



Research Article

Prevalence, Public Health Importance and Risk Factors  
Associated with Gastrointestinal Helminths of Domesticated  
Canines (*Canis familiaris*) from Yobe State, Nigeria

Jallailudeen Rabana Lawal<sup>1\*</sup>, Muhammad Mustapha<sup>1</sup>, Abdullahi Abubakar Biu<sup>2</sup> and Lawan Adamu<sup>1</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

\*Corresponding author: [rabana4real@unimaid.edu.ng](mailto:rabana4real@unimaid.edu.ng), [doi.org/10.55639/607.151400](https://doi.org/10.55639/607.151400)

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ABSTRACT

Dogs are serious hazard to public health despite many advantages of domesticating them. They harbor numerous infectious zoonotic intestinal parasites that can spread to humans and other animals. This study aimed to investigate the prevalence of canine gastrointestinal helminth infections and owners' understanding of zoonotic helminthiasis in Yobe State, Nigeria. Sedimentation/flotation technique was used to investigate helminths and structured questionnaire survey to evaluate level of awareness of canine zoonotic helminths. To achieve this, 750 domestic dog faeces samples were examined, and 150 dog owners were interviewed. Sex, age, breed, medical history, body condition score, purpose of dogs keeping and season of sample collection was noted and recorded. Out of 750 faecal samples examined, 84.5% (634/750) were infected, with nematodes (65.2%), cestodes (16.0%) and mixed (3.3%) gastrointestinal helminth infections. The most prevalent gastrointestinal helminth eggs were those belonging to the zoonotic worms *Ancylostoma caninum* (23.7%), *Toxocara canis* (21.5%), and *Trichuris vulpis* (16.5%). Other species found were *Taenia* species (7.1%), *Dipylidium caninum* (6.4%), *Spirocerca lupi* (3.5%), and *Diphyllobothrium latum* (2.5%). The prevalence of mixed infections with two helminth species comprising of *Ancylostoma caninum* + *Toxocara canis* (1.7%) and *Ancylostoma caninum* + *Trichuris vulpis* (1.1%) were found in affected dogs. Questionnaire interviews revealed that secondary school (50.0%) education is most common among dog owners and majority of them are unaware (76.0%) of zoonotic helminths in dogs. This study found that zoonotic helminths in dogs are common in the study area, implying a high risk of dog disease transmission. Age, season, inadequate health care, and lack of awareness were identified as risk factors for canine helminths infections. Therefore, immediate preventive and control measures targeted at eliminating dog helminths are required in the study area.

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

## INTRODUCTION

Dogs (*Canis familiaris*) are one of the world's most successful canines adapted to urbanized habitats, with population consisting of dogs that roam solely under owners' close supervision and stray dogs that lack existing owners (Ritchie *et al.*, 2014). Despite many benefits of domesticating dogs, however, these pets pose a major threat to public health (Elom *et al.*, 2015). They harbor a wide variety of infectious parasites including helminths that can be transmitted to humans and other domestic animals (Gugsa *et al.*, 2015). Many helminth infections have been shown to be a serious health constraint in dogs, resulting to decreased resistance to other infectious agents, emaciation, lethargy and, even death if not treated (Edet *et al.*, 2014; Alexander *et al.*, 2016). Geographical differences, poor hygiene, malnutrition, and insufficient medical treatment have all been linked to the spread and severity of helminth infections in dogs (Matthew *et al.*, 2016; Omonijo and Sowemimo, 2016). Lack of knowledge about zoonoses in certain areas of the world further intensifies the transmission of zoonotic diseases between dogs and humans (Mekbib *et al.*, 2013).

