.08 m² (Chapman, 2014). Some backyard and organic broiler producers keep birds in floorless pens and move them daily. Feeders and drinkers should be kept at a level that birds cannot defecate infected litter into them. Also, preventing birds from picking up oocysts from the floor or litter by keeping the feeders always full is another preventive practice (Fanatico, 2006).

Good Hygiene

Feeders and water should be kept clean because they can be contaminated with fecal matter. Daily removal of litter is important to get rid of infected droppings. The litter may be replaced after every flock or after several successive flocks; in the USA, it is common to change the litter every six flocks, indicating that in a built-up litter system, microbes in the litter can develop and destroy oocysts. Therefore, removing only half of the litter can maintain its anti-coccidial effect (Chapman, 2014).

Conclusion and Recommendations

Avian coccidiosis is one of the most important infectious diseases of poultry farming in the world. This protozoan causes millions of dollars in losses to the poultry industry every year. Chickens of all ages can come down with coccidiosis, anticoccidial drugs commonly used in the industry have decreased efficacy because of an increase in the occurrence of drug-resistant parasite strains. Infections with coccidia are often associated with severe economic losses. The probiotic (*Enterococcus faecium*) is a common component of intestinal microbial of normal humans and animals. The advantages of these bacteria are higher resistance against extreme internal and external conditions. It is non-pathogenic, non-hemolytic, and non-proteolytic and has an excellent propagation potential. The prevention and control of coccidiosis will focus on high standards of bird health, nutrition, and management of the production environment. The disease is widely distributed in Ethiopia and causing huge problems in the poultry industry.

Based on the above conclusion the following recommendations are forwarded;

- i. More attention should be given to improved sanitation and hygiene at the farm level.
- ii. Controlling moisture with the appropriate installation and management of watering systems is mandatory.
- iii. Extensive training should be given to poultry farmers on poultry husbandry methods.

Contribution by Authors

Equal contribution. All authors declared that ‘written informed’ consent was obtained from the approved parties for the publication of this article and accompanying images.

Conflict of Interests

There is no conflict of interest.

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