ESTIMATING THE POPULATION OF FREE-ROAMING AND OWNED DOGS AND THE GASTROINTESTINAL PARASITE BURDEN IN OWNED DOGS IN THE CAPITAL CITY OF QUITO, ECUADOR: A BASELINE STUDY FOR FUTURE ANIMAL HEALTH AND WELFARE INTERVENTIONS

By

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To Lucía, Patricia, my mom, my grandma and the citizens and dogs of Quito
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<tr>
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<td>TNR</td>
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<td>HQHVSN</td>
<td>High Quality High Volume Spay Neuter</td>
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<td>ABC</td>
<td>Animal Birth Control</td>
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<td>INEC</td>
<td>Instituto Nacional de Estadísticas y Censos (Ecuador)</td>
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<td>INAMHI</td>
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<td>MPH</td>
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<td>Km²</td>
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ESTIMATING THE POPULATION OF FREE-ROAMING AND OWNED DOGS AND THE GASTROINTESTINAL PARASITE BURDEN IN OWNED DOGS IN THE CAPITAL CITY OF QUITO, ECUADOR: A BASELINE STUDY FOR FUTURE ANIMAL HEALTH AND WELFARE INTERVENTIONS

By

Colón Jaime Grijalva Rosero

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Chair: Jorge Hernandez
Major: Veterinary Medical Sciences

Background: In 2011, authorities of Quito, Ecuador, approved an Ordinance to promote public health and animal welfare. Two limitations are that current population of dogs is not known, and the relationships between dog abundance, socio-economic factors, prevalence of dog with gastro-intestinal (GI) parasites and pet ownership responsibility has not been investigated in Quito.

Objectives: (i) To estimate the population of stray and owned dogs in Quito (ii) To examine relationships between studied household factors and pet ownership responsibility and (iii) To estimate the prevalence of and household factors associated with a positive diagnosis of GI parasites in owned dogs.

Methods: Stray and owned dogs from 65 parishes in Quito were considered for inclusion in this study. To accomplish the first objective, space-based, random sampling procedures recommended by the World Society for the Protection of Animals were used. A survey with instruments (indexes) to investigate Living Conditions (LCI) and Pet Ownership Responsibility (PORI) was prepared. Canine fecal samples were collected for diagnosis of GI parasites. Linear regression models were used to calculate dog abundance parameters (e.g., human-to-dog ratios).
Logistic regression was used for identification of investigated factors associated with PORI and a positive diagnosis of GI parasites.

Results: Data from 16 investigated parishes revealed an estimated human:free-roaming dog ratio=49:1; a human:owned dog ratio=3.5:1. A low human:free-roaming dog ratio was associated with high poverty rates (β=-0.77;r=0.77;R2=0.59;p<0.01), households with low PORI were associated with low LCI and ≥2 dogs in the households (p <0.01). The overall prevalence of households with dogs with GI parasites was 28% (95%CI =21, 37%). *Ancylostoma spp* was the most frequent parasite. We failed to identify risk factors associated with a positive diagnosis of GI parasites in dogs.
1.1 Quito, From Strychnine Baits to Trap Neuter Return

Canine overpopulation, responsible pet ownership and transmission of gastro-intestinal parasites from dogs to humans are concerns of interest among citizens and authorities in the Metropolitan District of Quito. On April 14th, 2011, authorities in the City of Quito approved an Ordinance to start regulating dog ownership and implement a Trap Neuter Return (TNR) program. This Ordinance includes two important elements: animal welfare (to prevent cruel treatment of animals) and public health (to reduce the risk of dog bites and to enhance awareness of zoonotic diseases that can be transmitted from companion animals to people) (Municipio del Distrito Metropolitano de Quito, 2011). Before this Ordinance, different approaches were used to manage dog populations and prevent zoonotic diseases.

National health authorities and citizens in Ecuador commonly used strychnine or other poisoned baits for dog population control (Zaldumbide, 2011). George Beran and Michael Frith (1988) reported the use of strychnine baiting in Guayaquil-Ecuador in the 1980s. In addition, Barnett & Rutt (1985) described the use of sodium monofluoroacetate (1080) for extermination of dogs in the Galapagos Islands. Although an Ordinance in Quito banned massive poisoning for dogs in 2004, in 2007, three children were accidentally poisoned and one passed away with baits that were spread on public spaces for dog population control purpose (El Hoy, 2007) (El Universo, 2007).

