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Ovine coccidiosis: prevalence and associated risk factors in and around Addis-Zemen, Northwest Ethiopia

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Abstract: This cross-sectional study was conducted in and around Addis-Zemen from November 2014 to April 2015 to determine the prevalence of ovine coccidiosis and to identify associated risk factors. Faecal samples were collected directly from the rectum of 384 randomly selected animals. A centrifugal faecal flotation technique using saturated salt solution was used to detect *Eimeria* oocysts. Out of 384 samples, only 88 were found to contain *Eimeria* oocysts. *Eimeria* infection was recorded in all age and sex groups of the study animals. A strong significant association was observed ($P < 0.05$) between *Eimeria* infection and the faecal consistency, production system, hygienic status, age, and body condition of the sampled animals. However, an insignificant ($P > 0.05$) association was recorded between *Eimeria* infection and the origins and sex of the animals. *Eimeria* infection is likely to become a more important problem in small ruminants and will have great significance for producers in the future, as the increasing scarcity of land for grazing is forcing people to adopt more intensive management systems. Therefore, planning an effective control and prevention programme is essential if the well-being and productivity of sheep are to be maintained.

Key words: Addis-Zemen, faecal flotation, coccidiosis, oocyst, prevalence, sheep

1. Introduction

Recent reports have shown that Ethiopia possesses about 33 million head of sheep, which ranks it the second country in Africa and sixth in the world in this respect (1). Sheep represent an important segment of the Ethiopian livestock system. They are important sources of income for the agricultural communities, represent one of the country's major sources of foreign currency through the export of skins and meat, and are a source of animal protein. They also play a major role in the food supply and social well-being of rural communities living in conditions of extreme poverty, which is the particular case in eastern parts of Ethiopia (2).

Despite their role in food supply and economic development of Ethiopia, various biological and environmental factors limit their productivity and reproductive efficiency (3). The sharing of both internal and external parasitic diseases is of paramount importance in this regard. Among parasitic diseases, ovine coccidiosis is an important protozoan parasitic infection responsible for low productivity, impaired growth, and mortality in sheep populations (4).

Ovine coccidiosis is caused by various species of *Eimeria*, which develop in the intestine and abomasum

and occur mostly in young animals (5–7). According to Yakhchali and Golami (8) and Nourollahi-Fard et al. (7), *Eimeria* infections are of great economic and veterinary importance in the sheep population of the world. This disease leads to economic losses due to high mortality and morbidity, low growth performance, loss of weight gain, reduced productivity, and treatment costs (5,9). Clinically, coccidiosis is mainly asymptomatic, but may be manifested with inappetence, weakness, loss of weight gain, bloody diarrhoea, depression, anaemia, fever, dehydration, and tenesmus. Clinical cases occur most commonly in animals housed or confined in small areas contaminated with oocysts (9). Moreover, though all ages of sheep are susceptible to *Eimeria* infection, lambs are the most severely affected by clinical coccidiosis and disease outbreaks (10). Clinical coccidiosis in domestic animals becomes an economically important problem with the introduction of intensive rearing systems. Several factors affect the occurrence of the disease, such as age of the animal, production system, stocking density, overcrowded and unhygienic housing, climatic conditions, very poor weather conditions, the use of restricted areas to supplement the flock with extra food, stressor factors such as feed and environmental changes, malnutrition,

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concurrent infections, weaning, and transportation (7,9,11,12).

The prevalence of coccidiosis in sheep has been reported from different parts of the world (7,8,10,13–15), including Ethiopia (4). However, information regarding the prevalence of coccidiosis in the sheep population of Ethiopia seems to be limited (4). Moreover, no attempt has been made to determine the prevalence of *Eimeria* infection in the sheep population in and around Addis-Zemen, Northwest Ethiopia, or to identify its associated risk factors. Therefore, the aims of the present study were: 1) to estimate the overall prevalence of coccidiosis in sheep in the study area and 2) to identify risk factors associated with coccidiosis infection.