Several surveys were conducted on the prevalence and intensity of gastrointestinal helminths in dogs from developing African countries, including Nigeria (Idika *et al.*, 2017; Chidumayo, 2018; Kamani *et al.*, 2021; Massetti *et al.*, 2021; Jajere *et al.*, 2022). Different prevalence rates were reported, most of which identified multiple species of nematodes, cestodes, trematodes and coccidians in single and mixed infections in dogs, among which nematodes species were deemed as the most predominant (Ayimode *et al.*, 2016; Ezema *et al.*, 2019). The most commonly identified zoonotic helminths of dogs are *Ancylostoma*, *Dipylidium caninum*, *Toxocara canis*, *Strongyloides stercoralis*, *Echinococcus granulosus* and *Trichuris vulpis* (Ayimode *et al.*,

2016; Massetti *et al.*, 2021). In many parts of Nigeria, prevalence, epidemiology, and public health significance of gastrointestinal helminths in dogs have been reported (Moro and Abah, 2019; Kamani *et al.*, 2021; Massetti *et al.*, 2021; Jajere *et al.*, 2022). This study was conducted in Yobe State, Northeastern Nigeria, to determine the prevalence of gastrointestinal helminths infestation/infection of dogs and to assess the current knowledge of dog owners on zoonotic helminthiasis.

## MATERIALS AND METHODS

### Study area, Design and Target Population

This study was carried out between January, 2019 and December, 2019 in Yobe State which is located in Northeastern Nigeria, with Damaturu as its capital and Potiskum as its main city. The State shares boundaries with Bauchi, Borno, Gombe, and Jigawa States, as well as the Diffa and Zinder regions of Niger to the north. The study location was chosen based on availability of owned dogs, accessibility of dog butchers, and cooperation of dog owners with the goal of the present study. A cross-sectional study was conducted adopting non-probability sampling techniques, involving microscopic qualitative assessment of helminths ova from faecal samples and questionnaire survey to assess dog owners' information on zoonotic helminths of dogs. The sample population consisted of live dogs and those supplied for slaughter at known dog abattoirs within the study locations.

### Faecal Samples and Data Collection

A total of 750 individual faecal samples were collected in sample tubes during the study. All faecal samples from living dogs were collected according to standard protocols with caution regarding the welfare of the dog. Using a disposable hand glove, 5–10 grams of fresh faeces samples were scooped directly from each sampled dog's rectum, transferred into clean dry sample collecting tubes, and labeled accordingly. Shortly after slaughter, the

stomachs of sacrificed dogs, small and large intestines were eviscerated, and about 20 grams of each component was collected into clean, dry collecting tubes. All faecal samples were transported ice-packed to the laboratory for processing and samples that were not processed immediately were scooped into a stool bottle containing 10% formalin and stored at room temperature.

### **Questionnaire survey**

A questionnaire survey with open-ended demographic questions was given to 150 respondents (dog owners and butchers) in order to assess the educational level, knowledge, and awareness of canine zoonotic gastrointestinal helminths. When necessary, native language interpreters translated interview questions into their original tongues while the numerical components of the data were gathered and analyzed.

### **Body condition score of dogs**

The Body Condition Score (BCS) category used in our study has scales from 1 to 9 (Scales 1 and 2 considered severely underweight and very thin (Poor); Scales 3 and 4 considered thin and slightly underweight (moderate); Scales 5 considered ideal weight (good); Scales 6 and 7 considered slightly overweight and markedly overweight (overweight); Scales 8 and 9 considered obese and clinically obese (Obese). Since we did not come across any dogs that fit the criteria for being overweight or obese, our study divides dogs into three groups: Good, Moderate, and Poor.

### **Coproscopy and Parasitology**

Each faecal sample was processed using the formalin-ethyl acetate technique of sedimentation and standard flotation with a 33% (w/v) zinc sulphate solution, as described by Zajac *et al* (2002). Samples were observed under the light microscope at 10x objective. The helminths were classified according to their species based on existing morphological keys and descriptions by Soulsby (1982).

### **Statistical analysis**

Data obtained from the study were analyzed using descriptive statistics (GraphPad Prism software) and the results were summarized as percentages. The Chi-square test was used to assess difference in the prevalence of the infection and categorical variables such as sexes, breeds, age, season, body condition score and medical records, purpose of dogs keeping. Pairwise correlation analysis utilizing multivariate analysis with JMP version 11 SAS, NC, Cary, was used to analyze the relationship between infection and dog owners' educational status and awareness of zoonotic helminths in dogs. Significant level was determined at 95% confidence intervals and  $p < 0.05$  for all the statistical results. Calculation of the lower and upper limits of the 95% confidence interval for a proportion was done according to the methods described by Newcombe (1998).

