Canine helminthiases and associated risk factors in Kigali city, Rwanda

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Research article

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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 associated risk factors in Kigali city. 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%, 95% CI: 29.84- 49.73. The most prevalent species was *Ancylostoma spp* with 32.3%, 95% CI: 22.76-41.76. About 38.7% and 3.4% (n= 31) of dogs having ancylostomosis and toxocarosis had high egg counts per gram of faeces (≥ 550) each. Logistic regression analysis showed that dog's age, dog feeding practices and location were significantly associated with the prevalence of canine helminthiases. Compared to dogs aged < 1 year, the adjusted odds ratio (AOR) of developing helminthiases was more than 10 times higher for dogs aged between 1- 2.5 years (AOR=10.310; 95% CI: 1.557- 68.288), more than 5 times greater for dogs aged between 2.5-5 years, and more than 7 times greater for dogs that were at least 5 years old (AOR=7.543; 95% CI: 1.1360.101). Furthermore, the AOR was more than 5 times higher (AOR=5.41; 95% CI: 1.28- 22.87) for dogs fed on raw animal origin supplements, leftovers from family food and restaurants and more than 13 times higher (AOR=13.581; 95% CI: 2.194-84.050) for dogs that ate leftovers from household food and scavenged compared to those that ate food prepared for them, respectively.

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 transmitting zoonotic helminthiases to other animals and to humans. The control of zoonotic helminthiases in dog population should focus on taking appropriate measures to promote hygienic dog feeding practices at all ages.

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 helminthiases prevalence that varies between 5.9% and 75.26% [12][13].

A wide range of factors can influence prevalence of helminthiases 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 helminthiases 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 anthelminthic 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 helminthiases are a public and a one health concern; there are no reports on canine helminthiases 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).

Table 1. Prevalence of various helminths in analysed faecal samples

Categories of helminths	Number of infected dogs	Percent (%)	95% CI for percentage	
			Lower limit	Upper limit
Ancylostoma spp	30	32.3	22.757	41.759
Tapeworms	6	6.5	1.459	11.445
Toxocara canis + *Ancylostoma spp*	1	1.1	0.00	3.171
Total	37	39.8	29.837	49.733

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 factors for canine helminthiases in dogs at 5% level of significance.

Table 2. Distribution of canine helminthiases and chi-square tests of its association with the selected potential risk factors in Kigali city

	Canine helminths			P-Value
Sample characteristics	Present (%)	Absent (%)	Total (%)	
Deworming frequency				
Never	23(24.7)	27(29.0)	50 (53.8)	0.588
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				
Food prepared for dogs	9 (9.7)	21 (22.6)	30 (32.3)	0.153
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				
Non-restricted	15 (16.1)	18 (19.4)	33 (35.5)	0.407
Restricted	22 (23.7)	38 (40.9)	60 (64.5)	
Total	37 (39.8)	56 (60.2)	93 (100)	
Breed				
Local	11	17	28	0.949

	(11.8)	(18.3)	(30.1)	
Pure or cross	26 (28)	39 (41.9)	65 (69.9)	
Total	37 (39.8)	56 (60.2)	93 (100)	
Age				
<1 year	2 (2.2)	12 (12.9)	14(15.1)	0.140
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				
Female	28(30.1)	15(16.1)	24(25.8)	0.791
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)	

A decision on which variable to include in a multivariate analysis can depend on different criteria [19] [20] [21]. In the present study, all the potential risk factors for which chi-square tests p-values were below 0.25 were considered for the subsequent multivariable logistic regression analysis, namely feeding practices, dog's age, and location (district).

