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Cross-sectional study of *Eimeria* species of poultry in Kwara State, North-Central Nigeria

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Abstract Coccidiosis is one of the biggest challenges faced by the global poultry industry as the protozoan is found anywhere poultry are reared. Before now, there have been no documents on the intensity and diversity of *Eimeria* species of poultry in Kwara State. This study aimed to determine the prevalence and intensity of *Eimeria* species and its species diversity among poultry in Kwara Central, North-Central Nigeria. Five hundred and two fecal samples (from four hundred and seventy two chickens and thirty turkeys) were collected from chickens and turkeys from 15 farms from December 2017 to May 2018. The samples were subjected to floatation technique. Positive samples were further subjected to the McMaster counting technique for determining the intensity of infection. Sporulation of unsporulated oocysts was carried out using 2.5% potassium dichromate ($K_2Cr_2O_7$), for the purpose of identifying the different *Eimeria* species. Ninety five (18.9%) of the sampled population, 10 (66.7%) of the 15 sampled farms were positive for *Eimeria* species. The total mean oocyst per gram was 6325.0. Eight *Eimeria* species were detected in the study: 7 in chickens and 1 in turkeys. *Eimeria tenella* was the most predominant among chickens, *E. meleagrimitis* was the only species detected in turkeys. Age, sex, bird type, physiological status, farm age, farm size (acres), management system, frequency of anthelmintic use, frequency of anticoccidial use, distance to dumping site (meters), level of biosecurity and frequency of cleaning the pen were significantly associated ($P < 0.05$) with the occurrence of *Eimeria* infection. It is envisaged that the information obtained in this study will contribute to a clearer understanding of the epidemiology of poultry coccidiosis, for better management protocol which will improve the productivity of the sector in Kwara State and Nigeria.

Keywords *Eimeria* species · Kwara State · Prevalence · Risk factors

Introduction

Coccidiosis is caused by the single celled obligate intracellular protozoan parasite of the genus *Eimeria*, Family *Eimeridae*, Order Eimeriorina and Phylum Apicomplexa (Taylor et al. 2007) with about 1800 *Eimeria* species known to colonize and infect the intestinal tract of different animals and birds (Haug et al. 2014). Poultry coccidiosis is found anywhere chickens are reared and it remains one of the most economically important parasitic diseases in poultry industry worldwide (Ola-Fadunsin and Ademola 2014; Lawal et al. 2016b) as it is associated with high morbidity and mortality. It is recognized as the parasitic disease that has the greatest economic impact on poultry industries throughout the world (Ola-Fadunsin and Ademola 2013). Infection with this protozoan parasite normally occurs through ingestion of feed or water contaminated with sporulated oocysts (Lawal et al. 2016b). Sporulated oocysts can also be transmitted through mechanical carriers such as feeding trough, water trough, clothing, farm workers and sometimes by other animals and insects (Hadipour et al. 2011). Poultry coccidiosis is usually

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characterized with various kinds of clinical signs such as dysentery, enteritis, diarrhea (which may be bloody with certain *Eimeria* species), emaciation, lower feed conversion rate, delayed sexual maturity, drooping wings, poor growth rate, low production, and even death (Ola-Fadunsin 2017), and this has resulted to an annual global losses of over US$2.4 billion (Shirley et al. 2005; Ola-Fadunsin and Ademola 2013).

Poultry in many parts of the world is considered the chief source of not only cheaper protein of animal origin but also of high quality human food (Lawal et al. 2016a). In Nigeria, the poultry sector is one of the most important component of the Agricultural sector, providing animal proteins such as meat and eggs to man, as well as contributing to the national income through revenue (Lawal et al. 2015). It has developed to the level of commercial enterprise involving millions of birds (about 150 million) that provide employment, income, animal protein for urban and rural dwellers as well as manure for crop production. It is an important instrument for alleviating problems associated with poverty and the fast growing human population in Nigeria and significantly contributes to women's income and helps meet some levels of household protein needs (Balami et al. 2014; Ola-Fadunsin 2017).

