Veterinary Parasitology: Regional Studies and Reports 16 (2019) 100289

Contents lists available at ScienceDirect

Veterinary Parasitology: Regional Studies and Reports

journal homepage: www.elsevier.com/locate/vprsr

Prevalence of intestinal helminth parasites of pigeons (*Columba livia domestica* Gmelin 1789) in Kano State, North-Western Nigeria

B.R. Mohammed[a,b,*], M.K. Simon[a,c], R.I.S. Agbede[a], A.H. Arzai[d]

[a] Department of Parasitology and Entomology, Faculty of Veterinary Medicine, University of Abuja, P.M.B 117, Abuja, Nigeria
[b] School of Science, Engineering and Technology, Abertay University, Dundee DD1 1HG, United Kingdom
[c] Department of Infection and Host Defense, Graduate School of Medicine, University of Chiba, 8-1 Inohana, Chuo-ku, Chiba 260-8670, Japan
[d] Department of Microbiology, Bayero University, P.M.B 3011, Kano, Nigeria

ARTICLE INFO

Keywords:
Pigeons
Squabs
Squeakers
Youngsters
Kano

ABSTRACT

In Nigeria, helminths have over the last decades been established as important parasite of poultry including pigeons. However, the prevalence of these parasites of pigeons in Kano State is yet to be established. The prevalence of helminth parasites of domestic pigeon (*Columba livia domestica*) in Kano State, Nigeria was investigated in this study. The differences in the prevalence of infection between the pigeons examined on the basis of sex of the pigeon and season of the year were analyzed statistically using the students' "t" –test. The intestinal contents of 144 pigeons were examined for gastrointestinal helminths between February and April representing the dry season and between June and August for the wet season. Pigeons were grouped according to Squabs (chicks) (0-4 weeks), Squeakers (Juveniles) (5-8 weeks) and Youngsters (Adults) (9 weeks onwards). Intestinal parasites found include Cestodes: *Raillietina tetragona,* 20 (13.80%), *R. echinobothrida,* 11 (7.64%), *Amoebotaenia cuneata*, 5 (3.47%), *Hymenolopis contaniana*, 10 (6.95%), *Davainea proglottina*, 1(0.69%) and *Ornithostrongylus quadriatus* 1(0.69%). Nematodes: *Capillaria obsignata*, 10(6.95%) and *Ascaridia columbae*, 9(6.25%). Forty-two (29.16%) of the birds had mild infection, 17 (11.81%) had moderate infection, 9 (6.25%) and 2(1.39%) had heavy and severe infection, respectively. The prevalence was higher during the wet season (36.65%) than during the dry season (27.97%). Of all the age groups, only Youngsters, 34 (23.61%) were infected with intestinal helminths. However, there were statistically significant differences between the age, sex and seasons in this study ($P < 0.005$). Pigeons raised on semi-intensive had the highest rate of infection (37.50%) and those raised on intensive management had the lowest rate of infection (9.03%). A number of measures are recommended for the control of these helminthic parasites.

1. Introduction

Recently, wide spread intestinal helminths infection in poultry including pigeons have been reported in Nigeria (Idika et al., 2016; Afolabi et al., 2016) and several other African countries (Nghonjuyi et al., 2014; Sente et al., 2016; El-Dakhly et al., 2016). Globally, intestinal helminths constitute the most commonly encountered disease causing agents in pigeons (Satish and Priti, 2013). Infections of pigeons by a plethora of these helminths impair successful breeding of these birds resulting in heavy economic losses manifested by lowered resistance to other infectious agents, stunted growth, weight loss, reduced feed conversion efficiency, general ill health and sometimes death if untreated (Parsani et al., 2014). Moreover, there is the prospect that domestic pigeons are capable of serving as surrogate hosts for a number of helminths of domestic poultry due to their interaction and phylogenetically close relationship (Adang et al., 2008). They can also serve as a source for different helminthic zoonotic diseases for humans and birds and can be parasitized by a wide variety of intestinal parasites which include; Acanthocephalans, Cestodes, Nematodes and Trematodes (Sivajothi and Sudhakara, 2015).

