



## Research Article

### Occurrence of Avian Haemosporidians in Rural chickens (*Gallus gallus domesticus*) from Kaltungo, Northeastern Nigeria

Jallailudeen Rabana Lawal<sup>1\*</sup>, Umar Isa Ibrahim<sup>1</sup>, Abdullahi Abubakar Biu<sup>2</sup>, Hassan Ismail Musa<sup>3</sup>

<sup>1</sup>Department of Veterinary Medicine, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria

<sup>2</sup>Department of Veterinary Parasitology and Entomology, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria

<sup>3</sup>Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria

\*Corresponding author: [rabana4real@unimaid.edu.ng](mailto:rabana4real@unimaid.edu.ng), [doi.org/10.55639/607.797877](https://doi.org/10.55639/607.797877)

#### ARTICLE INFO:

##### Keywords:

Haemosporidian  
Parasites,  
Rural chickens,  
*Plasmodium*,  
*Haemoproteus*,  
*Leucocytozoon*

#### ABSTRACT

Reporting the occurrence of haemosporidian parasites infection in birds in particular, is crucial for designing an efficient control programs targeted at minimizing the risks of transmission. A total of 800 rural chickens from Kaltungo, Nigeria were screened for haemosporidian parasites using standard parasitological techniques. Epidemiological risk factors associated with haemosporidian parasite infections were assessed using chi-square or Fisher's exact test. In total, 18.1% (145/800; 95% CI: 15.6 – 21.0) of chickens harboured one or more genera of haemosporidian parasites: *Plasmodium* species (9.0%; 95% CI: 7.2 – 11.2), *Haemoproteus* species (3.1%; 95% CI: 2.1 – 4.6) and *Leucocytozoon* species (1.0%; 95% CI: 0.5 – 2.0). Mixed haemosporidian parasitic infections *Haemoproteus* spp./*Plasmodium* spp. (3.4%; 95% CI: 2.3 – 4.9); *Leucocytozoon* spp./*Plasmodium* spp. (1.1%; 95% CI: 0.6 – 2.1) and *Haemoproteus* spp./*Leucocytozoon* spp./*Plasmodium* (0.5%; 95% CI: 0.2 – 1.3) were also encountered among infected chickens. Although not statistically significant ( $p = 0.1420$ ;  $p > 0.05$ ;  $\chi^2 = 2.156$ ), the prevalence of haemosporidian parasites was higher in chickens from households (10.1%; 95% CI: 8.2 – 12.4) than live birds markets (8.0%; 95% CI: 6.3 – 10.1). Male (OR=3.45;  $p < 0.0001$ ), adult (OR=2.931;  $p < 0.0001$ ) and rainy season (OR=0.19;  $p < 0.0001$ ) were strongly associated with *Plasmodium* infection. Similarly, statistically significant risk factors identified for mixed haemosporidian infections were age ( $p = 0.0139$ ), sex ( $p = 0.0001$ ) and season ( $p < 0.0001$ ). However, sex ( $p = 0.2245$ ), age ( $p = 0.0040$ ) and season ( $p = 0.2221$ ) were statistically not significant for *Haemoproteus* spp. infections. For, *Leucocytozoon* spp., significant risk factors were age ( $p = 0.0081$ ) and season ( $p = 0.0075$ ), while sex ( $p = 0.0694$ ) was not significant risk factor for Leucocytozoonosis in Rural chickens.

Corresponding author: Jallailudeen Rabana Lawal, Email: [rabana4real@unimaid.edu.ng](mailto:rabana4real@unimaid.edu.ng)  
Department of Veterinary Medicine, University of Maiduguri, Maiduguri, Borno State, Nigeria

## INTRODUCTION

Prevalence of Undernourishment (POU) has increased at an unprecedented rate from 2018 to 2019, with estimates for 2019 in Africa placing that figure at over 250 million, a 17.6% increase from 2014 (FAO *et al.*, 2021; Khalid *et al.*, 2021). However, due to the effects of the insurgency and other natural disasters, such as flooding in some parts of Northern Nigeria, millions of people have been forced to evacuate their homes in search of safety in nearby safe regions, creating an unprecedented demand for food to survive (Durodola, 2019; Mukhtar, 2020; Echendu, 2022). Poultry farming, which provides a highly nutritious source of animal protein (meat and eggs) and is thought to be the most economical method of livestock production when compared to cattle, sheep, and goats, is a dependable and affordable livestock production system that can help protect vulnerable people from poverty and malnutrition (Osabohien *et al.*, 2020; Mbuli *et al.*, 2021; Li *et al.*, 2022). The predominance of rural chickens in Nigeria's poultry sector is a good indicator that these species of birds need more attention for increased performance since they are among the most common and widely dispersed avian species among poultry birds worldwide (Ajala *et al.*, 2021; Amato and Castellini, 2022).

Unfortunately, there are a number of constraints that affect successful chicken production, including but not limited to the threat posed by infectious pathogens of bacterial, viral, parasitic, and protozoan origins (Alasadiy *et al.*, 2020; Hafez and Attia, 2020). Haemosporidian are one of the infectious haemoparasites that are becoming more prevalent in poultry production systems in developing countries, including Nigeria (Aiyedun *et al.*, 2022; Lawal *et al.*, 2022), and they may significantly limit productivity in backyard and small-scale poultry farming globally (Li *et al.*, 2022). Worldwide reports of more than 200 species of avian hemoparasites have been categorized generally

