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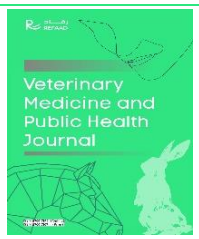

Cross Sectional Study of Poultry Coccidiosis in Adele Poultry Farm, Eastern Hararghe, Oromia, Ethiopia

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Abstract:

Objective: This study was to determine the number of chickens in intensively managed poultry farms and to assess the relationship between the number of chickens and risk factors in specific poultry farm.

Methods: A cross-sectional study was conducted in Adele town between December 2014 and November 2015. The presence of oocysts in the fecal samples was examine by floatation methods and post-mortem examinations looked for intestinal lesions.

Results: Out of the 262 chicken sample sources examined, 29 (11.01%) were positive for coccidian oocysts, and out of the 84 total Environmental sample source examined, 12 (14.4%) were positive for coccidian parasites. There were no statistically significant differences in prevalence across the sample type and source ($p>0.05$). There were no changes in the prevalence of coccidiosis between the sexes of birds. $P<0.05$ indicates a statistically significant difference between the age groups. Furthermore, a strong correlation was found between the sample times. The prevalence of coccidia was considerably higher in chicks than in adults ($P<0.05$). The environment had a greater prevalence of coccidiosis than faeces did. Of the environmental samples, the majority of coccidial infections are linked to management issues, and the prevalence of water and feed is higher than that of litter material.

Conclusions: This study showed that coccidiosis is a significant disease affecting poultry in the studied area and that effective control measures must be developed to reduce the illness's impact.

Keywords: *Adele; Chicken; Coccidiosis; Eimeria; Flotation; Oocyst; Prevalence.*

1 Introduction

Ethiopia produces an estimated 56.5 million chickens annually, of which 99% are farmed using the conventional backyard method and 1 percent are exotic breeds kept under strict management (Abadula *et al*, 2022). When compared to backyard chicken production, the intensive management approach exhibits more input, higher output, and less flock destruction from disease outbreaks (Sarba *et al*, 2019).

The poultry sector is a major source of animal protein for humans, specifically meat and eggs, and it also contributes significantly to the national economy by generating income (Mohammed & Sunday, 2015). Poultry is one of the most intensively reared of the domesticated species and one of the most developed and profitable animal production enterprises (Dutta *et al*, 2013). Even though Ethiopia produces a lot of chicken, the industry has very little economic impact or value because of disease, poor nutrition, and poor management (Sambo *et al*, 2015). These illnesses include dietary deficiencies, chronic respiratory conditions, Salmonellosis, Coccidiosis, and Newcastle disease (Asfaw *et al*, 2019).

A protozoan parasite that is a member of the Apicomplexa phylum, the Eimeridae family, and the genus Eimeria is the source of the serious chicken disease coccidiosis (Mesa-Pineda *et al*, 2021).

In chickens, seven pathogenically significant species of coccidia are known to exist: Eimeria acervulina, Eimeria brunetti, Eimeria maxima, Eimeria necatrix, Eimeria tenella, Eimeria praecox, and Eimeria mitis (Mesa *et al*, 2021). Poultry farmers, feed manufacturers, and experts in poultry diseases must pay attention to the serious disease problem of coccidiosis (Chalchisa & Deressa, 2016). The oocyst, the infectious form of the parasite, sporulate in the natural environment two days after excretion through the faeces and can be ingested by a susceptible host organism (McDougald *et al*, 2020). In addition, affecting digestive systems of birds, coccidiosis causes by enteritis and diarrhoea, which in some cases can turn bloody when it affects particular species of Eimeria (Abebe & Gugsa, 2018). Sporozoites replicate in the intestinal tract's epithelial cells, causing tissue damage that impairs digestion, stops feeding, dehydrates the body, and causes blood loss (McDougald *et al*, 2020).