In August 2004, the City of Quito approved the Ordinance 128 as a response to a mortal dog attack in a rural parish of Quito (El Universo, 2004). This policy started the inclusion of some animal welfare and responsible pet ownership aspects in the Ecuadorian Legislation. For instance, the ordinance banned free roam of owned dogs, torture, massive poisoning and dog
fights in the city (Zaldumbide, 2011) (Grijalva-Rosero, 2009). For dog population control purpose, the ordinance tried to establish a shelter mechanism with a holding period of 10 days. Nevertheless, this Ordinance was barely implemented since animal welfare was not an important matter for authorities at that time. Nevertheless, in September 2008, Ecuador approved a New Constitution that granted rights for nature including animals as rights holders. (Grijalva-Rosero, 2009)

On April 10th, 2008, the Constituent Assembly included rights for the nature in the new Constitution project. A group of agencies led by the College of Veterinary Medicine of the University of San Francisco de Quito (USFQ) proposed the inclusion of the animal welfare five freedoms concept as a constitutional principle. Nevertheless, at the end of the constitutional discussion the Assembly only admitted to include this concept for husbandry animals since other animal rights were already granted within the “Rights of Nature”. Furthermore, the Ecuadorian Constitution includes the management of urban fauna as one of the duties for national and local governments. (Grijalva-Rosero, 2009) Since this major legislative change, other laws and ordinances were adjusted to the new constitutional order. (Paredes, 2014)

In 2009, the Responsible Dog Ownership National Rule was approved as a consequence of a fatal accident caused by a dog in 2008 (El Universo, 2008). This was the first regulation approved under the new constitutional order prohibiting cruel dog culling methods and establishing euthanasia as the only legal way to end a dog life in cases of lack of animal welfare, public health emergency or untreatable aggressive behavior and by owner’s decision with a consequent prohibition of dog tenancy within the 2 years after the procedure. In addition, this national rule established governmental support for high quality high volumes spay neuter clinics establishing coordination with the local governments for dog population control.
Furthermore, the Rule promoted practices of dog responsible ownership and animal welfare prohibiting cruelty against animal nationwide. However, the rule does not have a mechanism to punish the established infractions. (Derecho Ecuador, 2009)

In November 2009, the Health Commission of the City of Quito started a discussion to change the Ordinance 128 approved in 2004. This was the first time in this century that the discussion of a new legislative body related with responsible pet ownership in Ecuador was not the product of a political response against a fatal dog bite. Moreover, this regulation had a discussion period of 29 months until the final approval by the Metropolitan Council of Quito. The discussion processes tried to include all of the stakeholders related to urban fauna such as veterinary schools, veterinarians, pet breeders, public health officials, food dealers, pet shops, humane societies and other animal related organizations. In 2010, The National Assembly (The Ecuadorian Legislative Power) approved a law that established City Halls as the competent governmental level to elaborate and implement policies related with Urban Fauna (Ministerio de Coordinación de la Política y Gobiernos Autónomos Descentralizados, 2011). This legislation encouraged city authorities to elaborate an ordinance assuming these competencies Therefore, this ordinance (Ordenanza 48 que Regula la Tenencia, Protección y Control de la Fauna Urbana en el Distrito Metropolitano de Quito) was approved on April 14th, 2011 establishing new policies related with dog population control and animal welfare in the city (Municipio del Distrito Metropolitano de Quito, 2011).

The Ordinance number 48 is based on two important elements: animal welfare (to prevent cruel treatment of animals) and public health (to reduce the risk of dog bites and to enhance awareness of zoonotic diseases that can be transmitted from companion animals to people). This legal body established TNR and High Volume High Quality Spay Neuter
(HVHQSN) clinics as the only method approved for free-roaming animal control purpose. In addition, allows euthanasia specifically with overdoses of barbiturates only in cases of lack of animal welfare or unmanageable aggressiveness of dogs punishing massive poisoning with 10 minimum monthly wages (10x$340=$3400). Likewise, the regulation establishes mechanisms to prevent, prosecute and punish animal cruelty and tools to promote responsible pet ownership such as the inclusion of animal welfare in the municipal education system and communitarian education. The first stages of implementation of this regulation started right after its approval. However, a lack of research in Quito at that time caused that the implementation started without an appropriate baseline. (Municipio del Distrito Metropolitano de Quito, 2011).

