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Epidemiological status of *Eimeria* species infection and associated risk factors in commercial poultry farms in Ibadan, Nigeria

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Abstract

This study investigated the prevalence of *Eimeria* species and associated risk factors in commercial chickens in Ibadan, Nigeria. Between May and December 2023, 330 faecal samples were randomly collected from chickens in 22 poultry farms across 11 Local Government Areas. Microscopic analysis was used to determine the prevalence and intensity of infections. Data on breed, sex, age, husbandry practices, and treatment history were also collected. Descriptive statistics, correlation, and Chi-square tests ($\alpha = 0.05$), were used for data analysis. Results showed that 81.2% of faecal samples were positive for *Eimeria* oocysts. Seven *Eimeria* species were identified, with varying prevalence: *E. mitis* (24.8%), *E. praecox* (17.8%), *E. acervulina* (16.8%), *E. brunetti* (14.6%), *E. maxima* (13.9%), *E. tenella* (5.9%), and *E. necatrix* (5.8%). Farm-level prevalence ranged from 72.3% (PINW2, PISE1, and PON1) to 86.7% (PAK2, PEG2, PID2, PLA1, PLA2, and PON2). The total oocyst count was 5154.7, with the highest mean oocysts per gram recorded in farm PLA1 (457.7± 204.9) and the lowest in farm PEG2 (88.5±36.3). Age, breed, and management system were significantly associated with *Eimeria* infection ($p<0.05$). This research indicates that *Eimeria* infection is endemic and a significant health concern in Ibadan poultry farms.

Introduction

The most commercialized livestock produced in Nigeria is poultry (Kassali *et al* 2022). Having an approximate net worth of 180 billion dollars ($600 million) and 165 million birds, poultry farming accounts for 25% of Nigeria's agricultural GDP (FAO 2010; Sahel 2015). According to recent estimates, Nigeria produces 650,000 metric tons (MT) of eggs and 290,000MT of poultry meat annually, making it the continent's top producer of eggs and the fourth biggest producer of chicken (USDA 2013). Due to its many advantages over other animal businesses, the poultry industry has gained a lot of recognition in Nigeria. Chickens are adept at turning grain into meat, which is a type of protein (Ojo 2003). It has a promising turnout rate and requires little initial investment for production. Poultry makes up roughly 15% of the overall yearly protein consumption, with each head consuming about 1.3kg of chicken (Ologbon and Ambali 2012). Therefore, it is impossible to overstate the significance of the poultry sector to the Nigerian economy.

Poultry production faces difficulties even though it plays a major role in the livestock sector (Anosike *et al* 2020). It is impossible to overstate the difficulties of Nigerian poultry production. The industry's output pace has slowed as a result of these difficulties. Aromolaran *et al* (2013) and Ajala *et al* (2020) and noted that a significant difficulty in chicken production is the high rate of disease and pest attack. Coccidiosis is an infectious disease of poultry birds.

Coccidiosis, caused by apicomplexan protozoan parasites of the genus *Eimeria*, remains a major economic burden on the poultry industry worldwide due to morbidity, mortality, reduced production, and treatment costs (Zaman *et al* 2012). *Eimeria* species multiply within the intestinal epithelial cells, with seven recognized species in chickens causing distinct disease presentations based on their location in the gut (Lawal *et al* 2016a). *Eimeria tenella* and *E. necatrix* are the most pathogenic, causing severe lesions, high morbidity, and mortality. Other species include *E. maxima*, *E. acervulina*, *E. mitis*, *E. praecox*, and *E. brunetti* (Zhang *et al* 2013). Transmission occurs through ingestion of sporulated oocysts, which are environmentally resistant (Majaro 2001). The increasing prevalence of drug-resistant *Eimeria* strains diminishes the effectiveness of coccidiostats and results in subclinical coccidiosis, reduced weight gain, and impaired feed conversion. In Nigeria and other developing countries, coccidiosis exacerbates malnutrition and food security issues, impacting household protein intake and income.