### **RESULTS**

Six hundred and thirty-four (84.5%; 95% CI: 81.8 – 86.9%) out of 750 fecal samples examined were found to be infected with eggs of at least one species of gastrointestinal helminths. The prevalence of single gastrointestinal nematodes (65.2%; 95% CI: 61.7 – 68.5%) infection was higher than cestodes (16.0%; 95% CI: 13.6 – 18.8%) and mixed gastrointestinal helminths infections (3.3%; 95% CI: 2.3 – 4.9%). The prevalence of gastrointestinal helminths infection in dogs were found to be higher among dogs examined from Fika (16.4%; 95% CI: 13.9 – 19.2%) followed by Nguru (16.1%; 95% CI: 13.7 – 18.9%), Fune (15.6%; 95% CI: 13.2 – 18.4%), Gujba (14.3%; 95% CI: 12.0 – 17.0%), Potiskum (12.0%; 95% CI: 9.9 – 14.5%) and Damaturu (10.1%; 95% CI: 8.2 – 12.5%) (Table 1).

Seven species of helminths in single and mixed infection rates were microscopically detected in faeces of infected dogs, among are *Ancylostoma caninum* which predominated with prevalence rate of 23.7% followed by *Toxocara canis*

(21.5%) and *Trichuris vulpis* (16.56%). Other ova of gastrointestinal helminths encountered were *Taenia* species and *Dipylidium caninum* with prevalence rates of 7.1% and 6.4% respectively. The nematode *Spirocerca lupi* and cestode *Diphyllobothrium latum* were also encountered in the infected dogs with prevalence rate of 3.5% and 2.5% respectively. Mixed helminth infections encountered were *Ancylostoma caninum* + *Toxocara canis*, *Ancylostoma caninum* + *Trichuris vulpis* and *Ancylostoma caninum* + *Toxocara canis* + *Trichuris vulpis* with prevalence rate of 1.7%, 1.1% and 0.5% respectively (Table 2).

The male (43.7%) were more infected with gastrointestinal helminths than the female (40.8%) dogs, however, the difference in prevalence was not statistically ( $p$ -value = 0.2729) significant. However, the young (43.2%) dogs were more infected than the adult (41.3%), and the difference in prevalence was statistically ( $p < 0.0001$ ) significant. Moreover, the prevalence of gastrointestinal helminths was higher among dogs sampled during the rainy (46.8%) than the dry (37.7%) season, and the difference in prevalence was also statistically ( $p < 0.0001$ ) significant. The prevalence of gastrointestinal helminths infection was significantly ( $p < 0.0001$ ) higher in local (mongrel) (52.1%) compared to cross (18.0%) and exotic (14.4%) breed of dogs. The prevalence was significantly ( $p < 0.0001$ ) higher in dogs with poor (41.3%) compared to moderate (29.3%) and good (13.9%) body condition scores. Based on the purposes of keeping dogs, prevalence of gastrointestinal helminths infections was not significantly ( $p = 0.7914$ ) higher in dogs used for hunting (36.5%) followed by security (27.5%) and companion/pet (20.5%) dogs. While, prevalence was significantly ( $p < 0.0001$ ) higher in dogs with no medical record (54.1%) than dogs with medical records (30.4%) (Table 3).

Out of the 150 respondents, those with secondary (50.0%) school education predominated followed by those with primary (20.0%) and Tertiary (18.0%) education, while those with non-formal (12.0%) education were the least common among dog owners. There was a negative correlation between infection status of dogs and educational status ( $r = -0.5324$ ;  $p < 0.0001$ ). The response of dog owners concerning their awareness or knowledge of zoonotic implications and public health significance of gastrointestinal helminths of dogs revealed that the percentage of those unaware (76.0%) was higher than those that are aware (24.0%). There was a negative correlation between infection status of dogs and awareness of zoonotic helminth infections in dogs ( $r = -0.6376$ ;  $p < 0.0001$ ) (Table 4).