Finally, in 2012, the Legislative Power started the discussion of a new Animal Protection Law. The project is based in a proposal presented by the legislator Saruka Rodríguez who put together some principles stated in Ordinance 48 with some other concerns from animal welfare organizations. This project passed the first of two debates and still under discussion in the National Assembly of Ecuador (Asamblea Nacional del Ecuador, 2012).

1.2 Estimating the Dog Population in Quito

Studies to estimate the canine population in Ecuador are limited. In the City of Guayaquil, in one study, a survey included 1,938 households within 394 blocks, and the human to dog ratio varied from 6:1 to 11:1 with a mean of 7:1. (Beran & Frith, 1988). Later, in 2005, Pan American Health Organization (PAHO) published a similar human: dog ratio for Ecuador in a report of the rabies situation for Latin America (Pan American Health Organization, 2005). In addition, a study developed in Isabela Galapagos, described a population of 131 owned dogs in Santo Tomás (Tomás de Berlanga) and 41 in Puerto Villamil (172 total) linking this animals with the free-roaming and feral dog population in Sierra Negra (Barnett & Rudd, 1983). In 2012, a poster presented in the “First International Conference on Dog Population Management”
described a population of 100 dogs for Tomás de Berlanga and 209 dogs for Puerto Villamil (309 total) (Herrera, et al., 2012). In September 2013, the Ecuadorian Ministry of Public Health published in its official web site a national dog population estimate of 1,765,744. However, more detailed information about this datum is not provided in this publication. (Ministerio de Salud Publica de Ecuador, 2013).

1.2. Free Roaming Dogs

The World Organization for Animal Health (OIE) recommends estimating the number, distribution and ecology of dogs as one of the steps to establish a dog population Control Program. The OIE Terrestrial Animal Health Code describes some methods to estimate the dog population number (World Organization for Animal Health, 2013). Some of them are simple as counting the dogs in small areas and other with more complexity such as Mark Recapture. In addition, the World Society for the Protection of Animals (WSPA) has developed a manual describing some methods to assess the free-roaming dog population (World Society For The Protection of Animals, 2008). Some variations of these methods have been utilized to estimate the free-roaming dog population in diverse parts of the world.

1.2.1 The WSPA guidelines

In 2008, Conservation Research Ltd. developed surveying dog population guidelines for the WSPA, based upon experiences during the surveys in Jaipur, Cairo, Dar es Salaam, Colombo, and Jodhpur. These guidelines are focused on estimating or monitoring the total number of free-roaming dogs at any one time. The WSPA presents two alternatives to assess the dog population of Free Roaming dogs: the use of an indicator or the use of an estimate. The indicator is a simple count that is based in the assumption that this number may increase or decrease when the true dog population changes. On the other hand, the estimate is based on a group of counts made in selected zones to assess the number of free-roaming dogs at a
determined time. To estimate a dog population of a defined area, the zone is divided in N study blocks that are spread in the whole study zone. Then, WSPA recommends to assign each block with one of four letters or colors never assigning the same color to adjacent blocks. Thereafter, one color is randomly selected to determine the blocks that will participate in the study. If the required sample size is less than the number of selected blocks, every selected block is given with a unique number. A second random selection could be developed depending on the number of blocks needed. Each block has the same probability to be selected (World Society For The Protection of Animals, 2008).

To determine the overall population of the whole zone (city, town, parish), the guidelines describe two methods. The first method is dividing the total number of the counted dogs by the sample fraction. For instance, if a zone is divided in 36 blocks, and 9 parishes participate in the study, the sampled fraction will be 9/36. Thus, if the total number of observed dogs were 200, the total number of dogs in the town could be estimated dividing 200 by 9/36. The second method is the use of a linear regression model using as independent variables parameters that are related to the number of dogs (human population, number of households in the area etc.). The WSPA suggested two methods estimate the proportion of dogs that were not roaming at the time of the count. The first method is the development of a survey identifying the number of owned dogs that were allowed to roam in the studied zone. Information about time of roaming should be included in this survey. The responses can be used to estimate how many dogs were not counted since they were at home or in public space. The second method is the sight-resight experiment which requires at least two observations. The method consist in record the characteristics of the observed dogs in a sample of the first observation using a photographic camera or other recording instrument. A second observation is developed in day two looking for animals that
were also observed during the first day. The proportion of dogs not observed in the second count provides an estimate of dogs not seen at any one observation. Two assumptions are required for this method. First similar effort was done during the first and the second observation. The second assumption is that the all of the dogs in the block are equally likely to be observed (World Society For The Protection of Animals, 2008).

