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The Intensity of Infection and Public Health Perception of Potentially Zoonotic Intestinal Parasites of Dogs in Kwara Central, Nigeria

Running title: Intensity and Public Health Perception of Parasites of Dogs

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Abstract

BACKGROUND: The close relationship between dogs and humans and the possibility of intestinal parasite transmission from dogs to humans calls for frequent assessment of the presence of these potential zoonotic intestinal parasites in dogs and the possibility of their transmission to humans.

OBJECTIVES: This study aimed to determine the presence, intensity of infection, and public health perception of potentially zoonotic intestinal parasites in dogs in Kwara Central, Nigeria.

METHODS: The study was conducted in 28 locations within Kwara Central Senatorial District of Kwara State, Nigeria. Three hundred and five apparently healthy dogs were sampled. **Two hundred and thirty** respondents **(dog owners/handlers) were questioned** using a well-structured questionnaire containing open-ended and closed-ended questions. Faecal samples

from the sampled dogs were subjected to the direct faecal smear technique, simple faecal centrifugation flotation technique, formalin-ethyl acetate concentration technique, and the modified Ziehl-Neelsen staining technique. Oocysts or eggs per gram of faeces were counted using the modified McMaster technique.

RESULTS: Seven different intestinal parasites (*Ancylostoma* spp., *Cryptosporidium* spp., *Dipylidium caninum*, *Isospora* spp., *Strongyloides stercoralis*, *Toxocara* spp., and *Uncinaria stenocephala*) were detected, with a prevalence ranging from 2.30% to 25.25%. Of these parasites, six were zoonotic. The mean intensity of infection was 91.43 eggs per gram (EPG) for *D. caninum*, 96.52 EPG for *S. stercoralis*, 129.36 (±28.12) oocysts per gram (OPG) for *Isospora* spp., 165.17 (±19.88) for *Toxocara* spp., 240.00 (±44.42) EPG for *U. stenocephala*, and 303.64 (±31.83) EPG for *Ancylostoma* spp. Some of the dog owners and handlers were not cautious about the possibility of zoonotic parasite transmission from dogs.

CONCLUSION: Zoonotic intestinal parasites of dogs are present and prevalent in Kwara Central, Nigeria. There is need to educate the public on the possibility of zoonotic parasite transmission to humans.

KEYWORDS: Dogs, Intestinal parasites, Nigeria, Public health, Zoonosis

Introduction

Dogs (*Canis lupus familiaris*) are believed to have come a long way with man, as they are the most successful canid species in close association with humans worldwide (Ugbomoiko *et al*., 2008; Ola-Fadunsin *et al*., 2019a). Dogs are one of the most important domestic animals seen in almost every human settlement globally (Kundu *et al*., 2015). Recently, there has been an increase in the number of dogs in Nigeria, as individuals are now more interested in having dogs for various reasons, especially for security and breeding. This has made the dog population in Nigeria well above 5 million (Ola-Fadunsin, 2018). Dogs are kept for companionship as pets, and they are used for hunting, security, sports, life-saving actions, scientific research and therapeutic programs, combatting crime by the military and para-military organizations, and income generation through breeding and sale. In some ethnic groups, dogs are raised as a source of animal protein (Curi *et al*., 2017; Ola-Fadunsin, 2018; Mosallanejad *et al*., 2021; Yousef *et al*., 2022). As pets, they contribute to their owners' physical, social, emotional, and mental well-being, particularly children and aged people (Ola-Fadunsin *et al*., 2019a; Gouin *et al*., 2021). The close association between humans and dogs can lead to contamination of man's environment,

hands, food, and water with infective oocysts of protozoans and eggs of helminths, which can lead to infections with serious consequences in humans (Taylor *et al*., 2016; Idika *et al*., 2017).

Intestinal parasites include protozoans and helminths that are present in the intestinal tracts of animals and humans (Taylor *et al*., 2016). Intestinal parasites of dogs cause serious damage in the host and humans, and in some cases they infect livestock and wildlife. They hinder the successful keeping of dogs and result in losses that are manifested by retarded growth, lowered resistance to infectious diseases, reduced work and feed efficiency, general ill health, and even death (Awoke *et al*., 2011; Abere *et al*., 2013). Among intestinal parasites of dogs, *Ancylostoma* species, *Cryptosporidium* species, *Giardia* species, and *Toxocara* species are important to public health (Sowemimo, 2009; Ngui *et al*., 2014; Ayan and Kilinç, 2020). These parasites are known to cause infections that are of great interest in most parts of the world, especially in developing countries and communities that may be socioeconomically challenged, where these parasites are responsible for some important zoonotic diseases (Robertson *et al*., 2000; Ngui *et al*., 2014).

The close relationship between dogs and humans and the possibility of intestinal parasite transmission from dogs to humans calls for frequent assessment of the presence of these potential zoonotic intestinal parasites in dogs. This study was aimed to determine the presence, intensity of infection, and public health perception of potentially zoonotic intestinal parasites in dogs in Kwara Central, Nigeria.