Some of the risk factors for numerous gastrointestinal bacterial poultry diseases, including Colibacillosis, Salmonellosis, and Clostridium, are the macroscopic lesions in the digestive tract Dakpogan & Salifou, 2013). Coccidiosis is made worse by a few immunosuppressive viral infections, including infectious bursal disease, Marek disease, and chick anemia infectious viral disease (Schat & Skinner, 2022). Because of the disease's high rates of morbidity and mortality in both young and adult birds, as well as its decreased feed conversion efficiency and egg production, particularly in subclinical cases, it is significant economically (Abebe & Gugsa, 2018).

Coccidiosis, a disease influenced by poor farm conditions, requires better management. Despite reduced incidence in commercial production due to improved housing, hygiene, and management, the disease remains a significant issue requiring further research. This study investigates Coccidiosis prevalence and risk factors in Adele Litter-based medium stocking exotic layer rearing system. Therefore, the present study aims at the following objective:

- To determine the prevalence of chicken Coccidiosis in selected areas of Adele poultry farms.
- To identify possible risk factors for the occurrence of the disease.

2 Materials and Methods

2.1. Study Area Description

The study was conducted from October 2014 to May 2015 in selected intensive poultry farms, Adele poultry production farm, which are found in Eastern Hararghe zone, Eastern Ethiopia. These farms are approximately 502 km far from Addis Ababa. The elevation of this farm is about 2000 m above sea level and geographically located at $\mathbf{41^0 59^1 58^{11}}$ latitude and $\mathbf{09^0 10^1 24^{11}}$ longitude. Adele poultry farms receive an average rain fall of approximately 900 mm, and climatically found at highland areas (Abera & Geta, 2014). The Adele Poultry Breeding and Multiplication Centre (APBMC) is a deep litter medium scale state owned intensive poultry farm with a land holding capacity of 4.8 hectare. Currently, the farm has 4 functional poultry houses which are used for rearing of 2200 grower chickens. The rearing houses have an area of 360 m^2.

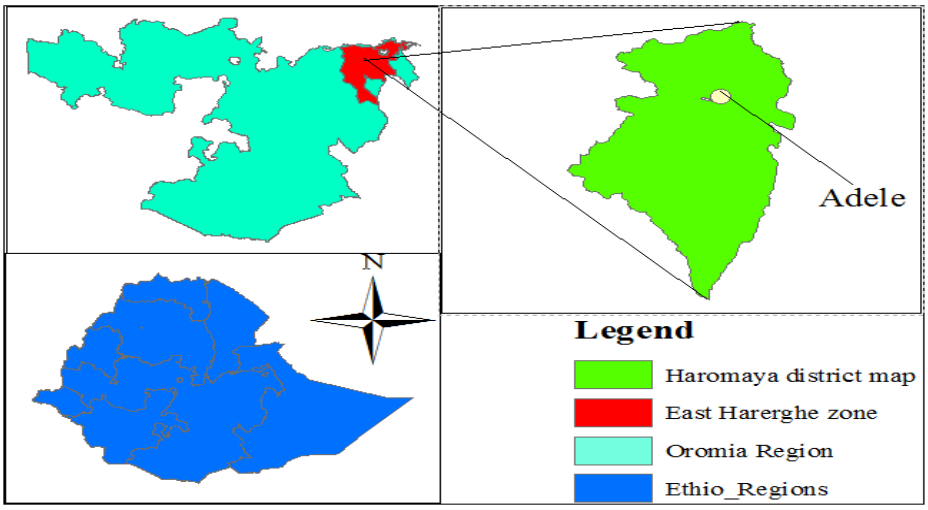

Fig. 1: Map of study area (Ethiopian GIS, 1994)

2.2. Study Population

The study population was made up of exotic white leg horn grower birds with less than a year old from intensive poultry farms, classified as layers and broilers, and divided into two age groups: young (2–8 weeks) and mature (above 8 weeks).

Study animals including breeds of both sexes and randomly chosen (purposive) samples from intensively raised chickens produced on the farm.