Moazzem Hossain et al. (2013) estimated the dog population of the rural area of Raipura, Bangladesh using one of the methods described by the WSPA Guidelines. The study was developed in a location that is totally isolated from the mass land by a river. A team of volunteers equipped with either digital cameras or mobile phones with in-built camera developed one count in 6 of 24 unions of Narsingdi district. A survey within local citizens and volunteers was used to determine the ownership status of free-roaming dogs. Therefore estimated human population of the observed zone was used to calculate the human dog ratio. As a result, they reported an overall human: free-roaming dog ratio of 120:1. Besides, sixty percent of studied free-roaming dogs had an owner was (Hossain, et al., 2013).

1.2.1.2 The two sampled method

In the eighteenth century, Laplace used this marking and resighting method to estimate the human population in France. This method consists in two observations sessions, one session for catching and marking and a second session for recapturing. Besides, it is appropriate only for closed populations. This means that it is assumed that there are no gains or losses within the observed population during the study period (Greenwood & Robinson, 2006).

Starting in November 2011, Ricardo Dias et al. (2013) studied the size and spatial distribution of the free roaming dog population in São Paulo University Campus (Prev. Vet. Med., 2013, pp. 263-273). Five estimates were obtained with intervals of approximately 3 months within one-year period. A photographic camera and a GPS device were used to “capture”
and “recapture” the observed animals. First, dogs were captured on photographic files from 7 to 9 am and recaptured from 4 to 6 pm during one day of observation (Dias, et al., 2013). The GPS information was recorded on each count. Equation 1-1 proposed by Greenwood & Robinson (2006) in the Chapter 3 of the book “Ecological Census Techniques” was used to calculate the daily dog abundance estimate utilizing data produced in both observations. In Equation 1-1, n1 is the number of dogs observed in the first observation (captured animals), n2 is the number of observed dogs in the second observation, m2 is the number of dogs observed in the first and the second observation (recaptured animals) and N is the estimated number of animals in the observation day. Equation 1-2 was proposed by the same authors was used to calculate the 95% Confidence Intervals of the proportion of recaptured dogs within the total observed animals in the second observation (W1, W2). To obtain the lower and upper 95% CI of N, N1 was divided by the confidence intervals obtained for the proportions (Greenwood & Robinson, 2006) (Dias, et al., 2013).

\[ \hat{N} = \frac{(n1 + 1)(n2 + 1)}{(m2 + 1)} - 1 \]  

(1-1)

\[ W1, W2 = P \pm \frac{1}{2n2} + 1.95 \sqrt{\frac{P(1 - P) \left(1 - \frac{m2}{n1}\right)}{n2 - 1}} \]  

(1-2)

1.2.1.3 Additional studies

George Beran and Michael Frith (1988) collected free-Roaming dogs and cats demographic data driving and walking through 394 randomly selected squares in Guayaquil, Ecuador. Analyzing the ecology of dogs in this city, they describe two behaviors of free roaming dog owners in Guayaquil. First, dogs that belonged to middle class were confined when their
owners were away but were allowed to roam during the mornings, evenings and sometimes at night. Second, dogs that belonged to lower classes were guardian dogs during the night but became free-roaming scavengers during the day. Moreover, the authors reported that no free-roaming dogs were considered as non-owned dog by Guayaquil citizens (Beran & Frith, 1988).

Between 1997 and 2002, John Reece and Sunil Chawla (2006) developed a free-roaming dog survey to establish a baseline and evaluate the outcomes of an Animal Birth Control (ABC) program in Jaipur India. In this prospective evaluation, direct observational counts of 6 subdivisions of a representative part of the city (Pink City) were developed by the same team every six months at the time of the year when the weather was benevolent. These counts were performed between 6:30 am and 9:00 am. Factors such as the proportion of sterilized dogs and the sexually entire males to sexually entire females ratio were analyzed in this study. The authors described a reduction of free-roaming dog population and the increase of the sexually entire males: female ratio after the intervention (Reece & Chawla, 2006).

Between October 2003 and March 2004, Ibarra et al. (2006) developed a survey to estimate the dog population in 34 districts of Santiago, Chile. At least 25 blocks by district were randomly included in the sample. Two of the 4 streets that form the block were observed for two hours to collect information about dogs. Information about some socioeconomic characteristics of the block was also collected. As a result, they describe an average number of dogs by block from 4.82-7.59. According to their description, 52.4% of the free-roaming dogs observed had an owner, 21.9% were feral and 8.9% belonged to the community (Ibarra, et al., 2006).