The challenges posed by coccidiosis, including difficult diagnosis based on oocyst morphology and widespread drug resistance, necessitate novel control strategies. Current research focuses on alternative control methods, including cloning *Eimeria* species for recombinant vaccines, to address the limitations of coccidiostats and live vaccines (Huang *et al* 2008; Blake and Tomley 2014). Subclinical coccidiosis leads to poor nutrient utilization and consequently, reduced

commercial performance in poultry (Blake and Tomley 2014). This study aims to determine the epidemiological status of *Eimeria* species in commercial poultry farms in Ibadan, Nigeria, and identify associated risk factors for oocyst transmission.

Materials and methods

Study area

Ibadan was founded in the 1820's (Mabogunje 1968) and lies between Latitude 7° 02′ 49″ and 7° 43′ 21″N longitude 3° 31′ 58″ and 4° 08′ 20″E (Figure 1). Ibadan is the capital of Oyo State and has been an important administrative centre since colonial times. The climate of Ibadan is tropical with distinct wet and dry seasons and a mean minimum annual temperature of 21°C (68.8°F) but in consonance with seasonal variations in radiation, sunshine and cloud cover, the mean annual temperature, could change. Between March and October, the prevalent winds in the city is the moist maritime South-west monsoon, which blows inland from the Atlantic Ocean, this is the period of rainy season. November to February is the period of dry season when the dry dust laden winds blow from the Sahara Desert. The mean annual rainfall of about 1,205 mm, falling in approximately 109 days with two rainfall peaks in June and September (Egbinola and Amobichukwu 2013). Regarding vegetation, the study area is situated within a freshwater wetland in the rainforest region and is densely covered with shrubs and tall, woody trees. The prevalence of dense tropical evergreen forests is another distinguishing feature of the region. The primary occupation in the region is farming (Yusuf *et al* 2008), although there are many factories located in the city. The local climate is conducive to growing a variety of crops such as maize, yam, cassava, millet, rice, plantains, cocoa, palm products, and cashews. Also, livestock production involving the rearing of animals for meat, eggs, milk, wool and skin production, while raising young ones are dominants in the area.

