

Canine helminthiases and associated risk factors in Kigali city, Rwanda

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Abstract

Background: Canine helminthiases pose a public health risk to humans and livestock; however, the prevalence of canine helminthiases in Rwanda is unknown. This study aimed to determine the prevalence of canine helminthiases and to identify the risk factors of such infections in Kigali, the capital city of Rwanda. A cross-sectional study involved 93 dogs selected across Kigali city. Faecal samples were collected from apparently healthy dogs and helminth eggs were identified and quantified under microscope using McMaster technique. Risk factors for canine helminthiases were analysed by multivariable binary logistic regression analysis.

Results: The overall prevalence of intestinal helminthiases in dogs was 39.8% \pm 5.08 ($\alpha=0.05$). The most prevalent species was *Ancylostoma spp* with 32.3% \pm 4.85 (30/93). About 38.7% and 3.4% (n= 31) of dogs suffering from ancylostomosis and/or toxocarosis had high egg counts per gram (EPG) of faeces (≥ 550) each. Approximately 97.3% (36/37) of dogs infected with helminths had mono-infection. Logistic regression analysis showed that dog's age (1 to 2.5 years old and at least 5 years old) and location (Gasabo and Kicukiro) were significantly associated with the prevalence of canine helminthiases. The adjusted odds ratio (AOR) of dogs suffering from helminthiases was more than 61% lower in dogs dewormed once to twice a year compared to those who were never dewormed. In addition, the AOR was more than 5 times higher for dogs fed on raw animal origin supplements, leftovers from family food and restaurants compared to those who ate food prepared for them. The AOR was also more than 8 times higher for dogs that ate leftovers from household food and scavenged compared to those who ate food prepared for them.

Conclusions: All the identified helminths including *Ancylostoma spp*, *Toxocara canis*, and tapeworms are zoonotic and they pose a public health risk to humans. There is an urgent need of increasing the awareness among pet owners on the role of dogs in the transmission of zoonotic helminthiases to other animals and also to humans. Moreover, it is highly relevant to inform and to take effective control measures in dog populations.

Background

Dogs play a considerable role in helping the man to improve the quality of life [1]. It has been demonstrated that pet dog owners are healthier than non-owners [2,3]. Pet dogs can help people under stressful conditions in enjoying their recreation and curing some pathological conditions such as high blood pressure [4]. In addition, people can own dogs for various reasons such as business, hunting, herding livestock, and guarding. Dogs also offer a variety of services such as helping the disabled live independently, search and rescue missions as well sniffing drugs and explosive [5]. Although the dog has become an indispensable companion of the man, it also constitutes a potential source of a variety of human infections [1].

Dogs can harbour parasitic infections that can be transmitted to livestock and humans including helminths and protozoa [6,7]. Ascarids and Ancylostomatids have been repeatedly reported to be the main helminths of dogs and cats with a global significance [8]. Dogs contract ancylostomosis through skin penetration or oral ingestion of larvae. Oral transmission occurs through ingesting milk or paratenic hosts or suckling [9]. Canine toxocarosis can be transmitted horizontally or vertically, that is through ingesting earthworms, milk and soil contaminated with viable embryonated eggs or direct maternal foetal transmission during gestation [10].

Human zoonotic helminthiasis is transmitted directly or indirectly via an infected dog or ingestion of contaminated items [11]. Studies conducted around the world reported canine helminthiasis prevalence that varies between 5.9 % and 75.26% [12,13].

A wide range of factors can influence prevalence of helminthiasis in dogs. These factors can be intrinsic such as age, sex and breed or extrinsic like feeding, environment, accuracy of testing, regular deworming and geographical location [14,15,16,13,17]. The control of helminthiasis in dogs consists of proper hygiene, regular preventive deworming and treatment of clinically ill individuals [12,18]. However, misuse of anthelmintic drugs may lead to anthelmintic resistance in the treatment of worms infections in both animals and humans [12]. Anthelmintic resistance is primarily prevented through laboratory testing based treatment and respect of drug dosage [8].

Despite that canine helminthiasis are a public and a one health concern; there are no reports on canine helminthiasis in Rwanda. The aim of this study was to determine the prevalence of intestinal helminths in dogs and associated risk factors in Kigali, Rwanda.