Materials and Methods

Study location

This study was carried out within Kwara Central Senatorial District of Kwara State, Nigeria. Kwara Central is the largest and most populous Senatorial District in Kwara State, and it covers Asa, Ilorin East, Ilorin South, and Ilorin West local government areas (KSGN, 2012; Adam *et al*., 2022). An average of 10 dogs and 7 respondents (dog owners/handlers) were sampled and questioned respectively from 28 randomly selected locations within Kwara Central of Kwara State (Figure 1). Global positioning system (GPS) coordinates from each location were recorded using an app. (Financept®).

Study design and sample collection

A cross-sectional study design was employed for this study. A total of 305 apparently healthy dogs were sampled, while 230 respondents were questioned for this study.

Faecal samples were collected directly from the rectum of each dog (305 dogs in total) following proper restraint of the dog.

Each faecal sample was collected into a well-labelled sterile sample bottle, put into an icebox, and transported to the Parasitology Labouratory of the Department of Veterinary Parasitology and Entomology, University of Ilorin, for further parasitological analyses. Collected

samples were then stored in the refrigerator at +4ºC. All parasitological analyses were performed within 48 hours of sampling.

Information about the sampled dogs and the dog owners and handlers was obtained from the owners or dog keepers (230 in total) using a well-structured questionnaire containing open-ended and closed-ended questions.

Detection of intestinal parasites

Faecal samples were examined for the presence of protozoan oocysts and/or helminth eggs. The direct faecal smear technique, simple faecal centrifugation flotation technique (using saturated NaCl solution), and the formalin-ethyl acetate (formol-ether) concentration technique were used for the detection of *Isospora* species and helminth parasites. These techniques were conducted as described by Cheesbrough (2009) and Taylor *et al*. (2016). The Modified Ziehl-Neelsen staining technique as described by Cheesbrough (2009) was used for the detection of *Cryptosporidium* species. Sediments from the formol-ether concentration technique were used for the modified Ziehl-Neelsen stain. Oocysts of *Isospora* species and eggs of helminth species were counted using the modified McMaster technique with modifications as described by Ola-Fadunsin *et al*. (2019b).

Intestinal parasites were identified by using parasitological keys as documented by Soulsby (1982), Foreyt (2001), and Taylor *et al*. (2016).

Parasite(s) positive faecal samples that were detected by one or more parasitological techniques were considered positive.

Ethical clearance and informed consent

Permission to conduct this study was granted by the Research and Ethical Committee of the Faculty of Veterinary Medicine, University of Ilorin, Nigeria with the protocol number FVER/017/2021. All samples were collected using standard sample collection methods without inflicting pain or harm on the dogs. Consent was sought and was willingly granted by the dog owners/**handlers** before questionnaires were filled and their dogs sampled for the study.

Data management and statistical analyses

The collected data for this study was initially recorded in a Microsoft Excel version 2016 spreadsheet. Afterward, the data was exported to the Statistical Package for the Social Sciences (SPSS, Chicago, Illinois, USA) Windows version 22.0 for statistical analyses. Descriptive statistics were conducted to estimate the prevalence using percentages in charts and tables. The charts were created using Microsoft Excel version 2016. The prevalence was calculated as the fraction between the number of dogs positive for a intestinal parasite and the total number of dogs sampled, multiplied by 100. The mean, standard error of the mean, and 95% confidence interval (CI) were determined accordingly.

Results

Seven different intestinal parasites (5 helminths (4 nematodes and 1 cestode), and 2 protozoans) were detected among dogs in the study area. The prevalence of these intestinal parasites was 2.30% (95% CI = 1.12–4.66) for *D. caninum*, 6.89% for *U. stenocephala*, 7.54% (23/305) for *S. stercoralis*, 15.41% (95% CI = 11.79–19.89) for *Isospora* spp., 19.02% (58/305) for *Toxocara* spp., and 25.25% (95% CI = 20.07–30.41) for *Ancylostoma* spp. and *Cryptosporidium* spp. *Ancylostoma* spp. recorded the highest intensity of infection with a mean EPG (eggs per gram of faeces) of 303.64 (±31.83). This was followed by *U. stenocephala* with a mean EPG of 240.00 (±44.42). The least intensity of infection was observed in *D. caninum* (mean EPG of 91.43 (±7.38)). The intensity of infection (measured in mean EPG) for the other parasites was 96.52 (±16.04) for *S. stercoralis*, 129.36 (±28.12) for *Isospora* spp., and 165.17 (±19.88) for *Toxocara* spp. (Table 1).

The prevalence of infection showed that 54.43% of the sampled dogs were infected with intestinal parasites. Of the infected dogs, 43.37% had single parasite infection, while 56.63% had mixed infections. Of the dogs with mixed infections, 55.32%, 36.17%, and 8.51% had two, three, and four parasitic infections, respectively (Figure 2).