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 feeding practices	Food prepared for dogs	1	Reference	
	Raw animal origin supplements, leftovers from household food and restaurants	5.415	1.282	22.874
	Scavenging and leftovers from household food	13.581	2.194	84.050
Dog's age	<1 year old	1	Reference	
	1-2.5 years old	10.310	1.557	68.288
	2.5-5 years old	5.257	0.849	32.566
	At least 5 years old	7.543	1.136	50.101
Location	Nyarugenge	1	Reference	
	Gasabo	10.830	2.355	49.814
	Kicukiro	8.191	1.842	36.418
	Constant	0.010		

The results in table 3 show that dog's age, dog feeding practices, and dog location (district) were significantly associated with the prevalence of canine helminthiases in Kigali City. The adjusted odds ratio (AOR) of having helminthic infection was more than 10 and 7 times higher for dogs that were aged 1-2.5 years and at least 5 years, respectively, compared to those that were younger than one year old. The AORs of infection were about 11 and more than 8 times higher in dogs located in Gasabo and Kicukiro districts, respectively than dogs located in Nyarugenge district. Dog feeding practices were also statistically significant.

Specifically, the AOR was more than 5 times higher (AOR=5.415; 95% CI: 1.282-22.87) for dogs fed on raw animal origin supplements, leftovers from family food and restaurants compared to those that were fed on food prepared for them. Further, the AOR was more than 13 times higher for dogs that ate leftovers from household food and scavenged (AOR=13.581; 95% CI: 2.194-84.050) compared to those that ate food prepared for them.

Discussion

In this study, the prevalence of canine helminthiases in Kigali city was 39.8%. The dog's age (1 to 2. 5 years old and at least 5 years old), location and feeding practices were statistically significant risk factors associated with the canine helminthiasis. The prevalence of canine helminthiases in the present study was lower but comparable to 51.7% reported by Idika et al. [22] in Nigeria. However, it was considerably

lower than 75.26% and 91.4% reported in Ethiopia and Gabon [13] [23], respectively. Management practices and climatic conditions might have influenced difference in prevalence in these various studies. In this study, 83.9% of dogs ate food provided by the owners and the AOR of developing helminthiases was more than 13 times higher for dogs that ate leftovers from household food and scavenged compared to those of which ate food prepared for them. Similarly, Abere et al. [13] reported high prevalence of helminthiases (82.2%) in dogs that ate uncooked food. Besides, Abere 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.

This study prevalence of *Ancylostoma spp* (32.3%) was comparable to 34.8% reported in Gabon [23]. However, it was higher than 24.6% reported in Nigeria [24], and lower than 93.8% reported in Zaïre (currently the Democratic Republic of Congo) [25] 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. [25] in the Democratic Republic of Congo were not properly looked after and they all were in poor condition. Furthermore, Schandevyl et al. [25] 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* [26]. 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 [27][28].

Studies conducted in Rwanda reported human ancylostomosis prevalence that varies between 6.33% and 33% [29][30]. In this study, 38.7% (12/31) of dogs that were infected with *Ancylostoma* had a high level of infection (EPG $\geq$ 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 [26], 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) was lower than 8.6% reported by Davoust et al. [23] in Gabon.

It was however higher than 2.7% reported by Schandevyl et al. [25] in the Democratic Republic of Congo. Dogs can harbour zoonotic cestodes, among others, *Echinococcus spp* and *Dipylidium caninum* [27]. The prevalence of *Toxocara canis* in the present study was 1%; lower than 9.8% reported by Ayinmode et al. [24] 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 [31][32]. Further, one study conducted in various groups of

professionals in Egypt detected anti-*T. canis* antibodies in 24% of the professionals [33]. Although there are no published data about human toxocariasis in Rwanda, 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 ≥ 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. [22] 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. Comparable to a study by Abere et al. [13] in Ethiopia, we found that feeding practices positively correlate with the prevalence of canine helminthiases.

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 [34].

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

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 transmitting zoonotic helminthiases to other animals and to humans. The control of zoonotic helminthiases in dog population should focus on taking appropriate measures to promote hygienic dog feeding practices at all ages.