Results

Characteristics of study dogs

Faecal samples were taken from 93 apparently healthy dogs from different locations and of different ages, sex and breeds. Among sampled dogs, some were regularly or irregularly dewormed. Some dogs were scavengers or fed on food prepared for them or leftovers from household food or restaurants. Also, some dogs were restricted while others were not-restricted. The occurrence of intestinal helminths in study dogs is indicated (Table 1).

The prevalence of helminthiasis in dogs was $39.8\% \pm 5.08$ (37/93). The predominant species was *Ancylostoma* spp with $32.3\% \pm 4.85$. Of all infected dogs (n=37), 97.3% were parasitised with one category of helminths whilst 2.7% were infected with two categories of helminths (Table 1). Parasitic load in dogs suffering from ancylostomosis and toxocarosis in Kigali city, Rwanda is shown (Fig. 1).

Figure 1. Parasitic egg load in dogs suffering from ancylostomosis and toxocarosis in Kigali city

Chi-square tests of the associations of the occurrence of canine helminthiases with the selected potential risk factors in Kigali city and corresponding p-values are presented in Table 2. All considered risk factors, namely, deworming frequency, feeding practices, control of dog movements; breed, age, sex and location (district) were not statistically significant for canine helminthiases in dogs at 5% level of significance.

A decision on which variable to include in a multivariate analysis can depend on different criteria, or cut-off (determinants screening significance) than the significance level [19,20,21]. In addition, some variables can adjust the effects of other variables in the model, even if they do not have any low p-value themselves [22]. In the present study, all the potential risk factors were considered for multivariable analysis presented in Table 3 to detect the direction and extent to which variable categories explain the difference in prevalence of canine helminthiases. This enabled our study to consider all the risk factors before assessing net association.

The results in table 3 show that dog's age and location (district) were significantly associated with the prevalence of canine helminthiases in Kigali City. The adjusted AOR of having helminthic infection was more than 14 and 9 times higher for dogs that were aged 1-2.5 years and at least 5 years, respectively, compared to those who were younger than one year old. Further, the AORs of infection were more than 17 and 8 times higher in dogs sampled in Gasabo and Kicukiro districts, respectively, compared to those sampled in Nyarugenge district. Deworming frequency, control of dog movements, feeding practices, breed, and dog's sex did not directly correlate with canine helminthiases. However, the results indicate important differences between categories of the sample characteristics.

For example, the AOR of dogs suffering from helminthiases was more than 61% lower in dogs dewormed once to twice a year compared to those never dewormed. In addition, the AOR was more than 5 times higher for dogs fed on raw animal origin supplements, leftovers from family food and restaurants compared to those who were fed on food prepared for them. Further, the AOR was more than 8 times higher for dogs that ate leftovers from household food and scavenged compared to those who ate food prepared for them.

Discussion

In this study, the prevalence of canine helminthiases in Kigali city was 39.8% \pm 5.08. The dog's age (1 to 2.5 years old and at least 5 years old) and location (Gasabo and Kicukiro) were statistically significant risk factors associated with the canine helminthiasis. Our findings can help policy makers to strategize effective control measures in dog populations and to inform dog owners of the role of dogs in transmitting zoonotic helminthiases to other animals and to humans.

The study overall prevalence of 39.8 \pm 5.08 was lower but comparable to 51.7% reported by Idika et al. [23] in Nigeria. However, it was much lower than 75.26% and 91.4% reported by Abere et al. [13] in Ethiopia and Davoust et al. [24] in Gabon, respectively. Management practices and climatic conditions might have influenced difference in prevalence in these various studies. Around 46.2% of dogs involved in this study were regularly or irregularly dewormed, while 83.9% ate food provided by the owners. However, majority of

the dogs investigated by Davoust et al. in Gabon did not receive veterinary care including deworming. Aberé et al. [13] conducted their study in Bahir Dar town, and the latter borders lake Tana and Blue Nile. The influence of these waterbodies on the weather of the region would influence the biology of helminths.

Again, Rwanda is located in the equatorial belt, but it has a modified humid climate including rainy forest and savannah types [25]. However, Gabon has a typical equatorial climate [24]. The climate can influence the biology of helminths and parasites at large. For instance, temperature (warm or cold), precipitation, and relative humidity can favour or impair the hatchery of helminth eggs or the development of larvae into mature worms. Again, the biology of intermediate hosts can be affected by extreme temperatures. For example, extreme temperatures can shrink habitats for snails (intermediate hosts for trematodes). Such temperatures can also influence breeding season for mosquitoes (vectors for filarial nematodes) [26,27].