A higher number of respondents in the study area were over 25 years old (188/230 (81.74%)), while more of the respondents were male (56.96%; 95% CI = 50.50–63.19). One hundred and thirty-six respondents knew about parasite transmission from animals to humans

(59.13%; 95% CI = 52.68–65.28), while 94 (40.87%; 95% = 34.72–47.32) were ignorant of possible parasitic zoonosis. Most of the respondents (73.91%; 95% CI = 67.88–79.16) and their children (39.57%; 95% CI = 33.47–46.01) were very close to their dogs. Two hundred and twenty-three of the respondents (96.96%; 95% CI = 93.85–98.52) wash their hands after coming in contact with dog faeces, while seven do not (3.04%; 95% CI = 1.48–6.15). Of those that wash their hands, 8 (3.59%) wash their hands with water alone, 181 (81.17%) use water and soap, 23 (10.31%) wash with water and soap and use hand sanitizer, and 11 (4.93%) wash their hands with water and use hand sanitizer afterward. About sixty-seven percent (153/230) of the respondents allow their children to play with dogs, while 33.48% (77/230) do not. Of those that allow their children to play with dogs, 78 (50.98%; 95% CI = 43.13–58.78) of them wash the hands of their children after playing with dogs, while 75 (49.02%; 95% CI = 41.22–56.87) do not. Fifty-two of the respondents (22.61%; 95% CI = 17.68–28.44) allow their children to play in areas where dogs defecate, while 178 (77.39%; 95% CI = 71.56–82.32) do not. About thirteen percent (21/230; 95% CI = 8.69–19.12) of the respondents treat their dogs monthly against parasitic infections, while 11.18% (18/230; 95% CI = 7.19–16.98) and 75.78% (122/230; 95% CI = 68.61–81.74) treat their dogs quarterly and yearly, respectively, against parasitic infections (Table 2). Other results of dog management practices among dog owners are recorded in Table 2.

Discussion

Ancylostoma spp., *Cryptosporidium* spp., *D. caninum*, *Isospora* spp., *S. stercoralis*, *Toxocara* spp., and *U. stenocephala* were the intestinal parasites detected, with most of them (six) having zoonotic potential (Taylor *et al*., 2016). Zoonosis of parasitic origin has become a great challenge in many countries of the world (Cavallero *et al*., 2021). The detection of more helminth parasites than protozoan parasites among dogs in this study could be attributed to the fact that helminth ova (eggs) can survive better in the environment and are more effectively transmitted to dogs than protozoan oocysts (Ayinmode *et al*., 2016).

Ancylostoma species of dogs include *Ancylostoma braziliense*, *A. caninum*, and *A. ceylanicum* (Taylor *et al*., 2016), these are zoonotic hook worms that cause cutaneous larva migrans and eosinophilic enteritis in infected humans (Prociv and Croese, 1990; Bowman *et al*., 2010).

Cryptosporidium canis is the major causative agent of cryptosporidiosis in dogs. However, *C. meleagridis*, *C. muris*, and *C. parvum* have also been reported in dogs (Ayinmode *et al*., 2018). These protozoan species have been incriminated to cause diarrhoea and even death in humans (Uehlinger *et al*., 2013).

Human infections with *D. caninum* are not common. However, it is more likely to infect young children who kiss, or are licked by infected dogs or cats. This condition is associated with mild diarrhoea in infected individuals (Jiang *et al*., 2017).

Strongyloides stercoralis is a soil-transmitted helminth in humans. It causes different conditions in humans ranging from dermatologic manifestations such as localized oedema or urticaria to gastrointestinal manifestations such as abdominal pain, constipation, diarrhoea, intermittent vomiting, and duodenal obstruction. It also exhibits cardiopulmonary and central nervous system (CNS) manifestations (Nutman, 2017). It is estimated to infect about 100 million people worldwide (Schar *et al*., 2013).

Toxocara canis is the major etiology of canine toxocariasis. Nevertheless, *T. leonina* can also infect dogs (Oguz *et al*., 2018). *Toxocara canis* is responsible for visceral and ocular larva migrans, neurotoxocariasis, and common toxocariasis in humans (Chen *et al*., 2018). *Uncinaria stenocephala* like *A. caninum* also causes cutaneous larva migrans and eosinophilic enteritis in humans (Bowman *et al*., 2010; Ayinmode *et al*., 2016).

The high prevalence of *Ancylostoma* spp., *Cryptosporidium* spp., and *Toxocara* spp. detected in the faeces of sampled dogs recapitulates previous reports in Nigeria (Ayinmode *et al*., 2016; Ezema *et al*., 2019; Kamani *et al*., 2021), and outside Nigeria (Abere *et al*., 2013; Ngui *et al*., 2014; Torres-Chablé *et al*., 2015). Prevalence of 33.24%, 36.45%, and 41.67% for *Ancylostoma* spp., *Cryptosporidium* spp., and *Toxocara* spp. respectively has been reported among dogs in Nigeria (Ugbomoiko et al., 2008; Idika *et al*., 2017; Eze et al., 2019). In countries outside Nigeria, prevalence of 33.04%, 33.46%, and 64.71% for *Ancylostoma* spp., *Toxocara* spp., and *Cryptosporidium* spp. respectively has been reported among dogs (Bahrami et al.,

2011; Ayan and Kilinç, 2020; Ilic et al., 2021). The high intensity of *Ancylostoma* spp. and *Toxocara* spp. eggs detected in dog faeces may be associated with the high fecundity of these helminths (Taylor *et al*., 2016), which translates to a high number of eggs passed in faeces.