The only study on chicken coccidiosis conducted in Kwara State was carried out only in Ilorin and it was a retrospective study making use of clinical data (Davou et al. 2015). Hence, this study aimed to determine the prevalence and intensity of *Eimeria* species, its species diversity and distribution, and the risk factors associated with the infection among poultry in Kwara Central, Kwara State.

Materials and methods

Study area and sample collection

The study was conducted in five local government areas of Kwara State ($8°05'$–$10°15'$N and $2°73'$–$6°13'$E). Kwara State lies almost at the middle of Nigeria and it is referred to as the "Gate way" State of Nigeria, as it links the northern and southern parts of the country (NBS 2016). Five hundred and two fecal samples (four hundred and seventy two chickens and thirty turkeys) were randomly collected from 15 poultry farms (with turkeys been present in only farm 1) from December 2017 to May 2018. Samples were collected immediately after defecation into well labeled sterile sample bottles and put in a cool box. The samples were immediately transported to the Parasitology Laboratory of the Faculty of Veterinary Medicine, University of Ilorin, Nigeria, for further processing.

Laboratory procedures

Fecal samples were examined for the presence of *Eimeria* oocyst using the floatation technique. Positive samples were further subjected to the McMaster counting technique so as to determine the intensity of *Eimeria* infection. Both aforementioned techniques were carried out as described by Soulsby (1982). Positive samples were pooled together at individual farm basis for the purpose of sporulation. Sporulation of *Eimeria* oocysts was carried out as described by Al-Quraishy et al. (2009) with some modifications. Briefly, the pooled faecal samples were placed in petri dishes, sprinkled with water to make it damp (not wet). About 2.5% potassium dichromate ($K_2Cr_2O_7$) solution was then added to the sample and allowed to stand for 5–7 days at room temperature away from sun rays to permit the coccidian oocysts to sporulate. After sporulation, flotation concentration technique was used to examine the sporulated oocyst using the $40\times$ objective lenses of the OLYMPUS (B-Bran) light microscope (Olympus Co, Japan). Identification of sporulated *Eimeria* oocysts was carried out based on the oocyst size and shape using morphological keys by Conway and McKenzie (2007) and Taylor et al. (2007).

Data collection

Data about the exposure to potential risk factors were collected through a structured questionnaire containing open-ended and closed ended (Dichotomous or multiple choices) questions. The questionnaires were filled by the farm manger or a staff that is actively involved in the daily activities of the farm.

Statistical analysis

Results were initially entered in Microsoft office Excel version 2014 for the determination of absolute frequencies and percentages (%). The Statistical Package for the Social Sciences (SPSS, Chicago, Illinois, USA) for windows version 22.0 was used to analyze the odds ratio and statistical significance between the presence/absence of *Eimeria* oocyst and the categorical variables using Chi Square (Univariable model) test for discrete variables at 95% confidence interval at $P < 0.05$. Multivariable unconditional logistic regression was used to determine the factors for each parasites controlling for other covariate at $P < 0.2$ and biologically plausible variables (e.g. presence of other animals in the farm). Hosmer and Lemeshow (H–L) goodness of fit test was used to assess the final multivariable model. A P value < 0.05 was considered statistically significant.

Table 1 Prevalence of *Eimeria* species and mean (± SD) oocyst per gram (OPG) from poultry farms in Kwara Central, Kwara State

Farms	N	n (prevalence (%))	Mean (± SD) OPG
1[a]	80	23 (28.8)	534.8 (251.5)
2	30	4 (13.3)	470.0 (80.8)
3	32	6 (18.8)	1590.0 (794.2)
4	30	10 (33.3)	868.0 (705.0)
5	30	22 (73.3)	1178.2 (437.6)
6	30	0	0
7	30	0	0
8	30	0	0
9	33	0	0
10	30	10 (33.3)	344.0 (246.4)
11	30	6 (20.0)	320.0 (189.3)
12	27	0	0
13	30	2 (6.7)	360.0 (56.7)
14	30	4 (13.3)	190 (11.5)
15	30	8 (26.7)	470.0 (133.1)
Total	502	95 (18.9)	6325.0