2. Materials and methods

2.1. Study area

The study was conducted in and around Addis-Zemen, Northwestern Ethiopia, about 630 km from the capital city, Addis Ababa. Addis-Zemen is located at 12°07'N, 37°47'E. The altitude of the study area is 1975 m above sea level. The area receives bimodal rainfall with a mean annual rainfall of 2500 mL; the long rainy season extends from June to September, while the short rainy season occurs from March to May. The mean annual minimum and maximum temperatures are 18 °C and 25 °C, respectively. The soil types encountered are red soil (36.25%), black soil (34.37%), and brown soil (29.38%). A mixed farming system is practiced by the communities in the study area.

2.2. Study design and sample size

A cross-sectional study type was employed during the dry season to determine the prevalence of *Eimeria* infection in sheep and to identify associated risk factors. A simple random sampling technique using a lottery system was used to select the study animals. The sample size of the present study was determined by using the single population proportion formula given by Thrusfield (16). Since there had been no previous work reporting the prevalence of ovine coccidiosis in the study area, the sample size was determined based on an expected prevalence of 50% and 5% absolute precision at a 95% confidence interval (CI). Accordingly, 384 animals were selected for the present attempt from four study sites/peasant associations.

2.3. Study animals

The 384 study animals were drawn from all age groups and both sex groups of the ovine population. They were indigenous breeds in origin, mainly kept for meat production and marketing purposes under an extensive and semiintensive management system. The age of the sampled animals was estimated using the technique given in ESGPIP (17). Accordingly, the sampled animals were grouped as lambs (<6 months), young (6–12 months), and adult (older than 12 months). The animals were also

categorised by good and poor body condition scores as given in ESGPIP (17) and Steele (18).

2.4. Sample collection

Fresh faecal samples were obtained directly from the rectum of randomly selected animals. The samples were then placed in air- and water-tight sample vials, labelled, and transported via a cool box to the Addis-Zemen veterinary clinic for faecal examination. Potential risk factors such as age, sex, origin, faecal consistency, production system, body condition, and hygienic status were recorded for each sampled animal.

2.5. Faecal examination

All collected faecal samples were processed using a simple flotation technique with saline solution (19). A qualitative faecal examination was made to search for *Eimeria* oocysts under a compound microscope to determine infection rate.

2.6. Study variables

Prevalence of *Eimeria* infection was the dependent variable, while age, sex, body condition score, hygienic status, production system, origin, and faecal consistency were examined as independent variables that could influence the occurrence of *Eimeria* infection in sheep.

2.7. Data management and analysis

The data were managed and summarised using SPSS version 16. Descriptive statistics such as percentage were used to express prevalence, while a chi-squared test was used to compare the association of *Eimeria* infection with different risk factors. The odds ratio (OR) and its 95% CI were calculated to determine the degree of association between potential risk factors and the *Eimeria* infection. All results were considered statistically significant when the P-value was <0.05 at a 95% CI.

3. Results

3.1. Overall prevalence of *Eimeria* infection in sheep

Three hundred and eighty-four faecal samples were collected from selected sheep to determine the prevalence of *Eimeria* infection in the study area. Out of 384 diagnosed faecal samples, 88 were found to harbour *Eimeria* oocysts with an overall prevalence of 22.9%. Regarding the study sites, the prevalence of *Eimeria* infection was 23.8% in Bura, 21.7% in Yfag, 22.4% in Angot, and 23% in Silkisa (Figure).