2.3. Housing and Poultry Management

With a 4.8-hectare land holding capacity, the state-owned Adele chicken Breeding and Multiplication Centre (APBMC) is a medium-sized, deep litter intensive chicken farm. There are currently 2,200 grower chicks raised on the farm in 4 operational poultry buildings. The rearing houses have an area of 360 m^2. The feeds are commercially prepared balanced feed that have vitamins and minerals. Feed is given in troughs. The trough is distributed properly in the houses to prevent overcrowding. The distribution and clean up time should be monitored routinely. Watering is given through water troughs, that put in different place and all chickens can acess fresh, clean and drinkable water. The litter turned regularly within two weeks to prevent contamination of disease.

The farm's flock health management was basically based on prevention and comprised of vaccination, medication, bio - security and sanitation (cleaning and disinfection). Vaccination against New castle, mareks Coccidial diseases was given in the farms.

2.4. Study Design

A cross-sectional study was assessed from December 2014-November 2015 to determine the prevalence and associated risk factors of coccidiosis in grower chickens in selected Adele poultry farms.

3.5. Sample Size Determination

The sample size was calculated using the formula of utilizing basic random sampling techniques and a 95% confidence interval with the necessary 5% precision (Thrusfield 2007).

$$n = \frac{1.96^2 \times p_{exp} \times (1-p_{exp})}{d^2}$$

Where; n= required sample size
Pexp=expected prevalence
d= required precision

Since the study was undertaken in Amhara at kombolcha poultry farm with prevalence of 25.04%. Accordingly, with 5% absolute precision at 95 % confidence level, the number of samples required to determine the prevalence was found to be 289. However, 346 samples were collected to increase the accuracy of the samples. The sample was taken from poultry feaces. Additionally, all environmental samples from feed, water, litter were included. The dead chick was also examined for the condion in the GIT.

2.6. Sample type and sampling method

Fecal samples**:** Samples of the birds' faeces were taken using a spatula for recently voided excrement or, if it wasn't feasible, right from the cloaca. The faeces sample was collected, labelled properly, and sent to the Veterinary Parasitology Laboratory at Haramaya University for processing. To be evaluated for coproscopy within 48 hours, samples were stored in a refrigerator at 4 ^oC.

Environmental samples**:** From each houses water, feed, litter samples were collected in cleaned

sampling bottles and transported for laboratory examination to Haramaya University.

Postmortem Examination: In addition, postmortem examinations were carried out on deceased chickens, and a comprehensive examination of the gastrointestinal system was performed to look for obvious pathological abnormalities.

2.7. Laboratory procedures

Eimeria oocysts were found by qualitative faecal testing employing the flotation technique and a concentrated sodium chloride solution (Kiltu *et al*, 2016). Postmortem samples were examined by opening the gut looking for oocyst by light microscope directly and culture for species identification.

2.8. Data management and analysis

The format created for this purpose was used to record the data collected from the research region and the results of the faecal examination. The data was then imported into Microsoft Excel 2007 and STATA 7.0 was used for analysis. The raw data that were recorded were imported into a Microsoft Excel database system so that they could be examined using the statistical software for social science version 16. It computed descriptive statistics. The number of chickens discovered to have coccidia infection, represented as a percentage of all the chickens inspected, was used to determine the prevalence of coccidiosis (Thrusfield 2007). The correlation between several parameters and the prevalence of coccidiosis was assessed using Pearson's chi-square analysis. Every analysis regarded a P-value of less than 0.05 significant (at the 5% level of significance).

3 Result

In the present investigation, the total coccidiosis prevalence was 11. 9% (41/346), but according to sample source, 14.4% and 11.1% from the environment and chicken respectively.

Table 1: Prevalence of coccidiosis in studied poultry farm by sample source and sample type.

Sample Source	Sample type	No. of examined samples	Positive samples No. (%)	X^2	P- Value
Environment	Feed	28	5 (17.9)		
	Litter	28	5 (17.9)	2.68	0.443
	Later	28	2 (7.1)		
	Sub total	**84**	**12 (14.4)**		
Chicken	Feces from male	160	17 (10.6)		
	Feces from female	102	12 (11.8)	0.08	0. 77
	Sub total	**262**	**29 (11.1)**		
	Total	**346**	**41 (11.9)**		

The frequency of coccidiosis by age:

Those who were younger than adults had the highest prevalence. Between the different age groups, there was a statistically significant difference ($p<0.05$) in the prevalence of coccidiosis.