N = number of birds sampled per farm; n = number of birds positive for *Eimeria* species; np = not present

[a]Prevalence [chickens = 8/50 (16.0%), turkeys = 15/30 (50.0%)]; mean (± SD) OPG [chickens = 475.0 (127.7), turkeys = 566.7 (296.8)]

Results

Eimeria species were detected in 95 (18.9%) out of the 502 sampled poultry species and in 10 (66.7%) of the 15 farms sampled. The total mean oocyst per gram (OPG) was 6325.0. The individual farm prevalence ranged between 6.7% (farm 13) and 73.3% (farm 5). The highest OPG was recorded in farm 5 (1590.0 (± 794.2)) and the lowest mean OPG was observed in farm 14 (190 (± 11.5)) (Table 1).

The diversity and distribution of *Eimeria* species in poultry farms is presented in Table 2. Eight *Eimeria* species (*E. acervulina*, *E. brunetti*, *E. maxima*, *E. mitis*, *E. necatrix*, *E. praecox*, *E. tenella* and *E. meleagrimitis*) were detected from the study with *E. tenella* been the most widespread, and detected in 9 (90.0%) of the 10 farms positive for *Eimeria* species. *Eimeria acervulina* and *E. necatrix* were detected in 7 farms while *E. praecox* and *E. meleagrimitis* were detected in one farm. Six out of the detected *Eimeria* species were detected in farms 1 and 3, while two to five species were detected in the other farms.

The Univariate analysis shows that age, sex, bird type, physiological status, farm age, farm size (acres), management system, frequency of anthelmintic use, frequency of anticoccidial use, distance to dumping site (meters), level of biosecurity and frequency of cleaning the pen were significantly associated ($P < 0.05$) with the occurrence of *Eimeria* infection (Table 3).

Age, bird type, presence of other animals in the farm, farm size (acres), management system and level of biosecurity were the risk factors for *Eimeria* infections based on the multivariate model (Table 4). Growers (8–16 weeks) were almost three times more likely to be infected with *Eimeria* species than adult birds. Layers were 3.3 times less prone to *Eimeria* infections compared to turkeys. There was a higher tendency of *Eimeria* infections in poultry raised in farm where other animals are kept compared to birds raised in farms where no other animal species are kept. A higher occurrence of *Eimeria* infections was recorded among poultry raised in large sized farms compared to those raised in small sized farms. Birds raised in deep litter were more prone to *Eimeria* infections compared to birds raised in battery cage. The level of biosecurity was directly associated with the presence of *Eimeria* infections.

Discussion

Epidemiological studies on the prevalence, intensity, distribution and diversity of *Eimeria* species are useful tools for the prevention and control of coccidiosis (Györke et al. 2013). This study appears to be the first to be conducted about poultry (chickens and turkeys) coccidiosis in a wider area of the state and of a field study. We identified 18.9% of the sampled population to be infected with *Eimeria* species. In poultry, contrasting prevalence rate of 11.4% has been reported by Grema et al. (2014) in Gombe State, north-east Nigeria, 14.0% by Adamu et al. (2009) in Sokoto State, north-west Nigeria, 33.6% by Ngele (2017) in Ebonyi State, South-east Nigeria, 41.3% by Ola-Fadunsin (2017) in Osun State, South-west Nigeria, 69.0% by Olanrewaju and Agbor (2014) in the Federal Capital Territory, North-Central Nigeria and 77.0% by Ojime-lukwe et al. (2018) in Rivers State, South-south Nigeria. Factors such as sampling periods, sample size, study design, geographical area and climatic conditions could have resulted in the disparity in the reported prevalence. Our findings is comparable to that reported in Pakistan (Ali et al. 2014) where 18.4% of the poultry sampled were infected with *Eimeria* parasites. Infection rate of *Eimeria* in poultry from Poland was 32.7% (Tomza-Marciniak et al. 2014), 36.9% from Ethiopia (Chalchisa and Deressa 2016), 54.3% from Turkey (Karaer et al. 2012), 78.0% from Jordan (Al-Natour et al. 2002); 81.0% from India (Kumar et al. 2015); 88.4% from Argentina (McDougald et al. 1997) and 92.0% from Romania (Györke et al. 2013). Diverse factors such as sampling periods, sample size, study design, geographical area, production systems, age of birds, management systems, climatic conditions and the epidemiology of *Eimeria* parasites could have resulted in

