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Toxocariasis in Ghanaian neighbourhoods: a need for action

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ABSTRACT

Background: Animal reservoirs of *Toxocara* spp., a neglected parasitic infection, are frequently found in many Ghanaian neighbourhoods. Despite various interactions occurring between these animals and humans which sustain zoonosis, not much focus has been directed at disease surveillance in Ghana, necessitating this study.
Methods: The study was cross-sectional. It combined the collection of biological samples with the survey approach. The study used purposive and convenience sampling techniques to collect data from eligible participants in the Greater Accra region of Ghana. Besides the collection of biological samples from animals which were processed using molecular techniques, semi-structured questionnaires were administered to the pet owners.
Results: In sum, 32.2% (95% CI, 27.6%–37.0%) of the targeted animals were positive for *Toxocara canis*, with most of the cases being found in dogs and rodents. Among the 204 rodents, more *Praomys tulbergi* were positive for this parasite compared to the others. From the survey, some risk factors culminating in high disease exposure were identified: more than one-third of pet owners did not deworm their pets although about a fourth shared bed with them. In addition, many respondents' kids played with these pets but not all supervised them to practice hand hygiene. Also, a good number of pet owners confirmed the frequent exposure of their pets to rodents.
Conclusions: The relatively high prevalence of *T. canis* recorded in animals and the increasing exposure of humans to this parasite point to a higher risk for human toxocariasis. Furthermore, *T. canis* found in cats cannot be ignored and merits further investigations. For Ghana to achieve SDG 3 by 2030, priority must also be placed on neglected diseases which calls for an integrated approach to disease surveillance and a redirection of research focus using the one health concept.

1. Introduction

Toxocariasis is a neglected parasitic infection that causes considerable socio-economic impact in poor communities and it is estimated to affect millions of children [1,2]. These past years, toxocariasis gained much attraction due to increased cases, especially in the United States. Eventually, it was put on the list of the five most neglected parasitic infections by the United States Centre for Disease Control [2]. Children acquire this disease when they ingest the embryonated parasite ova excreted into the environment or through contaminated products or undercooked meat containing encysted larvae [2,3]. Another suggested mode of transmission is contact with embryonated *Toxocara* eggs on the hair coat of dogs [4]. Even though human infections are mainly asymptomatic, the parasite can produce extra-intestinal pathologies in infected persons [5]. *Toxocara* spp. do not complete their maturation in humans, yet the larval migration through the body causes symptoms ranging from mild, inexplicit discomfort to visual disorders and other neurological syndromes [2,6].

Non-human mammals like dogs, cats, and rodents play critical roles in human toxocariasis transmission [6,7]. For dogs and cats, *Toxocara canis* and *Toxocara cati* are the main definitive hosts, respectively. Rodents are paratenic hosts and so are involved in both the active and passive transmission of these parasites. As dogs, cats, and rodents are usually found in our neighbourhoods, and various interactions exist between them and humans, the likelihood of cross-species transmission is high. For instance, some *Toxocara*-infected dogs are described as frequent shedders of the parasite eggs [8] and so are a threat to their owners' health and persons living in such communities. In Africa and Ghana, various studies have documented different prevalences in humans, dogs and cats. For instance, Kyei et al. [9] and Gyang et al. [10] reported an overall seroprevalence of 53.5% and 86.1% in children in Ghana and southern Nigeria, respectively. In Egypt, Aziz et al. [11] reported an overall prevalence of 53.4% in dogs,

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relatively higher than what was reported by Johnson et al. [12](5.85%) and Amissah-Reynolds et al. [13](18.5%) in Ghana.

Surveillance of this neglected disease is essential as sustainable health demands a preventive rather than a reactive approach. Again, the management practices of dog and cat owners were assessed based on the one health concept, which highlights the interconnectedness of humans, animals, and the environment.

2. Methods

2.1. Study design

The study was cross-sectional and employed primary data collected in the Greater Accra region of Ghana from October 2019 to October 2020. Besides the questionnaire survey, biological samples were collected from targeted animals and processed using molecular techniques.