## DISCUSSION

The overall prevalence rate of 84.5% gastrointestinal helminths infection in dogs recorded in the present study is considerably high, which could be due to allowing domesticated dogs to breed with infected stray dogs and favorable ecological conditions for helminths life cycle proliferation. Comparatively with previous studies from some parts of Nigeria, our finding was higher than 56.1% reported from Enugu (Idika *et al.*, 2017), 65.0% from Abua (Moro and Abah, 2019), 39.1 from Bende (Amadi *et al.*, 2021), and 77.9% from Gombe (Jajere *et al.*, 2022), however, lower than 81.3% reported from Abia (Onyeabor, 2014). Variations in the prevalence rates of gastrointestinal helminths in dogs reported from different parts of the country could be attributed to differences in climatic conditions, ecological difference and diagnostic techniques used in each study. In the current study, dogs investigated from Damaturu and Potiskum communities were less frequently observed to have canine gastrointestinal helminth infections. The fact that these are more urbanized areas with government-established veterinary health

care facilities, which may improve or provide routine dog deworming services and public knowledge of the necessity for routine dog deworming. These findings may be related to these factors.

Also, varying prevalence rates of gastrointestinal helminths infections in dogs have been reported from some parts of Africa and other parts of the world, 25.6% in Egypt (Ibrahim *et al.*, 2016), 52.6% in Ghana (Amissah-Reynolds 2016), 20.4% in Iran (Sardarian *et al.*, 2015), 88.5% in Grenada, West Indies (Tiwari *et al.*, 2016), 26.8% in Pakistan (Khan *et al.*, 2020) and 94.7% in Uzbekistan (Safarov *et al.*, 2022).

From the finding of the present study, the prevalence of gastrointestinal nematode (65.2%) was found to be higher than cestodes (16.0%) species and mixed helminth infections (3.3%). This finding is consistent with Amissah-Reynolds (2016) who has also reported higher prevalence of gastrointestinal nematode species in dogs from Ghana. In the present study, seven species of gastrointestinal helminths were found to infect dogs. This finding is consistent with Kutdang *et al.* (2010) and Jajere *et al.* (2022), who reported the same number of helminth species in dogs from Plateau and Gombe States respectively. However, some previous studies, have reported twelve and thirteen species from Eboyi (Elom *et al.*, 2015) and Sokoto (Mahmuda *et al.*, 2012) States in Nigeria respectively. The large range of helminth species seen in infected dogs in these investigations could be linked to variations in climatic conditions, which could impact the biology of the helminths' infective stages.

The finding of the present study revealed the hookworm *Ancylostoma caninum* as the most predominant helminth with prevalence rate of 23.7%. This zoonotic helminth have been reported as the widest transmitted gastrointestinal helminths in dogs throughout the world, probably due its direct mode of transmission and high fecundity of its female

species leading to heavy contamination of the environment with ova and larvae, as well as their high infectivity to dogs of all age (Soulsby, 1982). Our finding is consistent with the results of previous studies in some African countries including Nigeria (Idika *et al.*, 2017; Chidumayo, 2018; Moro and Abah, 2019; Amadi *et al.*, 2021; Massetti *et al.*, 2021; Jajere *et al.*, 2022). Although, the prevalence of *Ancylostoma caninum* reported in our study is lower than 33.2% reported in Enugu (Idika *et al.*, 2017), 44.2% reported in Abia (Amadi *et al.*, 2021) and 40.2% reported in Gombe States. The findings of the present study revealed 21.5% prevalence of *Toxocara canis* in infected dogs, which is similar to 21.1% reported from Ekiti (Omonijo and Sowemimo, 2016), however lower than 30.2% reported from Bende-Abia (Amadi *et al.*, 2021) and 35.1% from Gombe (Jajere *et al.*, 2022), but higher than 5.9% reported from Enugu (Idika *et al.*, 2017) States.

The 16.5% prevalence of *Trichuris vulpis* in this study is higher than 15.7% reported from India (Tiwari *et al.*, 2016). Other gastrointestinal helminths encountered at various prevalence rates in the present study include; *Taenia spp.* (7.1%), *Dipylidium caninum* (6.4%), *Spirocerca lupi*, (3.5%) and *Diphyllobothrium latum* (2.5%), which signifies availability of these gastrointestinal helminths species in the present study area. Mixed infections with more than one helminth species were recorded in 3.3% of the infected dogs. Several combinations of mixed infections have been reported in previous studies evaluating the prevalence of intestinal helminths in dogs (Idika *et al.*, 2017; Moro and Abah, 2019; Abulude, 2020).