Table 2 Diversity and distribution of *Eimeria* species in poultry farms from Kwara Central, Kwara State

Farms	*Eimeria* species								
	E. acervulina	*E. brunetti*	*E. maxima*	*E. mitis*	*E. necatrix*	*E. praecox*	*E. tenella*	*E. meleagrimitis*	Number of species
1	+	+	+	−	+	−	+	+	6
2	−	−	+	−	+	−	+	−	3
3	+	+	+	+	+	−	+	−	6
4	+	+	−	+	−	−	+	−	4
5	+	+	+	−	+	−	+	−	5
6	−	−	−	−	−	−	−	−	0
7	−	−	−	−	−	−	−	−	0
8	−	−	−	−	−	−	−	−	0
9	−	−	−	−	−	−	−	−	0
10	+	+	−	−	+	−	−	−	3
11	+	−	+	−	−	−	+	−	3
12	−	−	−	−	−	−	−	−	0
13	−	+	−	+	+	−	+	−	4
14	−	−	−	−	−	+	+	−	2
15	+	−	+	−	+	−	+	−	4
Total	7	6	6	3	7	1	9	1	

+ = present; − = not present

the variation of the reported prevalence. The lower prevalence rate (18.9%) recorded in this study compared to the 20.3% reported by Davou et al. (2015) and the 69.0% reported by Olanrewaju and Agbor (2014) in Ilorin and the Federal Capital Territory respectively both in North-Central Nigeria could be explained by the fact that the study population was raised intensively that is associated with good management practices.

Sharma et al. (2013) and Garbi et al. (2015) reported a lower *Eimeria* prevalence rate among intensively managed birds compared to those managed extensively in their study conducted in India and Ethiopia respectively. Avian coccidiosis is highly associated with poor management practice (Adhikari et al. 2008; Lawal et al. 2016a). The total mean OPG of 6325.0 shows that *Eimeria* infection is of concern in the study area as *Eimeria* infection is the most common enteric parasitic infection of poultry and a major constraint to a successful poultry farming in Nigeria and the world (Lawal et al. 2016b; Ola-Fadunsin 2017).

The seven species detected has been reported to infect chickens in Nigeria (Luka and Ndams 2007; Jatau et al. 2012; Agishi et al. 2016). In alliance with our findings, *E. tenella*, *E. acervulina*, *E. necatrix E. brunetti* and *E. maxima* has been reported to the predominant *Eimeria* species affecting chickens in Nigeria (Luka and Ndams 2007; Jatau et al. 2012; Agishi et al. 2016; Ngele 2017; Ojimelukwe et al. 2018) and Ethiopia (Garbi et al. 2015; Molla and Ali 2015). *Eimeria tenella* has been reported to

be the most predominant *Eimeria* species affecting poultry in Nigeria (Luka and Ndams 2007; Ngele 2017; Ojimelukwe et al. 2018), Ethiopia (Garbi et al. 2015; Molla and Ali 2015), India (Prakashbabu et al. 2017) and Pakistan (Shamim et al. 2015). *Eimeria meleagrimitis* has been reported to be one of the most important and most prevalent *Eimeria* specie of turkeys (Chapman 2008).