The epidemiological studies and knowledge on diversity of prevalence of pigeon parasites is quintessential for effective management. However, detailed information on the prevalence of these intestinal helminths amongst domestic pigeons in Kano State remains scarce, and it is unclear how the different husbandry practice systems can affect the infection of pigeons raised. In this study therefore, the prevalence of intestinal helminths of domestic pigeons *(Columba livia domestica)* in Kano State was investigated. Data for the prevalence of pigeons raised under semi- intensive system were compared to those under intensive systems of production. This investigation was performed with the aim

* Corresponding author at: PMB 117, Faculty of Veterinary Medicine, University of Abuja, Nigeria.
E-mail addresses: balarabemohammed161@yahoo.co.uk (B.R. Mohammed), Aharzai.bio@buk.edu.ng (A.H. Arzai).

https://doi.org/10.1016/j.vprsr.2019.100289
Received 10 August 2018; Received in revised form 30 January 2019; Accepted 11 April 2019
Available online 13 April 2019

Table 1
Overall prevalence and severity of infection of Intestinal Helminths of Pigeons in selected Local Government Areas of Kano State, Nigeria.

S/N0.	Local Government Area	N·S	Helminths								N·I	Prev. (%)		
			Cestodes						Nematodes					
			A. cunea.	*D. proglot.*	*H. contan.*	*R. tetrago.*	*R. echin.*	*O. quad.*	*A. Colum.*	*C. Obsigna.*			N·I	P(%)
1	Dala	12	−	−	−	+ + +	+ + +	−	+ + +	+ +	7	4.86	3	2.01
2	Dawakin kudu	12	−	−	−	+ + +	+	−	+ + +	+	4	2.78	1	0.69
3	Fagge	12	−	−	+ +	+ + +	+ +	−	+ + +	−	5	3.47	−	−
4	Gezawa	12	−	−	+	+ +	−	−	−	+ +	5	3.47	−	−
5	Gwale	12	−	−	+	+ +	−	+	−	+ +	5	3.47	−	−
6	Kumbotso	12	−	−	+	+ +	−	−	+ + +	+ +	8	5.56	4	2.78
7	Minjibir	12	−	+ +	+	+	+ +	−	+	+ + +	4	2.78	−	−
8	Municipal	12	−	+ + +	+	+ + +	−	−	−	+ + +	7	4.86	−	−
9	Nassarawa	12	−	+ +	+ +	+ + +	−	−	−	−	1	0.69	−	−
10	Tarauni	12	+ +	−	−	+ + +	+	−	+	+ + +	8	5.56	1	0.69
11	Tofa	12	−	+	+ +	+ +	−	−	+ + +	+ + +	7	4.86	2	1.39
12	Ungogo	12	−	−	+ +	+	−	−	+ + +	+ + +	6	4.17	−	−
NI		144	5(3.47)	1(0.69)	10(6.95)	20(13.80)	11(7.64)	1(0.69)	9(6.25)	10(6.95)			**11**	**(7.63)**
Total			5	1	10	20	11	1	9	10	**67**			

Key: (+ = mild, + + = moderate, + + + = severe), **S/N0.**- Serial number, **N.S.** - Number of samples, **NI**-Number infected, **Prev.**- Prevalence, ***A. cunea.***-*Amoebotaenia cuneata*, ***D. proglot.***- *Davainea proglottina*, ***H. contan.***- *Hymenolopis contaniana*, ***R. tetrago.***-*Raillietina tetragona*, ***R. echin.***- *Raillietina echinobothrida*, ***O. quad.***-*Ornithostrongylus quadriradiatus*, ***A. columbae***- *Ascaridia columbae*, ***C. obsigna***- *Capillaria obsignata.*

of evaluating the prevalence rate of intestinal helminths in domestic pigeon in Kano State and compares their distribution according to age, sex, seasons and management practices.

2. Materials and methods

2.1. Study area

Kano State lies in the Sudan Savannah zone of Nigeria (Latitude $12^0 12'$N and Longitude 8^0 3′E). It has at its North and Eastern borders, Plateau, Bauchi and Katsina States respectively. The climate is the Sudan type, with a mean temperature of 25 °C. The rainy season is from May to October, with an annual rainfall of 1000cm^3 (Olofin, 1987; Rabiu and Arzai, 2012). The study was conducted in 12 Central Local Government Areas (LGA) of Kano State, namely; Dala, Dawakin kudu, Fagge, Gezawa, Gwale, Kumbotso, Minjibir, Municipal, Nassarawa, Tarauni, Tofa and Ungogo.