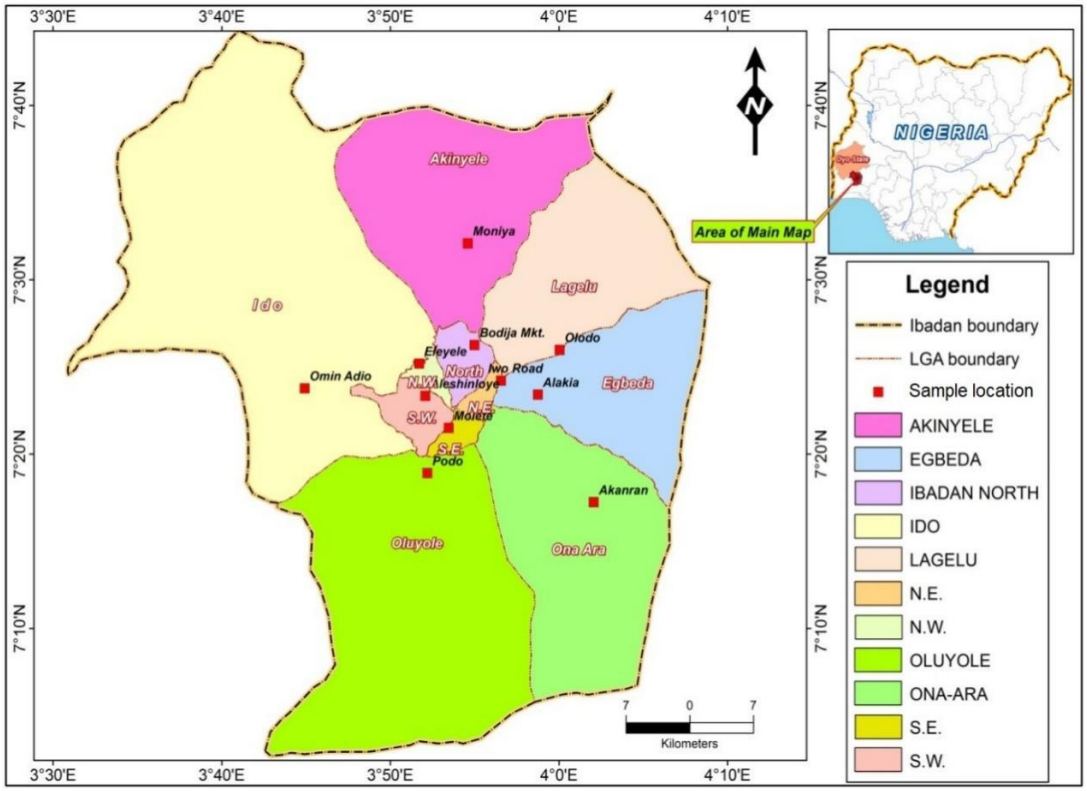

Figure 1: Map of Ibadan showing the eleven Local Government Areas
Source: Oyebamiji *et al* 2018

Study design

A cross-sectional study was conducted from May to December 2023 to investigate oocyst discharge in intensive poultry farms across all eleven LGAs in Ibadan. Using systematic random sampling, 22 farms (two per LGA for equal representation) were selected from an estimated 150 farms. Fifteen faecal samples were collected twice weekly from each farm to ensure equal sample representation. Faecal samples were qualitatively analyzed for oocyst presence. Data on chicken age (1–3 weeks, 4–6 weeks, and >6 weeks), sex (male and female), breed, management practices, and treatment history were collected to identify associated risk factors.

Ethics approval and consent to participate

This research study was approved by the Animal Care and Use Research Ethics Committee (ACUREC) of the University of Ibadan with assigned number UI-ACUREC/181-1124/27. Each of the 22 farms manager gave their verbal consent before the start of the commencement of the study.

Sample size determination

Grema *et al* (2014) estimated the disease's predicted prevalence rate to be 11.4%, and this prevalence was

used to calculate the sample size for this study. The formula used to calculate the sample size is the one used for a simple random sampling method, and it is given as:

$$n = \frac{z^2 * (P_{exp} * q)}{d^2}$$

Where n is the required sample size, p_{exp} is the expected prevalence, q is calculated as 1- p_{exp}, d is the desired absolute precision (5%), and z is equal to 1.96 (95%) (confidence interval based on the normal distribution). The minimum required sample size to use for this study was 155, however, 330 faecal samples were collected since many farms were visited for this study.

Sample collection

Fresh faecal samples were randomly collected from 22 poultry farms across 11 Local Government Areas (LGAs). The farms were identified by LGA: Ibadan North (PIN1, PIN2), Ibadan North-East (PINE1, PINE2), Ibadan North-West (PINW1, PINW2), Ibadan South-East (PISE1, PISE2), Ibadan South-West (PISW1, PISW2), Akinyele (PAK1, PAK2), Egbeda (PEG1, PEG2), Ido (PID1, PID2), Lagelu (PLA1, PLA2), Ona Ara (PON1, PON2), and Oluyole (POL1, POL2). Samples were collected immediately after deposition, using a cleaned spatula to transfer them from the upper surface into labeled, leak-proof universal bottles. Sealed in an ice box, samples were transported to the Parasitology Research Laboratory, Department of Zoology, University of Ibadan, for analysis. Data on chicken management, sex, age, breed, and treatments were recorded during sample collection.