This study prevalence of *Ancylostoma* spp (32.3 ±4.85) was comparable to 34.8% found by Davoust et al. [24] in Gabon. However, it was higher than 24.6% reported by Ayinmode et al. [28] in Nigeria, and lower than 93.8% reported by Schandevyl et al. [29] in Zaïre (currently the Democratic Republic of Congo). Difference in prevalence may be related to management practices and accuracy in coprological testing. For instance, the majority of dogs involved in the study by Schandevyl et al. [29] in the Democratic Republic of Congo were not properly looked after and they all were in poor condition. Furthermore, Schandevyl et al. [29] performed both McMaster technique and larval culturing to detect *Ancylostoma* spp.

Different species of *Ancylostoma* can infect dogs including *A. caninum*, *A. braziliense*, *A. ceylanicum* and *Uncinaria stenocephala* [30]. Of these, *A. braziliense*, *A. caninum* and *U. stenocephala* can cause cutaneous larva migrans (sand-worm disease) in humans, while *A. ceylanicum* is able to cause eosinophilic enteritis. Similarly, *A. caninum* has been reported to cause eosinophilic enteritis, but it rarely matures into adult in human small intestine [31,32]. Studies conducted in Rwanda reported human ancylostomosis prevalence that varies between 6.33% and 33% [33,34].

In this study, 38.7% (12/31) of dogs that were infected with *Ancylostoma* or *Toxocara* had a high level of infection (EPG ≥ 550) and developed mono-infection caused by *Ancylostoma* spp. These dogs could shed a high number of the eggs in the environment and potentially put people at risk of contracting hookworm disease. Given the challenges to distinguish species of *Ancylostoma* based on egg morphometry and that a host can be parasitised by several species concurrently [30], the investigation of human ancylostomosis in Rwanda should take into consideration the zoonotic aspect, thus, the collection of information about pet ownership by human patients could guide the diagnosis.

The prevalence of cestodes (6.5±2.55) was lower than 8.6 % reported by Davoust et al. [24] in Gabon. It was however higher than 2.7% reported by Schandevyl et al. [29] in the Democratic Republic of Congo. Dogs can harbour zoonotic cestodes, among others, *Echinococcus* spp and *Dipylidium caninum* [31].

The prevalence of *Toxocara canis* in the present study was 1%; lower than 9.8% reported by Ayinmode et al. [28] in Nigeria. *Toxocara canis* antibodies have been detected in people across Africa. For instance, two previous studies conducted in preschool children aged between 9 months to 5 years old in Nigeria and in children aged 1-15 years old in Ghana detected *Toxocara canis* antibodies in 37.3% and 53.5% of the study children, respectively [35,36]. Further, one study conducted in various groups of professionals in Egypt detected anti-*T. canis* antibodies in 24% of the professionals [37]. Although there are no published data on the situation of human toxocariasis in Rwanda, the EPG of faeces of the dog suffering from *Toxocarosis* and *Ancylostomosis* in this study, had an EPG of 750 for *Toxocara canis*. The high level of infection in tested dog (EPG \geq 550) suggests that the dog could shed a high number of eggs in the environment and potentially put people at risk of developing toxocariasis.

Similar to a previous study by Idika et al. [23] in Nigeria, this study found that dog's age correlates positively with the prevalence of helminthiases (all odds ratios increase for age groups above 1 year. The present study also found a direct correlation between dog's location and the prevalence of canine helminthiases. Difference in management practices across study sites might have influenced the prevalence of canine helminthiases. For example, 50.5% of the sampled dogs were in Nyarugenge district and part of the three sectors selected across Nyarugenge was suburban. The sampled dogs from Gasabo and Kicukiro districts accounted for 20.5% and 29% respectively and part of study area across the districts was urban. In addition, majority of dogs fed on food cooked for them and of scavenging dogs was in urban and suburban study sites, respectively.

have impacted the prevalence of canine helminthiases. Thus, the data in this study is a snapshot prevalence which may not necessarily represent the true burden of canine helminthiases. A kinetic study could shed some light on the prevalence and the dynamics of the helminthiases in dogs. Due to limited resources, researchers could not fully investigate the main canine helminths. Further studies using molecular laboratory technique would be most welcome.

