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Review

Coccidiosis in Poultry - A Review

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Abstract

Coccidiosis is caused by an intracellular protozoan parasite belonging to the genus Eimeria of the family Eimeridae. Eimeria are extremely host-specific. Poultry are mainly affected by nine species of Eimeria, which include E. acervulina, E. maxima, E. mitis, E. brunetti, E. mivati, E. necatrix, E. tenella, E. praecox, E. hagani, E. meleagrimitis, E. adenoeides, and E. gallopavonis. The disease causes decreased feed and water consumption, reduced body weight, and a drop in egg production. Clinical coccidiosis is characterized by lesions noticed in various areas of the small intestine, which may lead to secondary infections, mainly clostridium infections. The effective way to control coccidial infections is by adopting good husbandry practices at the farm level, inclusion of anti-coccidial drugs in the feed, and prevention can be done by vaccination of the flock.

Keywords: Coccidia, Poultry, Eimeria, Ionophores, Vaccines, Turkey.

Introduction

As per United Nations world population prospects, the global population is projected to reach 8.5 billion in 2030 and 9.7 billion in 2050. This rapid population growth created a massive demand for animal protein, which include both meat and eggs. Of all the animal species, the poultry industry has expanded at the greatest rate over the last four decades. Through the creation of value chains, it has become the most affordable source of protein for consumers.

Poultry production in India has taken a quantum leap in the last four decades, emerging from conventional farming practices to a commercial production system with state-of-the-art technological interventions. Currently, egg production is around 129.60 billion during 2021-22. Egg production has shown a positive growth of 6.19% during 2021-22. An estimated 5 million tons (MT) of broiler meat is produced each year, making up 50% of all meat produced in India. With the huge demand for poultry meat and eggs, if there is any disruption in the production process due to pathogens, it will have a great impact on the supply of affordable protein for human consumption.

Any pathogen that undermines the poultry production system's effectiveness could endanger global food security (Mesa-Pineda *et al*., 2021). There are several pathogens of greater importance in poultry, among which *Eimeria* is one of the important protozoan parasites. *Eimeria* species cause coccidiosis, an enteric disease in poultry. Coccidiosis is caused by protozoa of the phylum Apicomplexa, family Eimeriidae. The majority of species that infect chickens are found in the genus Eimeria and affect different intestinal locations. The disease course is rapid (4–6 days) and is characterized by parasite replication in host cells with extensive damage to the intestinal mucosa. Coccidia in poultry are generally host-specific, and the different species infect specific portions of the intestine. The effects of infection include malabsorption, enteritis, and a rise in mortality, compromising economic productivity and animal welfare (Blake *et al*. 2020). There are several strategies to control coccidiosis, which include management practices at the farm level, anti-coccidials i.e. ionophores, synthetic compounds, and vaccines.

This review's goal is to provide a brief overview of coccidiosis, including the many *Eimeria* species that infect poultry, their life cycle, etiology, clinical manifestations, and management strategies.

Etiology

The genus is named after the German Zoologist Theodor Eimer (1843-1898) who discovered it. The oocyst of *Eimeria steidai* was first seen by Anton Von Leeuwenhoek in the bile of a rabbit in 1674.

Coccidiosis is caused by Eimeria species. Although coccidia is usually always present in poultry farming operations, clinical signs don't appear until susceptible birds ingest a significant amount of sporulated oocysts. Both clinically infected and recovered birds shed oocysts in their feces, which contaminate feed, dust, water, litter, and soil. Fresh oocysts are not infective until they sporulate; under optimal conditions (21°–32°C) with adequate moisture and oxygen, this requires 1–2 days. Depending on the species, the coccidia cycle lasts 4-6 days. Sporulated oocysts may survive for long periods, depending on environmental factors. The severity of the disease depends on the species and the number of oocysts ingested. The most important factor in the occurrence of coccidia is oocysts continue to exist in the environment.

E. tenella, *E. necatrix*, and *E.brunetti* are the most harmful species and cause high mortality and morbidity. *E.maxima* and *E acervulina* are moderately harmful. *E. mitis* and *praecox* are the least harmful and affect duodenum.

Immunity

Day-old chicks do not get any maternal antibodies from the hen so the birds of all age groups are most likely to be affected. Immunity is best produced by repeated exposure to low numbers of oocysts. This is known as trickle infection. Immunity leads to a reduction in oocyst count and tissue damage. Cell-mediated immunity plays an important role. The parasite has a short prepatent period and high biotic potential. Immunity is acquired by infection and maintained by periodic re-infection.