2.2. Pigeon collection

Between February- April (dry season) and June- August (wet season), a total of 144 pigeons comprising 72 males and 72 females were sampled on two different seasons (wet and dry) during the period of the study. Six (6) pairs were sampled from homes (natural habitats) in each LGA and were grouped according to; Squabs (chicks) (0–4 weeks), Squeakers (Juveniles) (5–8 weeks) and Youngsters (Adults) (9 weeks onwards) (Mohammed, 2009; Mohammed et al., 2017a,b).The intestinal contents were examined in the Faculty of Science Laboratory, Bayero University, Kano State, Nigeria for the presence of intestinal helminths and their eggs.

2.3. Parasitological examinations

The birds were humanely slaughtered, dissected and necropsied in the laboratory to expose the intestines as described by (Fatihu et al., 1991). The distal portion of the intestinal tract was severed and placed in a petri dish containing 0.85% Physiological saline solutions (PSS). The intestinal mucosa were scraped using microscopic slides whilst the helminth parasites were collected using a fine brush and were fixed in hot A.F.A (Alcohol 70^o GL, 93 ml; Formaldehyde 5 ml, Acetic acid, 2 ml). The intestinal helminths were retrieved, counted and stained using alcoholic Chloride Carmine, dehydrated in a serial dilution of ethanol (70–100%), cleared in Phenol and mounted in Canada Balsam. Identification of the parasite was microscopically carried out using dissecting stereoscope as described by Mohammed, (2009).The remaining mucosal scrapings were examined using the floatation technique of saturated Sodium Chloride solution to identify the helminth ova at X400 magnification. Helminth eggs were identified based on their sizes measured using a mechanical Vernier caliper and morphology. The date, age and sex of birds as well as sites of sample collection were recorded as described by Greenberg et al., 2013. Infections with more than one species of helminth parasite were referred to as mixed infection.

2.4. Statistical analysis

Differences in the number of helminths parasites between the pigeons examined according to sex and season were compared using chi-square to test the strength of association and provide the odds ratio. Seasons were analyzed statistically using the students' "t" –test. Significant difference was accepted at $p < .05$.

3. Results

3.1. Prevalence of helminths parasite infection

During the period of investigation, 144 pigeons were examined comprising 72 males and 72 females. Similarly, seventy-two (72) pigeons each were sampled for the dry and wet seasons respectively. Of this number, 67 (46.52%) were infected with intestinal parasites.

The helminth parasites found include; Cestodes: *Raillietina tetragona*, 20 (13.80%), *R. echinobothrida*, 11 (7.64%), *Amoebotaenia cuneata*, 5 (3.47%), *Hymenolopis contaniana*, 10 (6.95%), *Davainea proglottina*, 1 (0.69%), *Ornithostrongylus quadriradiatus*, 1 (0.69%). Nematodes: *Capillaria obsignata*, 10 (6.95%) and *Ascaridia columbae*, 9(6.2.5%) (Table 1).

A breakdown of the prevalence of helminth parasites of pigeons as presented in Table 1 showed that the highest prevalence were recorded in Kumbotso and Tarauni LGAs (5.56%). This was followed closely by Municipal, Dala & Tofa (4.86%), Ungogo (4.17%) and Fagge, Gezawa & Gwale (3.47%) in that order. The lowest recorded prevalence (0.69%) was in Nassarawa.

Table 2
Age and Sex related distribution of intestinal helminths in the sampled pigeons.

		Total number examined	Number positive	% Prevalence
		144		
Sex	Male	72	21	14.58
	Female	72	12	8.33
Age	Squabs (0–4weeks)	48	–	–
	Squeakers (5–8weeks)	48	–	–
	Youngsters (9 weeks +)	48	34	23.61

3.2. Age and sex related distribution of intestinal helminths of pigeons

The prevalence of helminthic parasites analyzed according to sex, it was revealed that the male pigeons 21 (14.58%) had higher prevalence than females 12(8.33%), however, the difference was not statistically significant ($P > .005$) (Table 2). On the basis of age, only Youngsters 34 (23.61%) were infected whilst the Squabs and Squeakers were negative (Table 2).

3.3. Season variation in the prevalence of parasitic infection

The results in Fig. 1 showed that the prevalence rates of 27.97% and 36.65% were recorded for dry and wet seasons respectively.

Monthly seasonal variation in prevalence of infection as presented in Fig. 2, showed a progressive increase in the overall prevalence of infection from June through August whereby the highest prevalence (62.59%) was recorded in August followed closely by 58.83% in July (Fig. 2).