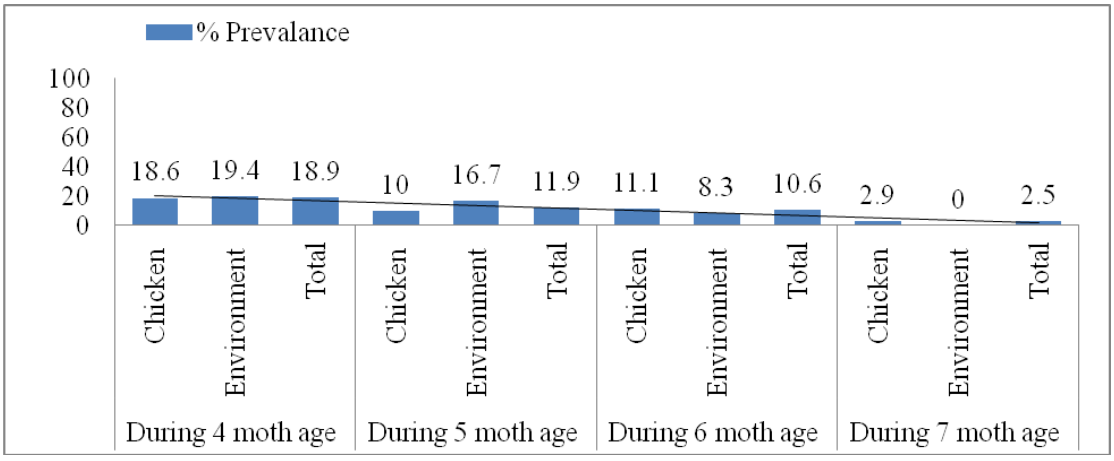

Fig. 2: Prevalence of coccidia in the poultry farm during different ages of chicken.

There was statistically a significant association between infection with coccidiosis and sampling time.

Table 2: Prevalence of Poultry coccidiosis based on sampling occasion.

Sampling Occasions	No. of examined samples	Positive samples No. (%)	X^2	P- Value
1st Occasion	42	11 (26.2)		
2nd Occasions	41	8 (19.5)		
3rd Occasions	33	3 (9.1)		
4th Occasions	42	7 (16.7)	20.14	0.01
5th Occasions	42	3 (7.1)		
6th Occasions	30	4 (13.3)		
7th Occasions	36	3 (8.3)		
8th Occasions	48	2 (4.2)		
9th Occasions	32	0		

The primary risk factors for the prevalence of coccidiosis (11.85%) in the current study were found to be cannibalism, high stocking density, inadequate cleaning of utensils, lack of an isolation pen (mixing sick and healthy birds in a house), defective feeders and waterers that allow the birds to enter the utensils and defecate in them, the deep litter system (quality of the litter/infrequent change and turning of the litter), and defective or intentionally inclusion of anti-coccidial drugs in feed and water.

4 Discussion

The overall prevalence of coccidiosis in the current study was 11.9% but according to the sample source 14.4% and 11.1% from the environment, and chicken respectively observed in studied farm was similar with **(**Grema *et al*, 2014), who reported a prevalence of 11.04% in Nigeria, Africa. Lower than the finding of 19.5% (Garbi *et al*, 2015), at East Wollega, Nekemte, 20.57% reported by (Oljira *et al*, 2012), in and around Ambo town. 25.24% reported by (Amare *et al*, 2012), in Kombolcha, Amara, Ethiopia. This could be due to differences in the farming system with differences in application of biosecurity where (Oljira *et al*, 2012) included chicken under backyard farming system with low prevalence 12.4% than the intensive farm (25.2%) showing risk minimization of free farming. Additionally, the differences in prevalence could be due to differences in the management types, husbandry practices and epidemiology of coccidian infection. Moreover, this could also be due to the fact that the study has been undertaken mainly in dry season (Grema *et al*, 2014) indicated low occurrences of coccidiosis during dry season in Nigeria.