The results of the binary logistic regression analysis showed unusually wide 95% confidence intervals of the odds ratios, especially for the dog's age, and location. This can largely be attributed to excessively small sample sizes for some age groups and districts as well as inconsistency in location data [38]. For example, the sample of infected dogs that were aged < 1 year and ≥ 5 years were only 2 and 9 dogs, respectively. Consistency in location data also appears to be a cause of wide confidence intervals for district covariate. The district of Gasabo had smaller samples for both infected and non-infected dogs.

Conclusion

The findings of this study indicate that the prevalence of intestinal helminths in domestic dogs in Kigali city, Rwanda is relatively high (39.8% \pm 5.08). All the identified helminths including *Ancylostoma spp.*, *Toxocara canis*, and tapeworms are zoonotic and they pose a public health risk to humans. There is an urgent need of increasing the awareness among pet owners on the role of dogs in the transmission of

zoonotic helminthiases to other animals and also to humans. Moreover, it is highly relevant to inform and to take effective control measures in dog populations.

Methods

Study sites

This study was carried out in Kigali city, the capital city of Rwanda from September 2016 to March 2017. Kigali city is administratively subdivided into three Districts and each district is in turn subdivided into administrative sectors [39]. The present study covered nine sectors that selected from the three districts of Kigali city, each district was represented by three sectors. Figure 2 shows the map of Kigali City with district and sector level boundaries.

Study design and sample size

This cross-sectional study involved collecting data on management practices and faecal samples from dogs. Sample size was determined based on dogs population of 18,117 reported in 2016 [40]. The number of dogs in Kigali represented 2,157, thus 11.9% of the national dog population [41]. The population of dogs in the 9 selected sectors was 782. Due to lack of previous studies on canine helminthiases in Rwanda, the prevalence of helminthiases in dogs was assumed to be 50%.

Based on previous population-based health studies such as Rwanda demographic and health survey where the response rate has generally remained above 95% [42], we expected a relatively high response rate. Considering the scarcity of studies involving dog's health in Rwanda, and also considering that this study was conducted in the capital where most of people are relatively busy and away from homes during daytime, we increased the sample size by 10% to cater for possible non-response [43,44]. The minimal sample size (n) of dogs needed for testing hypothesis on risk factors of helminthiases in the present study was thus estimated using Cochran's formula for determining sample size for proportions [45], as follows:

$$\frac{\frac{Z^2 p(1-p)}{e^2}}{1 + \frac{Z^2 \cdot p(1-p)}{e^2 N}} = \frac{\frac{1.96^2 \times 0.50^2}{0.10^2}}{1 + \frac{1.96^2 \cdot 0.50^2}{0.10^2 \times 2157}} = \frac{96.04}{1 + \frac{96.04}{2157}} = 91.94 \cong 92 \text{ dogs}$$

Where N is the population size and e is the level of precision. Adjusting for 10% non-response rate (9 additional dogs), the present study targeted an effective sample of 101 dogs. This study sample was selected through a two-stage sampling procedure. In the first stage, we randomly selected three administrative sectors from each of the three districts of Kigali City. Thus, nine sectors were randomly selected across Kigali City, namely, Gatenga, Niboye and Kicukiro in Kicukiro district; Kacyiru, Kimironko and Gisozi in Gasabo district; and Mageragere, Nyamirambo and Kigali in Nyarugenge district.

Based on district-level registers for dog population, which showed households where dogs were kept, a listing of all dogs for each of the selected sectors was done and it served as a sampling frame for this study. In the second stage, systematic random sampling was applied to choose households owning dogs from constructed lists that were available at sector-level.

Considering the sampling frame size, sampling interval i was determined to be $2157/101=21$. We randomly selected the first household that owned a dog and then we considered households at a regular interval of size 21 on the list until the target sample size was achieved. Given some households owned many dogs; only one dog per household was randomly selected for data collection.