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 [35]. 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 [36]. The number of dogs in Kigali represented 2,157, thus 11.9% of the national dog population [37]. 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% [38], 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 [39][40]. 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 [41], 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, a "systematic sample" with a selection interval 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 [42]. The preparation of float fluid involved dissolving sodium chloride (Park Scientific Limited, UK) in tap water [43]. 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 [44][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 [45].

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 [42].

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) [46]. 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 [47]. 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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Figures

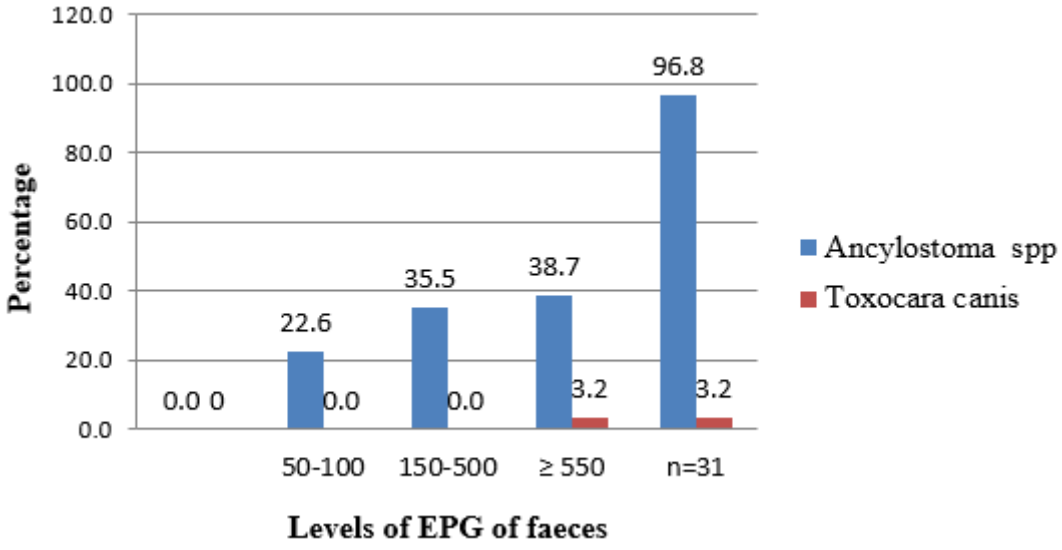
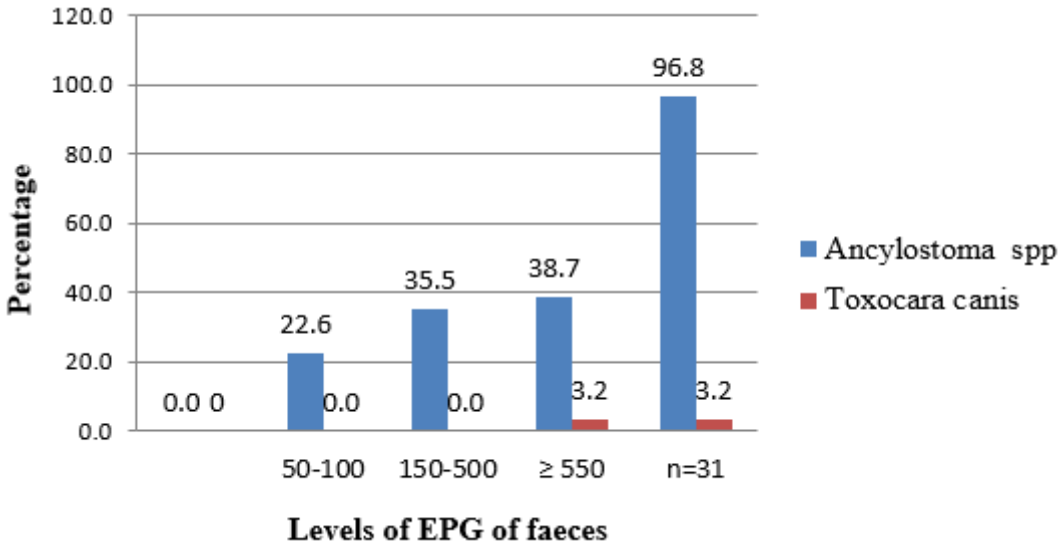


Figure 1

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.



