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Coccidiosis in Domestic Ruminants: Review

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Abstract: Coccidiosis is an important protozoan disease of domestic animals that is known to cause heavy morbidity and mortality in domestic animals. Tenacious oocysts are found ubiquitously in the environments and are responsible to cause infection in calves and young cattle, lamps and kids, are the most susceptible age group, almost inevitable. Further development, comprising of asexual multiplication, the merogony and subsequent sexual stage, the gametogony, takes place within cells of the small and large intestines, after which numerous unsporulatedoocysts are formed and shed within feces. Active (species specific) immunity, both humeral and cellular, develops rapidly after first antigen contact, its intensity being dependent on the number of oocysts ingested. However, no absolute protection is achieved and ever older animals can excrete oocysts, contributing to state of endemic stability. For efficient control, exact diagnosis of the *Emeria* species involved and the evaluation of animal management and husbandry practices are of most importance. Therefore, the main objective of this paper is to review the status of coccidiosis in domestic ruminants.

Key words: Coccidiosis · Domestic Ruminants · Emeria Species

INTRODUCTION

Ethiopia has approximately 47.7 million cattle, 26.7 million sheep, 23.33 million goats, 21.7 million horses, 5.57 million donkeys and 1million camels [1]. Overall 48 million head of sheep and goats, third largest among African nations and ranks eighth in the world. Sheep and goats are widely adapted to different climates and are found in all production whichcontributes quarters of domestic meat consumption, in crowded domestic wool production and 40% of fresh skin and 92% of semi processed skin export trade [2].

Thousands of coccidian species of herbivorous, omnivorous and carnivorous animals have been described and many more exist that remain unnamed. Some cause serious disease, whereas others are of minor or no clinical importance [3].

Ruminant livestock are important resources for sustainable development and land resources utilization throughout the world. In tropical countries like Ethiopia, however, under developed infrastructure coupled with poor management practice, low nutritional status, poor genetic make-up and disease considerably affect the productivity of this sub-sector. The parasitic diseases in this regard has been of paramount importance. Loses from livestock production due to parasitic diseases are very high both in developed and developing countries [4]. Among parasitic diseases, coccidiosis due to different species is responsible for low productivity and mortality in ruminant especially in young ones. Coccidiosis is a parasitic disease caused by intracellular protozoa. The disease is of economic importance affecting cattle, sheep, goats and other domestic ruminants [5]. Clinical coccidiosis has an important disease in pre-weaned and recently weaned animals. But adult animals do not show sign of disease [6]. This sub clinical coccidiosis has a significant impact on the economics of animal production, causing a reduction in weight gain and feed efficiency and increased susceptibility to other diseases. Clinical coccidiosis results in financial losses to produces because of costs of medical treatment, more severe effects on growth performance and sometimes losses due to death of infected animals.

Clinical coccidiosis in domestic ruminants becomes an economically important problem with the introduction of intensive rearing system. Disease outbreaks are usually associated with high stocking density, very poor weather conditions and use of restricted areas to supplement the flock/herd with extra feed [7]. Young animals in intensive grazing areas and feedlots are at great risks of coccidiosis

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as result of shipping, ration change, crowding stress, severe weather and contamination of the environment with oocyst from adults or other animals. Kids appear to be much more susceptible to coccidiosis acquiring the infection through ingestion of sporulated oocyst of *Eimeria* species [8].

The incidents and the prevalence of coccidiosis have been studied in the several countries of the world. For instance, Majewska *et al*.[9] reported 98% infection rate of coccidia in populations of goats in Australia and 20%-40% mortality of coccidiosis among kids on different farms in Zimbabwe has been documented [10]. In study conducted North-west Poland, Pilarczyk *et al*. [11] reported 27% and 49.6% infection rate of coccidiosis in diary in cows and calves, respectively. In Ethiopia, only few studies conducted so far on coccidiosisin ruminants are by Kassa *et al*. [12], in Bahirdar, kebedu [13] in Bishoftu, Dinka [14] in Bishoftu and Rahmeto [15] in Addis Ababa and Bishoftu. This implies that the economic significance, distribution, species composition and prevalence of *Emeria* species are not well studied in Ethiopia. Reliable and up-to-date information on this aspects of coccidiosis is however, needed to investigate and tackle the diseases. Therefore, the objective of this paper is to review the status of coccidiosis in domestic ruminants.