3.2. Potential risk factors

Hygienic status, production system, age, sex, faecal consistency, and body condition score were the considered risk factors in this attempt (Tables 1 and 2). Analysis of all potential risk factors was made by OR, with a 95% CI, and chi-squared analysis. The result showed strong significant associations between *Eimeria* infection and hygienic status ($\chi^2 = 47.816$, $P < 0.05$), production system ($\chi^2 = 38.273$, P

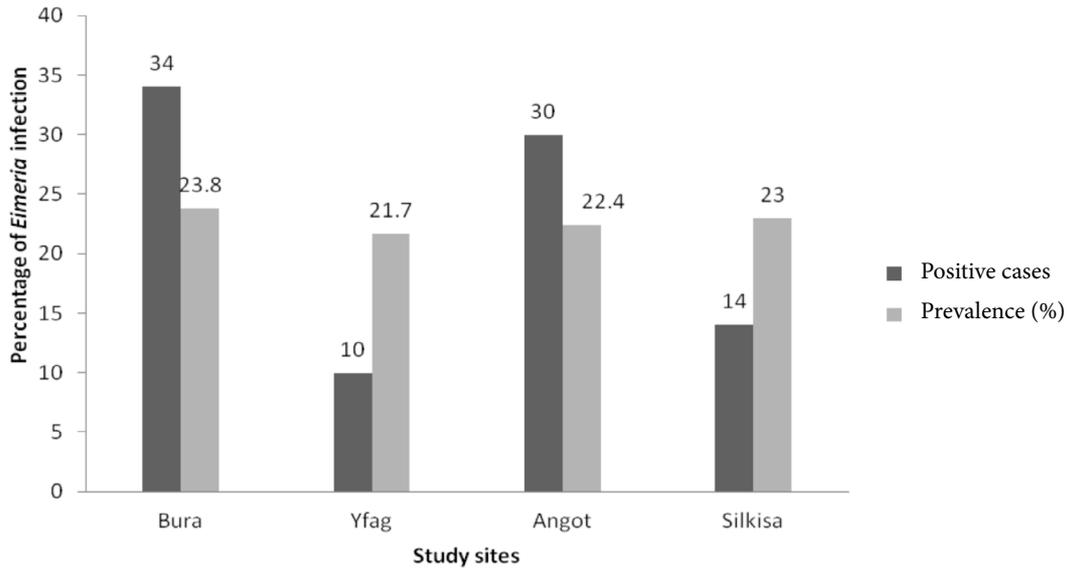


Figure. Prevalence of *Eimeria* infection in relation to the origin of the study animals.

Table 1. Prevalence of coccidiosis in relation to host-related factors.

Risk factors		N. examined sheep	N. positive cases	Pre (%)	95% CI	χ^2 (P-value)
Sex	Male	158	37	23.4	17.1–30.8	0.04 (0.845)
	Female	226	51	22.6	17.3–28.6	
Age	Lamb	77	33	42.9a	31.6–54.7	25.78 (0.00)
	Young	143	33	23.1b	16.5–30.9	
	Adult	164	22	13.4c	8.6–19.6	
Body condition	Poor	80	33	41.3a	30.4–52.8	19.23 (0.000)
	Good	304	55	18.1b	13.9–22.9	
Faecal consistency	Normal	201	21	10.5a	6.6–15.5	51.94 (0.00)
	Soft	106	28	26.4b	18.3–35.9	
	Diarrhoeic	77	39	50.7c	39.0–62.2	
Overall prevalence		384	88	22.92	18.8–27.5	

Different letters in the same column indicate statistically significant differences ($P < 0.05$) at each factor.

Table 2. Prevalence of ovine coccidiosis in relation to environmental factors and feeding type.

Risk factors		N. examined sheep	N. positive cases	Pre (%)	95% CI	χ^2 (P-value)
Hygienic status	Poor	169	67	39.6a	32.3–47.0	47.82 (0.000)
	Good	215	21	9.8b	5.8–13.7	
Production system	Semiintensive	172	63	36.6a	29.4–43.8	38.27 (0.000)
	Extensive	212	25	11.8b	7.5–16.1	
Overall prevalence		384	88	22.92	18.7–27.1	

Different letters in the same column indicate statistically significant differences ($P < 0.05$) at each factor.