The presence of mixed infections with more than one parasite at the same time is very common in animals, including dogs (Viney and Graham, 2013; Ola-Fadunsin *et al*., 2019a), which is the reason more of the infected dogs had mixed parasitic infections. Mixed infections of *Ancylostoma* spp., *Toxocara* spp., and *D. caninum* was reported among dogs in Nigeria (Idika et al., 2017), while co-infections of *Ancylostoma* spp., *Toxocara* spp., and *Isospora* spp. has been documented among dogs in Malaysia (Ngui *et al*., 2014).

The absence of documented cases of canine zoonotic parasitic infections among humans in the study area could be attributed to the fact that more respondents are knowledgeable about the possible transmission of parasites from dogs to humans. The hygiene level of dog owners and handlers after coming in contact with dogs, the level of closeness between dogs and their owners together with their children, and the level of the management practices of dog owners and handlers could predispose to the possibility of canine parasitic infections in humans in the study area. The low frequency of intestinal parasites control by dog owners does not guarantee adequate protection of dogs against parasitic infections (Alho *et al*., 2018), and this could have contributed to the high prevalence of intestinal parasites recorded in this study.

In conclusion, the high prevalence and number of potentially zoonotic intestinal parasites detected among dogs and the level of hygiene and dog management practices by dog owners and handlers in Kwara Central, Nigeria pose a possible risk to human health with regard to zoonotic infections. Therefore, it is necessary to educate dog owners and handlers on the need to regularly treat their dogs against intestinal parasites and to improve their personal hygiene in order to control parasitic infections among dogs and prevent possible zoonotic infections in humans, respectively.

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References

Abere, T., Bogale, B., Melaku, A. (2013). Gastrointestinal helminth parasites of pet and stray dogs as a potential risk for human health in Bahir Dar town, north-western Ethiopia. *Veterinary World*, *6(7)*, 388–392. DOI:10.5455/vetworld.2013.388-392

Adam, M., Bakare, R.A., Ola-Fadunsin, S.D., Akanbi, O.B., Kigir, E.S., Barka, S.A. (2022). Pathological changes of *Fasciola* species infection in cattle slaughtered in Ilorin abattoir Kwara State, Nigeria. *Iranian Journal of Veterinary Medicine, 16*(4), 356–363. DOI:10.22059/ijvm.2022.342551.1005270

Alho, A.M., Lima, C., Colella, V., de Carvalho, L.M., Otranto, D., Cardoso, L. (2018). Awareness of zoonotic diseases and parasite control practices: a survey of dog and cat owners in Qatar. *Parasites & Vectors*, *11*, 133–139. https://doi.org/10.1186/s13071-018-2720-0 PMID: **29554937.** PMCID: PMC5859551.

Awoke, E., Bogale, B., Chanie, M. (2011). Intestinal nematode parasites of dogs: prevalence and associated risk factors. *International Journal of Animal and Veterinary Advances*, *3(5)*, 374–378.

Ayan, A., Kilinç, O. (2020). Prevalence of *Cryptosporidium* spp. in diarrheic dogs in Van Province. *Turkiye Klinikleri Journal of Veterinary Sciences*, *11(2)*, 64–68. DOI:10.5336/vetsci.2020-77151

Ayinmode, A.B., Obebe, O.O., Falohun, O.O. (2018). Molecular detection of *Cryptosporidium* species in street-sampled dog faeces in Ibadan, Nigeria. *Veterinary Parasitology: Regional Studies and Reports*, *14*, 54–58. DOI:10.1016/j.vprsr.2018.08.005. PMID: **31014737.**

Ayinmode, A.B., Obebe, O.O., Olayemi, E. (2016). Prevalence of potentially zoonotic gastrointestinal parasites in canine faeces in Ibadan, Nigeria. *Ghana Medical Journal*, *50(4)*, 201–206. http://dx.doi.org/10.4314/gmj.v50i4.2. PMID: 28579625.

Bahrami, A., Doosti, A., Nahravanian, H., Noorian, A., Asbchin, S.A. (2011). Epidemiological Survey of Gastro-Intestinal Parasites in Stray Dogs and Cats. *Australian Journal of Basic and Applied Sciences*, *5(9)*, 1944–1948.

Bowman, D.D., Montgomery, S.P., Zajac, A.M., Eber-hard, M.L., Kazacos, K.R. (2010). Hookworms of dogs and cats as agents of cutaneous larva migrans. *Trends in Parasitology*, *26*, 162–167. DOI:10.1016/j.pt.2010.01.005. PMID: 20189454.