Coccidiosis

Etiology: Coccidiosis is contagious enteritis of predominantly domestic animals caused by infection with *Emeria* species characterized by diarrhea and dysentery, anemia, inferior growth rate and production [16]. Taxonomically, *Emeria* belongs to the phylum apicoplexa (which is possess an apical complex), class Sporozoasida (which reproduce by asexual and sexual cycles, with oocysts formation), sub class Coccidiasina (with the life cycle involving merogony, gametogony and Sporogony), Order Eucoccidida (in which Schizogony occurs), sub order Emeria (in which independent micro and macrogamy develop), Family Emeridae and the Gunus [17].

It has been thought for many years that coccidian of cattle, sheep and goats are interchangeable. These days, however, it became established that species *Emeria* known to cause infection in ruminants. Hence, the species of clinical importance in cattle are *Emeria zuerni* and *Emeria bovis*. In sheep, the species of clinical importance are *Emeria ovina*, *Emeria ahsata*. *Emeria crandallis* and *Emeria parva* [18]. In goats, species of *Emeria* which are responsible for causing coccidiosis are *Emeria arloigni*, *Emeria chrestense* and Emeria for causing coccidiosis are *Emeria arloingi*, *Emeria chrestense* and *Emeria ninakohlyakimovae* [19]. Moreover, multiple infections comprising more than a single species of Emeria are the rule in natural infection [20].

Host and Site Specificity of *Emeria* Species: *Emeria* species demonstrate both site and host specificity; only to some degrees. The majority of species, for which endogenous development is known, undergo development in certain cells of the gastrointestinal tract, but not all species are found in this location. Once within their specific organ system of choice, *Emeria* species seem to be limited to specific zones within that system, specific cells within that zone and specific location within those cells. Thus, one species may be found only in the middle third of the small intestine and another only in the cells of the caecum. Within their specific region, one species may be found only in the cells at the base of the crypts of Lieberkuhn, a second species in epithelial cells along the villi. Some species develop below the striated (microvillus) border of endothelial cells, but above the nucleus, others below the nucleus and a few within the nucleus [21].

The degree ofhost specificity seems to vary between host groups:it has been studied best in mammals and to a lesser degree in birds. *Emeria* species from goats cannot be transmitted to sheep and vice versa [22, 23], but *Emeria* from cattle (Bos) are known to cause infection in American bison (Bison).Thus numerous biotic interactions, particularly the genome of both parasite and host, must contribute to the host specificity, or lack thereof, attributed to each *Emeria* species.

Life Cycle of Emeria Species: The Life cycle includes both asexual and sexual multiplication. Sexual multiplication culminates in the formation of oocysts, which are discharged with faeces and in the development, within each of these oocysts, four sporocysts each containing two infective organisms, sporozoites exist. If the infective sporocysts each containing two infective organisms, sporozites exist. If the infective sporocysts each containg two infective organisms, sporozoites exist. If the infective sporulated oocyst is ingested by asuitable host, the sporozoites emerge and each may enter an epithelial or lamina propria cell, roundup as a trophozoite, grow larger and become a first generation schizont (meront). The schizontproduces first generation merozoites that burst the cell and invade fresh cells to become second generationschizont. A merozite produced by final schizogony enters a new host cell and develops in to either a male or afemalegametosyts or developing sex cells [15].