Table 1: Different species of *Eimeria* affecting Poultry

Poultry	Species	Development site	Lesions
Chicken	*Eimeria acervulina*	Duodenum	Whitish, transverse patches in the upper half of the small intestine.
Chicken	*E. maxima*	Jejunum, Ileum	Thickened intestinal wall with petechial hemorrhage.
Chicken	*E. brunetti*	Cecum and Rectum	Thickened intestinal wall with petechial hemorrhage.
Chicken	*E. necatrix*	Jejunum, Ileum, Cecum	The intestinal lumen is filled with blood, mucus, and fluid.
Chicken	*E. mitis*	Duodenum, Jejunum	Mild enteritis
Chicken	*E. tenella*	Cecum	Accumulation of blood in the cecum.
Chicken	*E. praecox*	Duodenum	Mild enteritis
Turkey	*E. meleagrimitis*	Duodenum and jejunum	Thickened intestinal wall with petechial hemorrhage
Turkey	*E. adenoeides*	Ceca	Normal cecal contents are replaced with watery cecal contents
Turkey	*E. gallopavonis*	Ileum	White spots on the mucosa and thickened intestinal wall

Economic Impact of Poultry Coccidiosis

It is estimated that the global cost of coccidiosis in chickens in 2016 was around £10.36 billion, which includes productivity losses as well as expenses related to prevention and treatment. In India, the cost of control, mortality, and morbidity of coccidiosis are mentioned below:

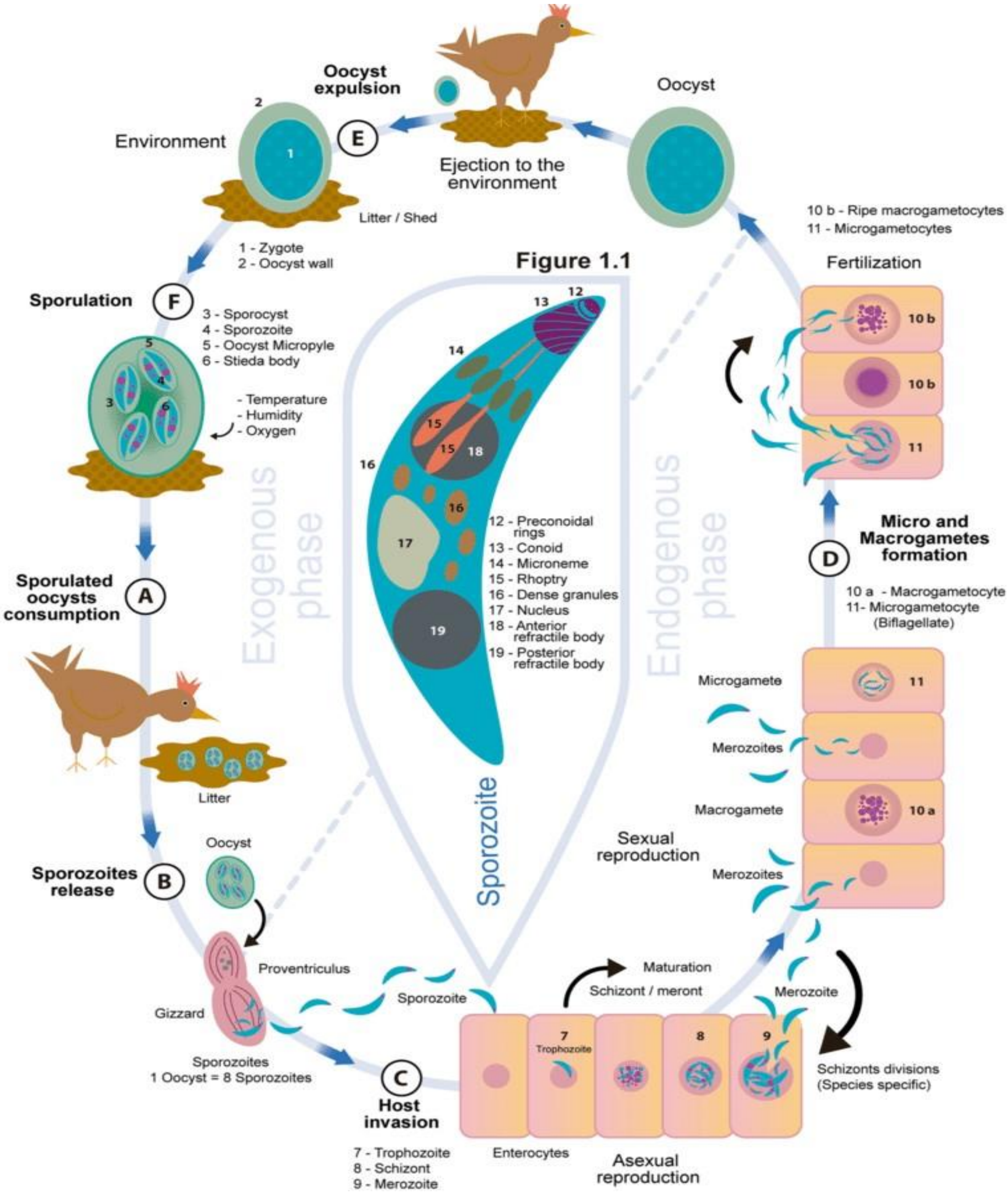
Table 2: The overall cost of coccidiosis (millions) for control, mortality, and morbidity