Cavallero, S., Gabrielli, S., Gazzonis, A.L., Pombi, M., Šnábel, V. (2021). Editorial: zoonotic parasitic diseases in a changing world. *Frontiers in Veterinary Science*, *8*, 715112. DOI:10.3389/fvets.2021.715112. PMID: **34307539**. PMCID: PMC8295988.

Cheesbrough, M. (2009). District laboratory practice in tropical countries, Part 1. Cambridge University Press. United Kingdom.

Chen, J., Liu, Q., Liu, G.H., Zheng, W.B., Hong, S.J., Sugiyama, H., Zhu, X.Q., Elsheikha, H.M. (2018). Toxocariasis: a silent threat with a progressive public health impact. *Infectious Diseases*

of Poverty, *7*, 59–71. https://doi.org/10.1186/s40249-018-0437-0. PMID: **29895324**. PMCID: PMC5998503.

Curi, N.H.A., Paschoal, A.M.O., Massara, R.L., Santos, H.A., Guimarães, M.P., Passamani, **M.,** Chiarello, **A.G.** (2017). Risk factors for gastrointestinal parasite infections of dogs living around protected areas of the Atlantic Forest: implications for human and wildlife health. *Brazilian Journal of Biology*, *77(2)*, 388–395. http://dx.doi.org/10.1590/1519-6984.19515. PMID: **27533731.**

Eze, U.U., Ezeh, I.O., Nzeakor, T.A., Attama, S.C., Ezenduka, E.V., Onah, D.N. (2019). Prevalence and risk factors associated with *Cryptosporidium* spp. infection in local breed of dogs in Enugu State, Nigeria, *Veterinary World*, *12(5),* 729–734. DOI: 10.14202/vetworld.2019.729-734. PMID: **31327912.** PMCID: PMC6584865

Ezema, K.U., Malgwi, S.A., Zango, M.K., Kyari, F., Tukur, S.M., Mohammed, A., Kayeri, B.K. (2019). Gastrointestinal parasites of dogs (*Canis familiaris*) in Maiduguri, Borno State, Northeastern Nigeria: Risk factors and zoonotic implications for human health. *Veterinary World*, *12(7)*, 1150–1153. DOI:10.14202/vetworld.2019.1150-1153. PMID: **31528046**. PMCID: PMC6702552.

Foreyt, W.J. (2001). Veterinary parasitology reference manual. (5th ed.), Iowa State University Press. United States of America.

Gouin, G.-G., Aenishaenslin, C., Lévesque, F., Simon, A., Ravel, A. (2021). Description and determinants of at-risk interactions for human health between children and dogs in an Inuit village. *Anthrozoös*, *34(5)*, 723–738, DOI:10.1080/08927936.2021.1926713

Idika, I.K., Onuorah, E.C., Obi, C.F., Umeakuana, P.U., Nwosu, C.O., Onah, D.N., Chiejina, S.N. (2017). Prevalence of gastrointestinal helminth infections of dog in Enugu State, South Eastern Nigeria. *Parasite Epidemiology and Control*, *2*, 97–104. http://dx.doi.org/10.1016/j.parepi.2017.05.004. PMID: 29774287.

Ilic, T., Nisavic, U., Gajic, B., Nenadovic, K., Ristic, M., Stanojevic, D., Dimitrijevic, S. (2021). Prevalence of intestinal parasites in dogs from public shelters in Serbia. *Comparative Immunology, Microbiology and Infectious Diseases*, *76*, 101653. DOI: 10.1016/j.cimid.2021.101653. PMID: **33930631**

Jiang, P., Zhang, X., Liu, R.D., Wang, Z.Q., Cui, J. (2017). A human case of zoonotic dog tapeworm, *Dipylidium caninum*, China. *Korean Journal of Parasitology*, *55(1)*, 61–64. https://doi.org/10.3347/kjp.2017.55.1.61. PMID: **28285500.** PMCID: PMC5365269.

Kamani, J., Massetti, L., Olubade, T., Balami, J.A., Samdi, K.M., Traub, R.J., Colella, V., Gonz´alez-Miguel, J. (2021). Canine gastrointestinal parasites as a potential source of zoonotic infections in Nigeria: a nationwide survey. *Preventive Veterinary Medicine*, *192*, 105385. https://doi.org/10.1016/j.prevetmed.2021.105385. PMID: **34023722.**

Kwara State Government News (KSGN). (2012). Kwara State Diary. Kwara State of Nigeria, Nigeria.

Mosallanejad, B., Gooraninejad, S., Rezaie, A., Fatemi Tabatabaei, R., Imani Rastabi, H., Salmani, S. (2021). The Effects of stanozolol and nandrolone decanoate hormones on erythropoietin and testosterone serum concentrations in dogs. *Iranian Journal of Veterinary Medicine*, *15(3)*, 325–334. DOI:10.22059/ijvm.2020.307743.1005116

Ngui, R., Lee, S.C., Yap, N.J., Tan, T.K., Aidil, R.M., Chua, K.H., Aziz, S., Sulaiman, W.Y.W., Ahmad, A.F., Mahmud, R., Lim, Y.A.L. (2014). Gastrointestinal parasites in rural dogs and cats in Selangor and Pahang states in Peninsular Malaysia. *Acta Parasitologica*, *59(4)*, 737–744. DOI:10.2478/s11686-014-0306-3. PMID: **25236287.**

Nutman, T.B. (2017). Human infection with *Strongyloides stercoralis* and other related *Strongyloides* species. *Parasitology*, *144(3)*, 263–273. DOI:10.1017/S0031182016000834. PMID: 27181117.