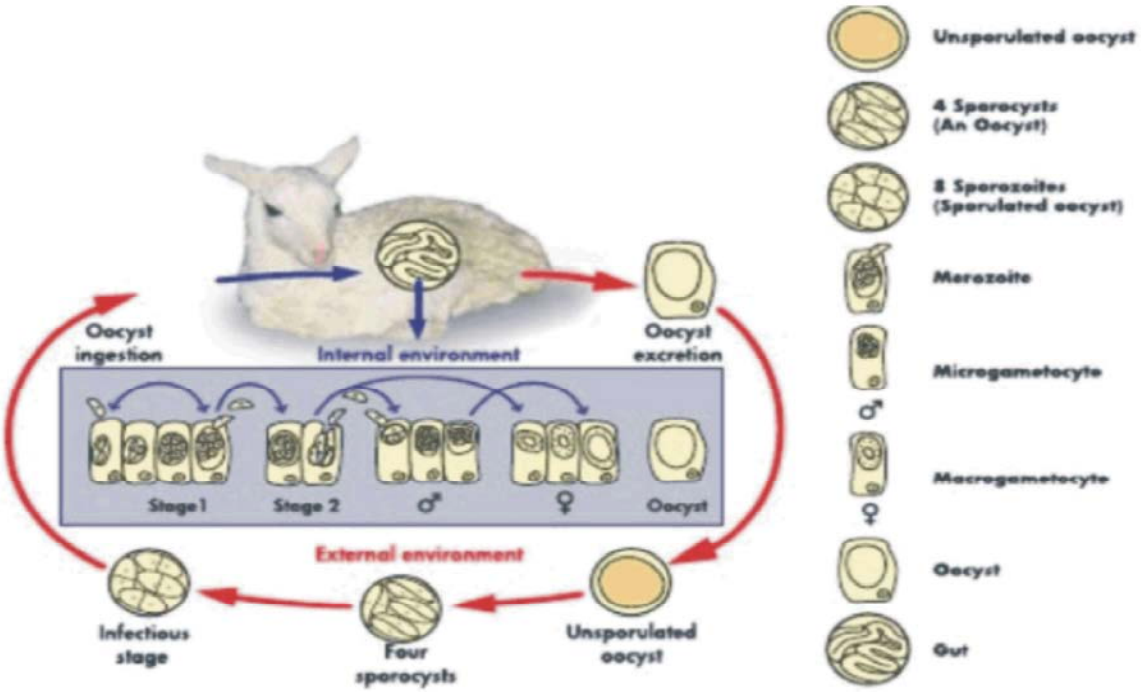

Fig. 1: Basic life cycle of ovine coccidia
Source: [26]

The gametocytes (microgametocytes or micro gamete) enlarges, stores food materials and induces hyper trophy of both cytoplasm and nucleus of its host cells. When mature, it's called amicrogamete or female sex cells [14, 15].

The male gametocytes (microgametosyts or microgamete) under goes repeated nuclear division and becomes multi nucleate. Each nucleus is finally incorporated into abiflagellatemicro gamete, or male sex cell. Then microgamete fertilizes macrogametes to form zygotes. A wall forms around the zygotes by the coalescence of hyaline granules at its peripheryto form an oocyst. The oocyst is realized by rupture of the host cells and passes out with the faces to undergo sporulation [24]. The life history of atypical Emeria species is shown in Figure 1.

Development of the *Emeria*oocyst to the effective depends on suitable temperature, oxygen and moisture. In general, sporulation of oocyst is most rapid at 28°C to 31°C. Low temperature of 0°C to 5°C retard sporulation, but it will then occur when the temperature increased [25].

Epidemiology, Source of Infection and Transmission: Coccidiosis occurs universally but is of most importance where animals are housed or confined in small area. Shipping ratio change and severe weather have also been considered to be predisposing factors to coccidiosis. All domestic animals are susceptible but coccidia are in general specific and infection does not pass readily from one animal species to another animal species another nor does cross immunity between species of coccidian [26].