Despite the higher prevalence in male (40.0%) compared with female (36.3%), the finding of this study revealed no statistical significant difference ( $p>0.05$ ) between both sexes. This indicates that both sexes of dogs shares equal chance of getting infection where exposed to the infective stages of the helminths. However, the

higher prevalence rates recorded in male dogs could be attributed to far distance wandering habits of male dogs in search of food and mating mates that might expose them to infective stages and intermediate host of the helminths compared to the females. This is consistent with the result of a previous study (Moro and Abah, 2019; Khan *et al.*, 2020), but in contrasts to the findings of Onyeabor (2014), Iboh *et al.* (2015) and Jajere *et al.* (2022) who have reported higher prevalence in female than the male dogs. This present study revealed a significant higher prevalence of helminths infection in young compared to adult dogs. This finding agrees with Kamani *et al.* (2021), but contrasts the report of Yacob *et al.* (2007) in Ethiopia who have recorded significantly higher prevalence of gastrointestinal helminths infections in adult compared to the younger dogs. However, Awoke *et al.* (2011) reported that gastrointestinal helminths infection in dogs was not statistically related to the dogs' age.

The higher prevalence of gastrointestinal helminths infection during the rainy compared to the dry season in this study, might be associated with the fact that rainy season offers optimum humidity (moisture) and ambient temperature which is considered favourable for the survival of helminth eggs and infective stages. This finding buttress previous studies of Minnaar *et al.* (2002) and Onyeabor (2014) who have shown that most of the gastrointestinal parasitic infections apparently occurred more in rainy than any other season of the year, and heavy rainfall enhances wide spread of environmental contamination with infections due to water flooding, logging and spreading of infective eggs and larvae stages of helminths.

The present study revealed significantly higher prevalence of gastrointestinal helminths infection in local (mongrel) compared to cross or exotic breed of dogs. This finding might be attributed to valued medical attentions, management and husbandry systems provided to

the exotic breeds, rather than a consideration of the breed susceptibility. This finding concurs with previous reports from similar studies of Iboh *et al.* (2015), Ibrahim *et al.* (2016) and Idika *et al.* (2017) who also reported high prevalence of gastrointestinal helminths infections in local compared to the cross or exotic breeds of dogs. Moreover, exotic breed of dogs are customary kept in confinement, thus, less exposed to infective stages of gastrointestinal helminths infection or contaminated environments. They are used as pets and more treasured, well nourished, and given extra attentions in terms of management and health care compared to local breeds of dogs. In another scrutiny, most of the stray dogs in the present study area are the local (mongrel) breed; they are usually allowed to scavenge freely in search of food and mates with little or no routine deworming. The freedom to roam around contaminated places predisposes the stray dogs to several infective stages and intermediate hosts of the different helminths (Aiyedun and Olugasa, 2012).

The current study has revealed significantly higher prevalence of gastrointestinal helminths in dogs with poor (41.3%) followed by moderate (29.3%) and good (13.9%) body condition score. This finding suggests that gastrointestinal helminths infection could be one of the factors contributing to canine emaciation. It is well known that gastrointestinal helminths infection causes epithelia layers to be injured, preventing complete absorption of nutrients from the gastrointestinal tract. Traub *et al.* (2007) have reported that infections with several helminth species usually results to losses due to incomplete absorption of nutrient leading to poor growth, weight loss, progressive emaciation and wasting away in flesh.

The present study also revealed high prevalence of gastrointestinal helminths in dogs used for hunting (36.5%) followed by security (27.5%) and companion/pet (20.5%) dogs. This finding