3.4. Prevalence of intestinal helminths of pigeons according to management system

Table 3 shows the prevalence of pigeon parasitism according to management systems, it was found that pigeons reared under Pauline and Rafter (18.75%) significantly ($P < .0001$) showed high infection compared to those reared using suspended wooden structure (0.69%).

On general hygiene, pigeon lofts cleaned quarterly (every 3 months) had the highest rate of infection (25.69%) whilst those cleaned bi-monthly had the lowest (4.86%). However, considering the prevalence of parasitism according to the type of feeding management, showed that pigeons reared under semi- intensive housing have significantly ($P < .0001$) higher percentage of infection (37.50%) compared to those reared under extensive housing (9.03%) (Table 3).

Considering the distribution of parasitized birds according to management systems, it was found that pigeons fed only twice in a day (26.39%) significantly ($P < .0001$) showed high infection compared to those fed ad-libtum (2.78%) (Table 4).

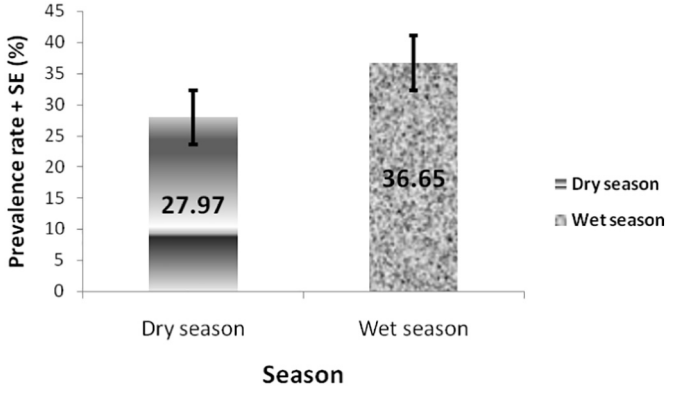

Fig. 1. Seasonal variations in percentage occurrence of helminthic infections in pigeons from selected Local Government Areas in Kano State.

The results as presented in Table 5 showed that two species of nematode (*Capillaria obsignata* & *Ascaridia columbae*) and six species of cestodes (*Raillietina tetragona, E. echinobothrida, Amoebotaenia cuneata, Hymenolopis contaniana, Davainea proglottina and Ornithostrongylus quadriradiatus)* were encountered in the study area.

Similarly the result in Table 5 showed that *Raillietina tetragona* was found most often in the study area, with a prevalence rate of 13.89%, followed by *R. echinobothrida* and *Ascaridia columbae* which had prevalence rates of (7.64%) and (6.95%), respectively. Mixed infections with one or more helminth parasite species as presented also in showed that (10.42%) were infected with two different helminth parasite species while (4.86%) pigeons infected with three and four different species of helminths parasites were 4.86% and 2.78% respectively.

4. Discussion

This study is the first to reveal the prevalence of intestinal helminths of pigeons in Kano State, Nigeria. The recorded prevalence levels of Cestodes (48.0%) were higher than all the other parasites. This is an indication of a higher availability of infective stages and intermediate hosts among the reared pigeons (Adang et al., 2008). Similar overall high prevalence was reported in the North-East zone (Oniye et al., 2000; Abdu et al., 2004). Adang et al. (2006) in Zaria (North West) and Atsineka and Banke (2006) in Makurdi (Middle belt) of Nigeria. This finding is dissimilar to that of El-Dakhly et al. (2016) who reported the prevalence rate of 7.29% of cestodes was in Ben—Saif province in Egypt; but considerably lower than 61.62% reported by Umaru et al. (2017) in Taraba State (North East), Nigeria.

The emergence of cestodes is dependent on suitable intermediate hosts (snails, beetles, pill bugs, ants and earthworms) required for further development; pigeons can become infected by ingesting such intermediate host (Demis et al., 2015). Of these; beetles and ants were commonly found in the study area suggesting that this could be responsible for the very high prevalence of the recorded cestode infection. Most of the cestodes were encountered in the small intestine where the microhabitat favors its survival and the structural adaptation of cestodes, as well as the presence of digested nutrients in the intestine of host may influence their restriction to the small intestine, thereby causing obstruction of the intestine, weight loss and decreased egg production in laying birds (Soulsby, 1982; Mohammed, 2009).