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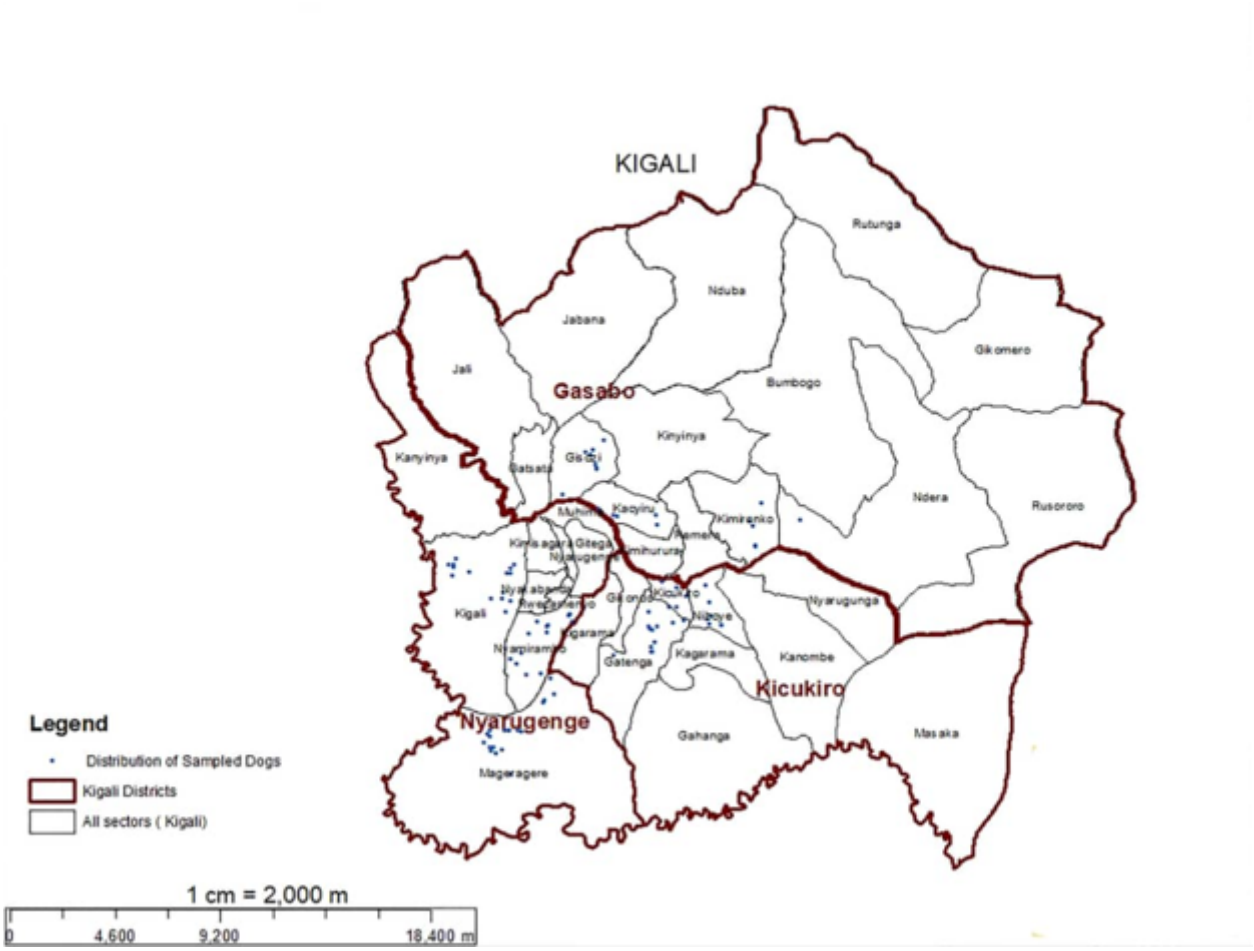
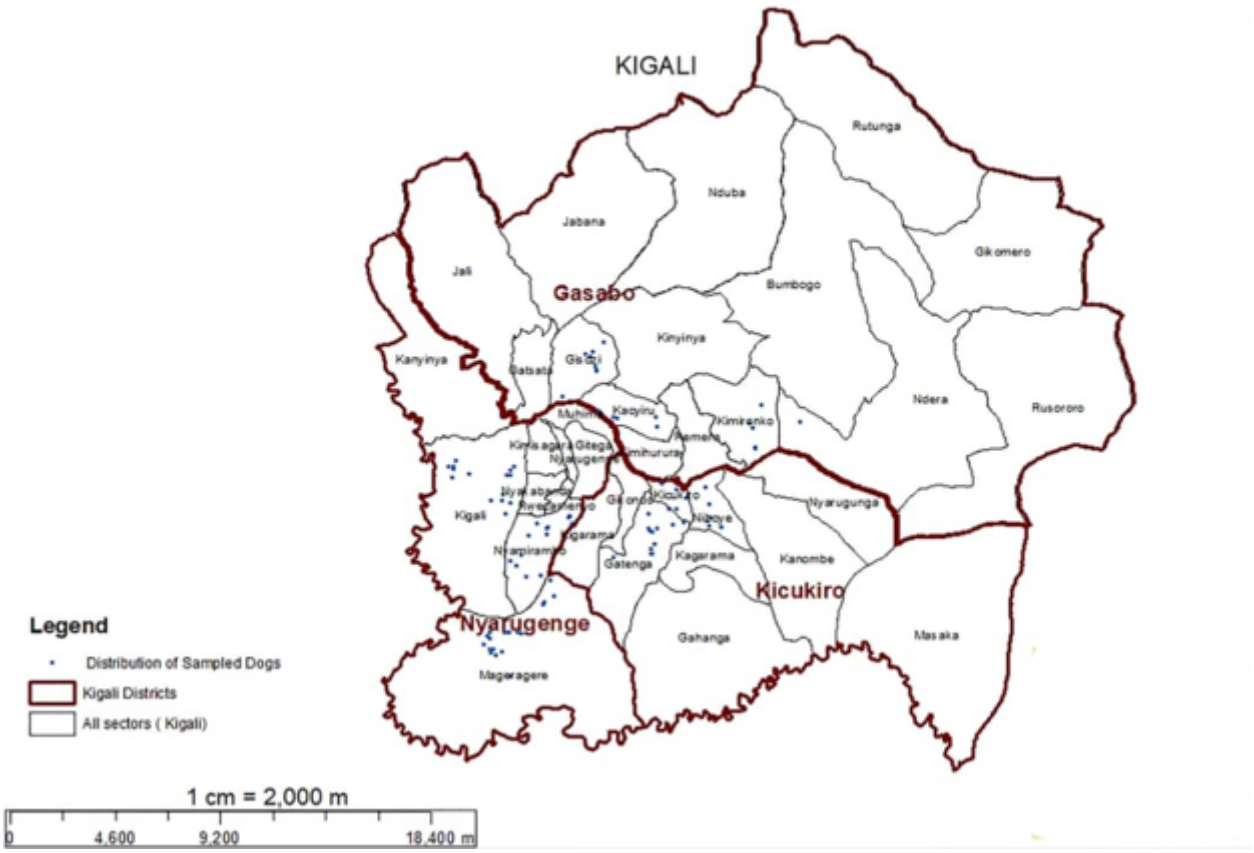


Figure 2

Map of the study area with the nine selected study sectors. Fig.2 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.



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