into four different genera: *Plasmodium*, *Haemoproteus*, *Leucocytozoon*, and *Hepatocystis* (Valkiunas, 2005; Bensch *et al.*, 2009; Palinauskas *et al.*, 2009; 2015). These parasites are only transmitted by bloodsucking dipteran insects from 17 different genera (Pramual *et al.*, 2020). Unrelated to the haemosporidians, trypanosomes are also frequently found in avian blood and can be spread by a variety of insect species, usually by ingesting the vector, like the *Culex* mosquito (Votypka *et al.*, 2012; Svobodova *et al.*, 2015). Other vector-borne blood parasites of birds include sporozoan parasites of the genera *Hepatozoon*, *Babesia*, and *Atoxoplasma*, and nematode microfilariae are also frequently seen in avian blood (Silveira *et al.*, 2010). The poultry industry has recently focused on disease diagnosis and prevention, high production, high-quality products, and affordable production costs. Avian haemoparasites have been documented to have significant effects on the health status of infected domesticated and wild birds by reducing their growth, body condition, and productivity (Yang *et al.*, 2021; Li *et al.*, 2022). However, severe infections by avian haemoparasites can result in death and could involve various physio-pathological phenomena like anemia, thrombocytopenia, and inflammation (Cannell *et al.*, 2014; Lee *et al.*, 2016; Nourani *et al.*, 2018). Failure to provide timely preventive treatment will lead to higher rates of infection, impaired immune responses and a decreased survival rate (Naqvi *et al.*, 2017; Miranda *et al.*, 2022). Investigation of haemoparasites from affected birds may involve DNA amplification and sequencing, as well as microscopic identification of the parasites in blood smears (Valkiunas *et al.*, 2005). The sensitivity of both approaches to identify these haemoparasites can be comparable. Although studies on avian haemoparasites of birds were conducted in Nigeria (Opara *et al.*, 2014; Ogbaje *et al.*, 2019; Mohammed *et al.*, 2019), majority

of these studies exclusively reported the prevalence of haemoparasitosis in chickens with scanty data on epidemiological information from the Northeastern region of the country. The aim of the current study is to provide an epidemiological baseline data of avian haemosporidians parasitizing rural chickens (*Gallus gallus domesticus*) from Kaltungo, Gombe State, Northeastern Nigeria.

## **MATERIALS AND METHODS**

### **Study Area**

This study was carried out in Kaltungo Local Government Area, one among the 11 Local Governments Area of Gombe State, Nigeria. The L.G.A is situated between approximately Latitude 9° 49' 51" N Longitude 11° 18' 32" E. The Köppen climate is characterized by heavy rainfall and high temperatures typical of tropical savanna. Kaltungo has a mean annual rainfall of 818.5mm, with a mean maximum temperature of 37°C and a mean minimum temperature of 12°C. The months of April (29.5°C) and January (22.6°C) represents the warmest and driest periods of the year respectively. The months between April and October are the rainy periods, whereas months between November and March of every year are the dry season periods (Lawal *et al.*, 2016b). The climatic and edaphic factors favour crop and livestock production. According to the National Population Commission's 2006 population census, the state has about 149,805 citizens and it has a landmark area of 881 km<sup>2</sup> (Okafor, 2016). Kaltungo is well known for having various kinds of snakes in Northern Nigeria.

### **Sampling Period, Study design, study population and target population**

The present study, which involved a cross-sectional survey employing convenient sampling procedures, was conducted from March 2019 to February 2020. During this period, all study locations were visited in order to collect samples and other data. Sampling locations include backyard poultry farms and live birds markets

where majority of livestock farmers bring their birds for sales. The study population includes apparently healthy village chickens that were randomly selected during visits to particular study locations. The target population comprised all the rural chickens in the study area.

### **Ethical consideration**

First, verbal authorization and acceptance from the poultry farmers or merchants were acquired. The scope of the study and its importance to the system of poultry production were explained to chicken owners.

### **Inclusion and exclusion criteria**

Age (defined as >5 months for adults chicken and 3 – 4 months for growers chicken – age categorization of the studied chickens was spanned for better statistical interpretations), sex (defined as hens or cocks), season of sampling (defined as rainy or dry), management and husbandry system of chickens (defined as extensive or semi-intensive), were variables that were considered as previously described (Aiyedun *et al.*, 2022). These details were obtained from chicken owners or vendors at farms or live birds' markets, accordingly. Only chickens with verbal consent from their owners and those who had never before received an antiprotozoal or an acaricide chemical treatment were eligible for inclusion.

### **Sampling Collection**

Each bird that was being sampled was appropriately restrained and prepared for blood sample collection. Following Rukhsana (2005) instructions, 3–4 ml of blood were immediately drawn from each chicken's brachial vein (wing vein) using a sterile 5 ml syringe and 23 gauge needles. Each blood sample was dispensed instantly into an EDTA anticoagulant vial. All samples were properly labeled and transported in an ice pack container to the Department of Veterinary Parasitology and Entomology laboratory, Faculty of Veterinary Medicine, University of Maiduguri for analysis.

### **Preparation of Blood Smears for Haemoparasites Identification, Parasitological Examination and Detection**

Thin blood and buffy coat smears from each blood sample were made on a clean, dry slide, allowed to air dry for a few minutes, and then labeled accordingly as described by Mello *et al.* (2014). The slides were fixed with methanol and stained with diluted 10% Giemsa stain in accordance with the protocols outlined by Zajac and Conboy (2012). The stained blood smears were then viewed under a light Olympus<sup>R</sup> (Japan) microscope at low (40×) and high magnifications (100×) oil immersion objective for the presence of intracellular or extracellular blood parasites schizonts, gametocytes, and trophozoites based on morphology as previously described by Valkiunas (2005).

### **DATA ANALYSIS**

Microsoft Office<sup>R</sup> Excel 2010 was used to collect the data, which was subsequently extended with SPSS version 22.0 (IBM<sup>R</sup>) for additional statistical analysis. For haemosporidian infections, the frequency and prevalence were determined as percentages of proportion and their 95% confidence interval were also computed. These parameters were determined according to the explanatory variables such as sex, age (months), season of sampling, management and husbandry systems. The proportions of positive to haemosporidian parasites associated to the categorical factors (such as sex, season, husbandry system and age) were compared using the Chi-square test, or Fisher's exact test if appropriate, with *P*-values equal to or less than 0.05 considered statistically significant.