2.2. Study area

Though the smallest of the sixteen (16) regions in Ghana, Greater Accra is the second most densely inhabited region and the most urbanized, with over 87% of its population living in urban areas [14]. This region has 2 metropolitan, 23 municipal, and 4 district assemblies, referred to as MMDAs. A further breakdown of the MMDAs is shown in Appendix 1. Using the purposive sampling approach, at least, two study sites were selected, each from a metropolitan, municipal and district assembly (Table 1).

2.3. Sample size determination of the study population

Assuming a minimum prevalence of 50%, a sample size of 384 was obtained at a 95% confidence interval using the formula by Daniel (1999) cited in [15].

$$n = \frac{z^2 * p(1-p)}{e^2}$$

Where n is the sample size, Z is the Z score at a 95% confidence interval (1.96); p = minimum estimated prevalence (50%); e = margin of error/absolute error (5%) at a 95% confidence interval. There was no reliable population data of targeted animals in the region to serve as a sample frame for the present study. Hence, purposive and convenience sampling techniques were used to obtain an eligible and representative sample size of the study population.

2.4. Ethical clearance and informed consent

This study involved animal and human participants; therefore, ethical approval was obtained from the University of Ghana-Institutional Animal Care and Use Committee (UG-IACUC 009/18–19). Additionally, informed consent was obtained from study participants and pet owners before sample collection.

2.5. Sample collection

2.5.1. Rodent trapping and blood collection

An average of 50 trap lines were set for the trapping of rodents using various sizes of Sherman's LFA live trap (H.B. Sherman Traps, Inc., Tallahassee, FL). At each location, the live traps were labelled, baited with a mixture of peanut butter, palm nut and maize flour and placed in strategic places: logs, burrows, farmlands, homes and dumpsites 10 m apart. These traps were inspected for three consecutive days, and traps with rodents were recorded. Not more than 1 ml of blood was collected from the tail following standard protocols and procedures [16] and then transported to the laboratory under a cold chain. Rodents were identified with the help of morphometric keys or guides.

Table 1
MMDAs and selected study sites.

MMDAs	Assembly	Study sites
Metropolitan	Accra Metropolitan Assembly	Legon, Shiashie, Okponglo
Municipal	La-Nkwantanang Municipal Assembly	Madina, Madina estate
District	Shai-Osudoku District Assembly	Dodowa township, Dodowa forest, Adumanya

2.6. Sampling and blood collection from dogs and cats

Dogs and cats were sampled from households and veterinary institutions after their owners gave informed consent. Also, less than 1 ml of blood was collected from either the cephalic vein or medial saphenous veins following standard protocols. Biological samples were transported to the laboratory under a cold chain.

2.7. DNA isolation and Polymerase Chain Reaction

Frozen blood was thawed to room temperature, and then DNA was extracted using DNAzol® following the manufacturer's protocol (ThermoFisher Scientific). *T. canis* and *T. cati*-specific primers were used to amplify many copies of the DNA fragments. Previously described primer sets, *Tcan1* (5′- AGTATGATG GGCGCGCCAAT-3′) and *NC2* (5′- TAGTTTCTTTTCCTCCGCT-3′), as well as *Tcat1* (5′- GGAGAAGTAAACTC-3′) and *NC2* (5′- TAGTTTCTTTTCCTCCGCT-3′) for *T. canis* and *T. cati*, respectively were used [17]. However, after several optimization attempts, no gel bands were visible for the primer *Tcat1*.

Polymerase chain reaction amplification reactions consisted of 7.5 μl sterile nuclease-free PCR water, 12.5 μl OneTaq® Quick-Load® 2× Master Mix with Standard Buffer (New England Biolabs Inc.), 1 μl primers (forward and reverse) and 4.0 μl DNA template making a final volume of 25.0 μl. The reaction was carried out using Bio-Rad iCycler Thermal Cycler (Bio-Rad) at initial denaturation of 95 °C for 2 min, final denaturation of 94 °C for the 40 s, the annealing temperature of 57 °C for 1 min followed by initial extension at 72 °C for 3 min. This was followed by a final extension at 72 °C for 7 min and a holding temperature of 4 °C. Lastly, 6.0 μl PCR products were run on 1.2% agarose gels stained with 4.0 μl *Ethidium bromide* at 80 V for 90 min. The amplicons were then visualized under Ultra Violet (UV) Trans-illuminator for further analysis.