Clinical coccidiosis of sheep and goat occur mainly in young lamps, kids and there appears to be an increasing prevalence under conditions of intensive husbandry. Lamps are usually infected between 4-7 weeks of age with a peak infection approximately at 6 weeks. The outbreaks reported have occurred where ewes and lamps were housed inunhygienicconditions or grazed intensively. Transmission is by facial-oral route, either directly or indirectly via contaminated water or feed washed or irrigated with water contaminated with faeces. Older animals usually serve as career of coccidia and continue to pass oocyst in the faeces to the environment [19, 27] which result in build-up of infection in yards, Barnes and on pasture, so that severe and fatal coccidiosis may occur when a new batch of calves, lamps, or kids are placed on pasture or in yard which hitherto has appeared perfectly save [19].

The feeding of concentrate in stationary troughs around which has occurred heavy contamination with oocyst can also be predisposing factor. In the U.S.A, coccidiosis has occurred when older lamps confined in

feed lots after winning as result of stress which is associated with shipping, sudden in changes in ration and weather and overcrowding [10, 19]. Coccidiosis can also occur in free-ranging conditions resulting fromweather stress, crowding around a limited water sources as many occur during drought period, which concentrate the hosts and the parasites in restricted area. In spring, lamping flocks in Western Europe, infection of lamps resulted from oocyst, which have survived the winter and form produced by ewes during the pre-parturientperiod [8]. Coccidiosis is usually sporadic during the wet seasons of the year, but may occur at anytime in animals confined in feed lots. Severe infections have been reported in cattle confined in feed lots during periods of extremely cold weather. The disease can be a problem at any time as long as conditions adequate moisture exists for the survival and development of oocyst.

Goat appears to be very much susceptible and coccidiosis is a serious problem in rising kids in many goats herds. Clinical disease typically follow winning by 2 or 3 weeks but coccidiosis can be suspected whenever diarrhea is observed in a kids older than 2 weeks, heavily infected kids are likely to die, the stronger less heavily infected survive but fail to grow normally [24]. Acute coccidiosis may occur in animal of any age when their resistance is affected by concurrent disease or inclement weather [19].

Pathogenesis and Clinical Signs: The coccidian of domestic ruminants pass through all stages of their life cycle in the alimentary mucosae and do not invade other organs although schiotzonts have been found in mesenteric lymph nodes of sheep and goats [16]. They have also been several reports of biliary coccidiosis with liver failure in dairy goats [8, 28]. *Emeria* induces changes in the intestinal mucosa. The pathogenic lesions cause local hemorrhage and oedema, villus Atrophy may be sequel resulting in mal-absorption. Less is known about the problems of coccidiosis in goats even though oocysts are frequently recorded from as causing severe pathology [8].

The clinical syndromes caused by various coccidia are similar in all animals' species. The first sign of clinical coccidiosis is usually the sudden onset of severe diarrhea with foul smelling, fluid faeces containing mucus and blood. In groups of lambs raised and fed under intensified conditions, the major clinical findings may be inferior growth rate, gradual onset of weakness, inappetence, recumbence, emaciation and death with 1-3 weeks [16]. If a young kid is suddenly exposed to many sporulated oocysts, it may become severely ill for 1-2 weeks later. It will be off feed, listless and weak. It may also show abdominal pain by crying or getting up again as soon as it lies down. Diarrhea begins and it is pasty and then becomes watery. The animal may be dehydrated rapidly and it may even be killed rapidly by a severe attack of coccidiosis [29].

Pathogenic species of *Eimeria* and site of infestation in cattle, sheep, and goats

	Species of *Eimeria*	Site of Infestation
Cattle	*Eimeria zuernii*	Small and large intestine
	Eimeria bovis	Small and large intestine
	Eimeria alabamensis	Small and large intestine
Sheep	*Eimeria ovinoidalis*	Cecum and colon
	Eimeria crandalis	Small and large intestine
Goats	*Eimeria arloingi*	Small intestine
	Eimeria christenseni	Small intestine
	Eimeria ninakohlyakimovae	Small and large intestine

Source: [30]