In 2005, Alena Gsell et al. (2013) estimated the free roaming dog populations of four wards in Iringa, Tanzania using a capture recapture method. This study was developed during a massive vaccination campaign. First, each vaccinated dog was provided with a colored plastic
collar. Next, the research team drove thru 3 selected transect that covered 5% of the area of selected wards. Each transect was driven two times at day time and two times in the night at approximately 15 Km/h. The GPS reading and the presence of a collar were registered for all observed dog. Finally, they describe than less than 1% of dogs were catalogued as feral and 37% of the dogs were allowed to roam (Gsell, et al., 2012).

Finally, in 2013 the World Animal Awareness Society with the cooperation of the University of Michigan is developing a research project to estimate the free-roaming dog population in Detroit, Michigan. The researchers created a map dividing Detroit in 42 sections that were further divided in 50 random points. Volunteers observed for free-roaming for 5 minutes and registered their observations including Geographic Location, descriptive characteristics of the dog and a photographic archive (Anon., 2013). Preliminary results from 23 of 42 sections (1,150 of 2,100 possible points) surveyed between September and November 2013 estimated that “there are fewer than 3,000 loose dogs on the streets within the city of Detroit on any given day”. (World Animal Awareness Society, 2013).

1.2.2 Estimating the Owned Dog Population.

Some methodologies have been described to estimate the owned dog population. Martin Downes et al. (2013) made a classification of these methods depending on the type of survey that was used. The first method described is the mail out survey using a commercial list of contacts. This method is used by the American Veterinary Medical Association (AVMA) to estimate the dog population and other ownership parameters in the U.S. An advantage of this method is that reduce the bias related with households that do not have phone service but can introduce election bias since some households in the area could be excluded from the commercial list. In addition, measurement bias could be introduced since the participant will be aware “what the study is about” (Downes, et al., 2013). The second method described by
Downes et al. is the door to door survey and consist in a survey visiting each selected household to reduce no responses. This method was used by Ortega-Pacheco, et al. (2007) to determine the owned dog population in rural areas of Yucatán, Mexico. However, this technique is time consuming and selection bias could be introduced depending of the accessibility and source of observed households (Downes, et al., 2013). The third described method was the random-digit dialed telephone survey which consists in a randomized selection of phone numbers based upon certain digit of the digits of these numbers. This method was used by Ortega-Pacheco (2007) to assess the dog population of Merida, Yucatan. Downes, et al. (2013) suggest that this method is cost effective and help the inclusion of a large sample in a short period of time. Nevertheless, a large group of non-domestic numbers could be included incrementing the probability of non-response and the households that do not have telephonic service will be excluded from the survey. The final method described by (Downes, et al., 2013) is the Randomized telephone survey using a list of numbers. This method was used by Slater, et al. (2008) to estimate population parameters of owned dogs in central Italy. This method is also cost effective and reduces the non-response explained for the random-digit dialed telephone survey. Nonetheless, the method does not include the households without telephone service (Downes, et al., 2013).

1.2.2.1 The mail out survey

Since 1987, the AVMA develop a survey “to help policy-makers and other interested parties calculate and benchmark pet populations in their own areas” (American Veterinary Medical Association, 2007) (American Veterinary Medical Association, n.d.). During January 2007, the AVMA distributed a questionnaire by mail to 80,000 randomly selected households in the U.S. A total of 47,842 (59.8%) completed and returned the survey until the last week of February 2007. First, the member of the household that was responsible for the pets were asked to report their sex and age. Regarding to animals, the participant reported the number of animals
owned at any time in 2006, the amount of pets owned on December 31, 2006, and other characteristics of the animals such as age information, veterinary expenses and numbers of visit to a veterinarian within the previous year. The AVMA used data from households that owned animals on December 31, 2006, to calculate pet and pet owners’ population. The national population estimates were calculated using the total percentage estimate of the survey and percentage estimates were also calculated for the states. As a result, the mean number of dogs per household was 1.7 (72,114 dogs/1000 people). In addition, 62.2% of households owned just one dog (American Veterinary Medical Association, 2007).