Country	**Cost of control (millions)**	**Cost of mortality (millions)**	**Cost of morbidity (millions)**
India	£10.47	£35.92	£400.61
	As a percentage of the total cost		
	2.4 %	8 %	89.6 %

(Blake *et al.*, 2020)

Lifecycle

The life cycle of coccidiosis starts with the oocysts, which contain a zygote that extrudes from the host tissue and passed in the feces. Oocysts are non-sporulated and non-infective. They undergo sporulation under certain conditions of temperature and moisture and then become infective. Sporulation is the conversion of the non-infective form of oocysts to infective form. It takes 1-2 days for sporulation in the presence of warmth, 20-30% moisture, oxygen and temperatures between 25-30^{o}C. This is an extremely important factor in the occurrence of coccidiosis. The host ingests these sporulated oocysts. One sporulated oocyst consists of 2 sporocysts, which in turn consist of 4 sporozoites each. Excystation of the sporocysts occurs in the presence of CO_2, bile and trypsin and results in the formation of motile sporozoites. These motile sporozoites invade the intestinal epithelium and enter into enterocytes, and develop into tropozoites (rounded in shape). The nucleus in the trophozoite divides by schizogony, resulting in the formation of first-generation merozoites. These merozoites enter epithelial cells and undergo continuous asexual reproduction forming the second generation schizonts. These second-generation schizonts under favorable conditions develop into micro and macro gametes. These gametes fertilize (syngamy) and result in the formation of oocysts, which are extruded from the host tissue and excreted in feces. As a result, both asexual and sexual reproduction take place in coccidiosis. (Waldenstedt *et al.*, 2001). In the case of *E. tenella*, the life cycle is 7 days and the prepatent period is 4-5 days. The prepatent period is the time between ingestion of sporulated oocyst and the appearance of oocysts in the feces. A small amount of feces from a bird infected with severe coccidiosis consists of millions of oocysts. Consumption of as few as 10000 sporulated oocysts will produce coccidiosis. The life cycle of Eimeria is presented below in Fig 1.



Fig;1 Life cycle of Eimeria (Mesa Pineda C *et al.*,2021).

Clinical Signs and Lesions

Birds affected with coccidiosis will show decreased growth rate with severe diarrhoea and high mortality. There may be decreased feed and water intake, and also egg production, soiling around the vent, mucus and blood in droppings (caecal coccidiosis). Lesions occur mostly in intestines and are species-specific.

For ex: *E. necatrix*- proximal and middle portions of small intestines and *E.tenella*- blood in the caecum.

Diagnosis

Diagnosis is mainly done by the clinical signs. The presence of feces with blood, diarrhea, and dysentery suggests coccidiosis. The earliest symptom with the most harmful coccidia is a sudden increase in mortality. Conversely, the less harmful coccidial symptoms include only reduced growth rate and poor feed consumption. In the case of postmortem examination, the internal and external intestinal lesions should be scrutinized carefully. E. *tenella* - caeca is enlarged and distended with clotted blood. E. *necatrix*- the ballooning of the middle portion of the small intestine and the lumen is filled with blood. E. *brunetti*- tiny hemorrhages in the mucosal lining of small intestines, clotted blood, and mucosa are seen in droppings. E. *maxima*- the ballooning of the middle portion of the small intestine. E. *acervulina*- mucosa is covered with white plaques, causing a ladder-like appearance due to striations (J.L Vegad., 2018). A small amount of mucosal scrapings should be diluted with normal saline on the glass slide and covered with a coverslip, then examined under the microscope. Oocysts can be seen very easily. The presence of a large number of groups of schizonts in the middle portion of the intestines indicates *E.necatrix*. Molecular diagnosis can be done using the Eimeria specific primers using PCR, Multiplex PCR, qPCR (Fatoba, A. J., & Adeleke, M. A., 2018). The PCR-based assay can be used for the detection and identification of different species of Eimeria.