Age is an important index when the prevalence of *Eimeria* infection is concerned, as all ages of birds are susceptible to the protozoon (Lawal et al. 2016b; Ola-Fadunsin 2017). In this current study, all age groups were infected with *Eimeria* species with growers (> 8–16 weeks) having the highest prevalence rate. This body of evidence agrees with that conducted by Lawal et al. (2016b) who reported that all ages of birds are susceptible to coccidiosis, and that grower birds were most susceptible to *Eimeria* infection compared to other age groups. Physiological stress associated with sexual maturity of grower birds in preparation for production may be the reason for our findings. Physiological stress may leave them susceptible to infection even with the lower or less pathogenic strain of *Eimeria* species.

Male poultry were significantly more susceptible to *Eimeria* infection compared to female. Studies in Nigeria (Olanrewaju and Agbor 2014; Ola-Fadunsin 2017) and Ethiopia (Garbi et al. 2015) reported male poultry to be more prone to *Eimeria* infection compared to female. Ola-Fadunsin (2017) proposed that the aggressive feeding

Table 3 Univariate analysis of putative risk factors associated with *Eimeria* species infection among poultry in Kwara Central, Kwara State

Variables	*Eimeria* + ve (%)	*Eimeria* − ve (%)	OR (95% Cl)	P
Age (weeks)				
Chick (0–8)	2 (7.69)	24 (92.31)	0.40 (0.06, 1.49)	0.21
Grower (> 8–16)	22 (33.33)	44 (66.67)	2.38 (1.33, 4.21)	< 0.01[b]
Adult (> 16)[a]	71 (17.32)	339 (82.68)	1.00	
Sex				
Male	16 (31.37)	35 (68.53)	2.15 (1.11, 4.05)	0.02[b]
Female[a]	79 (17.52)	372 (82.48)	1.00	
Bird type				
Layers	72 (18.00)	328 (82.00)	0.22 (0.10, 0.48)	< 0.01[b]
Broilers	8 (11.11)	64 (88.89)	0.13 (0.04, 0.35)	< 0.01[b]
Turkey[a]	15 (50.00)	15 (50.00)	1.00	
Physiological status				
Unproductive	44 (24.18)	138 (75.82)	0.21 (0.05, 0.82)	0.02[b]
Productive	45 (14.52)	265 (85.48)	0.11 (0.03, 0.43)	< 0.01[b]
Spent layers[a]	6 (60.00)	4 (40.00)	1.00	
Production purpose				
Meat	23 (22.55)	79 (77.45)	1.33 (0.77, 2.24)	0.30
Egg[a]	72 (18.00)	328 (82.00)	1.00	
Farm age (years)				
< 5	22 (14.47)	130 (85.53)	0.64 (0.33, 1,23)	0.18
> 5–10	18 (12.00)	132 (88.00)	0.52 (0.26, 1.02)	0.06
> 10–15	32 (35.56)	58 (64.44)	2.08 (1.11, 3.95)	0.02[b]
> 15–20[a]	23 (20.91)	87 (79.09)	1.00	
Presence of other animals in the farm				
Yes	67 (19.03)	285 (80.97)	1.02 (0.63, 1.69)	0.93
No[a]	28 (18.67)	122 (81.33)	1.00	
Flock size (birds)				
< 1000	55 (18.33)	245 (81.67)	0.95 (0.52, 1.81)	0.87
1000–2000	24 (20.34)	94 (79.66)	1.09 (0.54, 2.23)	0.83
> 2000[a]	16 (19.05)	68 (80.95)	1.00	
Farm size (acres)				
< 5	62 (18.67)	270 (81.33)	0.57 (0.33, 1.01)	0.05
5–10	10 (11.11)	80 (88.89)	0.31 (0.13, 0.70)	< 0.01[b]
> 10[a]	23 (28.75)	57 (71.25)	1.00	
Management system				
Deep litter	27 (28.13)	69 (71.88)	1.94 (1.15, 3.24)	0.01[b]
Battery cage[a]	68 (16.75)	338 (83.25)	1.00	
Farm type				
Multiple bird species	58 (19.21)	244 (80.79)	1.05 (0.66, 1.67)	0.85
Single bird species[a]	37 (18.50)	163 (81.50)	1.00	
Frequency of anthelmintic use				
Every 2 months	24 (35.29)	44 (64.71)	1.06 (0.51, 2.22)	0.87
Every 3 months	38 (13.97)	234 (86.03)	0.32 (0.17, 0.60)	< 0.01[b]
Occasionally	12 (12.00)	88 (88.00)	0.27 (0.12, 0.60)	< 0.01[b]
No at all[a]	21 (33.87)	41 (66.13)	1.00	
Frequency of anticoccidial use				
Weekly	7 (9.72)	65 (90.28)	0.11 (0.04, 0.32)	< 0.01[b]
Monthly	6 (30.00)	14 (70.00)	0.44 (0.12, 1.44)	0.18