Oguz, B., Ozdal, N., Deger, M.S. (2018). Genetic analysis of *Toxocara* spp. in stray cats and dogs in Van province, Eastern Turkey. *Journal of Veterinary Research*, 62(3), 291–295. DOI:10.2478/jvetres-2018-0042. PMID: **30584607**. PMCID: PMC6296006.

Oladeji, A.S., Sule, B.F. (2015). Electrical load survey and forecast for a decentralized hybrid power system at Elebu, Kwara State, Nigeria. *Nigerian Journal of Technology*, *34(3)*, 591–598. http://dx.doi.org/10.4314/njt.v34i3.23

Ola-Fadunsin, S.D. (2018). Parasitic diseases of dogs in Osun State, south-west Nigeria, and its zoonotic implications. *Nigerian Journal of Parasitology*, *39(2)*, 211–219. http://dx.doi.org/10.4314/njpar.v39i2.17

Ola-Fadunsin, S.D., Hussain, K., Rabiu, M., Ganiyu, I.A. (2019a). Co-infection dynamics of canine parasitic diseases in Osun State, Nigeria: a retrospective approach. *Journal of Veterinary and Biomedical Sciences*, *1(2)*, 54–65. DOI:10.36108/jvbs/8102.10.0260

Ola-Fadunsin, S.D., Uwabujo, P.I., Sanda, I.M., Ganiyu, I.A., Hussain, K., Rabiu, M., Elelu, N., Alayande, M.O. (2019b). Gastrointestinal helminths of intensively managed poultry in Kwara Central, Kwara State, Nigeria: Its diversity, prevalence, intensity, and risk factors. *Veterinary World*, *12(3)*, 389–396. DOI:10.14202/vetworld.2019.389-396. PMID: **31089308**. PMCID: PMC6487243.

Onah, I., Ayuba, H.K., Idris, N.M. (2020). Estimation of fuelwood-induced carbon emission from the use of improved cook stoves by selected households in Kwara State, Nigeria. *Climatic Change*, *160*, 463–477. https://doi.org/10.1007/s10584-019-02603-6

Prociv, P., Croese, J. (1990). Human eosinophilic enteritis caused by dog hookworm *Ancylostoma caninum*. *Lancet*, *335*, 1299–1302. DOI:10.1016/0140-6736(90)91186-e. PMID: 1971376.

Robertson, I.D., Irwin, P.J., Lymbery, A.J., Thompson, R. C. (2000). The role of companion animals in the emergence of parasitic zoonoses. *International Journal for Parasitology*, *30*, 1369–1377. DOI:10.1016/s0020-7519(00)00134-x. PMID: 11113262.

Schar, F., Trostdorf, U., Giardina, F., Khieu, V., Muth, S., Marti, H., Vounatsou, P., Odermatt, P. (2013). *Strongyloides stercoralis*: global distribution and risk factors. *PLoS Neglected Tropical Diseases*, *7(7)*, e2288. DOI:10.1371/journal.pntd.0002288. PMID: 23875033.

Shima, K.F., Tion, T.M., Mosugu, I.J., Apaa. T.T. (2015). Retrospective study of disease incidence and other clinical conditions diagnosed in owned dogs in Delta State, Nigeria. *Journal of Advanced Veterinary and Animal Research*, *2(4)*, 435–449. DOI:10.5455/javar.2015.b115.

Soulsby, E.J.L. (1982). Helminths, arthropods and protozoa of domesticated animals. (7th ed.), Baillière Tindall. London.

Sowemimo, O.A. (2009). The prevalence and intensity of gastrointestinal parasites of dogs in Ile-Ife, Nigeria. *Journal of Helminthology*, *83*, 27–31. DOI:10.1017/S0022149X08067229. PMID: 18838021.

Taylor, M.A., Coop, R.L., Wall, R.L. (2016). Veterinary parasitology. (4th ed.), Willey Blackwell. Oxford, UK.