Examination of faecal samples

Faecal samples were immediately examined in the laboratory using a floatation technique (Conway and Mckenzie 2007). Briefly, 3g of faeces were thoroughly mixed with 5ml of hyper-saturated salt floatation ($NaNO_3$) medium in a rubber tube. The resulting mixture was filtered into a test tube, which was then filled with floatation medium to allow oocysts to float. A cover-slip was gently placed on top of the test tube for 5 minutes to allow oocysts to adhere. The cover-slip was then carefully removed and placed on a microscope slide for examination under a 40× microscope to detect the presence of oocysts. Oocyst counts were determined using a McMaster egg counting chamber and a 40× light microscope, following the method of Taylor *et al* (2007). Specifically, the number of oocysts in each sample was calculated by adding the counts from the right and left wells of the counting chamber and multiplying by 24.

Eimeria species identification

Eimeria species were identified based on the size and shape of the sporulated oocysts, using the morphological keys of Conway and McKenzie's (2007).

Data analysis

Data analysis was performed using Microsoft Excel 2011, and Chi-square tests were conducted with SPSS version 22 to determine the statistical significance of correlations ($p<0.05$) between *Eimeria* prevalence and sex, age, bird type, management system, feed, and treatments. Prevalence was calculated as P = (d/n) * 100, where d represents the number of positive samples and n the total number of hens sampled (Adang and Isah 2016). The specific prevalence of each *Eimeria* species was determined by dividing the number of chickens infected with that species by the total number of infected chickens, then multiplying by 100 to express the result as a percentage. Oocyst count per gram indicated infection intensity.

Results

Oocysts types encountered during examination

The different *Eimeria* species found in this study were: *E. maxima* (Plate 1), *E. brunetti* (Plate 2), *E. praecox* (Plate 3), *E. tenella* (Plate 4), *E. necatrix* (Plate 5), *E. mitis* (Plate 6), and *E. acervulina* (Plate 7).

Prevalence and distribution of Eimeria species

Eimeria mitis was the most prevalent species, identified in 20 of the 22 farms sampled. *Eimeria praecox* was found in 18 farms, followed by *E. maxima* and *E. acervulina* (16 farms each), *E. brunetti* (13 farms), *E. necatrix* (8 farms), and *E. tenella* (6 farms). Farm PISW1 harbored all *Eimeria* species, while the other farms had between 3 and 6 species (Table 1). The most frequently occurring *Eimeria* species (Table 2) was *Eimeria mitis* (25.0 %) followed by *Eimeria praecox* (17.8%), *Eimeria acervulina* (16.8%), *Eimeria brunetti* (14.9%), *Eimeria maxima* (13.9%), *Eimeria tenella* (5.9%) and *Eimeria necatrix* (5.7%).

Prevalence and mean oocyst per gram of coccidia infection based on the sampling site

Eimeria species were detected in 81.21% (268/330) of sampled poultry and in all 22 investigated farms. Farm prevalence ranged from 72.33% (farms PINW2, PISE1, and PON1) to 86.67% (farms PAK2, PEG2, PID2, PLA1, PLA2, and PON2). Oocyst prevalence was consistent across farms PIN1, PIN2, PINE1, PINE2, PINW1, PISE2, PISW1, PISW2, PAK1, PEG1, POL1, and POL2 (Table 3).

The overall mean Oocyst Per Gram (OPG) was 5154.7, with the highest mean OPG was recorded in PLA1 (457.7±204.99) and the lowest in PEG2 (88.5±36.25). Mean OPG varied significantly between farms (Table 3).

Effects of associated risk factors on Eimeria infection in commercial poultry farms in Ibadan

Chi-square analysis revealed a significant association ($p<0.05$) between *Eimeria* infection and bird type, age, and management system, but not sex, feed type, or treatment methods (Table 4). Among age groups, bird older than 6 weeks had the highest *Eimeria* infection prevalence (90%), followed by 1-3 weeks (75.5%) and 3-6 weeks (78.2%) and the 1-3 weeks' old *Eimeria* infected female birds showed a slightly higher prevalence (2%) than the males (80.4%). Layers had a greater prevalence of *Eimeria* infection (91.9%) compared to broilers and local breeds (74.8%). The deep litter system showed a higher prevalence of *Eimeria* infection (89.07%) compared to the battery cage (71.43%). Chickens fed with external feed had the highest prevalence of *Eimeria* infection (86.67%).