Table 3 continued

Variables	Eimeria + ve (%)	Eimeria − ve (%)	OR (95% CI)	P
Every 3 months	1 (3.33)	29 (96.67)	0.04 (0.01, 0.23)	< 0.01[b]
Every 4 months	2 (25.00)	6 (75.00)	0.34 (0.04, 1.91)	0.24
Occasionally	64 (18.71)	278 (81.29)	0.23 (0.11, 0.50)	< 0.01[b]
Not at all[a]	15 (50.00)	15 (50.00)	1.00	
Distance to dumping site (m)				
< 250	16 (25.81)	46 (74.19)	4.46 (1.07, 30.68)	0.04[b]
250–500	77 (18.69)	335 (81.31)	2.98 (0.81, 19.00)	0.12
> 500[a]	2 (7.14)	26 (92.86)	1.00	
Level of biosecurity (%)				
0–25	44 (13.33)	286 (86.67)	0.37 (0.23, 0.58)	< 0.01[b]
25–50[a]	51 (29.65)	121 (70.35)	1.00	
Frequency of cleaning the pen				
Twice a week	62 (23.31)	204 (76.69)	0.70 (0.37, 1.35)	0.27
Weekly	16 (8.89)	164 (91.11)	0.23 (0.10, 0.49)	< 0.01[b]
Occasionally[a]	17 (30.36)	39 (69.64)	1.00	

OR odds ratio, CI confidence interval

[a]Reference category

[b]Significant

Table 4 Multivariate analysis of putative risk factors associated with Eimeria species infection among poultry in Kwara Central, Kwara State

Variables/categories	β	SE	P	OR	95% CI Lower	CI Upper
Age (weeks)						
Chick (0–8)	− 5.442	2.161	0.150	0.004	0.001	0.300
Grower (> 8–16)	1.095	0.760	0.012[b]	2.988	0.674	13.242
Adult (> 16)[a]				1.000		
Bird type						
Layers	− 1.098	1.787	0.002[b]	0.299	0.090	0.995
Broilers	− 6.913	2.198	0.539	0.101	0.013	0.747
Turkey[a]				1.000		
Presence of other animals in the farm						
Yes	0.862	0.639	<0.001[b]	1.077	0.522	4.270
No[a]				1.000		
Farm size (acres)						
< 5	− 0.469	0.619	0.449	0.626	0.186	2.106
5–10	− 2.561	0.894	0.004[b]	0.077	0.013	0.445
> 10[a]				1.000		
Management system						
Deep litter	2.432	0.738	0.001[b]	11.382	2.679	48.353
Battery cage[a]				1.000		
Level of biosecurity (%)						
0–25	− 3.766	0.966	< 0.001[b]	0.023	0.003	0.154
25–50[a]				1.000		

OR odds ratio, CI confidence interval

[a]Reference category

[b]Significant

nature of male birds makes them pick up more sporulated oocyst from contaminated feed, water, or litters and this maybe the reason for the higher prevalence seen in male.