2.8. Questionnaire administration

Semi-structured questionnaires were administered to pet owners to identify risk factors and also assess their management practices. The questionnaire was in two parts: the first part was designed to solicit information on the demographics and pets' contact with rodents if any. The other part was on the owners' management of their pets and household practices associated with zoonoses transmission.

2.9. Data analysis

Data entry and statical analysis were done with IBM Statistical Package for Social Sciences (SPSS version 20). Descriptive data analyses were used to describe the distribution of animals, the prevalence of infections, and the demographic characteristics of respondents using frequencies, percentages and graphs. Non-parametric Chi-square statistic and Kruskal–Wallis H tests and the parametric Student's t-test were used to assess the statistical significance or otherwise of differences between two or more independent samples.

The prevalence of infection was calculated based on results from the gel electrophoreses using the formula

$$\text{Prevalence} = \frac{\text{Number of positive samples}}{\text{Number of samples}} \times 100$$

The level of statistical significance was set at $p < 0.05$ (95% confidence level).

3. Results

3.1. Sociodemographic characteristics of survey respondents

Two hundred and thirty respondents filled out and returned the questionnaires, giving a response rate of 88.5% (230/260). More than 58% of the survey respondents were males, 36.8% were 18–30 years old, and 66.7% had tertiary education (Table 2). Nearly all the survey respondents (99.1%) had some form of formal education.

Furthermore, over 54% of the respondents had a household size of 4–6 persons while the largest household size of more than ten (10) persons was recorded by 5.5% of the respondents.

3.2. Risk of zoonoses associated with pet management

3.2.1. Distribution of pets by respondents

Dogs were the most common pet. From the survey, 54.4% of respondents had dogs whereas the remaining kept cats or owned both animals (Fig. 1).

3.3. Risks identified from survey responses

Owners of pets may become exposed to toxocariasis when proper care management systems are not in place. From the data, nearly 40% of owners do not deworm their pets, although 44% allow their dogs to search for food outside the house (Table 3).

The responses also revealed that 4.8% of the respondents share a bed with their pets, while 11.4% did so occasionally (Table 3). In examining the relationship between some of the variables, statistically significant associations between respondents' level of education and deworming of pets ($p < 0.001$) as well as sharing of bed with pets ($p = 0.001$)(Appendix III) were observed.

Furthermore, over 70% of respondents with children allowed them to play with these pets, yet only 66.0% supervised them to wash their hands before eating or drinking. Using crosstabs, a statistically significant association was also found between respondents' educational level and the supervision of children to practise hand hygiene ($p < 0.001$)(Appendix III).

3.4. Risk of zoonoses associated with rodents

From the survey, 52.4% of pet owners reported a recent history of contact with rodents (Table 4). Forty-three percent (43%) had also seen their pets ingest rodents before, with 17.8% and 44.4% describing this phenomenon as very often and not often, respectively (Table 4).

3.5. Infection status of sampled animals

3.5.1. Prevalence of T. canis in non-human mammals

Of the 404 animals sampled, 67.8% (95% CI, 63.0%–72.4%) tested negative for *T. canis*. However, 32.2% (95% CI, 27.6%–37.0%) were positive.

Out of the total animals positive for *T. canis*, most of the cases were from dogs followed by rodents (Fig. 2). A chi-square analysis also