With regards to chicken sex, absences of differences between both sex from this investigation was parallel with the reports of (Oljira *et al*, 2012) and (Amare *et al*, 2012). This could be associated with equal exposure of both sexes under the same farm management. But the present finding in female (11.8%) and male (10.6%) was lower than the 1.43% and 19.38% (Oljira *et al*, 2012) and 36.8% and 32.3% (Amare *et al*, 2012)**,** in than respective of sex which might be difference in the farming system. Unlike this finding of (Oljira *et al*, 2012), (Amare *et al*, 2012), and (Garbi *et al*, 2015), dictated higher prevalence of coccidiosis in male than female.

Difference in prevalence of coccidiosis among age group observed from the present finding was differed from the report of (Oljira *et al*., 2012), whose reports absence of difference between age groups of birds which could be due to differences in the studied farm type. In the present finding there is consistence decrease in prevalence with increase in age of children (Oljira *et al*, 2012), also fined a significantly higher mean oocytes count per gram of faeces in young than adult birds. This may be due to early age stress of adaptation to new environment and low exposed immunity at early age (Garbi *et al*., 2015), and **(**Muazu *et al*, 2008) suggested all age group poultry are vulnerable to infections, but these typically go away by the time they are 6 to 8 weeks old. It seems that the relationship between age and prevalence of coccidiosis is direct due to the complete life cycle and increase of oocysts consumption **(**Radiostitis *et al*., 2007), indicated the association of immunity and infection. In the reverse (Amare *et al*, 2012), also concluded the prevalence has decreased among growers (22.3%) but is reciprocal in the adults (35.3%) which could be due to the differences in the agroecology of studied areas and farming systems of poultry.

Prevalence of coccidiosis in different facilities used in the studied poultry farm where 17.9% equal occurrence in feed and litter showed contamination of feed and its action as possible sources of infection of poultry. Moreover, the observation of 7.1% in water shows high risk of source for chicken and for contamination of utensils during cleaning. The primary risk factors

for the prevalence of coccidiosis were found to be cannibalism, high stocking density, inadequate cleaning of utensils, lack of an isolation pen (which mixes healthy and sick birds in a home), defective feeders and waterers that allow the birds to enter the utensils and become deficient in them, and a deep litter system (quality of the litter/infrequent change and turning of the litter). This outcome concurred with the discovery of (Akcay *et al*., 2011).

The sampling occasion showed significantly differences in the prevalence of coccidiosis where high during the first (26.2%) and second (19.5%) in the October month of the study. This May be associated with differences in daily management activities, presence of random sampling occasions and humid weather condition of October in the area (Al-Natour *et al*., 2002) also showed at 1-5 sampling occasions of their work the wet and humid environment essential factor for maintaining oocysts sporulation and survivability weather favors the growth and multiplication of the organism (Grema *et al*, 2014).

The application of preventive measures, which were primarily related to the use of anticoccidial drugs that were given at an early age starting in the second week of life for a duration of 7–14 days of growing period in the studied farm management practices, may be primarily responsible for the relatively high reduction in the prevalence of coccidiosis during sampling sequence observed in the current study. There may also be a result from the chicken's immune system developing after exposure, a minor improvement in the management system, and biosecurity. Other researchers and authors might concur with this conclusion (Amare *et al*, 2012).

5 Conclusion and Recommendations

The present study's conclusion showed that coccidiosis is a significant disease affecting poultry in the study area and is still regarded as a major factor impacting the performance of poultry raised in intensive production systems globally. Serious sickness brought on by a high coccidiosis infection rate has increased morbidity and mortality rates in the chicken industry.

It was also shown that the age and length of the sample collection period were related to the occurrence of coccidiosis, indicating that it is a significant parasite disease that may be linked to ineffective management practices, ineffective use of anticoccidial medications, and variations in meteorological conditions.