Among bird types, turkeys recorded the highest prevalence of *Eimeria* infection, followed by layers and broilers. The prevalence of *Eimeria* infection in turkeys reported in our study is within the reported prevalence of 22.4% in Nigeria (Udoh et al. 2014) and 66.0% in the USA (Ruff et al. 1988). As observed during our sampling, turkeys were not giving as much medical treatment as layers and broilers and this could be the reason for the prevalence rate recorded among them. Jatau et al. (2012) reported a higher prevalence and intensity of *Eimeria* infection among layers compared to broilers. The higher prevalence recorded in layers may be attributed to the fact that breeder and layer pullets are kept on litter for several weeks thereby increasing their chances of infection. The stress of laying could also be a factor influencing to the higher prevalence recorded in layers as against broilers (Jatau et al. 2012).

Physiological status of poultry was significantly associated with the prevalence of *Eimeria* infections, as spent layers were most susceptible followed by unproductive and productive poultry species. This may not be readily explained; generally the physiological state of animals is a significant factor in the epidemiology of coccidiosis in animals (Pfukenyi et al. 2007).

The size of poultry farms has been reported to have a significant effect in the epidemiology of avian coccidiosis (Etuk et al. 2004; Györke et al. 2013). We report the highest prevalence rate in farms of above 10 acres, followed by farms of less than 5 acres and those between 5 and 10 acres.

Poultry raised in deep litter were more prone to *Eimeria* infections compared to those raised in battery cage. This observation concurs with previous reports that coccidiosis is common to birds raised on deep litter (Etuk et al. 2004; Taylor et al. 2007; Agishi et al. 2016). The high prevalence recorded among birds raise in deep litter is expected as the deep litter type of poultry house offers optimal condition of temperature and humidity for oocyst sporulation, thus increasing the risk of infection. Also, rearing birds on deep litter favours accumulation of oocysts and birds are constantly in close contact with sporulated oocysts in the litter.

The undefined pattern in the prevalence of *Eimeria* infection among poultry with the different anthelminthic treatment regimens appears to be dicey in explanation. Although, a study conducted on a species of wild mammal (Alpinemarmot, *M. marmota latirostris*) by Václav and Blazeková (2014), reported that helminth infection has a protective effect on the reproductive rates of coccidia parasites as the use of anthelmintic decreases the shedding rate of *Eimeria* oocysts.

Lower prevalence of *Eimeria* infection was recorded among poultry treated with anticoccidials. This is expected as the use of anticoccidial drugs is the predominant form of control against coccidiosis (Lawal et al. 2016a, b; Kadykalo et al. 2018). Caution on the use of anticoccidials should be taken as its indiscriminate use in feed and water has led to serious drug resistance problems.

Frequent removal of waste during flock cycles may impair oocyst transmission as a consequence of litter disturbance (Prakashbabu et al. 2017). Strict hygiene and good biosecurity are important factors in the control of poultry coccidiosis (Ojimelukwe et al. 2018; Kadykalo et al. 2018). Flies, other insects (e.g. beetles, cockroaches), rodents, pets and other animals are believed to be involved in the mechanical transmission of sporulated oocyst in avian species leading to *Eimeria* infection (Majaro 2001). Flies serves as mechanical vector of sporulated oocyst by picking it from an infected area on its body and transferring it to another place when it perches. These may be the reason we detected a high prevalence of *Eimeria* infection among birds raised close to dumping site, birds raised in farms that are not cleaned regularly and among poultry raised in the presence of other animals.

Conclusion

This study has shown that *Eimeria* infection is endemic among poultry in Kwara Central, as 66.7% of the sampled farms were infected. *Eimeria tenella* happens to be the most predominant species. A variety of risk factors favours the infection of *Eimeria* in poultry. The devastating effect of coccidiosis to poultry production makes this study of great concern as the country is moving towards improving her livestock (poultry) production sector. It is envisaged that the data obtained in this study will contribute to a clearer understanding of the epidemiology of poultry coccidiosis in Kwara State and Nigeria, which is an important facet for the formulation of effective treatment, control and preventive measures to assist in improving the poultry industry. There is need for further studies at molecular level to unravel the genetic characteristic of poultry *Eimeria* in Kwara State, North-Central Nigeria.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest among them.

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