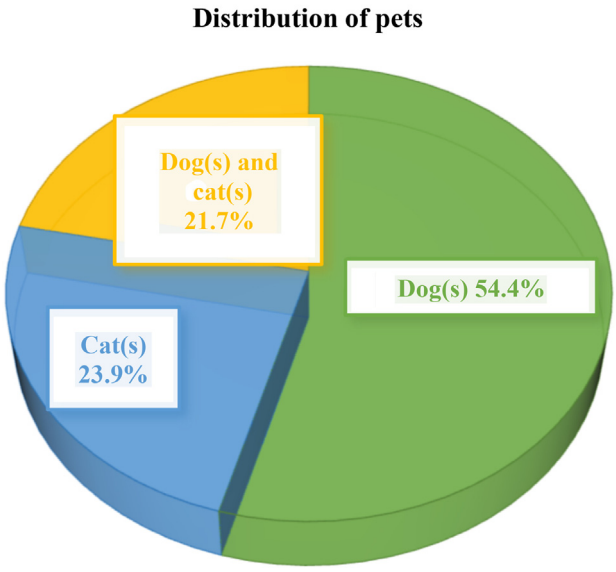

Fig. 1. Distribution of pets owned by respondents.

Table 2
Descriptive characteristics of respondents from the survey.

Variable	Frequency	Percentage	95%
Gender			
Male	133	58.8	1.35–1.48
Female	93	41.2	
Age of respondent			
<18	7	3.2	
18–30	81	36.8	
31–40	62	28.2	2.83–3.138
41–50	41	18.6	
51–60	28	12.7	
61+	1	.5	
Educational level			
Non-formal Education	2	.9	
Basic/Primary school	7	3.15	
Junior high school	19	8.56	4.367–4.60
Secondary/high school	46	20.72	
Tertiary	148	66.67	
Size of household			
<4	47	21.36	
4–6	119	54.1	1.99–2.19
7–9	42	19.09	
>10	12	5.45	

Table 3
Associated risk factors of toxocariasis.

Risk factor	Frequency	Percentage	95%
Do you deworm your pets?			
Yes	138	61.1	
No	88	38.9	
Frequency of deworming pets			
Once every month	33	25.2	
Once every three months	54	41.2	2.11–2.70
Three times a year	20	15.3	
Other[a]	24	18.3	
Does the pet look for food outside the house?			
Yes	55	44.0	1.62–1.87
No	70	56.0	
Do you share the same bed with your dog/cat?			
Yes	11	4.8	1.97–2.20
No	192	83.8	
Sometimes	26	11.4	
Does your dog/cat share the same plate/bowl with the household?			
Yes	2	.9	1.90–2.02
No	225	99.1	
Do you supervise children to wash their hands before feeding/drinking after playing with their pets?			
Yes	107	66.0	1.11–1.43
No	47	29.0	
Sometimes	8	4.9	

[a] Other: this signifies respondents who dewormed pets (dogs and cats) at irregular intervals beside the categories stated above. This was due to the different growth stages of their pets as well as some respondents not adhering to routine deworming schedules.

revealed significant differences in the prevalence of *T. canis* among the animals studied (Table 5).

Similarly, a Kruskal–Wallis H test showed that there was a statistically significant difference in the prevalence of *T. canis* between the sampled animals ($\chi^2 = 9.456$, $p = 0.009$)(Appendix II).

3.6. Infection prevalence in rodent species

Seven rodent species making up 204 individual rodents, were trapped. These rodents were from the genera: *Praomys tullbergi* (n = 38, 18.6%), *Arvicanthis niloticus* (n = 113, 55.4%), *Rattus rattus* (n = 19, 9.3%), *Cricetomys gambianus* (n = 5, 2.5%), *Rattus norvegicus* (n = 18, 8.8%), *Mus musculus* (n = 10, 4.9%), *Crocidura olivieri* (n = 1, 0.5%).

From the data shown in Table 6, more *Praomys tulbergi* (55.3%) were positive for *T. canis.*

3.7. Gel electrophoresis of polymerase chain reaction products

The molecular weight marker denoted by M (Lane M), was used to detect the approximate size of the molecules run on the gel (See Fig. 3).

4. Discussion

Everyone is at risk of contracting toxocariasis even though children are at a higher risk than adults. Animal and environmental exposure has been identified as significant risk factors for *Toxocara* transmission [18]. Studies indicate that owners of pets become exposed to zoonoses when proper care management systems are not in place. Consequently, households and persons in the immediate environment of these pets may be at risk of such diseases. From the survey, a good number of people did not supervise their children to adhere to hand hygiene, which has been identified as a high risk for acquiring zoonotic infections from pets. This suggests that in households where there are pets, children practising good hand hygiene is essential to avoid incidentally ingesting the parasite ova or oocyst while playing.