Prevention and Control of Avian Coccidiosis

There has been evidence of research on anti-coccidiosis in the past few years. Control of coccidiosis has been a challenge in veterinary parasitology. Different approaches have been used to control coccidiosis. A combination of different strategies has been used to control coccidiosis.

Farm hygiene and strict biosecurity measures, such as rodent control, will help in reducing the spread of oocysts. Avoid moisture in the litter, as oocysts require moisture for sporulation. Another method is the use of anti-coccidial agents in the feed, which is widely used in commercial poultry. Below are some of the anti-coccidial compounds available in the market:

Three types of molecules: Ionophores, Chemicals, and Ionophore + Chemical (combination) products Ionophores:

1. Monovalent Ionophores: Salinomycin and Monensin
2. Monovalent glycosides: Maduramicin and Semduramicin.
3. Divalent Ionophoes: Lasalocid Chemicals: Robenidine, DOT, Dicalzuril, Clopidol and Nicarbazine Chemical + Ionophores: Nicarbazine+Narasin, Nicarbazine+Maduramicn, Nicarbazine+Monensin.

A few anticoccidial drugs are presented in Table 3.

Table 3: Anticoccidial agents used to control coccidiosis

Product	Composition	Dose (mg per kg of feed)
Polyether ionophores	Monensin sodium	100 – 125
	Lasalocid sodium	75 – 125
	Maduramicin	5
	Narasin	60 - 70
	Salinomycin sodium	50 - 70
	Semduramicin sodium	20 - 25
Non-polyether ionophores	Robenidine hydrochloride	30 - 36
	Halofuginone hydrobromide	2 - 3
	Diclazuril hydrochloride	1
	Nicarbazin	40 - 50

(Adopted from Anadon, A., & Martinez-Larranaga (2014). Veterinary Drugs Residues: Coccidiostats)

The common problem associated with using anticoccidials is resistance. The usage of the same anticoccidial molecule for a long time causes resistance for that molecule. Cross-resistance is the usage of the same anticoccidial molecule for a long time causes resistance for not only to that molecule but also to the other molecules of the same class. The only solution for resistance and cross-resistance is changing one anticoccidial molecule to another molecule of a different class after a certain period with either full or shuttle programs. Full program: Usage of a single molecule in all types of feed like pre-starter, starter, and finisher. Shuttle program: Usage of one molecule in one phase of feed and another molecule in another phase of feed like one molecule up to starter and another one in finisher.

Vaccination

Currently, 2 types of vaccines are used live attenuated and live non-attenuated. First commercial vaccine: Coccivac. The details of a few vaccines are presented in Table 4.

Table 4: Vaccines that are available and used commercially to control coccidiosis

S.No	Vaccine	Strain	Company	Usage
1	Paracox 8	*Eimeria maxima*, *E. acervulina*, *E.tenella*, *E. mitis*, *E.necatrix*, *E.praecox*, and *E. brunetti*	MSD	Chicken
2	Hipra evalon	E. *maxima*, *E. tenella*, *E. acervulina*, *E. necatrix*, and *E. brunetti*	Hipra	Chicken
3	Huveguard MMAT	*E. acervulina*, *E. mitis*, *E. maxima*, and *E. tenella*	Huve Pharma	Chicken
4	Huveguard NB	*E. necatrix and E. brunetti*	Huve Pharma	Chicken
5	Advent	*E. acervulina*, *E. maxima*, and *E. tenella*	Huve Pharma	Broilers
6	Coccivac D2	*E. acervulina*, *E. maxima*, *E. mivati*, *E. tenella*, *E. necatrix and E. brunetti*	Merck	Chicken
7	Coccivac B52	*E. acervulina*, *E. maxima*, *E. maxima MFP*, *E. mivati*, *E. praecox*, and *E. tenella*	Merck	Chicken
8	Immucox 3	*E. acervulina*, *E. maxima*, and *E. tenella*	Ceva	Broilers
9	Immucox 5	*E. acervulina*, *E. maxima*, *E. tenella*, *E. necatrix and E. brunetti*	Ceva	Layers and Breeders
10	Inovocox	*E. acervulina*, *E. maxima*, and *E. tenella*	Zoetis	Broilers
11	Livacox® Q	*Eimeria tenella*, *E. acervulina*, *E. maxima* and *E. necatrix*	Hester Bioscience	Chicken

(Source: websites of each organization)

Conclusion

This review concludes that coccidiosis is a prevalent parasitic disease that leads to huge production losses in poultry. The best way to control the infection is by adopting best farm management practices, using anti-coccidial drugs in feed, and commercial vaccines that are also available to prevent the infection.

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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