Overall, these findings indicate that infection was generally higher during the wet season (36.65%) than the dry season (27.97%). This could be due to the fact that insects and other invertebrates which serve as food for the birds also harbor the intermediate hosts of these parasites, and are more abundant during the wet season. This position was confirmed by the fact that in Nigeria Columbids feed more on animal materials comprising of termites, earthworms, Papio larvae, *Polyxus* spp. ants and other unidentified insects than seeds which are scarce during the wet season (Adang, 1999). Moreover, the harsh and unfavorable conditions that characterize the dry season may be responsible for the low population of invertebrate hosts which might negatively affect the availability of onchosphores of some cestodes and the hatching of some nematode eggs, resulting in low infection rates and worm loads during the dry season (Dede and Richards, 1998).

The results from this study showed that helminthic infections were higher in males (14.58%) than females (8.33%). This finding agrees with that of Umaru et al., 2017 in Taraba State (North-East), Nigeria who recorded the prevalence of (55.0%) in male compared to female pigeons (23.3%). This also concurs with numerous reports which indicated the existence of intrinsic biological differences between host sexes could lead to one sex being more prone to parasitic infections than the other (Poulin, 1996).

Furthermore, behavioral, morphological and physiological variations between males and females have been implied to create a slight

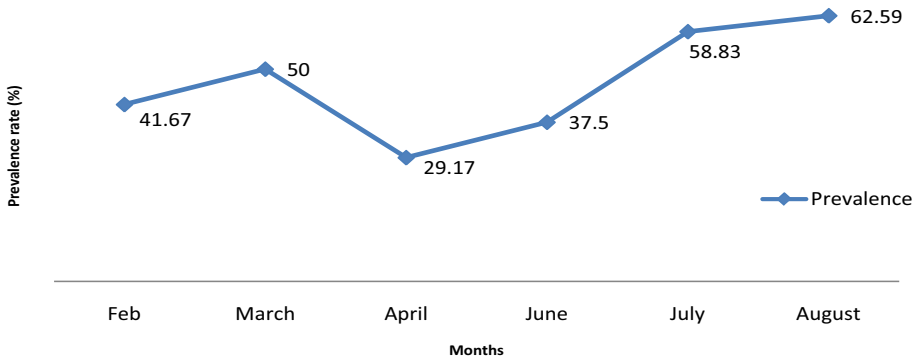

Fig. 2. Monthly prevalence of intestinal helminth parasites in the selected Local Government Areas of Kano State.

Table 3
Distribution of parasitized birds in relation to husbandry/management system of the sampled pigeons.

S/N0.	Number of breeders	Number of pigeons infested (n = 144)	% infected
A. Period of breeding (experience)			
i. > 5 years	3	15	10.42
ii. 5- 10 years	4	19	13.19
iii. 11-15 years	2	12	8.33
iv. > 16 years	3	21	14.58
B. Scale of production (Number of pigeons in a loft)			
i. < 100	8	42	29.17
ii. 101–300	1	12	8.33
iii. 301–500	2	7	4.86
iv. > 500	1	6	4.17
C. Purpose of production			
i. Commercial	6	27	18.75
ii. Domestic	2	16	11.11
iii. Companionship	4	24	16.67
D. Housing system			
i. Hanging clay	5	25	17.36
ii. Pauline and rafter	4	27	18.75
iii. Suspended wooden structure	1	1	0.69
iv. Both i and ii	2	14	9.72
E. Feeding management			
i. Semi- intensive	9	54	37.50
ii. Intensive	3	13	9.03

Table 4
Distribution of parasitized birds in relation to pigeon welfare of the sampled pigeons.

S/N0.	Number of breeders	Number of pigeons infested (n = 144)	% infested
A. Type feed fed to the birds			
i. Formulated feed	2	15	10.42
ii. Guinea corn + millet+ supplement	3	18	12.50
iii. Guinea corn + millet	4	23	15.97
iv. Millet	3	11	7.64
B. Frequency of feeding			
i. Morning	4	25	17.36
ii. Morning + Afternoon (twice)	7	38	26.39
iii. Ad - libtum	1	4	2.78
C. General cleaning of the loft (Hygiene)			
i. Monthly	2	12	8.33
ii. Bimonthly	2	7	4.86
iii. Quarterly	6	37	25.69
iv. None	2	13	19.40

Table 5
Pattern of intestinal helminths infection in pigeons in the selected Local Government Areas of Kano State surveyed (n = 144).