### **RESULTS**

Overall, the prevalence of haemosporidian parasites of 18.1% (95% CI: 15.6 – 21.0) was recorded. The prevalence of haemosporidian parasites in rural chickens was found to be higher in chickens examined from households

(10.1%; 95% CI: 8.2 – 12.4) compared to live birds markets (8.0%; 95% CI: 6.3 – 10.1) of the study area, however, the difference in the prevalence rates was not statistically ( $P = 0.1420$ ;  $P > 0.05$ ;  $\chi^2 = 2.156$ ) significant (Table 1).

Three species of haemosporidian parasites (*Plasmodium* spp, *Haemoproteus* spp. and *Leucocytozoon* spp.) were found in single and co-infections in the infected chickens. For the single infections, the prevalence of *Plasmodium* species (9.0%; 95% CI: 7.2 – 11.2) was found to be higher followed by *Haemoproteus* species (3.1%; 95% CI: 2.1 – 4.6) and *Leucocytozoon* species (1.0%; 95% CI: 0.5 – 2.0). The prevalence of co-infection with *Haemoproteus* spp./*Plasmodium* spp. (3.4%; 95% CI: 2.3 – 4.9) was found to be higher followed by *Leucocytozoon* spp./*Plasmodium* spp. (1.1%; 95% CI: 0.6 – 2.1) and *Haemoproteus* spp./*Leucocytozoon* spp./*Plasmodium* (0.5%; 95% CI: 0.2 – 1.3) the infected Rural chickens (Table 2).

According to the Chi-square analysis, sex, age of chickens and season of sampling were statistically significant factors associated with *Plasmodium* species infection in rural chickens (Table 3). Similarly, significant risk factors identified for mixed haemosporidian infections were age of chickens, sex of chickens and season of sampling (Table 3). However, the prevalent rates of haemosporidian parasites between the different sexes, ages of chickens and seasons were not statistically ( $p > 0.05$ ) significant for *Haemoproteus* spp. infections in chickens. However, for, *Leucocytozoon* spp., the difference in the prevalent rates of haemosporidian parasites between the different ages of chickens and seasons was found to be statistically ( $p < 0.05$ ) significant, while the difference in the prevalence rates between the sex of chickens was not statistically ( $p > 0.05$ ) significant for Leucocytozoonosis in Rural chickens (Table 3).

**Table 1:** Prevalence of Haemosporidian Parasites in Rural chickens (*Gallus gallus domesticus*) from Kaltungo Local Government Area, Gombe State, Nigeria

Study location	No. of chickens examined	No. of chickens (%) infected	Prevalence (%) 95% CI LL – UL	P- value	$\chi^2$	Odd Ratio	Relative Risk
Households	400	81	10.1 <sup>a</sup> (8.2 – 12.4)	0.1420	2.156	0.7501	0.9494
Live birds' markets	400	64	8.0 <sup>a</sup> (6.3 – 10.1)				
<b>Overall</b>	800	145 (18.1)	15.6 – 21.0				

<sup>a,a</sup>Values with same superscripts indicate not significant ( $p > 0.05$ ) difference in prevalence rates

**Table 2:** Composition of Haemosporidian Parasites infections in Rural chickens (*Gallus gallus domesticus*) from Kaltungo Local Government Area, Gombe State, Nigeria

Type of Infection	Haemosporidian parasites	Number of chickens infected N = 800	Prevalence (%)	95% CI LL – UL
<b>Single</b>	<i>Plasmodium</i> spp.	72	9.0	7.2 – 11.2
	<i>Haemoproteus</i> spp.	25	3.1	2.1 – 4.6
	<i>Leucocytozoon</i> spp.	8	1.0	0.5 – 2.0
<b>Mixed</b>	<i>Haemoproteus</i> spp. + <i>Plasmodium</i> spp.	27	3.4	2.3 – 4.9
	<i>Leucocytozoon</i> spp. + <i>Plasmodium</i> spp.	9	1.1	0.6 – 2.1
	<i>Haemoproteus</i> spp. + <i>Leucocytozoon</i> spp. + <i>Plasmodium</i>	4	0.5	0.2 – 1.3
	Overall	145	18.1	15.6 – 21.0

**Key:** N = Total number of chickens examined

**Table 3:** Risk factors linked to the presence of Haemosporidian Parasites in Rural chickens (*Gallus gallus domesticus*) (N = 800) from Kaltungo Local Government Area, Gombe State, Nigeria

Variables	Risk factors	No. of chickens (%) sampled	No. of chickens (%) infected	Prevalence (%) 95% CI LL – UL	Odd Ratio	No. of chickens (%) infected:			
						<i>Plasmodium</i> spp.	<i>Haemoproteus</i> spp.	<i>Leucocytozoon</i> spp.	Mixed infections
Sex	Male	408	108 (26.5)	13.5 <sup>a</sup> (11.3 – 16.0)	3.454	53 (6.6 <sup>a</sup> )	16 (2.0 <sup>a</sup> )	7 (0.9 <sup>a</sup> )	32 (4.0 <sup>a</sup> )
	Female	392	37 (9.4)	4.6 <sup>b</sup> (3.4 – 6.3)	Reference	19 (2.4 <sup>b</sup> )	9 (1.1 <sup>a</sup> )	1 (0.1 <sup>a</sup> )	8 (1.0 <sup>b</sup> )
	$\chi^2$ P- value	37.940 <0.0001				17.197 <0.0001	- 0.2245	- 0.0694	- 0.0001
Age (months)	3-4	379	40 (10.6)	5.0 <sup>a</sup> (3.7 – 6.7)	Reference	21 (2.6 <sup>a</sup> )	8 (1.0 <sup>a</sup> )	0 (0.0 <sup>a</sup> )	11 (1.4 <sup>a</sup> )
	>5	421	105 (24.9)	13.1 <sup>b</sup> (11.7 – 15.7)	2.931	51 (6.4 <sup>b</sup> )	17 (2.1 <sup>a</sup> )	8 (1.0 <sup>b</sup> )	29 (3.6 <sup>b</sup> )
	$\chi^2$ P- value	26.856 <0.0001				9.735 0.0018	0.1540 0.0040	- 0.0081	- 0.0139
Season	Rainy	400	116	14.5 <sup>a</sup> (12.2 – 17.1)	0.1914	55 (6.9 <sup>a</sup> )	16 (2.0 <sup>a</sup> )	8 (1.0 <sup>a</sup> )	37 (4.6 <sup>a</sup> )
	Dry	400	29	3.6 <sup>b</sup> (2.5 – 5.2)	Reference	17 (2.1 <sup>b</sup> )	9 (1.1 <sup>a</sup> )	0 (0.0 <sup>b</sup> )	3 (0.4 <sup>b</sup> )
	$\chi^2$ P- value	62.298 <0.0001				20.894 <0.0001	- 0.2221	- 0.0075	- <0.0001