Chickens with coccidiostat in feeds and water showed 82.22% of *Eimeria* infection, followed by birds with combined chemoprophylaxis (81.33%) and use of vaccines (78.67%) (Table 4).

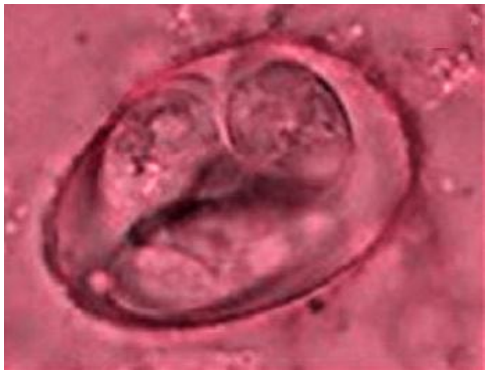

Plate 1: *E. maxima*

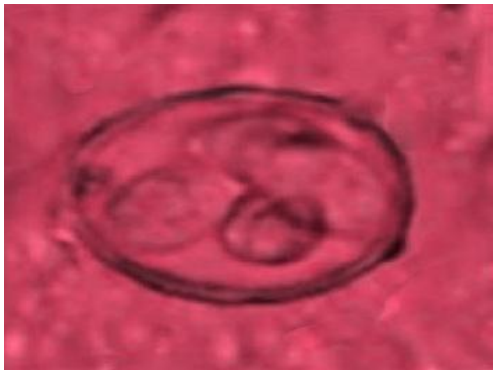

Plate 2: *E. brunetti*

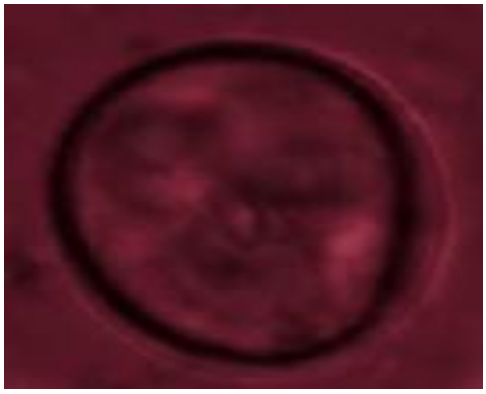

Plate 3: *E. praecox*

Plate4: *E. tenella*

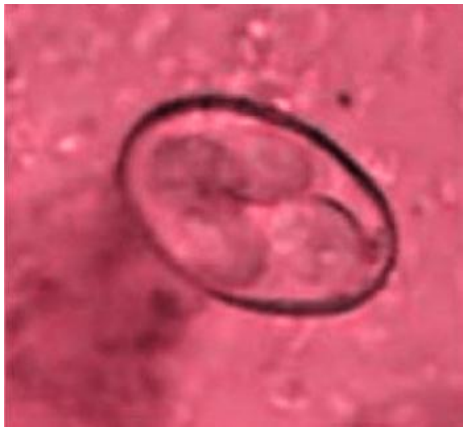

Plate 5: *E. necatrix*

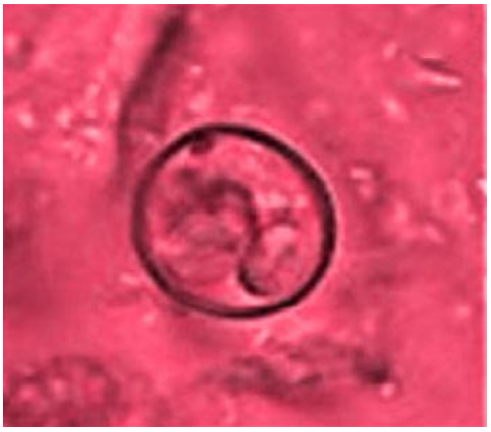

Plate 6: *E. mitis*

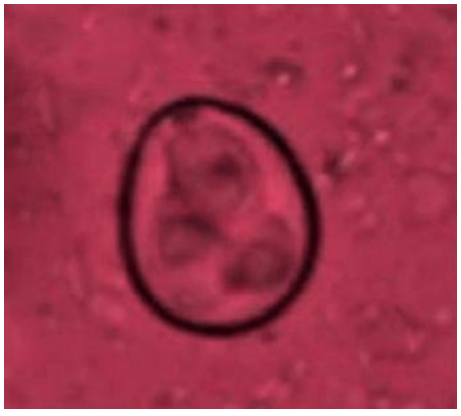

Plate 7: *E. acervuline*

Table 1: Diversity and distribution of Eimeria species in poultry farms

Pouitry farms	*Eimeria* species							Number of species
	tenella	*necatrix*	*maxima*	*mitis*	*praecox*	*acervulina*	*brunetti*	
PIN1	+	+	+	+	+	-	-	5
PIN2	-	+	+	+	-	+	-	4
PINE1	-	-	+	-	+	+	-	3
PINE2	+	-	-	-	+	-	+	3
PINW1	-	-	-	+	-	+	+	3
PINW2	-	-	-	+	-	+	+	3
PISE1	-	+	-	+	+	+	-	4
PISE2	+	-	-	+	+	-	+	4