Diagnosis: Diagnosis of coccidiosis is based up on the history (stress), clinical signs (unthriftiness, diarrhea), the presence of large numbers of oocysts in the faeces and intestinal lesion at necropsy [31]. For specific diagnosis of the parasite, one should depend on morphological identification of the oocyst in sugar flotation of faeces, micrometry; and sporulation of the oocysts in 2.5% potassium dichromate solution [24, 32]. However, diagnosis will often missed if one relies only on finding of oocysts in the faeces. There may be none at all in the acute atage of coccidiosis. Similarly, the presence of oocysts in the faeces may not proof the presence of overt coccidiosis. To be sure of a diagnosis, scrapings should be made from the affected intestinal mucosa and examined under the microscope. It is not enough to look for every oocyst, however, merozoites and gametes should be recognized [5]. In animals which had previous contact with coccidia and which may be relatively immune, other causes of diarrhea such as *E. coli*, *Salmonella* species, *Clostridium perfringens* type C and Helminthosis should be considered [16].

Immunity: Specific immunity to each coccidian species develops after infection so that young animals exposed for the first time are often more susceptible to a severe infection and clinical disease than other animals [10]. Even though resistance to re-infection with *Emeria* species lasted for at least 3-6 months and possibly longer was demonstrated by different researchers, the immunity was not complete [19] and thus, frequent re-infection is required to boost up immunity [16]. However, cellular immunity is probably more important in resistance against re-infection than humoral immunity [33, 34]. Since immunity to coccidiosis is specific, animalsrecovered from a certain species of*Emeria* are atrisk of infection by other species [35] and the strength of immunity is different for the various species.

Table 1: Recommendedtherapeutics for the treatment and control of coccidiosis in lambs and kids

Chemotherapeutic agent	Treatment	Prevention
Sulphadimidine	140 mg/kg body weight for 3 days individually.	25 mg/kg body weight daily for a week
Nitrofurazone	15 mg/kg body weight daily for seven day or 0.04% in feed for 7 days. In water at 0.0133% for 7 days.	For one week 0.04% for 21 days in feed
Amprolium	Individual dose 50mg/kg body weight for 4 days.	50mg/kg body weight in feed for 21 days
Monensin	2mg/kg body weight daily for 20 days	20mg/kg in feed continuously
Lasalocid		25-100 mg/kg feed from weaning until market. Also in ewe's diet from 2 weeks before and until 60 days after lambing.

Source: [16].

Treatment, Control and Prevention: Prophylactic medication of feed and water supplies of feeder calves and lamps with most economic coccidiostat have been suggested to control the disease and allow the development of immunity. Coccidiosis is a self-limiting disease and clinical signs subside spontaneously when the multiplication stage of the parasite has passed. Sulpha drugs and others such as amprolium are drugs that are mostly used for the treatment of clinical coccidiosis [10]. Recommended drugs for the treatment and control of coccidiosis are indicated in Table 1. Maintaining an adequate resistance level in the herd, controlling the parasite multiplication in the animal and reducing pasture contamination, can prevent coccidiosis. These could be achieved by the following control measures:

- Avoiding overcrowding of animals
- Lambing and calving grounds should be well drained and kept as dry as possible
- Lambing pen should be kept dry: cleaned out frequently so that oocystsdo not have time to sporulate and become infective.

Presentation of Coccidiosis

In Different Countries of the World: Coccidiosis in small ruminant occurs word wide [8, 10, 36] but is of most important where animals are housed or confined in small areas [10]. Despite its worldwide distribution, data or its prevalence are scanty and are mostly reported from Europe and only few are reported from Africa and the prevalence ranges from 12.74 to 100% [37, 38]. The prevalence of Eimeria infection in cattle is generally high and can reach 100% in calves [39]. Calves at an age of 3 weeks to 6 months are particularlysusceptible to clinical coccidiosis [40], which rather reflects lack of immunity than age resistance, but high prevalence rates have also been documented in yearlings [39]. Prevalence of coccidiosis in ruminants in some countries of the world is given in Table 2, 3 and 4 below.