may be associated with the fact that most hunting dogs are owned by local hunters in the present study area. The hunters seldom provide their dogs with proper attentions in terms of nutrition, husbandry and health care, they allow these dogs to wander near and far distances in the bush during hunting, which predispose them to infections with gastrointestinal helminths. During hunting, the dogs are usually allowed to mingle with other stray dogs which may bring about dog to dog transmission of infectious diseases including eggs of helminths. Irrespective of what purpose dogs are kept, the closeness of dogs to their owners may constitute risks of transmission of helminths from dogs to their owners. The observations in the current study is in accordance with Zanzani *et al.* (2014) who found that cohabitation and mingling of many dogs as one of the most significant risk factors associated with endoparasitism, it enhances cross transmission and continuous environmental contamination with egg from infected faeces of dogs. Generally, the lower prevalence of gastrointestinal helminths found in security dogs in this study might be attributed to routine deworming, intensive confinement, good nutrition and proper hygienic measures adopted in keeping dogs, in order to maintain proper stamina and health to serve required purposes. Moreover, the prevalence of gastrointestinal helminths recorded in companion/pet dogs implies that even with relative high level of care and humane handling, the companion dogs still harbor gastrointestinal helminths. However, our finding is not consistent with Ibrahim *et al.* (2016) who have reported higher prevalence of gastrointestinal helminths in dogs used for security compared to companion dogs. It was observed in this study that all the three purposes of keeping dogs (hunting, security, companion/pet) brings the animal into close contact with their owners and members of the family. This reflects high risk of transmission of

zoonotic helminths infections from infected dogs to humans in the study area.

The present study has revealed significantly higher prevalence of gastrointestinal helminths in dogs with no medical records compared to those with medical records. This finding is consistent with the previous study of Ibrahim *et al.* (2016) and Kamani *et al.* (2021) who also reported lower prevalence rate of gastrointestinal helminths in dogs attending veterinary clinics compared to stray dogs that do not receive routine health care.

The present study revealed that there was a negative correlation ( $r = -0.5324$ ;  $p < 0.0001$ ) between dog infection status and educational status. That is to say, when dog owners' educational status improves, the rate of infection decreases, similarly, as dog owners' educational status declines, the rate of infection rises. Questionnaire survey revealed that majority of the dogs owners in the study areas had secondary school (50.0%) followed by primary (20.0%) education. This signifies low level of education among dog owners; this may lead to ignorance in the proper handling of dogs basic needs including health care. However, 18.0% of dogs' owners in the present study area had Tertiary education, which are probably the group of individuals that owned exotic breeds of dogs and are able to provide their dogs with the basic needs, including seeking for veterinary services. This reports confirmed those of Swai *et al.* (2010) who have reported low prevalence of intestinal parasitic infections among dogs owned by educated compared to those owned by less educated individuals, and they have attributed their findings to non-adoption of the modern animal health care programmes by less educated dog owners, most of who are ignorant and unable to provide their pets' daily needs.

The current study's findings also revealed a negative correlation ( $r = -0.6376$ ;  $p < 0.0001$ ) between dog infection status and knowledge of zoonotic helminth infections of dogs. That is to

say, as awareness of zoonotic helminth infections in dogs increases, the number of infections in dogs decreases. Similarly, as knowledge of zoonotic helminth infections in dogs declines, the rate of infection rises. The findings of the present study showed that most of the dog owners in the study area were unaware (76.0%) of zoonotic helminth infections in dogs, which is attributed to ignorance and low level of education amongst dog keepers. This finding confirmed the finding of Amadi *et al.* (2021) who have also reported very low level of awareness among pet owners regarding canine zoonotic helminths in a similar survey. The lack of knowledge about zoonoses further intensifies the transmission of zoonotic diseases between dogs and humans in many developing countries (Mekbib *et al.*, 2013).

### CONCLUSION

In conclusion, the present study revealed that gastrointestinal helminths of domestic dogs are prevalent (84.5%) in the study area. In particular, the results highlighted a relatively high prevalence of *Ancylostoma caninum*, *Toxocara canis* and *Trichuris vulpis* in infected dogs, which are of zoonotic importance. Although, some of the gastrointestinal helminths encountered in infected dogs in the present study may have little or no public health importance, yet great attention is required to study their

epidemiology. Therefore, this necessitates urgent public health enlightenment and awareness campaign among dog owners in the study area so as to reduce the prevalence and curb the chance of transmission of zoonotic helminths of dogs such as *Ancylostoma* to human. In addition, due to the close association between dogs and humans, routine deworming, adequate husbandry management of dogs and strict biosecurity measures is therefore recommended. It is also suggested that a One Health approach be used in developing and implementing programs, policies, legislation, and research in which multiple sectors involved in animal, human, and environmental health communicate and collaborate to improve public health outcomes aimed at protecting dogs and humans from zoonotic gastrointestinal helminths. Veterinary clinics should be established in the strategic region of the study area to facilitate dog owners' stress-free access to regular veterinary diagnosis and treatments.