PISW1	+	+	+	+	+	+	+	7
PISW2	-	-	+	+	+	+	+	5
PAK1	-	-	-	+	+	-	+	3
PAK2	-	+	+	+	+	+	+	6
PEG1	-	+	+	+	+	+	-	5
PEG2	-	-	+	+	+	+	-	4
PID1	-	-	+	+	+	+	+	5
PID2	-	-	+	+	+	+	+	5
PLA1	+	+	+	+	-	-	-	4
PLA2	-	-	+	+	+	+	+	5
PON1	-	-	+	+	+	+	-	4
PON2	+	+	+	+	+	-	-	5
POL1	-	-	+	+	+	+	+	5
POL2	-	-	+	+	+	+	+	5
TOTAL	6	8	16	20	18	16	13	

Key: Ibadan North (PIN1, PIN2), Ibadan North-East (PINE1, PINE2), Ibadan North-West (PINW1, PINW2), Ibadan South-East (PISE1, PISE2), Ibadan South-West (PISW1, PISW2), Akinyele (PAK1, PAK2), Egbeda (PEG1, PEG2), Ido (PID1, PID2), Lagelu (PLA1, PLA2), Ona Ara (PON1, PON2), and Oluyole (POL1, POL2)

Table 2: Overall prevalence of Eimeria species found in the study areas

***Eimeria* species**	**Number of oocysts identified**	**Prevalence (%)**
Eimeria maxima	140	13.9
Eimeria brunetti	150	14.9
Eimeria praecox	180	17.8
Eimeria tenella	60	5.9
Eimeria necatrix	58	5.7
Eimeria mitis	252	25.0
Eimeria acervulina	170	16.8
Total	**1010**	**100**