<sup>a,b</sup>Values with different superscripts indicate significant ( $p < 0.05$ ) difference in prevalence rates; <sup>a,a</sup>Values with same superscripts indicate not significant ( $p > 0.05$ ) difference in prevalence rates

## DISCUSSION

The present study on the prevalence of haemosporidians in rural chickens in Kaltungo, Gombe State, is very significant and timely. In this study, the overall prevalence of infection with haemosporidian parasites was 18.1%. This finding indicated the presence of adequate arthropod vectors able to transmit avian haemosporidian to chickens, together with restricted access to medical and veterinary services, which may result in lower rates of haemosporidian parasite screening and treatment in the study area. However, recent reports from other parts of Nigeria has revealed varying prevalence rate of haemosporidian infections in chickens such as 37.7% in Nassarawa (Hasan *et al.*, 2018), 23.2% in Makurdi (Ogbaje *et al.*, 2019), 13.8% from Yobe (Lawal *et al.*, 2021), 91.3% from Kwara central (Aiyedun *et al.*, 2022) and 81.0% from Zaria (Buhari *et al.*, 2022). The variations in haemosporidian parasite infection prevalence rates found in rural chickens in different parts of Nigeria could be attributed to multiple factors, including geographic differences, chicken husbandry practices, chicken genetics, social-economic factors and availability of the vector. Other factors could be the quantity of samples examined, the method of diagnosis, and the time of year when samples were collected.

In the present study, although, the prevalence of haemosporidian parasites in rural chickens was found to be higher in chickens examined from households compared to live birds markets, however, the difference in the prevalence rates was not statistically significant. Our results may be explained by a wide range of observable factors in the study area, including but not limited to poor sanitary conditions in the households, such as stagnant water pools, inadequate and unhygienic housing conditions, which may increase the prevalence of haemosporidian parasites in households compared to live bird markets. Moreover, biological factors remaining unknown such as differences in the species of

vectors capable of transmitting haemosporidian infections to chickens present in the two study locations may explain the discrepancy between the prevalence of parasites observed in the two settings. In addition, factors such as the density of chickens in each study site may explain the contrasting prevalence of haemosporidian parasites in households and live birds markets. The higher density of chickens in live birds markets may afford greater opportunities for the spread of parasites in the study area. Our study agrees with previous studies which have reported higher prevalence of 81% and 100% in Rural chickens sampled from live bird markets in Zaria, Nigeria (Buhari *et al.*, 2022) and Kenya (Wamboi *et al.*, 2020) respectively. The susceptibility of chickens to avian haemosporidian parasites infection is determined by the abundance of the vector responsible for the transmission of the parasite among host (Valkiūnas *et al.*, 2005; Palinauskas *et al.*, 2011). Three haemosporidian parasites genera which are *Plasmodium*, *Haemoproteus* and *Leucocytozoon* were found in the infected chickens according to the findings of the present study, which are in agreement with reports by Van Hemert *et al.* (2019) and Mirzaei *et al.* (2020). These three haemosporidian parasites genera are the most often reported in chickens as well as other domesticated and wild birds. Our study found single haemosporidian infections of *Plasmodium* species followed by *Haemoproteus* species as the most prevalent in rural chickens in the study area. Also, this study was able to find conjoint haemosporidian infections in some of the infected chickens. This finding could be explained by the fact that rural chickens in the present study area are scavengers, which could expose them to various haemosporidian vectors. Other predisposing factors seen in the study area include inadequate housing, poor biosecurity, insufficient sanitation and cleaning, poor nutrition, and exposure to

stressful environmental conditions. Previous findings from Nigeria, other African nations, and other places across the world have verified concomitant infections with double as well as multiple haemosporidian infections in indigenous chickens raised under extensive management and husbandry systems (Abdul Momin *et al.*, 2014; Etisa *et al.*, 2017; Hasan *et al.*, 2017; Naqvi *et al.*, 2017; Hasan *et al.*, 2018; Ogbaje *et al.*, 2019). This suggest the global occurrence of avian haemosporidian infections making it a worldwide disease of domesticated birds (Bell *et al.*, 2015; Smith and Ramey, 2015; Hasan *et al.*, 2017).

According to the finding of the present study, sex, age of chickens and season of sampling were statistically significant factors associated with *Plasmodium* species and mixed haemosporidian infections in rural chickens in the study area. Our study showed that male chickens had a significantly higher prevalence of *Plasmodium* species in single and conjoint infection rates than female chickens. These results might be related to "Comb height" in male chickens, which may be a risk predictor of *Plasmodium* infection; chickens with larger combs may be more likely to be exposed to the bite of mosquitoes and other arthropods carrying the parasite (Sabuni *et al.*, 2011; Opara *et al.*, 2016; Etisa *et al.*, 2017; Hasan *et al.*, 2017; ). Additionally, male chickens are more tempting prey for mosquitos due to their bigger size and less feathered body regions than female chickens. Males may be more exposed to vector transmission and may be more likely to be subjected to higher predation risk due to the differences in their roaming and scratching behavior. Male chickens are often raised for a limited time and saved for religious sacrifices and cultural celebrations, they may not receive the same level of care or access to preventive measures as females that are raised for breeding (Lawal *et al.*, 2016a). Previous study have revealed that testosterone, which is higher in male chickens, may play a role in *Plasmodium* infection susceptibility due to immunosuppressive activities of the

hormone (Calero-Riestra and García, 2016). Furthermore, differences in parasite prevalence between males and females of vertebrates have typically been attributed to the impact of sex hormones on endocrine-immune interactions (Schalk and Forbes, 1997; Zuk and McKean, 1996). Examples include androgens - primarily testosterone - which can suppress cell-mediated and humoral immunity in males (Grossman, 1985; Grossman, 1989; Schuurs and Verheul, 1990), and oestrogen, which can suppress cell-mediated immunity while at the same time stimulating the humoral response in females (Grossman, 1985). In addition, male chickens may be less likely to display signs of illness, making them more likely to remain undiagnosed with parasites.