Data collection

Data were successfully collected from 93 dogs and a questionnaire was used to collect data on dogs (age, sex, breeds and location), and on dog keeping practices (frequency of deworming, feeding practices and control of dog movements) (see additional file 1). Faecal samples were collected directly from the rectum using a gloved finger and kept in faecal jars. All samples were stored in a cool box and were analysed at the laboratories of the Rwanda Agriculture and Animal Resources Development Board (RAB).

Faecal analysis

The analysis was done on the day sampling using the McMaster technique as previously described by Hansen and Perry [46]. The preparation of float fluid involved dissolving sodium chloride (Park Scientific Limited, UK) in tap water [47]. Cestodes, either worms or segments were detected in fresh faecal samples with the naked eye at time of the collection and they were identified based on a protocol by Baron; Ballweber [48,9]. Various nematode eggs were identified by examining the sample under the light microscope at 10x magnification based on shape, thickness of shell and presence of morulae [49].

Data processing and analysis

Data were entered and then analysed in the IBM SPSS Statistics for windows, version 20. EPG of faeces were obtained by multiplying the number of eggs by a factor of 50 as previously described by Hansen and Perry [46]. The infection was quantified by EPG which was grouped into low infection (50-100 EPG), moderate infection (150-500 EPG) and high infection (≥ 550 EPG) (50). The analysis of faecal samples resulted into a binary response variable that indicated whether a sampled dog was infected or not infected. These data were used to determine the infection prevalence. To investigate associations between selected factors and prevalence of canine helminthiases, data were analysed using a multivariable binary logistic regression model as described by Peng and So [51]. The 95% confidence intervals for the AORs were used to assess the significance and direction of the associations.

Abbreviations

AOR: Adjusted Odds Ratio

EPG: Egg counts Per Gram

RAB: Rwanda Agriculture and Animal Resources Development Board

SPSS: Statistical Package for Social Sciences

BHEARD: Borlaug Higher Education for Agricultural Research and Development

RNEC: Rwanda National Ethics Committee

Declarations

Ethics approval and consent to participate

The study was approved by Rwanda National Ethics Committee (Ethical approval 115/RNEC/2017). Dog owners were explained about this study and signed written consents before participating in the study.

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study are included in this article.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

PN and PNN conceptualised the work. PN, PNN, FN designed the work. PN collected data and analysed faecal samples. PN and FN analysed and interpreted the data. PN drafted original manuscript. HG, PNN and FN revised the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1. Prevalence of various helminths in analysed faecal samples

Categories of helminths	Number of infected dogs	Percentage	Standard error
<i>Ancylostoma spp</i>	30	32.3	±4.85
Tapeworms	6	6.5	±2.55
<i>Toxocara canis</i> + <i>Ancylostoma spp</i>	1	1.0	±1.07
Total	37	39.8	±5.08

Table 2. Chi-square tests of the associations of the occurrence of canine helminthiases with the selected potential risk factors in Kigali city and corresponding p-values are presented

Sample characteristics	Canine helminths			P-Value
	Present (%)	Absent (%)	Total (%)	
Deworming frequency				0.588
Never	23(24.7)	27(29.0)	50 (53.8)	
Once to twice a year	4 (4.3)	10(10.8)	14 (15.1)	
At least three times per year	3 (3.2)	5(5.4)	8 (8.6)	
Irregularly	7(7.5)	14(15.1)	21 (22.6)	
Total	37 (39.8)	56(60.2)	93(100)	
Feeding practices				0.153
Food prepared for dogs	9 (9.7)	21 (22.6)	30 (32.3)	
Raw animal origin supplements, leftovers from household family food and restaurants	19 (20.4)	29 (31.2)	48 (51.6)	
Scavenging and leftovers from household food	9 (9.7)	6 (6.5)	15 (16.1)	
Total	37 (39.8)	56 (60.2)	93 (100)	
Control of movements				0.407
Non-restricted	15 (16.1)	18 (19.4)	33 (35.5)	
Restricted	22 (23.7)	38 (40.9)	60 (64.5)	
Total	37 (39.8)	56 (60.2)	93 (100)	
Breed				0.949
Local	11 (11.8)	17 (18.3)	28 (30.1)	
Pure or cross	26 (28)	39 (41.9)	65 (69.9)	
Total	37 (39.8)	56 (60.2)	93 (100)	
Age				0.140