Discussion

Understanding the diversity, distribution, intensity, and prevalence of *Eimeria* species is crucial for effective coccidiosis prevention and management. This study found a high prevalence (81.21%) of poultry coccidiosis in Ibadan, comparable to the 81.0% reported in India by Kumar *et al* (2015) and other studies reporting 88.4% in Argentina (McDougald *et al* 1997), 92.0% in Romania (Gyo¨rke *et al* 2013), 69.0% in North-Central Nigeria (Olanrewaju and Agbor 2014), and 77.0% in South-south Nigeria (Ojimelukwe *et al* 2018). The relatively high prevalence observed here may be linked to the age of the birds, as age is a known indicator of *Eimeria* infection susceptibility (Lawal *et al* 2016b). Conversely, lower prevalence rates have been reported in other Nigerian states: 18.9% in Kwara (Shola *et al* 2019), 11.4% in Gombe (Grema *et al* 2014), 14.0% in Sokoto (Adamu *et al* 2009), 33.6% in Ebonyi (Ngele 2017), and 41.3% in Osun (Ola-Fadunsin 2017). Disparities in reported prevalence are likely influenced by variations in *Eimeria* epidemiology, sampling methodologies, study design, geographical location, and climatic conditions.

This study found the highest prevalence of coccidiosis in birds aged 6 weeks or older, aligning with previous research (Lawal *et al* 2016b; Shola *et al* 2019) indicating age-related susceptibility to *Eimeria* infection. This vulnerability may be attributed to physiological stress during sexual maturation in grower birds, even with less virulent *Eimeria* species.

The seven *Eimeria* species identified in this study are known to infect poultry in Nigeria (Jatau *et al* 2012; Agishi *et al* 2016). Consistent with prior reports from Ethiopia (Garbi *et al* 2015; Molla and Ali 2015) and Nigeria (Jatau *et al* 2012; Ngele 2017; Ola-Fadunsin 2017; Ojimelukwe *et al* 2018), *Eimeria tenella*, *E. acervulina*, *E. necatrix*, *E. brunetti*, and *E. maxima* were among the most prevalent. *E. tenella* has also been identified as the most common *Eimeria* species in poultry in studies conducted in Nigeria (Ngele 2017; Ojimelukwe *et al* 2018), Ethiopia (Garbi *et al* 2015;

Molla and Ali 2015), Pakistan (Shamim 2015), and India (Prakashbabu *et al* 2017).

Although female birds exhibited a higher prevalence of *Eimeria* oocysts compared to males, this difference was not statistically significant, suggesting equal susceptibility to coccidiosis in both sexes. This aligns with Lawal *et al* (2016b), who also reported higher parasite loads in female birds, but contradicts previous studies (Alemayehu *et al* 2012; Oljira *et al* 2012) that found the opposite.

Consistent with Jatau *et al* (2012), this study found a high incidence of *Eimeria* infection among bird breeds, with layers exhibiting a higher prevalence and severity compared to broilers. This likely results from layers and breeder pullets being maintained on litter for extended periods, increasing their exposure. The stress of laying may also contribute to the greater prevalence in layers (Jatau *et al* 2012), suggesting an association between bird type and *Eimeria* infection.

Consistent with Lawal *et al* (2016b), bird management systems were significantly associated with *Eimeria* infection, reinforcing the link between avian coccidiosis and poor management. Deep litter systems, providing ideal temperature and humidity for oocyst sporulation and promoting oocyst buildup, resulted in a higher prevalence compared to battery cage systems. This supports previous findings (Agishi *et al* 2012) on the susceptibility of birds raised on deep litter to coccidiosis.

Table 3: Intensity of *Eimeria* species based on the sampling site

Farms	N	n (prevalence (%))	Mean (±SD) OPG
PIN1	15	12(80)	170.8 (107.57)
PIN 2	15	12(80)	100.0 (36.93)
PINE1	15	13(80)	142.3 (49.40)
PINE2	15	12(80)	275.0 (119.66)
PINW1	15	12(80)	145.8 (45.02)
PINW2	15	11(72.33)	136.4 (59.54)
PISE1	15	11(72.33)	359.1 (184.14)
PISE2	15	12(80)	375.0 (200.57)
PISW1	15	12(80)	320.8 (148.41)
PISW2	15	12(80)	158.3 (66.86)
PAK1	15	12(80)	83.3 (38.92)
PAK2	15	13(86.67)	407.7 (262.87)
PEG1	15	12(80)	341.7 (153.49)
PED2	15	13(86.67)	88.5 (36.25)
PID1	15	12(80)	250.0 (67.42)
PID2	15	13(86.67)	134.6 (47.37)
PLA1	15	13(86.67)	457.7 (204.99)
PLA2	15	13(86.67)	196.2 (80.26)
PON1	15	11(72.33)	145.5 (56.81)
PON2	15	13(86.67)	457.7 (171.81)
POL1	15	12(80)	158.3 (66.86)
POL2	15	12(80)	250.0 (67.42)
Total	**330**	**268(81.21)**	**5154.7**