Torres-Chablé, O.M., García-Herrera, R.A., Hernández-Hernández, M., Peralta-Torres, J.A., Ojeda-Robertos, N.F., Blitvich, B.J., Baak-Baak, C.M., García-Rejón, J.E., Machain-Wiliams, C.I. (2015). Prevalence of gastrointestinal parasites in domestic dogs in Tabasco, southeastern Mexico. *Brazilian Journal of Veterinary Parasitology*, *24(4)*, 432–437. DOI:10.1590/S1984-29612015077. PMID: **26648011.**

Uehlinger, F.D., Greenwood, S.J., McClure, J.T., Conboy, G., O'Handley, R., Barkemae, H.W. (2013). Zoonotic potential of *Giardia duodenalis* and *Cryptosporidium* spp. and prevalence of intestinal parasites in young dogs from different populations on Prince Edward Island, Canada. *Veterinary Parasitology*, *196*, 509–514. DOI:10.1016/jvetpar.2013.03.020. PMID: **23601666.**

Ugbomoiko, U.S., Ariza, L., Heukelbach, J. (2008). Parasites of importance for human health in Nigerian dogs: high prevalence and limited knowledge of pet owners. *BMC Veterinary Research*, *4*, 49–57. DOI:10.1186/1746-6148-4-49. PMID: **19068110.** PMCID: PMC2615757.

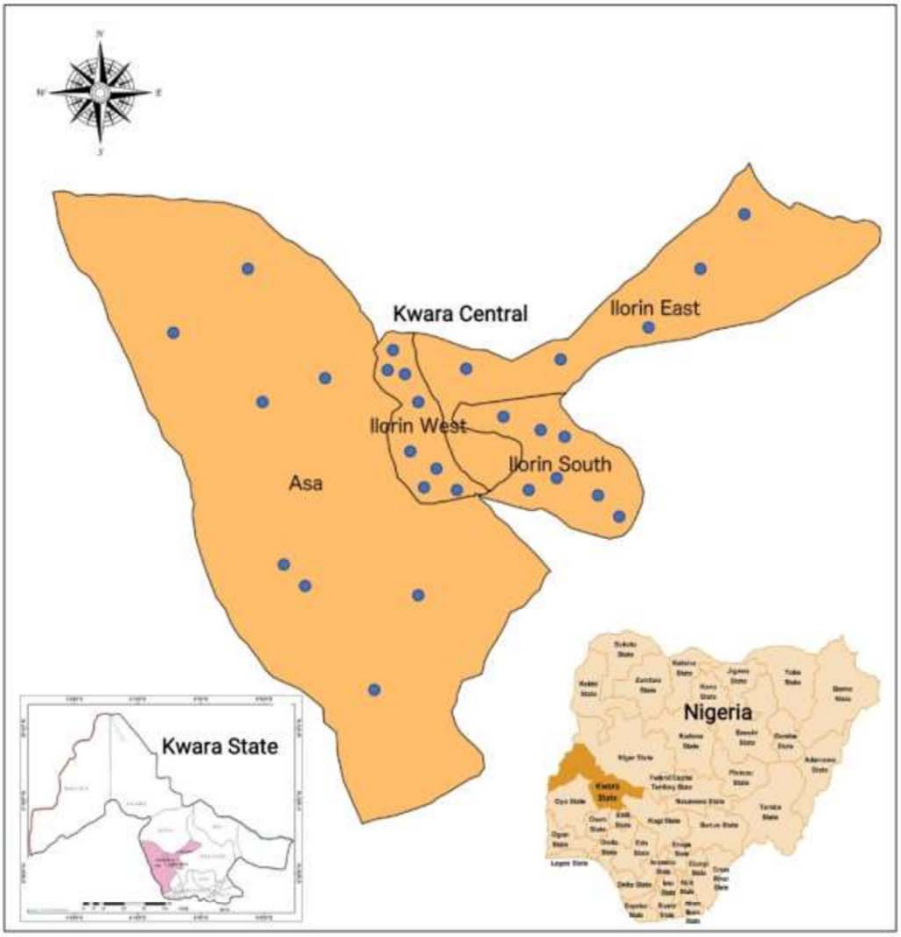
Viney, M.E., Graham, A.L. (2013). Patterns and Processes in Parasite Co-Infection. *Advances in Parasitology*, *82*, 321–369. DOI:10.1016/B978-0-12-407706-5.00005-8. PMID: **23548088.**

Yousef, A., Ghasemzadeh-Nava, H., Tajik, P., Akbarinejad V., Towhidi, A. (2022). Evaluation of soy lecithin efficacy in comparison with egg yolk on freezing of epididymal sperm in dogs. *Iranian Journal of Veterinary Medicine*, *16(2)*, 166–177.DOI:10.22059/ijvm.2021.329603.1005191

Figure legends

Figure 1. Map of Kwara Central, the study location (designed using QGIS Version 2.6.1). The insert map (on the left) shows Kwara Central within Kwara State (Onah *et al*., 2020). The insert map (on the right) shows Kwara State within Nigeria (Oladeji and Sule, 2015).

Figure 2. Prevalence of infections (a) between infected and uninfected groups; (b) between mixed and single infection categories of the infected group; (c) the different categories within the mixed infection group.