Other risk factors like not deworming pets, sharing a bed with pets and pets preying on paratenic hosts were also identified. Adhering to a deworming protocol is necessary to make an infected pet *Toxocara*-free, therefore not deworming them or doing so infrequently exposes owners to *Toxocara* and other helminthic zoonotic pathogens. Again, recent studies suggest that one could get infected with embryonated *Toxocara* eggs on the hair coat of dogs [4], therefore sharing the same bed with these pets increases one's exposure to this parasite.

Table 4
Summary information on pets' contact with rodents.

Variable	Frequency	Percentage	95%
Do you see rodents in your immediate environment?			
Yes	123	53.5	1.26–1.46
No	107	46.5	
Is there a history of contact of your pet with rodents recently?			
Yes	119	52.4	1.14–1.40
No	89	39.2	
I do not know	19	8.4	
Have you ever seen your dog or cat eating any rodents before?			
Yes	98	43.0	.98–1.11
No	120	52.6	
I do not know	10		
If yes, how often does this happen?			
Very often	16	17.8	2.06–2.36
Not often	40	44.4	
Rarely	34	37.8	

Table 5
Prevalence of *T. canis* among sampled animals, n (%).

Animals	Total number sampled	Prevalence of *T. canis*		Chi–Square test
		Positive	Negative	
Dogs	185 (45.8%)	73 (56.2%)	112 (40.9%)	$\chi^2 = 9.480$,
Cats	15 (3.7%)	2 (1.5%)	13 (4.7%)	$p = 0.009$
Rodents	204 (50.5%)	55 (42.3%)	149 (54.4%)	
Total	**404**	**130**	**274**	

Table 6
Number and prevalence of *T. canis* among trapped rodents.

Species of rodent	*Prevalence of T. canis*		Prevalence (%)	Chi–square test
	Negative	Positive		
Praomys tulbergi	17	21	55.3	
Arvicanthis niloticus	91	22	19.5	$\chi^2 = 26.514$, $p < 0.001$
Rattus rattus	14	5	26.3	
Cricetomys gambianus	5	0	0.0	
Rattus norvegicus	14	4	22.2	
Mus musculus	8	2	20.0	
Crocidura olivieri	0	1	100.0	
Total	149	55	27.0	

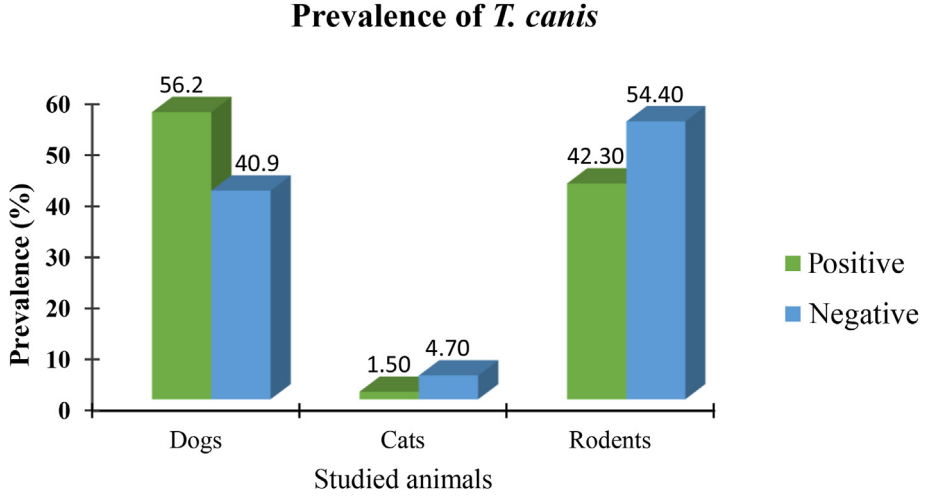

Fig. 2. Prevalence of *T. canis* in studied animals.