Table 2: Prevalence of coccidiosis in goats in different countries of the world

Country	Prevalence (%)	Source
South Iran	89.91	[41]
North East China	87.9	[42]
Northern Jordan	54	[43]
Netherlands	94.5, 65.5	[44]
England	98	[45]
Egypt	60	[46]
Czech republic	92.2	[47]
Malaysia	89	[48]
India	36	[48]
Poland	74	[49]
West Ukrine	100	[49]

Table 3: Prevalence of coccidiosis in sheep in some countries of the word

England	13.7	[50]
Iran	99.8	[51]
Tanzania	13.7	[52]
Turkey	47.7	[53]
Iran	16.7	[54]
Northeastern China	92.9	[42]
Egypt	57.7	[46]
Western Iran	91.5	[55]

Table 4: Prevalence of bovine Coccidiosis in different countries of the world

Countries	Prevalence (%)	Age affected	Source
Poland	27.1	cows	[56]
Poland	49.6	Calves	[56]
Colombia	75.5	Calves	[57]
India(Assam)	11.97	Cows	[58]
The Netherlands	16	Cows	[39]
Kenya	67.4	Calves and adult	[59]
South Africa	29-52	Calves and adult	[60]
Korea	25.9	Nor reported	[61]
Japan	59	2 weeks to adult	[62]
Saudi Arabia	31.27	Calves and adult	[63]
India(Punjab)	29.39	Calves	[64]
Turkey	68	Calves and adults	[65]
Mexico	87.8	Calves	[66]

In Africa: Few data suggest that the prevalence of *Emeria* infection in small ruminants generally ranges from 11.5% to 64.2% [67]. Most adult goats were observed to shed number of oocysts in their faeces. Thus Adult goat could be regarded as a source of infection for their kids.

However, the few infected weaners released the largest number of oocysts per gram of feces. The observation that weaners produce large number of oocystscompared to adults has also been reported elsewhere [67]. Weaners tend to produce more oocysts due to low immunity. The older goats have acquired immunity over periods of time and can therefore suppress *Emeria* infection leading to shedding of only a small number of oocysts.

In general, goats affected by *Emeria* specieswere reported from Africa, in Senegal [68], Zimbabwe [69], Tanzania [70] and 10 *Emeria*species from South Africa, with a prevalence of 96.6% was reported by Kebadu [71].

In Ethiopia: There is report of 20% prevalence in calves over 2 months of age in small scale dairy farms of Bishoftu [72], 68.1% prevalence of *Emeria*infection in calves in dairy farms in Addis Ababa and Bishoftu [15] and 59.6% and 37.8% prevalence of Eimeria infection in small ruminants in ELFORA export and Bishoftu, respectively [14].

CONCLUSION AND RECOMMENDATIONS

Coccidiosis is economically important protozoan disease of domestic animals responsible for heavy morbidity mortality worldwide. Young domestic animals are most susceptible hosts and the disease is more common where animals are housed or confident in small areas. The most commonly reportedrisk factors associated with its occurrence are shipping, crowding stress, ration change, severe weather change, poor nutrition and management and non-effective veterinary services. *Emeria* species are not generally host specific to another nor does cross immunity between parasites species couldoccur. Clinicalcoccidiosis is most common in domestic ruminants like cattle, goats and sheep.

Coccidiosis in domestic ruminants is well studied and ample information is available from different parts of the world like Europe, Asia, USA, Latin America and some few African countries. In Ethiopia, there is paucity of information on prevalence, species composition, pathogenicity, geographic distribution and economic significance of coccidiosis in domestic ruminants. But for efficient and sustainable control, this information and the exact identity of *Emeria* species are very helpful and most important. Based on the above concluding remarks the following points are forward;

- Further studies should be concluded to know the prevalence, geographic distribution, spp. composition and risk factors ofruminants' coccidiosis in different agro-ecology and animal management system in Ethiopia.
- Community awareness creation at all levels about economic significance of coccidiosis of ruminants should be in place
- More sensitive techniques should be employed for diagnosis of coccidiosis of ruminants in Ethiopia.

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