< 0.001), age ($\chi^2 = 25.8$, $P < 0.05$), faecal consistency ($\chi^2 = 51.9$, $P < 0.001$), and body condition ($\chi^2 = 19.2$, $P < 0.001$) (Tables 1 and 2). The lambs were two times (OR = 2.5; 95% CI: 1.32–4.73, $P = 0.002$) and four times (OR = 4.84, 95% CI: 2.44–9.63, $P < 0.0001$) more likely to contract *Eimeria* infection than young or adult sheep, respectively. Similarly, young sheep had approximately two times (OR = 1.94, 95% CI: 1.03–3.69, $P = 0.027$) higher odds of being infected with *Eimeria* than adults.

Diarrhoeic sheep were approximately nine times (OR = 8.797; 95% CI: 4.4–17.5, $P < 0.0001$) and three times (OR = 2.86, 95% CI: 1.47–5.58, $P = 0.0008$) more likely to be diagnosed with *Eimeria* oocysts than sheep that had normal or soft faecal consistency, respectively. Moreover, sheep with soft faecal matter were demonstrated to be three times (OR = 3.08, 95% CI: 1.57–6.05, $P = 0.0003$) more likely to be infected with *Eimeria* than sheep that had the normal faecal consistency.

Regarding body condition score, *Eimeria* infection was three times (OR = 3.18, 95% CI: 1.79–5.58, $P < 0.0001$) higher in sheep with poor scores than in sheep with good scores. Likewise, *Eimeria* infection was approximately four times (OR = 4.323, 95% CI: 2.5–7.59, $P < 0.0001$) more likely to occur in semiintensively managed sheep than in extensively managed sheep. Further, *Eimeria* infection was also six times (OR = 6.068, 95% CI: 3.423–11.004, $P < 0.0001$) more frequently diagnosed in sheep with poor sanitation/hygiene than in sheep with good sanitation/hygiene. However, origin and sex did not demonstrate a significant ($P > 0.05$) interaction with *Eimeria* infection.

4. Discussion

Having information on the prevalence of coccidiosis and relevant risk factors is an important step in the design and implementation of an effective control programme to minimise its economic and health impacts in the sheep population. In the present study, the overall prevalence of *Eimeria* infection was found to be 22.9% based on coprological examination. This is comparable with the reports by Yakhchali and Rezaei (14) and Ntonitor et al. (20) in Iran and Cameroon, with 23.3% and 28.8% infection rates, respectively. However, the current finding is lower than the previous finding in Ethiopia by Ayana et al. (4) of a 59.6% infection rate in the small ruminant population. Similarly, Kanyari et al. (21) and Altaf et al. (22) also reported higher rates of *Eimeria* infection, with a prevalence of 54.68% and 35% in Iran and Kenya, respectively. According to Radostits et al. (9), Abebe et al. (23), and Heidari et al. (24), this variation might be attributed to the differences in agroecology, climate, weather conditions, season, the immune state of the host, sample size, sampling period, management type, and husbandry practices relating to the study animals in different areas.

In our study, *Eimeria* infection was higher in animals exposed to poor sanitation/hygiene. Poor sanitation/hygiene could be considered as a risk factor for coccidiosis, as it can increase levels of infection/exposure and incidence of the disease due to feed and water contamination and stress-induced immunosuppression (9,11,19). It has been reported that poor hygiene and overcrowded conditions may result in the development of higher levels of infection in the presence of noncemented floors, a closed housing system, and large herd size, due to greater contamination of overcrowded animals and feeding and watering troughs (14,22).

A significantly higher rate of *Eimeria* infection has also been recorded in semiintensive as exposed to extensive production systems for sheep. Lughano (25) noted that clinical coccidiosis is more frequently encountered in semiintensive than in extensively managed animals. He also stated that coccidiosis is likely to become a more important disease of small ruminants in sub-Saharan countries in the future, as the increasing scarcity of land is forcing people to adopt more intensive management systems. This might be due to the lower chance of infection with oocysts in extensive management systems, as they have larger, freer, and less contaminated areas than semiintensive management systems. In extensive systems, the degree of stress produced in relation to overcrowding and ventilation could be lower than in semiintensive systems. On the other hand, continuous exposure to low numbers of oocysts, which is often the case under field conditions, results in endemic stability (9,26), which makes animals managed in this way more resistant than housed animals.