Key: Ibadan North (PIN1, PIN2), Ibadan North-East (PINE1, PINE2), Ibadan North-West (PINW1, PINW2), Ibadan South-East (PISE1, PISE2), Ibadan South-West (PISW1, PISW2), Akinyele (PAK1, PAK2), Egbeda (PEG1, PEG2), Ido (PID1, PID2), Lagelu (PLA1, PLA2), Ona Ara (PON1, PON2), and Oluyole (POL1, POL2)

Table 4: Effects of associated risk factors on coccidia infection in commercial poultry farms in Ibadan.

Variables	*Eimeria* +ve (%)	*Eimeria* -ve (%)	p
Age (weeks			
1-3	83 (75.5)	27 (24.5)	0.013*
3-6	86 (78.2)	24(21.8)	
6>	99(90.0)	11(10.0)	
Sex			
Male	131(80.4)	32(19.6)	0.7
Female	137(82.0)	30(19.9)	
Bird-type			
Local Breed	77(74.8)	26(25.3)	0.0006***
Broiler	77(74.8)	26(25.3)	
Layers	114(91.9)	10(8.1)	
Management system			
Deep litter	163(89.1)	20(10.9)	<0.0001***
Battery Cage	105(71.43)	35(28.6)	
Feed			
Self- Compounded feed	111(82.2)	24(17.8)	0.87
Commercial feed	85(81.0)	20(19.1)	
Self-compounded + commercial feed	59(78.7)	16(21.3)	
External	13(86.7)	2(13.3)	
Treatment			
Addition of Coccidiostat	148(82.2)	32(17.8)	0.80
Addition of vaccines	59(78.7)	16(21.3)	
Combined Chemoprophylaxis	61(81.3)	14(18. 7)	

Conclusion

The continued high prevalence of *Eimeria* infection despite coccidiostat, vaccine, and combined chemoprophylaxis treatment suggests potential issues with treatment regimes. These may include indiscriminate use leading to drug resistance, incorrect dosages, inconsistent administration by farm managers, and a lack of rotational regimes for anticoccidial drugs.

Coccidiosis, caused by *Eimeria* species, is endemic in poultry farms in Ibadan, affecting all sampled farms. Its prevalence correlates inversely with farm hygiene standards, with *E. mitis* being the most common species. Poor management, oocyst accumulation and sporulation, and humid environments contribute to its establishment. Given its catastrophic impact on poultry production, coccidiosis poses a serious threat to Nigeria's efforts to improve its livestock sector.

Maintaining strict sanitation and hygiene is crucial because coccidia are resistant to many disinfectants. Feeders and waterers should be elevated to minimize contamination by feces and litter, and to prevent water spillage. Implementing strict biosecurity measures, such as requiring poultry attendants to change clothing when moving between farms or poultry houses, is necessary to prevent oocyst transmission. Finally, incorporating all *Eimeria* species identified in this study into a coccidiosis vaccine and encouraging its widespread use among poultry farmers is imperative for effective control and prevention. Study limitations included restricted farm access due to lack of manager permission and poor road networks. Furthermore, inadequate funding limited molecular characterization of *Eimeria* species

Acknowledgements

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Conflict of interest

There is no conflict of interest for the study

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