The finding of the present study also showed that adult chickens had a significantly higher prevalence of *Plasmodium* species in single and concurrent infections than young chickens. These results might be associated with adult chickens being at higher risk of contracting haemosporidian parasites due to their larger body size, more prominent and developed combs and wattles providing more surface area for parasites to attach, weaker immune systems due to aging, poorer diet and nutrition, and crowded living conditions which increases the chances of exposure and spread of infection. Furthermore, adult chickens have fewer behavioral defenses than young chickens and are thus less likely to avoid risk areas. The tendency of adult chickens to search for food and mates across great distances, which often takes them to unhygienic surroundings, makes them vulnerable to coming into contact with haemosporidian infections transmitting arthropods. In contrast, the flocks the younger chickens, on the other hand, frequently remain near to their roosts. This finding is consistent with that made by Etisa *et al.* (2017) in Ethiopia, who found that adult chickens had a significantly ( $p < 0.05$ ) higher prevalence of haemosporidian infections than growers. Nonetheless, our result



contradicts that of Naqvi *et al.* (2017) in Pakistan who found that avian haemosporidian infections were more widespread in growers in contrast to adult chickens, although the difference in the prevalence rates was not statistically significant ( $p > 0.05$ ).

The presence of preferred vectors of these haemosporidians in the study area is indicated by the occurrence of single infections with *Haemoproteus* species (3.1%) and *Leucocytozoon* species (1.0%) in the infected chickens, but the apparently low prevalence rate indicates that the haemosporidians are not a significant problem for the poultry industry in the study area. Though the prevalence of *Haemoproteus* species in the present study is equivalent to the 3.3% reported from Uganda (Nakayima *et al.*, 2019), the finding of the present study is higher than the 0.8% and 2.5% from Malaysia and Bangladesh, as reported by Gimba *et al.* (2014) and Nath and Bhuiyan (2017), respectively. The prevalence of *Leucocytozoon* found in the present study is lower than the 2.3% in Uganda reported by Nakayima *et al.* (2019).

However, sex, age of chickens and season of sampling were not significantly risk factors for *Haemoproteus* spp. infections in chickens which is consistent with previous report by Hasson (2015) and Naqvi *et al.* (2017). For, *Leucocytozoon* spp., significant risk factors were age of chickens and season of sampling, while sex of chickens was not significant risk factor for Leucocytozoonosis in Rural chickens, which agrees with Abdul Momin *et al.* (2014).

In the present study, the prevalence of all detected avian haemosporidian parasites was found to be higher during the rainy season compared to the dry season, agreeing with Okanga *et al.* (2013) who reported high prevalence of avian haemosporidian parasites during the raining season compared to other seasons. On the contrary, the prevalence of *Haemoproteus* specie was not significantly higher during the rainy season. This might be

tied to the favourable breeding season for several species of arthropods, such as mosquitoes, biting midges, louse flies and tabanid flies, facilitating the transmission of the avian haemosporidian parasites infection as proposed by Islam *et al.* (2013) and Smith and Ramey (2015). Moreover, Adriano and Cordeiro (2001) remarked that avian haemosporidian parasites infection are more common during the rainy season. Additionally, the occurrence of mixed haemosporidian parasites infection was found to be increased in the rainy season, concurs with the findings of Smith and Ramey (2015). Moreover, *Leucocytozoon* specie was only encountered during the rainy season, whereas no detection was made in the dry season. Okanga *et al.* (2013) and Zhao *et al.* (2014; 2016) have likewise reported seasonal variation in the prevalence of avian haemoparasite diseases.

#### CONCLUSION

It was discovered that infected chickens either had a single infection or a combination of these haemosporidian parasites. *Plasmodium* was found to be the most prevalent haemosporidian parasite infecting rural chickens in Kaltungo, Nigeria. Age, sex of chickens, and season of sample collection all affected the prevalence of avian haemosporidian parasites, with the prevalence significantly higher in adults compared to grower chickens, the prevalence of infection is also significantly higher in males compared to female chickens and significantly higher in rainy season compared to dry season of the study period. Sex, age of chickens and season of sampling were statistically significant factors associated with *Plasmodium*, *Leucocytozoon* and mixed haemosporidian infections in rural chickens. However, sex, age of chickens and season of sampling were not significantly risk factors for *Haemoproteus* species.

#### CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest

## REFERENCES

- Abdul Momin, M. A., Begum, N., Dey, A. R., Paran, M. S. and Alam, M. Z. (2014). Prevalence of Blood Protozoa in Poultry in Tangail, Bangladesh. *Scholars Journal of Agriculture and Veterinary Science*, 7(7): 55-60.
- Adriano, E. A. and Cordeiro, N. S. (2001). Prevalence and Intensity of *Haemoproteus columbae* in three Species of Wild Doves from Brazil. *The Memórias do Instituto Oswaldo Cruz*. 96: 175-178.
- Aiyedun, J. O., Elagroudi, M. G., Ola-Fadunsin, S. D., Nuhu, N. M., Sanda, I. M., Hussain, K., *et al.*, (2022). Cross-species Prevalence and Risk Factors Associated with Avian Haemoparasitic Infections in Kwara Central, Nigeria. *Zagazig Veterinary Journal*, 50 (2): 116-125.
- Ajala, A. O., Ogunjimi, S. I., Famuwagun, O. S. and Adebimpe, A. T. (2021). Poultry production in Nigeria: exploiting its potentials for rural youth empowerment and entrepreneurship. *Nigerian Journal of Animal Production*, 48(1): 114-123. doi:10.51791/njap.v48i1.2890
- Alasadiy, Y. D. K., Alhasnawi, A. N. and Eabaid, F. A. (2020). The Prevalence of Parasitic Infection in Domestic Chicken: A Review. *Medico-legal Update*, January-March 2020, 20(1): 864-869.
- Amato, M. G. and Castellini, C. (2022). Adaptability Challenges for Organic Broiler Chickens: A Commentary. *Animals* (Basel).12(11): 1354. doi: [10.3390/ani12111354](https://doi.org/10.3390/ani12111354)
- Bell, J. A., Weckstein, J. D., Fecchio, A. and Tkach, V. V. (2015). A New Real-Time PCR Protocol for Detection of Avian Haemosporidians. *Parasites and Vectors*, 8:383.
- Bensch, S., Hellgren, O. and Perez-Tris, J. (2009). MalAvi: a public database of malaria parasites and related haemosporidians in avian hosts based on mitochondrial cytochrome b lineages. *Molecular Ecology Resources*, 9:1353-1358.
- Buhari, H. U., Habibu, B., Maidala, H. M. B. and Ikira, N. M. (2022). Prevalence of Haemoparasites in Chickens Slaughtered at a Live Bird Market in Samaru Zaria, Nigeria. *Sahel Journal of Veterinary Sciences*, 19(4): 6-9. <http://dx.doi.org/10.54058/saheljvs.v19i4.259>
- Calero-Riestra, M. and García, J. T. (2016). Sex-dependent differences in avian malaria prevalence and consequences of infections on nestling growth and adult condition in the Tawny pipit, *Anthus campestris*. *Malaria Journal*, 15, 178. <https://doi.org/10.1186/s12936-016-1220-y>
- Cannell, B. L., Krasnec, K. V., Campbell, K., Jones, H. I., Miller, R. D. and Stephens, N. (2014). The pathology and pathogenicity of a novel *Haemoproteus* spp. infection in wild Little Penguins (*Eudyptula minor*). *Veterinary Parasitology*, 15; 205(1-2): 416. doi: 10.1016/j.vetpar.2013.04.025
- Durodola, O. S. (2019). The Impact of Climate Change Induced Extreme Events on Agriculture and Food Security: A Review on Nigeria. *Agricultural Sciences*, 10(4): 487-498. doi: 10.4236/as.2019.104038
- Echendu, A. J. (2022). Flooding, Food Security and the Sustainable Development Goals in Nigeria: An Assemblage and Systems Thinking Approach. *Social Sciences*, 11(2), 59. <https://doi.org/10.3390/socsci1102059>
- Etisa, E., Chanie, M. and Tolossa, Y. H. (2017). Prevalence of Haemoparasites Infections in Scavenging Indigenous Chickens in and around Bishoftu. *World Applied Sciences Journal*, 35 (2): 302-309.

- Food and Agriculture Organization (FAO) of the United Nations (2021). The Future of Food and Agriculture—Trends and Challenges. Rome. [(accessed on 29 May 2023)];2023 Available online: <http://www.fao.org/3/i6583e/i6583e.pdf>
- Gimba, F. I., Zakaria, A., Mugok, L. B., Siong, H. C., Jaafar, N., Moktar, M., A., *et al.*, (2014). Haemoparasites of Domestic Poultry and Wild Birds in Selangor, Malaysia. *Malaysian Journal of Veterinary Research*, 5 (1): 43-51.
- Grossman, C. J. (1989). Possible underlying mechanisms of sexual dimorphism in the immune response, fact and hypothesis. *The Journal of Steroid Biochemistry*, 34: 241-251.
- Grossman, C. J. (1985). Interactions between the gonadal steroids and the immune system. *Science*, 227: 257-261.
- Hafez, H. M. and Attia, Y. A. (2020). Challenges to the Poultry Industry: Current Perspectives and Strategic Future after the COVID-19 Outbreak. *Frontiers in Veterinary Science*, 7:516. doi: 10.3389/fvets.2020.00516
- Hasan, A. M., Hossain, M. S., Anita Rani Dey, A. R. and Alam, M. Z. (2017). Prevalence of Malaria Parasites in Indigenous Chickens and Ducks in Selected Districts of Bangladesh. *Journal of Bangladesh Agricultural University*, 15(2): 260-265.
- Hasan, D. I., Faith, E. A., Yusuf, N. D., Azaku, E. A and Mohammed, J. (2018). Haemosporidians of village chickens in the southern ecological zone of Nassarawa state, Nigeria. *Nigerian Journal of Animal Science and Technology*, 1(2): 29-37.
- Hasson, R. H. (2015). Haemosporidians parasites of *Gallus domesticus* poultry in Iraq. *International Journal of Advanced Research*, 3(8):1046-1054.
- Islam, M. A., Anisuzzaman, Rabbi, A. K. M. A., Rahman, A., Islam, M. A. and Rahman, M. H. (2013). *Haemoproteus* spp. infection of domestic poultry of Bangladesh. *VetScan*, 7: 81–84.
- Khalid, A. M., Iqbal, G. D., Aderounmu, B., Onabote, A., Osabohien, R., Ashraf, J., *et al.*, (2021). Social Inclusion, Innovation and Food Security in West Africa. *Sustainability*, 13: 2619. doi: 10.3390/su13052619.
- Lawal, J. R., El-Yuguda, A. D. and Ibrahim, U. I. (2016b). Efficacy of Feed Coated Newcastle Disease I2 Vaccine in Village Chickens in Gombe State, Nigeria. *Journal of Veterinary Science and Technology*, 7: 349. doi:10.4172/2157-7579.1000349
- Lawal, J. R., Ibrahim, U. I., Biu, A. A. and Musa, H. I. (2022). Molecular Detection of Avian Haemosporidian Parasites in Village Chickens (*Gallus gallus domesticus*) in Gombe State, Nigeria. *Journal of Veterinary Medicine and Animal Science*, 5(1): 1095.
- Lawal, J. R., Bello, A. M., Balami, S. Y., Wakil, Y., Yusuf, Z. B., Dauda, J., *et al.*, (2016a). Prevalence and Economic Significance of Ectoparasites Infestation in Village Chickens (*Gallus gallus domesticus*) in Gombe, Northeastern Nigeria. *Direct Research Journal of Agriculture and Food Science*, 4 (5): 94-103.
- Lawal, J. R., Ibrahim, U. I., Biu, A. A. and Muhammed, K. (2021). Emerging Haemosporidian Infections in Village Chickens (*Gallus gallus domesticus*) in Yobe State, Nigeria. *American Journal of Biomedical and Life Sciences*, 9(4): 190-196. doi: 10.11648/j.ajbls.20210904.13
- Lee, H. R., Koo, B. S., Jeon, E. O., Han, M. S., Min, K. Ch., Lee, S. B., *et al.*, (2016). Pathology and molecular characterization of recent *Leucocytozoon caulleryi* cases in layer flocks. *Journal of Biomedical Research*, 30:517-524.
- Li, Z., Ren, X., Zhao, Y., Yang, L., Duan, B., Hu, N., *et al.*, (2022). First report of haemosporidia and associated