<1 year	2 (2.2)	12(12.9)	14(15.1)	
1-2.5 years	14 (15.1)	13(14)	27(29)	
2.5-5 years	12(12.9)	17(18.3)	29(31.2)	
Overs 5 years	9(9.7)	14(15.1)	23(24.7)	
Total	37(39.8)	56(60.2)	93(100)	
Sex				0.791
Female	28(30.1)	15(16.1)	24(25.8)	
Male	9(9.7)	41(44.1)	69(74.2)	
Total	37(39.8)	56(60.2)	93 (100)	
Study district				0.054
Nyarugenge	13(14)	34(36.6)	47(50.5)	
Gasabo	10(10.8)	9(9.7)	19(20.5)	
Kicukiro	14(15.1)	13(14)	14(29)	
Total	37(39.8)	56(60.2)	93(100)	

Table 3. Factors influencing helminthic infections among dogs in Kigali city

Variable	Categories	Adjusted Odds Ratio (AOR)	95% C.I. for AOR	
			Lower	Upper
Dog's deworming frequency	Never	1	Reference	
	Once to twice a year	0.383	0.058	2.511
	At least three times per year	1.504	0.122	18.483
	Irregularly	0.893	0.179	4.449
Dog's feeding practices	Food prepared for dogs	1	Reference	
	Raw animal origin supplements, leftovers from household food and restaurants	4.552	0.747	27.743
	Scavenging and leftovers from household food	8.891	0.802	98.614
Control of dog's movements	Non-restricted	1	Reference	
	Restricted	0.573	0.125	2.632
Dog's breed	Local	1	Reference	
	Pure or cross	1.372	0.389	4.843
Dog's age	<1 year old	1	Reference	
	1-2.5 years old	14.099	1.938	102.594
	2.5-5 years old	6.860	0.980	48.002
	At least 5 years old	9.166	1.194	70.383
Dog's sex	Female	1	Reference	
	Male	1.230	0.370	4.091
Location	Nyarugenge	1	Reference	
	Gasabo	17.084	3.061	95.356
	Kicukiro	8.756	1.744	43.952
	Constant	0.010		

Figures

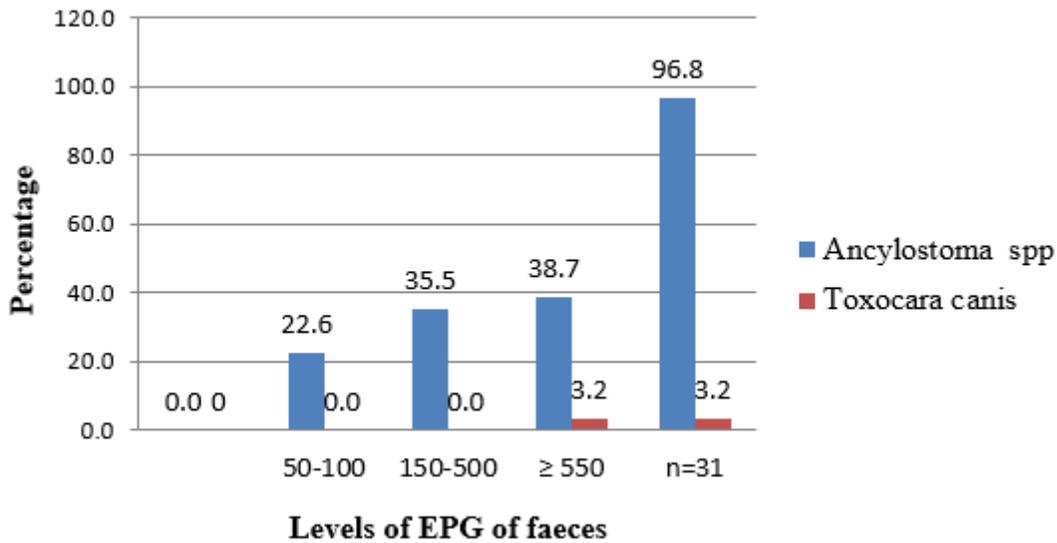


Figure 1

Parasitic egg load in dogs suffering from ancylostomosis and toxocarosis in Kigali city. Around 38.7% and 3.2% of the dogs infected with *Ancylostoma* spp and *Toxocara canis* had high egg load (≥ 500 EPG), respectively. In addition, 35.5% and 22.6% of those infected with *Ancylostoma* spp had moderate egg load (150-500 EPG) and low egg load (50-100 EPG), respectively. Data on egg counts per gram of faeces were not available for dogs infected with cestodes. In these dogs, the worms or their segments were detected macroscopically.