Different factors could be at play in backyard poultry farming systems, such as inadequate housing or the easy dispersal of coccidial oocysts between susceptible and infected hosts. Additionally, because of their increased capacity for reproduction, the agent used to maintain chickens free of coccidian is quite complex. As a result, farm veterinarians will enhance the way that time and management are changed on the farm. Therefore, it needs extensive study and interventions to create long-term, sustainable prevention and control measures in order to eradicate the disease.

Therefore, in line with the above facts the following are recommended:

- awareness creation to the farm workers and owner on the hygienic measure is very essential.
- Emphasis should be given to an appropriate use of anti coccidial drugs to avoid the development of drug resistance.
- Integrated control and prevention measures should be designed by professionals.

Further research on epidemiology and risk factors for the prevalence of the disease on the poultry under backyard farming system in the area recommended.

References:

Abadula, T. A., Jilo, S. A., Hussein, J. A., & Abadura, S. Z. (2022). Poultry production status, major constraints, and future prospective. *Journal of World's Poultry Science*, 1(1), 22-28. https://doi.org/10.58803/jwps.v1i1.4

Abebe, E., & Gugsa, G. (2018). A review on poultry coccidiosis. *Abyssinia Journal of Science and Technology*, 3(1), 1-12.

Abera, B., & Geta, T. (2014). Study on challenges and opportunities of village chicken production in Haramaya District, Eastern Ethiopia. *International Journal of Science Research Publication*, 4(12), 2250-3153.

Akcay, A., Ertugrul, O., Gurcan, İ. S., & Karaer, Z. (2011). Quantification of risk factors of coccidiosis in broilers by using logistic regression analysis. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, 58(3), 195-202. https://doi.org/10.1501/vetfak_0000002474

Al-Natour, M. Q., Suleiman, M. M., & Abo-Shehada, M. N. (2002). Flock-level prevalence of Eimeria species among broiler chicks in northern Jordan. *Preventive veterinary medicine*, 53(4), 305-310. https://doi.org/10.1016/s0167-5877(01)00281-1

Amare, A., Worku, W., & Negussie, H. (2012). Coccidiosis prevailing in parent stocks: A comparative study between growers and adult

layers in Kombolcha poultry breeding and multiplication center, Ethiopia. *Global Veterinaria*, 8(3), 285-291.

Asfaw, Y., Ameni, G., Medhin, G., Alemayehu, G., & Wieland, B. (2019). Infectious and parasitic diseases of poultry in Ethiopia: a systematic review and meta-analysis. *Poultry science*, 98(12), 6452-6462. https://doi.org/10.3382/ps/pez521

Chalchisa, T., & Deressa, F. B. (2016). Poultry coccidiosis: Prevalence and associated risk factors in extensive and intensive farming systems in Jimma Town, Jimma, Ethiopia. *Journal of Veterinary Medicine and Animal Health*, 8(12), 223-227. https://doi.org/10.5897/jvmah2015.0425

Dakpogan, H. B., & Salifou, S. (2013). Coccidiosis prevalence and intensity in litter based high stocking density layer rearing system of Benin. *J. Anim. Plant Sci*, 17(2), 2522-2526.

Dutta, R. K., Islam, M. S., & Kabir, A. (2013). Production performance of indigenous chicken (Gallus domesticus L.) in some selected areas of Rajshahi, Bangladesh. *American J. Expt. Agric*, 3(2), 308-323. https://doi.org/10.9734/ajea/2013/2846

Garbi, F., Tesfaye, A., & Woyessa, M. (2015). Study on prevalence of poultry coccidiosis in Nekemte town, East Wollega, Ethiopia. *African Journal of Agricultural Research*, 10(5), 328-333. https://doi.org/10.5897/ajar2013.6946

Grema, H. A., Suleiman, A., Rabana, J. L., & Geidam, Y. A. (2014). A six year (2005-2010) retrospective study of avian coccidiosis diagnosed in Gombe veterinary clinic, Nigeria. Sokoto *Journal of Veterinary Sciences*, 12(2), 8-13. https://doi.org/10.4314/sokjvs.v12i2.2

Kiltu, G., Keffale, M., & Muktar, Y. (2016). Study on Prevalance of Small Ruminant Coccidiosis in and Around Harmaya, Eastern Haraghe Ethiopia. *Acta Parasitologica Globalis*, 7(1), 7-11.