- risk factors in red junglefowl (*Gallus gallus*) in China. *Parasites and Vectors*, 15:275. <https://doi.org/10.1186/s13071-022-05389-2>
- Mbuli, C. S., Fonjong, L. N. and Fletcher, A. J. (2021). Climate Change and Small Farmers' Vulnerability to Food Insecurity in Cameroon. *Sustainability*, 13:1523. doi: 10.3390/su13031523.
- Mello, M. B. C., Luz, F. C., Leal-Santos, F. A., Alves Jr, E. R., Gasquez, T. M. and Fontes, C. J. F. (2014). Standardization of Blood smears prepared in transparent acetate: An alternative Method for the Microscopic Diagnosis of Malaria. *Malaria Journal*, 13: 238.
- Miranda, P. A., Chalkowski, K., Zohdy, S. and Willoughby, J. R. (2022). Management of avian malaria in populations of high conservation concern. *Parasites and Vectors*, 15:208.
- Mirzaei, F., Siyadatpanah, A., Norouzi, R., Pournasir, S., Nissapatorn, V. and Pereira, M. L. (2020). Blood Parasites in Domestic Birds in Central Iran. *Veterinary Sciences*, 7, 126; doi:10.3390/vetsci7030126
- Mohammed, B. R.; Ojo, A. A.; Opara, M. N.; Jegede, O. C. and Agbede, R. I. S. (2019): Haemo- and endoparasites of indigenous chickens reared in Gwagwalada Area Council, Abuja, Nigeria. *Annals of Parasitology*, 65: 293-296. doi: 10.17420/ap6503.213
- Mukhtar, M. (2020). Impact of Boko-Haram conflict on food security status among the households in Kano Metropolis. *Lapai Journal of Economics*, 10(1): 134-147.
- Nakayima, J., Arinaitwe, E., Kabasa, W. M., Kasaija, P. D., Agbemelo-Tsomafo, C. and Omotoriogun, T. C. (2019). Phylogeny and Prevalence of Haemosporidian Parasites of Free-ranging Domestic Birds in Northwestern Uganda. *International Journal of Livestock Research*, 19(12): 244-258. doi 10.5455/ijlr.20191104070146
- Naqvi, M. A., Khan, M. K., Iqbal, Z., Rizwan, H. M., Khan, M. N., Naqvi, S. Z., et al., (2017). Prevalence and Associated Risk factors of Haemoparasites, and their Effects on Haematological Profile in Domesticated Chickens in District Layyah, Punjab, Pakistan. *Preventive Veterinary Medicine*, 1; (143): 49-53.
- Nath, T. C. and Bhuiyan, M. J. U. (2017). Haemoprotozoa infection of domestic birds in hilly Areas of Bangladesh. *Independent Journal of Management and Production*, 8:82.
- Nourani, L., Aliabadian, M., Mirshamsi, O., Dinparast, D. N. (2018). Molecular detection and genetic diversity of avian haemosporidian parasites in Iran. *PLoS ONE*, 13(11): e0206638. <https://doi.org/10.1371/journal.pone.0206638>
- Ogbaje, C. I., Jerry A. Okpe, J. A. and Oke, P (2019). Haemoparasites and Haematological Parameters of Nigerian Indigenous (local) and Exotic (broiler) Chickens Slaughtered in Makurdi Major Markets, Benue State, Nigeria. *Alexandria Journal of Veterinary Sciences*, 63 (2): 90-96.
- Okafor, S. O. (2016). 2006 Nigeria Population Census and Errors in Age Reporting: A Critical Assessment of the Priority Table. Conference Paper presentation at the Biennial Conference on Interdisciplinary Studies (BCIS) Organized by the Faculty of Management and Social Sciences Godfrey Okoye University Enugu, Enugu State Nigeria. March, 2016, Volume: 1.
- Okanga, S., Cumming, G. S. and Hockey, P. A. R. (2013). Avian malaria prevalence and mosquito abundance in the Western Cape, South Africa. *Malaria Journal*, 12: 370.
- Opara, M. N., Osowa, D. K. and Maxwell, J. A. (2014). Blood and Gastrointestinal Parasites of Chickens and Turkeys Reared in