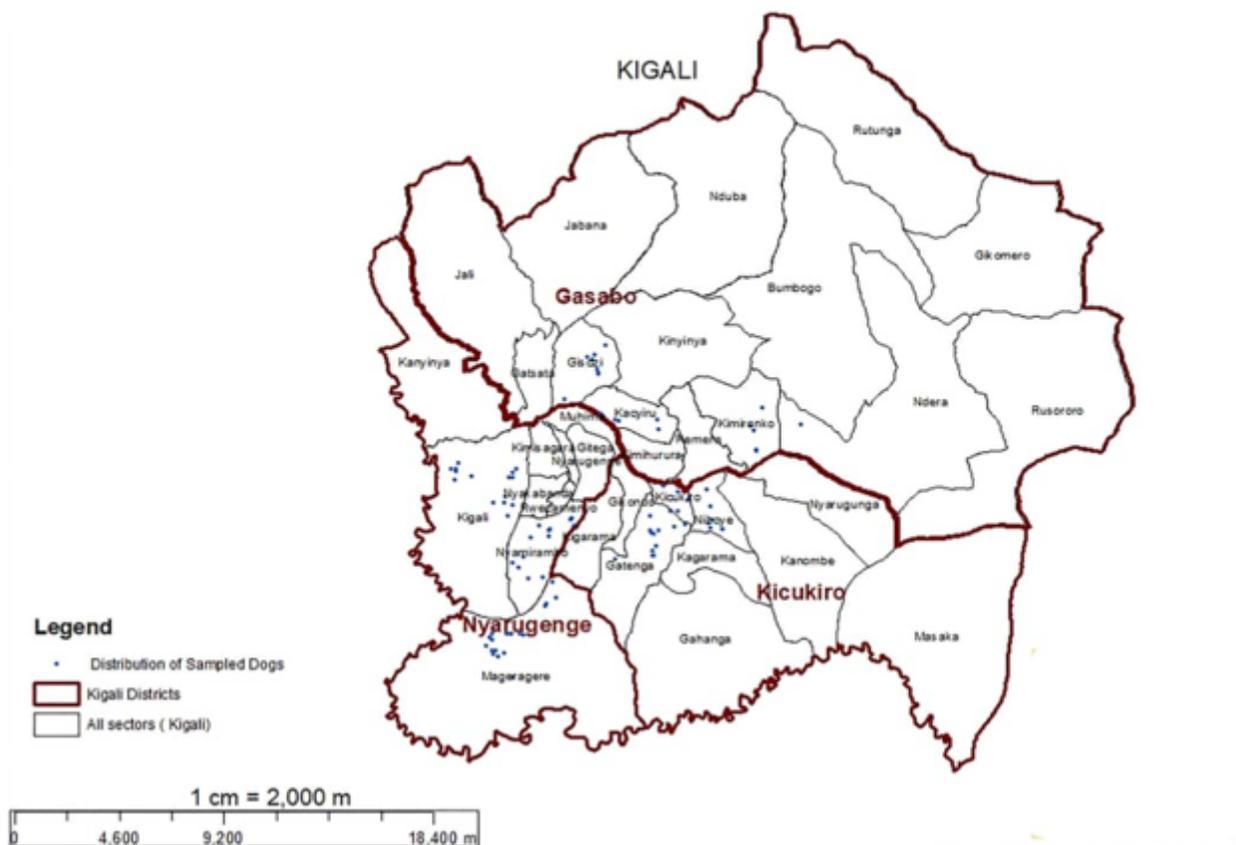


Figure 2

Map of the study area with the nine selected study sectors. shows administrative districts (red boundaries) and sectors (gray boundaries) of Kigali City. The blue dots show location of households owning sampled dogs across the study sites. The locations are Kigali, Nyamirambo and Mageragere sectors of Nyarugenge district; Kicukiro, Niboye and Gatenga sectors of Kicukiro district as well as Gisozi, Kimironko and Kacyiru sectors of Gasabo district. Data on the location of each study dog was collected using GPS and allowed generating the map using ArcGis10.2 software.

Supplementary Files

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