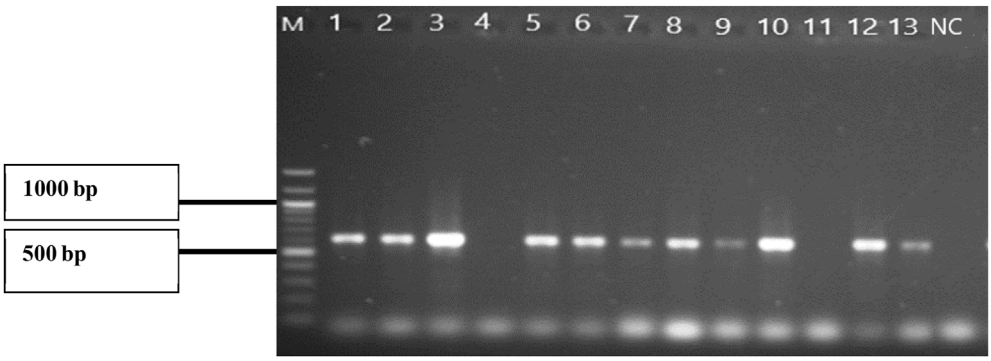

Fig. 3. Agarose gel (1.2%) of amplified PCR products for the identification of *T. canis*. (Lane M = 100 bp ladder, Lane NC = negative control, Lanes 1–3, 5–10, 12–13 tested positive, Lanes 4 and 11 tested negative, Lanes 1 to 13 contain DNA from the blood of sampled animals after preparation with DNAzol and PCR).

Varying prevalences of toxocariasis have been recorded across the globe. In particular, several studies have documented different prevalences of *Toxocara* in pets which has been attributed to factors such as methodologies employed and environmental conditions. In the review by Rostami et al. [19,20] a global pooled prevalence of 11.1% (95% CI, 10.6%–11.7%) and 17.0% (95% CI, 16.1%–17.8%) *Toxocara* was observed in dogs and cats respectively. In this study, the overall prevalence was 32.2% (95% CI, 30.5%–34.2%) with a high proportion of positive cases found in dogs. In related studies in the Netherlands and Thailand, Nijsse et al. [8] and Phoosangwalthong et al. [21] documented a prevalence of 4.5% and 5.4% of dogs infected with *T. canis* respectively, while a relatively higher prevalence of 29.4% was reported in Australia [22].

In sub-Saharan Africa, a prevalence of 9.8% was recorded by Ayinmode et al. [23] in Ibadan, Nigeria whereas, in Hossana, Ethiopia, 34% of dogs sampled by Mulugeta et al. [24] were infected. Previous studies conducted in some regions of Ghana also showed various prevalences. Johnson et al. [12] reported a prevalence of 5.8% *Toxocara* infection in dogs found in the Greater Accra region of Ghana using microscopy. Comparatively, Amissah-Reynolds et al. [13] recorded a higher prevalence of more than 18% in Mampong in the Ashanti Region. However, a seroprevalence study by Boyko et al. [25] found anti-*Toxocara* antibodies in 62% of dogs in Kintampo, Bono East region. The variation in prevalence could be due to the different methodologies employed in these studies, pet management practices as well as the ownership statuses (owned or stray) of the dogs. Nonetheless, it seems there is an increase in *Toxocara* infections in dogs in our Ghanaian neighbourhoods since most of these dogs feed and sleep on the ground resulting in persistent infection and re-infection as this parasite is a soil-transmitted helminth.

Data from this study also suggest there may be ongoing *T. canis* cross-infection in the communities as 1.5% of domestic cats tested positive for *T. canis*, a situation which merits further research. A few studies have found *T. canis* in the faeces of cats although they are not natural hosts to this particular ascarid parasite [6]. Cross-infection was identified to be the possible reason for this observation. According to Lello et al. [26], cross-infection between species could impact significantly factors like the transmission dynamics of the parasite, disease severity and parasite control and therefore such outcomes deserve further investigation.

Findings from this study also revealed domestic cats and dogs had variable contact with rodents in the communities. Some studies indicate that the consumption of mammalian paratenic hosts by domestic dogs and cats supports the enzootic cycle of this parasite. The larvae of *Toxocara* sp., although cannot mature into the adult worm in paratenic hosts, the larvae can migrate into tissues and remain there still infectious for up to a decade [27]. This suggests that the presence of these non-human mammals in our communities increases our exposure to *Toxocara* and other zoonotic pathogens.