Helminth species	No. positive	Prevalence (%)
Single parasitic infection		
Raillietina tetragona	20	
R. echinobothrida	11	
Davainea proglottina	1	
Ascaridia columbae	10	
Capillaria obsignata	9	
Subtotal	41	48.25
Double parasitic infection		
R. tetragona + *R. echinobothrida*	7	
R. tetragona + *C. obsignata*	3	
R. tetragona + *A. columbae*	1	
R. tetragona + *Hymenolopis contaniana*	2	
A. columbae + *Amoebotaenia cuneata*	1	
Capillaria columbae + *D. proglottina*	1	
Subtotal	15	10.42
Triple parasitic infection		
C. columbae + *R. echinobothrida* + *O. quadriradiatus*	1	
C. columbae + *R. echinobothrida* + *H. contaniana*	1	
A. columbae + *R. tetragona* + *A. cuneata*	3	
A. Cuneata + *R. tetragona* + *H. contaniana*	2	
Subtotal	7	4.86
Quadruple parasitic infection		
R. echinobothrida + *R. tetragona* + *H. contaniana* + *D. proglottina*		
Subtotal	4	2.78
Grand total	67	

but consistent sexual bias in infection level as observed in the present study. However, Begum and Sehrin (2012), in a related study observed no statistically significant difference between male and female pigeons infected by helminthes and concluded that gender was not an important factor in helminthes infection of pigeons (Alam et al., 2014).

In this study, it was also observed that there were lofts where no parasites were found during both dry and wet seasons. This suggests that early prophylaxis with anthelminthics and acaricides combined with sufficient feed supplement could help in the total eradication or prevention of parasitic infection (Nel, 1999). However, the high degree of parasitism common in most of Local Government Areas of Kano State studied could be attributed to the random purchase and transfer often practiced devoid of any professional services, thereby introducing new parasites into the environment. This could be attributed to the pigeon breeder's general ignorance of the intestinal helminths and their sources (Pam et al., 2006). Generally, pigeon health management is generally very poor among pigeon breeders with little or no anthelmintic intervention except when the bird is obviously sick.

Findings from this study further revealed, the helminthic infection rate was only present Youngsters respectively whilst Squeakers and

Squabs were negative for these infections (Table 1). This difference could be attributed to age-related factors which tend to predispose adult birds to helminthes infection than young birds (Poulin, 1996; Umaru et al., 2017).

Concurrent infection with more than one species of helminths in the same bird was very common in the study areas of Kano State. The study identified single parasite infections (48.25%) to be higher than double (10.42%), triple (4.86%) and quadruple (2.78%). This finding agrees with the reports of Umaru et al., 2017 in Taraba State (North-East), Nigeria & Khezerpour and Naem, 2013 in Iran where single infection was more common (18.84%) than double (3.62%) and triple infections (0.72%).

The lower prevalence of quadruple infection pattern may therefore suggest the inability of parasites to co-habit conveniently in the host. It is plausible that the higher prevalence of single species infestation depends on the order of initiation of infestation in the host as the first to infect host may acquire higher microhabitat and establishment advantage thus rendering it less suitable for late entrants as observed by Mbinkar et al., 2006. Whilst this may suggest a form of competition, Kennedy (1975) argued that food preference at a particular time may determine the establishment of either single or mixed parasites. Whether these have significant effects on the overall wellbeing of these birds remains to be investigated.

The present study revealed high prevalence of infection in Kumbotso, Tarauni & (5.56%) and Municipal, Dala & Tofa (4.86%) could be an indication of a high incidence of the infective stages and intermediate hosts of the parasites in places where these pigeons are bred. The presence of these intermediate hosts which form part of the diet of pigeons (Adang, 1999) could be linked to the poor hygienic and unsanitary conditions (garbage dumps in the streets, dumping of raw sewage, animal excreta and refuse into ponds) as its often associated with most Local Government Areas within the municipality and its environs. In contrast, lower levels of parasitic infections were recorded in Minjibir, Dawakin Kudu and Gezawa Local Government areas located in the rural areas and can be attributed to the birds' minimal exposure to such unsanitary locations.

5. Conclusions

This study demonstrated that the most predominant group of helminth parasites of pigeons in Kano State, Nigeria was Cestodes (48.0%) and all pigeons are infected with one or more intestinal helminth. However, questions are raised regarding their capabilities to develop and infect these pigeons efficiently. It was further discovered that most of the lofts examined were infected with *Raillietina tetragona*, meaning that this parasite is well established in the study area, thereby leading to significant weight loss and decrease in egg production. It was further observed that poor management practices and inadequate health care were attributed to this parasitic infection. Although, *Khaya senegalensis* was routinely used in the control of these intestinal helminths in the study area, further research is imperative to evaluate its anti-parasitic efficacy. This study will help on the need for proper management practices including effective regular deworming be employed to improve the health status of pigeons in the study area which has an implication on sustainable pigeon production.