### Conflicts of Interest

The authors declare they do not have any conflicts of interest in publishing this article.

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**Table 1:** Prevalence of Gastrointestinal Helminths in Domesticated Canines (*Canis familiaris*) in Yobe State, Nigeria

Study Locations	Number of dogs examined	Number (%) of dogs infected with (N= 750)			Overall Prevalence (%)
		Nematodes	Cestodes	Mixed	
Damaturu	125	66 (52.8)	7 (5.6)	3 (2.4)	76 (60.8)
Prevalence (%)		8.8	0.9	0.4	10.1
95% CI (LL – UL)		7.0 – 11.0	0.5 – 1.9	0.1 – 1.2	8.2 – 12.5
Potiskum	125	76 (60.8)	11 (8.8)	3 (2.4)	90 (72.0)
Prevalence (%)		10.1	1.5	0.4	12.0
95% CI (LL – UL)		8.2 – 12.5	0.8 – 2.6	0.1 – 1.2	9.9 – 14.5
Gujba	125	80 (64.0)	21 (16.8)	6 (4.8)	107 (85.6)
Prevalence (%)		10.7	2.8	0.8	14.3
95% CI (LL – UL)		8.7 – 13.1	1.8 – 4.2	0.4 – 1.7	12.0 – 17.0
Fune	125	86 (68.8)	25 (20.0)	6 (4.8)	117 (93.6)
Prevalence (%)		11.5	3.3	0.8	15.6
95% CI (LL – UL)		9.4 – 14.0	2.3 – 4.9	0.4 – 1.7	13.2 – 18.4
Nguru	125	88 (70.4)	29 (23.2)	4 (3.2)	121 (96.8)
Prevalence (%)		11.7	3.9	0.5	16.1
95% CI (LL – UL)		9.6 – 14.2	2.7 – 5.5	0.2 – 1.4	13.7 – 18.9
Fika	125	93 (74.4)	27 (21.6)	3 (2.4)	123 (98.4)
Prevalence (%)		12.4	3.6	0.4	16.4
95% CI (LL – UL)		10.2 – 15.0	2.5 – 5.2	0.1 – 1.2	13.9 – 19.2
Overall Prevalence (%)	750	489 (65.2)	120 (16.0)	25 (3.3)	634 (84.5)
95% CI (LL – UL)		61.7 – 68.5	13.6 – 18.8	2.3 – 4.9	81.8 – 86.9

**Table 2:** Species-Specific Prevalence of Gastrointestinal Helminths in Domesticated Canines (*Canis familiaris*) in Yobe State, Nigeria

Type of infection	Helminths	Species of Helminths encountered	Number of dogs infected (N = 750)	Prevalence (%) 95% CI (LL - UL)	
Single	Nematodes	<i>Ancylostoma caninum</i>	178	23.7 (20.8 – 26.9)	
		<i>Toxocara canis</i>	161	21.5 (18.7 – 24.6)	
		<i>Trichuris vulpis</i>	124	16.5 (14.0 – 19.4)	
		<i>Spirocerca lupi</i>	26	3.5 (2.4 – 5.0)	
		Cestodes	<i>Taenia spp.</i>	53	7.1 (5.5 – 9.1)
			<i>Dipylidium caninum</i>	48	6.4 (4.9 – 8.4)
			<i>Diphyllobothrium latum</i>	19	2.5 (1.6 – 3.9)
Mixed		<i>Ancylostoma caninum</i> + <i>Toxocara canis</i>	13	1.7 (1.0 – 2.9)	
		<i>Ancylostoma caninum</i> + <i>Trichuris vulpis</i>	8	1.1 (0.5 – 2.1)	
		<i>Ancylostoma caninum</i> + <i>Toxocara canis</i> + <i>Trichuris vulpis</i>	4	0.5 (0.2 – 1.4)	