5. Conclusion

In this study, the use of a PCR-based molecular technique aided in the accurate identification of this parasite in pets and rodents. Although the highest prevalence of *T. canis* was found in dogs, some cats were found positive for this canid ascarid suggesting the possibility of cross-infection between these animals. From the data, several exposures of humans to *T. canis* were observed which included direct contact, the sharing of bed, and lack of hand hygiene after playing with pets. Findings from the study demonstrate the important role of human and non-human mammals in the transmission of this parasite in our neighbourhoods. Considering the growing human attachment and interactions with pets, the high prevalence of *T. canis* coupled with risk factors found in the survey suggests a looming threat. Unfortunately, Toxocariasis has not received much attention in Ghana, so the high prevalence of infection documented in this present study merits swift attention to avert any potential zoonotic outbreak of this helminthic parasite.

This study has some limitations.

Although findings from this study substantiated the fact that persons living in selected neighbourhoods in the Greater Accra region are highly exposed to toxocariasis, due to financial and logistical constraints, the infection status of dog and cat owners could not be determined. As such transmission could not be established. We, therefore, recommend further studies targeting pet owners to establish transmission which gives a holistic picture.

Data availability

The results presented are sufficient to support the conclusion of this study. Nonetheless, the lead author is available to provide additional data upon request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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APPENDICES.

APPENDIX I: The MMDAs of the Greater Accra Region and their capitals

MMDAs			
No.	MMDAs	Capital	Website
1	Accra Metropolitan	Accra	ama.gov.gh
2	Tema Metropolitan	Tema	tma.gov.gh
3	Ablekuma Central Municipal	Latebiokorshie	http://abcma.gov.gh
4	Ablekuma North Municipal	Ablekuma North	http://abnma.gov.gh
5	Ablekuma West Municipal	Dansoman	http://abwma.gov.gh
6	Adenta Municipal	Adenta	adma.gov.gh/
7	Ashaiman Municipal	Ashaiman	https://ashma.gov.gh
8	Ayawaso Central Municipal	Kokomlemle	https://acma.gov.gh
9	Ayawaso East Municipal	Nima	http://aema.gov.gh
10	Ayawaso North Municipal	Accra NewTown	https://ayawasonma.gov.gh
11	Ayawaso West Municipal	Dzorwulu	https://aywma.gov.gh
12	Ga South Municipal	Ngleshie Amanfrom	https://gsma.gov.gh
13	Ga Central Municipal	Sowutuom	https://gcmagh.com
14	Ga East Municipal	Abokobi	http://gema.gov.gh
15	Ga North Municipal	Ofankor	http://gnma.gov.gh/
16	Ga West Municipal	Amasaman	
17	Korle Klottey Municipal	Osu	https://kokma.gov.gh
18	Kpone Katamanso Municipal	Kpone	https://kkma.gov.gh
19	Krowor Municipal	Nungua	https://kroma.gov.gh
20	La Dade-Kotopon Municipal	La	https://ladma.gov.gh
21	La-Nkwantanang Municipal	Madina	https://lanmma.gov.gh
22	Ledzokuku Municipal	Teshie	lekma.gov.gh
23	Okaikwei North Municipal	Abeka	https://www.onmaonline.com
24	Tema West Municipal	Tema Community 2	http://twma.gov.gh
25	Weija-Gbawe Municipal	Weija	https://wgma.gov.gh
26	Ada East District	Ada Foah	http://aeda.gov.gh

Appendix II: Chi-square analysis of T. canis among sampled animals

Ranks			
	Type of animal	N	Mean Rank
T. canis	Dog	185	217.21
	Cat	15	164.43
	Rodent	204	191.96
	Total	404	
Test Statistics			
			T. canis
Chi–square			9.456
df			2
Asymp. Sig.			.009

Appendix III: Associations between variables

Educational level * Do you deworm your pet(s)?