Competing interests

The authors declare they have no competing interests.

Acknowledgements

We the authors gratefully acknowledge the support of all the participating pigeon breeders in Kano Central Metropolis, and its environs, colleagues who contributed in sample collection and the staff of Faculty of Sciences, Bayero University, Kano State for their technical assistance.

Conflict of interest

This is to certify that there is no conflict of interest from the Authors.

References

Abdu, P.A., Oniye, S.J., Okechukwu, P.U., 2004. Helminths parasites of domesticated pigeons (*Columba livia domestica*) on Zaria. Nig. J. Pest Dis. Vec. Manag. 5, 356–360.
Adang, K.L., 1999. Some Aspects of the Biology of four Columbid Species in Zaria, Nigeria. M. Sc. Thesis. Ahmadu Bello University, Zaria, Nigeria.
Adang, K.L., Ezealor, A.U., Abdu, P.A., Ajanusi, O.J., 2006. Helminth parasites of doves and pigeons (Aves: Columbidae) in Zaria. Nigeria. Zool. Soc. Nig. 9, AB38.
Adang, K.L., Oniye, S.L., Ajanusi, O.J., Ezealor, A.U., Abdu, P.A., 2008. Gastrointestinal helminths of the domestic pigeons (*Columba livia domestica* Gmelin, 1789 aves: Columbidae) in Zaria, northern Nigeria. Sci. World J. 3 (1).
Afolabi, O.J., Simon-Oke, I.A., Olasunkanmi, A.O., 2016. Intestinal parasites of domestic chicken (*Gallus gallus domesticus*) in Akure, Nigeria. J. Biomed. 1 (4).
Alam, M.N., Mostofa, M., Khan, M.A.H.N.A., Alim, M.A., Rahman, A.K.M.A., Trisha, A.A., 2014. Prevalence of gastrointestinal helminth infections in indigenous chicken of selected areas of Barisal, *Bangladesh*. Bangl. J. Vet. Med. 12 (2), 135–139.
Atsineka, O.K., Banke, R.O.K., 2006. Gastro-intestinal helminth parasites of Domestic Pigeons (*Columba livia domestica*) in Makurdi Metropolis, Benue State, Nigeria. In: Book of Abstracts, 3rd Annual Conference of Zoological Society of Nigeria (Keffi 2006) 7th–10th November 2006.
Begum, A., Sehrin, S., 2012. Gastrointestinal helminths in pigeon (*Columba livia*GMELIN, 1789). J. Asiatic Soc. Bangl. Sci. 38 (1), 93–98.
Dede, P.M., Richards, W.S., 1998. Prevalence of helminthiasis in wild and domestic pigeons from north-east zone of Nigeria. Bull. Anim. Health Prod. African. 46, 193–195.
Demis, C., Anteneh, M., Basith, A., 2015. Tapeworms of poultry in Ethiopia: a review. Bri. J. Poult. Sci. 4 (3), 44–52.
El-Dakhly, K.M., Mahrous, L.N., Mabrouk, G.A., 2016. Distribution pattern of intestinal helminths in domestic pigeons (*Columba livia domestica*) and turkeys (*Meleagris gallopavo*) in Beni-Suef province. Egypt. J. Vet. Med. Res. 1, 112–120.
Fatihu, M.Y., Ogbogu, V.C., Njoku, C.V., Sarror, D.I., 1991. Comparative studies of gastrointestinal helminths of poultry in Zaria, Nigeria. Rev. Elev. Med. Vet. Pays. Trop. 2, 175–177.
Greenberg, R., Etterson, M., Danner, R.M., 2013. Seasonal dimorphism in the horny bills of sparrows. Ecol. Evol. 3, 389–398.
Idika, I.K., Obi, C.F., Ezeh, I.O., Iheagwam, C.N., Njoku, I.N., Nwosu, C.O., 2016. Gastrointestinal helminth parasites of local chickens from selected communities in Nsukka region of south eastern Nigeria. J. Parasit. Dis. 40 (4), 1376–1380.
Kennedy, C.R., 1975. Ecological Animal Parasitology. Blackwell Scientific Publication, London, pp. P163.