- the Tropical Rainforest Zone of Southeastern Nigeria. *Open Journal of Veterinary Medicine*, 4, 308-313.  
<http://dx.doi.org/10.4236/ojvm.2014.412037>
- Opara, N. M., Okereke, E. R., Olayemi, O. D. and Jegede, O. C. (2016). Haemoparasitism of Local and Exotic Chickens Reared in the Tropical Rainforest Zone of Owerri, Nigeria. *Alexandria Journal of Veterinary Sciences*, 51(1): 84-89.
- Osabohien, R., Olurinola, I., Matthew, O. and Ufua, D. E. (2020). Social Protection Intervention and Agricultural Participation in West Africa. *African Journal of Science, Technology, Innovation and Development*, 12:1-6. doi: 10.1080/20421338.2020.1853315.
- Palinauskas, V., Valkiūnas, G., Bolshakov, C. V. and Bensch, S. (2011). *Plasmodium relictum* (lineage SGS1) and *Plasmodium ashfordi* (lineage GRW2): The Effects of the co-infection on experimentally infected Passerine Birds. *Experimental Parasitology*, 127: 527-533.
- Palinauskas, V., Valkiūnas, G., Križanauskienė, A., Bensch, S. and Bolshakov C. V. (2009). *Plasmodium relictum* (lineage P-SGS1): Further observation of effects on experimentally infected Passeriform Birds, with remarks on treatment with Malarone™. *Experimental Parasitology*, 123: 134-139.
- Palinauskas, V., Ziegyte, R., Ilgunas, M., Iezhova, T.A., Bernotiene, R., Bolshakov, C. *et al.*, (2015). Description of the first cryptic Avian Malaria Parasite, *Plasmodium homocircumflexum* n. sp., with experimental data on its Virulence and Development in Avian Hosts and Mosquitoes. *International Journal of Parasitology*, 45: 51-62.
- Pramual, P., Thaijarern, J., Tangkawanit, U. and Wongpakam, K. (2020). Molecular identification of blood meal sources in black flies (Diptera: *Simuliidae*) suspected as *Leucocytozoon* vectors. *Acta Tropica*, 205:105383.
- Rukhsana, T. (2005). Infectious Haematozoan parasites found in Birds of Pakistan. *Pakistan Journal of Biological Sciences*, 8(1): 1-5.
- Sabuni, Z. A., Mbutia, P. G., Maingi, N., Nyaga, P. N., Njagi, L. W., Bebora, L. C. *et al.*, (2011). Prevalence of haemoparasites infection in indigenous chicken in Eastern Province of Kenya. *Livestock Research for Rural Development*, 23 (11): 2011. Article #238.
- Schalk, G. and Forbes, M. R. (1997). Male biases in parasitism of mammals: effects of study type, host age, and parasite taxon. *Oikos*, 78:67-74.
- Schuurs, A. and Verheul, H. (1990). Effects of gender and sex steroids on the immune response. *Journal of Steroid Biochemistry*, 35:157-172.
- Silveira, P., Belo, N. O., Rodello, D., Pinheiro, R. T. and Braga, E. M. (2010) Microfilariae infection in wild birds from the Brazilian cerrado. *Journal of Wildlife Diseases*, 46(4): 1305-1309. doi: 10.7589/0090-3558-46.4.1305.
- Smith, M. M. and Ramey, A. M. (2015). Prevalence and Genetic Diversity of Haematozoa in South American Waterfowl and evidence for intercontinental redistribution of Parasites by migratory Birds. *International Journal for Parasitology: Parasites and Wildlife*, 4: 22-28.
- Svobodova, M., Weidinger, K., Peske, L., Volf, P., Votýpka, J. and Voríšek, P. (2015). Trypanosomes and Haemosporidia in the Buzzard (*Buteo buteo*) and Sparrow-hawk (*Accipiter nisus*): Factors affecting the Prevalence of Parasites. *Parasitology Research*, 114: 551-560.
- Valkiūnas, G. (2005). *Avian malaria parasites and other haemosporidia*, CRC

- Press, Boca Raton, Florida, pp. 946.
- Valkiūnas, G., Anwar, A. M., Atkinson, C. T., Greiner, E. C., Paperna, I. and Peirce, M. A. (2005). What distinguishes Malaria Parasites from other pigmented Haemosporidians? *Trends in Parasitology*, 21(8): 357-358.
- Van Hemert, C., Meixell, B. W., Smith, M. M. and Handel, C. M. (2019). Prevalence and diversity of avian blood parasites in a resident northern passerine. *Parasites and Vectors*, 12, 292.
- Votýpka, J., Szabová, J., Radrova, J., Zidkova, L. and Svobodová, M. (2012) *Trypanosoma culicavium* sp. nov., an avian trypanosome transmitted by Culex mosquitoes. *International Journal of Systematic and Evolutionary Microbiology*, 62(3): 745-754. doi: 10.1099/ijs.0.032110-0.
- Wamboi, P., Waruiru, R. M., Mbuthia, P. G., Nguhiu, J. M. and Bebor, L. C. (2020). Haemato-biochemical changes and prevalence of parasitic infections of indigenous chicken sold in markets of Kiambu County, Kenya. *International Journal of Veterinary Science and Medicine*, 8(1): 18-25.
- Yang, G., He, H., Zhang, G., Zhao, W., Zhou, J., Qian, Y., *et al.*, (2021). Neglected parasite reservoirs in wetlands: prevalence and diversity of avian haemosporidians in waterbird communities in Northeast China. *International Journal for Parasitology: Parasites and Wildlife*, 15, 177-183.
- Zajac, A. M. and Conboy, G. A. (2012). *Veterinary Clinical Parasitology*. 8th edition. Wiley- blackwell. A John Wiley and Sons. Inc. publication, pp. 186.
- Zhao, W., Cai, B., Qi, Y., Liu, S., Hong, L., Lu, M., *et al.*, (2014). Multi-strain infections and 'relapse' of *Leucocytozoon sabraezesi* gametocytes in Domestic Chickens in Southern China. *PLoS One*. 2014; 9(4):e94877.
- Zhao, W., Pang, Q., Xu, R., Liu, J., Liu, S., Li, J. *et al.*, (2016) Monitoring the Prevalence of *Leucocytozoon sabraezesi* in Southern China and Testing Tricyclic Compounds against Gametocytes. *PLoS One* 11(8): e0161869.
- Zuk, M. and McKean, K. A. (1996). Sex differences in parasite infections: patterns and processes. *International Journal of Parasitology*, 26(10):1009-1023.