Educational level		Do you deworm your pet(s)?		Total
		Yes	No	
No formal education	Count	0	2	2
	% within educational level	0.0%	100.0%	100.0%
Basic/primary school	Count	1	6	7
	% within educational level	14.3%	85.7%	100.0%
Junior high school	Count	5	14	19
	% within educational level	26.3%	73.7%	100.0%
Secondary/high school	Count	23	23	46
	% within educational level	50.0%	50.0%	100.0%
Tertiary	Count	105	39	144
	% within educational level	72.9%	27.1%	100.0%
Total	Count	134	84	218
	% within educational level	61.5%	38.5%	100.0%

(*continued on next column*)

(*continued*)

Chi-square tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson chi–square	30.206[a]	4	.000
Likelihood ratio	31.013	4	.000
Linear-by-linear association	29.698	1	.000
N of valid cases	218		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is 0.77.

Educational level * Do you share the same bed with your dog/cat?

Educational level		Do you share the same bed with your dog/cat?			Total
		Yes	No	Sometimes	
No formal education	Count	0	0	2	2
	% within educational level	0.0%	0.0%	100.0%	100.0%
Basic/primary school	Count	0	7	0	7
	% within educational level	0.0%	100.0%	0.0%	100.0%
Junior high school	Count	3	15	1	19
	% within educational level	15.8%	78.9%	5.3%	100.0%
Secondary/high school	Count	4	36	5	45
	% within educational level	8.9%	80.0%	11.1%	100.0%
Tertiary	Count	4	128	16	148
	% within educational level	2.7%	86.5%	10.8%	100.0%
Total	Count	11	186	24	221
	% within educational level	5.0%	84.2%	10.9%	100.0%

Chi–square tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson chi–square	25.918[a]	8	0.001
Likelihood ratio	18.011	8	0.021
Linear-by-linear association	0.102	1	0.750
N of valid cases	221		

a. 9 cells (60.0%) have expected count less than 5. The minimum expected count is .10.

Educational level * Do you allow children in the house to play with the dog/cat?

Educational level		Do you allow children in the house to play with the dog/cat?		Total
		Yes	No	
No formal education	Count	2	0	2
	% within educational level	100.0%	0.0%	100.0%
Basic/primary school	Count	6	1	7
	% within educational level	85.7%	14.3%	100.0%
Junior high school	Count	13	2	15
	% within Educational level	86.7%	13.3%	100.0%
Secondary/high school	Count	31	10	41
	% within educational level	75.6%	24.4%	100.0%
Tertiary	Count	92	49	141
	% within educational level	65.2%	34.8%	100.0%
Total	Count	144	62	206
	% within educational level	69.9%	30.1%	100.0%

Chi–square tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson chi–square	5.783[a]	4	0.216
Likelihood ratio	6.795	4	0.147
Linear-by-linear association	5.502	1	0.019
N of valid cases	206		

a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is .60.

Educational level * After the children play with the pets, do you supervise them to wash their hands before eating/drinking?

Educational level		After the children play with the pets, do you supervise them to wash their hands before eating/drinking?			Total
		Yes	No	Sometimes	
No formal education	Count	0	2	0	2
	% within educational level	0.0%	100.0%	0.0%	100.0%
Basic/primary school	Count	2	4	0	6
	% within educational level	33.3%	66.7%	0.0%	100.0%
Junior high school	Count	4	3	4	11
	% within educational level	36.4%	27.3%	36.4%	100.0%
Secondary/high school	Count	29	2	2	33
	% within educational level	87.9%	6.1%	6.1%	100.0%
Tertiary	Count	70	32	2	104
	% within educational level	67.3%	30.8%	1.9%	100.0%
Total	Count	105	43	8	156
	% within educational level	67.3%	27.6%	5.1%	100.0%

Chi–square tests

	Value	df	Asymp. Sig. (2-sided)
Pearson chi–square	42.551[a]	8	0.000
Likelihood ratio	33.284	8	0.000
Linear-by-linear association	7.335	1	0.007
N of valid cases	156		

a. 9 cells (60.0%) have expected count less than 5. The minimum expected count is .10.

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