Kwara Central
Ilorin East
Ilorin West
Ilorin South
Asa
Kwara State
Nigeria

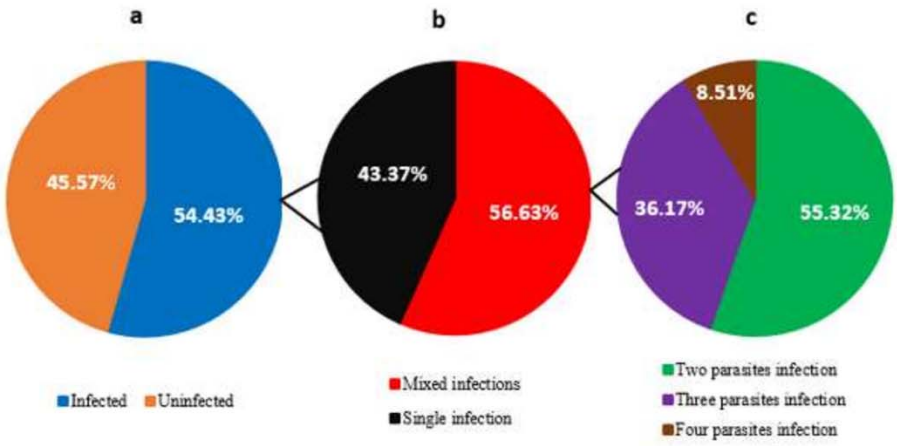

a
b
c
45.57%
54.43%
43.37%
56.63%
8.51%
36.17%
55.32%
Infected
Uninfected
Mixed infections
Single infection
Two parasites infection
Three parasites infection
Four parasites infection

Table 1. Prevalence and mean intensity of intestinal parasites infection among dogs in Kwara Central Nigeria (n = 305).

Parasites	n	Prevalence (%)	95% CI	Mean (±SEM) EPG/OPG
Ancylostoma spp.	77	25.25	20.07–30.41	303.64 (31.83)
Toxocara spp.	58	19.02	15.01–23.80	165.17 (19.88)
Strongyloides stercoralis	23	7.54	5.08–11.06	96.52 (16.04)
Uncinaria stenocephala	21	6.89	4.55–10.30	240.00 (44.42)
Dipylidium caninum	7	2.30	1.12–4.66	91.43 (7.38)
Isospora spp.	47	15.41	11.79–19.89	129.36 (28.12)
Cryptosporidium spp.	77	25.25	20.07–30.41	X

n = number positive; CI = confidence interval; EPG = egg per gram; OPG = oocyst per gram; SEM = standard error of mean; X = not applicable.

415 **Table 2.** Sociodemographic profile, knowledge of zoonosis, level of hygiene, and dog management practices of respondents in Kwara Central, Nigeria (n = 230).

Variables	Category	Proportion (%)	95% CI
Age of respondents (years)	< 25	42 (18.26)	13.80–23.76
	≥25	188 (81.74)	76.24–86.20
Gender of respondents	Male	131 (56.96)	50.50–63.19
	Female	99 (43.04)	36.81–49.5
Do you know about zoonotic parasites	Yes	136 (59.13)	52.68–65.28
	No	94 (40.87)	34.72–47.32
How close are you to your dog	Not close	27 (11.74)	8.20–16.54
	Close	33 (14.35)	10.40–19.46
	Very close	170 (73.91)	67.88–79.16
How close are your children to dogs	Not close	62 (26.96)	21.64–33.03
	Close	77 (33.48)	27.70–39.80
	Very close	91 (39.57)	33.47–46.01
Do you wash your hand after coming in contact with dog faeces	Yes	223 (96.96)	93.85–98.52
	No	7 (3.04)	1.48–6.15
What do you use to wash your hand after coming in contact with dog faeces	Water alone	8 (3.59)	1.83–6.92
	W+S	181 (81.17)	75.52–85.75
	W+S+HS	23 (10.31)	6.97–15.00

	W+HS	11 (4.93)	2.78–8.62
Do your children play with dogs	Yes	153 (66.52)	60.20–72.30
	No	77 (33.48)	27.70–39.80
Do you wash the hands of your children after playing with dogs	Yes	78 (50.98)	43.13–58.78
	No	75 (49.02)	41.22–56.87
Do your children play in areas where dogs defecate	Yes	52 (22.61)	17.68–28.44
	No	178 (77.39)	71.56–82.32
How many dog(s) do you have	One	5 (2.17)	0.93–4.99
	More than one	225 (97.83)	95.01–99.07
How is your dog housed	Caged	104 (45.22)	38.92–51.68
	Roam	121 (52.61)	46.17–58.97
	Caged/roam	5 (2.17)	0.93–4.99
Do you dispose your dog faeces	Yes	179 (77.83)	72.03–82.71
	No	51 (22.17)	17.29–27.97
How often do your dispose your dog faeces	Daily	104 (58.10)	50.78–65.08
	Every 2 days	72 (40.22)	33.32–47.54
	Weekly	3 (1.68)	0.57–4.81
Do you treat your dogs against parasites	Yes	161 (70.00)	63.79–75.55
	No	69 (30.00)	24.45–36.21

Frequency of antiparasitic treatment(s) given to your dogs	Monthly	21 (13.04)	8.69–19.12
	Quarterly	18 (11.18)	7.19–16.98
	Yearly	122 (75.78)	68.61–81.74

CI = confidence interval; W= water; S = soap; HS = hand sanitizer