**Keys:** N= Total of dogs examined; CI= Confidence Interval; LU – UL= Lower Limit – Upper Limit.

**Table 3:** Some Risk Factors Associated with the Prevalence of Gastrointestinal Helminths in Domesticated Canines (*Canis familiaris*) in Yobe State, Nigeria

Parameters	Risk factors	Number of Dogs Examined (N = 750)	Number of Dogs (%) infected	Prevalence (%) 95% CI (LL – UL)	$\chi^2$	p- value	Odd Ratio	Relative Risk
Sex	Male	381	328 (86.1)	43.7 <sup>a</sup> (40.2 – 47.3)	1.202	0.2729	0.7848	0.8148
	Female	369	306 (82.9)	40.8 <sup>a</sup> (37.3 – 44.4)				
Age (months)	Adult (> 12)	409	310 (75.8)	41.3 <sup>a</sup> (37.9 – 44.9)	51.081	<0.0001	6.087	4.855
	Young (< 12)	341	324 (95.0)	43.2 <sup>b</sup> (39.7 – 46.8)				
Season	Dry	369	283 (76.7)	37.7 <sup>a</sup> (34.3 – 41.3)	32.974	< 0.0001	3.555	2.960
	Rainy	381	351 (92.1)	46.8 <sup>b</sup> (43.3 – 50.4)				
Breed	Local (mongrel)	395	391 (99.0)	52.1 <sup>a</sup> (48.6 – 55.7)	266.62	< 0.0001	-	-
	Cross	141	135 (95.7)	18.0 <sup>b</sup> (15.4 – 20.9)				
BSC	Exotic	214	108 (50.5)	14.4 <sup>c</sup> (12.1 – 17.1)	115.44	< 0.0001	-	-
	Good	169	104 (61.5)	13.9 <sup>a</sup> (11.6 – 16.5)				
PDK	Moderate	266	220 (82.7)	29.3 <sup>b</sup> (26.2 – 32.7)	0.4679	0.7914	-	-
	Poor	315	310 (98.4)	41.3 <sup>c</sup> (37.7 – 44.9)				
Medical Records	Companion / Pet	183	154 (84.2)	20.5 <sup>a</sup> (17.8 – 23.6)	119.68	< 0.0001	18.875	13.202
	Hunting	327	274 (83.8)	36.5 <sup>a</sup> (33.2 – 40.0)				
Medical Records	Security	240	206 (85.8)	27.5 <sup>a</sup> (24.4 – 30.8)	119.68	< 0.0001	18.875	13.202
	Available	334	228 (68.3)	30.4 <sup>a</sup> (27.2 – 33.8)				
Medical Records	No Record	416	406 (97.6)	54.1 <sup>b</sup> (50.6 – 57.7)	119.68	< 0.0001	18.875	13.202

<sup>a,b,c</sup>Values with different superscripts indicate significant ( $p < 0.05$ ) difference in prevalence rate

Key: CI = Confidence Interval; LL – UL = Lower limit – Upper limit;  $\chi^2$  = Chi-square; OR = Odd ratio; BSC = Body Condition Score; PDK = Purpose of Dogs Keeping

**Table 4:** Questionnaire survey prevalence of helminth infection in dogs from Yobe State, Nigeria, in different educational groups and between groups of unaware and aware owners, as well as a correlation between infected dogs and owner education and knowledge of zoonotic helminth infections

Variables	Information	Number of Respondents (%) N = (150)	Infection status of dogs		Prevalence (%)	Correlation	p – value
			Infected	Uninfected			
Educational status	Non-formal	18 (12.0)	18 (100.0)	0.0	78.7	-0.5324	< 0.0001
	Primary	30 (20.0)	30 (100.0)	0.0			
	Secondary	75 (50.0)	60 (80.0)	15 (20.0)			
	Tertiary	27 (18.0)	10 (37.0)	17 (63.0)			
Overall		150	118 (78.7)	32 (21.3)			
Knowledge of zoonotic helminth infections of dogs	Aware	36 (24.0)	10 (27.8)	26 (72.2)	80.7	-0.6376	< 0.0001
	Unaware	114 (76.0)	111 (97.4)	3 (2.6)			
Overall		150	121 (80.7)	29 (19.3)			

Key: N = Total Number of Respondents, - Negative