McDougald, L. R., Cervantes, H. M., Jenkins, M. C., Hess, M., & Beckstead, R. (2020). Protozoal infections. Diseases of poultry, 1192-1254.

Mesa, C., Gómez-Osorio, L. M., López-Osorio, S., Williams, S. M., & Chaparro-Gutiérrez, J. J. (2021). Survey of coccidia on commercial broiler farms in Colombia: frequency of Eimeria species, anticoccidial sensitivity, and histopathology. *Poultry Science*, 100(8), 101239. https://doi.org/10.1016/j.psj.2021.101239

Mesa-Pineda, C., Navarro-Ruíz, J. L., López-Osorio, S., Chaparro-Gutiérrez, J. J., & Gómez-Osorio, L. M. (2021). Chicken coccidiosis: from the parasite lifecycle to control of the disease. *Frontiers in Veterinary Science*, 8, 787653. https://doi.org/10.3389/fvets.2021.787653

Mohammed, B. R., & Sunday, O. S. (2015). An overview of the prevalence of avian coccidiosis in poultry production and its economic importance in Nigeria. *Veterinary Research International*, 3(3), 35-45.

Muazu, A., Masdooq, A. A., Ngbede, J., Salihu, A. E., Haruna, G., Habu, A. K., … & Jamilu, H. (2008). Prevalence and identification of species of Eimeria causing coccidiosis in poultry within Vom, Plateau State, Nigeria. *International journal of Poultry Science*, 7(9), 917-918. https://doi.org/10.3923/ijps.2008.917.918

Oljira, D., Melaku, A., & Bogale, B. (2012). Prevalence and risk factors of coccidiosis in poultry farms in and around Ambo Town, Western Ethiopia. *American-Eurasian Journal of Scientific Research*, 7(4), 146-149.

Radiostitis, O. M., Gay, C., Constable, P. D., & Hinchliff, K. W. (2007). *Disease associated with protozoa.* veterinary medicine a text book of the disease of horse, sheep, pig, and goat.

Sambo, E., Bettridge, J., Dessie, T., Amare, A., Habte, T., Wigley, P., & Christley, R. M. (2015). Participatory evaluation of chicken health and production constraints in Ethiopia. *Preventive veterinary medicine*, 118(1), 117-127. https://doi.org/10.1016/j.prevetmed.2014.10.014

Sarba, E. J., Bayu, M. D., Gebremedhin, E. Z., Motuma, K., Leta, S., Abdisa, K., … & Borena, B. M. (2019). Gastrointestinal helminths of backyard chickens in selected areas of West Shoa Zone Central, Ethiopia. *Veterinary Parasitology: Regional Studies and Reports*, 15, 100265. https://doi.org/10.1016/j.vprsr.2019.100265

Schat, K. A., & Skinner, M. A. (2022). Avian immunosuppressive diseases and immune evasion. *In Avian immunology* (pp. 387-417). Academic Press.

Smith, M. K., Buhr, D. L., Dhlakama, T. A., Dupraw, D., Fitz-Coy, S., Francisco, A., … & Kiss, M. M. (2023). Automated enumeration of Eimeria oocysts in feces for rapid coccidiosis monitoring. *Poultry Science*, 102 (1), 102252. https://doi.org/10.1016/j.psj.2022.102252

Thrusfield, M., (2007). Veterinary Epidemiology 3 ed, Epidemiology Veterinary Clinical Studies, Royal (Dick) School of of Eimeria and associated risk factors in cattle of Veterinary Studies, University of Edinburgh, district Toba Tek Singh, Pakistan. *Parasitol Res., Blackwell Science Ltd, a Blackwell Publishing Company*, pp: 232-246.