Khezerpour, A., Naem, S., 2013. Investigation on parasitic Helminthes of gastrointestinal, liver and lung of domestic pigeons (*Columba livia*) in Urmia. Iran. Int. J. Livest. Res. 3, 35–41.
Mbinkar, D.L., Oniye, S.J., Ezealor, A.U., 2006. Helminth parasites of the gastrointestinal tract of the double spurred francolin, *Francolinus icalcaratus* (Lineus) in Zaria, northern. Nigeria. The Zool. 1 (2), 39–44.
Mohammed, B.R., 2009. A Survey of Ecto and Intestinal Parasites of Pigeons (*Columba livia domestica*) in Selected Local Government Areas of Kano State, Nigeria. Master of Science Dissertation. Bayero University, Kano State, Nigeria.
Mohammed, B.R., Simon, M.K., Agbede, R.I.S., Arzai, A.H., 2017a. Detection of *Capillaria obsignata* of pigeons (*Columba livia domestica*) from Kano state. **Nigeria.** Ann. Parasitol. 63 (3), 199–203.
Mohammed, B.R., Simon, M.K., Agbede, R.I., Arzai, A.H., 2017b. Coccidiosis of domestic pigeons (*Columba livia domestica* Gmelin, 1789) in Kano state, Nigeria. Ann. Parasitol. 63 (3), 199–203.
Nel, C., 1999. Dosing of ostriches for internal parasites. Ellensburg J. 4 (2), 31–33.
Nghonjuyi, N.W., Kimbi, H.K., Tiambo, C.K., 2014. Study of gastro–intestinal parasites of scavenging chickens in Fako Division, Southwest Cameroon. J. Adv. Parasitol. 1 (2), 30–34.
Olofin, E.A. 1987. Some Aspects of the Physical Geography of Kano Region and Human Responses, Lecture Notes Series, N0.1, Department of Geography, Bayero University, Kano-Nigeria.
Oniye, S.J., Abdu, P.A., Adebote, D.T., Kwage, B.B., Ajanusi, O.J., Nfor, R.B., 2000. Survey of Helminth parasites of laughing dove, *Streptopellasenegalensis* in Zaria. African J. Nat. Sci. 4, 65–66.
Pam, V.A., Ashi, R.R., Daniel, L.N., Omalu, C.J., 2006. The role of wild birds in the dissemination of parasite infection in Jos (North and South), Plateau State. Nigeria. Zool. Soc. Nig (P37 AB36).
Parsani, H.R., Momin, R.R., Lateef, A., Shah, N.M., 2014. Gastro-intestinal helminths of pigeons (*Columba livia*) in Gujarat, India. Egypt. J. Biol. 16, 63–71.
Poulin, R., 1996. Sexual inequalities in helminth infections: a cost of being male? Am. Nat. 147, 287–295.
Rabiu, B.M., Arzai, A.H., 2012. Incidence of *Pseudolynchiacanariensis* (Macquart) of domestic pigeons (*Columba livia domestica*) in Kano State, Nigeria. Biol. Environ. Sci. J. Trop. 1, 102–106.
Satish, S., Priti, M., 2013. Gastro intestinal Helminths parasites of local chickens samples from tribal areas of Madhya Pradesh, India. Int. J. Life Sci. 1 (4), 284–287.
Sente, C., Kabasa, J.D., Dranzoa, C., Gwabali, D.A., Tushabe, J., 2016. Gastrointestinal helminths of semi-domesticated helmeted guinea fowl (Numidameleagris) under different management systems in Arua district, Uganda. African J. Poult. Farm. 4 (2),

123–129.
Sivajothi, S., Sudhakara, R.B., 2015. A Study on the Gastro Intestinal Parasites of Domestic Pigeons in YSR Kadapa District in Andhra Pradesh, India. J. Dairy Vet. Anim. Res. 2 (6), 00057. https://doi.org/10.15406/jdvar.2015.02.00057.
Soulsby, E.J.L., 1982. Helminths, Arthropods and Protozoa of Domesticated Animals, 7th. Edn. Baillier Tindall, London, pp. 246.
Umaru, G.A., Bello, O.A., Abubakar, Y.U., Umar, Y.A., Adamu, N.B., Adamu, S.G., 2017. Prevalence of helminth parasites of domestic pigeons (*Columba livia*) in Jalingo Metropolis, Taraba state. Nig. J. Parasitol. 38 (1), 43–47.