The prevalence of *Eimeria* infection showed no significance difference between male and female sheep. This is in agreement with the reports by Maingi and Munyua (27), Yakhchali and Rezaei (14), and Craig et al. (28). This is probably due either to equal likelihood of being exposed to *Eimeria* oocysts or to the absence of differences in protective immunity to the disease between sex groups. On the other hand, the present finding is inconsistent with the report by Khan et al. (10), who described that ewes are more susceptible to *Eimeria* infection. Similarly, Yakhchali and Golami (8) reported sex influences the prevalence of ovine coccidiosis. This might be ascribed to sex-related factors, such as the physiological stress experienced by female animals in relation to pregnancy; giving birth and lactation could also cause female animals to be more susceptible to *Eimeria* infections (24,29).

According to Heidari et al. (24), age is one of the major risk factors that influence the occurrence of *Eimeria* infection in domestic animals; morbidity, mortality and risk of infection are greater in calves, kids, and lambs (23, 30). In our study, lambs were found to be more infected

by *Eimeria* species than adults and older animals. This is in line with the reports of Radostits et al. (9), Ayana et al. (4), Khan et al. (10), and Lopes et al. (29), who stated that lambs are more susceptible than ewes or yearlings. Similarly, Nourollahi-Fard et al. (7) encountered a higher prevalence of *Eimeria* infection in lambs than in yearlings and adults. This could be attributed to the development of acquired immunity in adults following previous exposure over a period of time, which therefore suppresses *Eimeria* infection so that animals become resistant to subsequent reinfection (9,10). The presence of oocysts in all age groups of sheep indicates that this parasite can infect sheep in every age group. This is in accordance with the findings reported by Ayana et al. (4) in Ethiopia and Craig et al. (28), Rehman et al. (30), Heidari et al. (24), and Nourollahi-Fard et al. (7) elsewhere in the world.

A strong significant association was recorded between body condition score and *Eimeria* infection in our study. Similarly, Khan et al. (10) reported a higher infection rate in sheep with poor body scores than in sheep with good body scores. This might be due to the weak immune status of poorly scored animals as a result of malnutrition and other parasitic infections, which results in immunocompromise. This condition produces a higher infection rate in poor-state animals than in good-state animals (9).

Lastly, the occurrence of *Eimeria* oocysts in the faeces was significantly associated with diarrhoea rather than with normal or soft faecal consistency. This finding agrees with the reports by Yakhchali and Golami (8) and Yakhchali and Rezaei (14), which found a positive correlation between diarrhoeic animals and *Eimeria* infection in all age groups of sheep. A higher level of *Eimeria*, especially in lambs, damages the intestinal lining

and results in improper or reduced absorption of nutrients and weight loss. This damage can also result in bloody and dark diarrhoea, causing dehydration and death (31).

5. Conclusion

To the best of the authors' knowledge, this work, which found an overall prevalence of the infection of 22.9%, is only the second report in Ethiopia to address this subject. *Eimeria* infection rate was never significantly associated with the sex or origin of the animals examined. However, it was significantly associated with age, production system, body condition score, hygienic status, and faecal consistency. Even if *Eimeria* oocysts were detected in all age groups, higher prevalence was recorded in lambs than in adults or yearlings. In general, *Eimeria* infection is prevalent and considered to be of great concern to the farmers in and around Addis-Zemen. Therefore, attention should be focused on colostrum feeding within 24 h of lambs' birth, minimising stressful conditions (weaning, overcrowding, and poor hygiene conditions), and separating sick and diarrhoeic animals from the group. Moreover, further studies should be undertaken to identify the most pathogenic *Eimeria* species and to reveal more information about the economic effects of *Eimeria* infection, which would be useful for establishing control programmes.

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