1.2.2.2 The door to door survey

To obtain the owned dog population estimate in rural areas of Yucatán, Antonio Ortega et al. (2007) used a door to door survey. The survey included dog demographic information such as age, gender, number of dogs, number of dogs that died within the last year, free roaming status and other responsible pet ownership aspects. First, three representative communities with ≤ 2500 inhabitants (Molas, Dzununcan, San José Tzal) were selected for the study. Using a multistage sampling method, 5 household of each street from each community were visited. The total number of dogs was calculated multiplying the official total number of households by the average of dogs observed in the survey. Two hundred eighty seven householders completed the survey (95% of the expected sample). As a result, the rural human: dog ratio ranged from 1.7:1 to 4.6:1 with a dog population density from 75 to 390/km². Regarding to sex, males were the 58.3% of the populations and 0.5% of them were sterilized. On the other hand, females were the 41.7% and 1.3% of them were spayed. In fact, the overall proportion of sterilized animals in the rural survey was 1.8%. Moreover, 77% of the households in studied rural areas did not have an adequate fence to prevent free roaming on dogs (Ortega-Pacheco, et al., 2007).
1.2.2.3 Random-digit dialed telephone survey

To obtain the owned dog population estimate in Merida, Yucatán, Antonio Ortega et al. (2007) utilized a random-digit dialed telephone survey. The survey was similar to that used in rural areas. Three hundred and ten randomly selected households were interviewed by phone in Merida. The specific phone codes for the four zones in which Merida is divided were obtained from the telephone company and 100 households were interviewed for each zone. The total number of dogs was calculated multiplying the official total number of households by the average of observed dogs in the survey. The human dog ratio was 3.4:1 within the observed households in the city and the density of owned dogs was 1,163 dogs/Km$^2$. In this case, there was a minimal deterministic difference between the proportion of females (51.2%) and males (48.8%). Besides, 3.1% of the dogs were spayed or neutered (1.2% of males and 1.9% of females) and 7.2% of the dogs had free access to the street. (Ortega-Pacheco, et al., 2007)

1.2.2.4 Randomized telephone survey using a list of numbers

Between May and June of 2004, Margaret Slater et al. (2008) utilized a telephone survey using randomly selected data from the residential telephone network management firm to describe the population of owned dogs and cats in Central Italy. The survey included question related to the number and kind of pet owned by the householder. In Addition, the survey included questions related with individual animal characteristics and pet ownership parameters such as sex, age, training status and roaming status. As a result, thirty three percent of three hundred and ninety-seven participant households had at least one dog. Seventy three percent of the households with dogs kept only one dog and 27% owned at least two dogs. Besides, 109/176 of the dogs were males and 67/176 were females. Thus, 16% of the dogs were sterilized; 8% of males were neutered compared to 30% of females. Finally, 13% of respondents reported that their dogs were allowed to roam (Slater, et al., 2008).
1.2.2.5 Additional studies

George Beran and Michael Frith (1988) used a door to door survey to establish the owned dog population estimate of Guayaquil, Ecuador. A survey was developed in 1938 randomly selected homes within 394 randomly selected squares. As a result, the human: dog ratio varied from 5.8:1 to 11:1 with an average of 7.2:1. Besides, 61% of males and 39% of females were observed in the sample. In addition, close to 73% of the dogs were obtained as a gift and only 3.2% were adopted from the streets. Finally, 70.1 % of the dogs were classified as guard dogs and 63% of female dogs ≥ 1 year had never whelped (Beran & Frith, 1988).

In Antananarivo, Madagascar, Ratsitorahina, et al.(2009) developed a cross-sectional study to estimate population of dogs associated or not associated with households was developed using a multistage sampling method. Two questionnaires related to owned dogs were distributed door to door to householders from the selected arrondissements. The first questionnaire was related to demographic factors and the second with ownership factors. In addition, a survey for free roaming dogs was developed asking selected householders about factors related to free roaming dogs found during the owned dog survey. The investigated factors in owned dogs were age, sex, aggressivity, if dogs were kept on a leash, guard status, if dog scavenge in the garbage, history of dog-to-person aggression and vaccination status. For free-roaming dogs, the variables age, sex, aggressivity, body condition score, social behavior and if the dog were known in the neighborhood were investigated in this study. As a result, the authors reported a human:owned dog ratio of 4.9:1. In addition, juvenile dogs (< 6 months) was more likely to be owned compared to young (≥6 months and ≤ 1year) and mature (> 1 year) dogs. Moreover, males were more abundant within free-roaming dogs than females with a male:female ratio of 1.5 (Ratsitorahina, et al., 2009).
Finally, G. Acosta-Jamett et al. (2010) developed a door to door survey along two transects in the Coquimbo region of Chile in 2005-2007. The first transect ran for 80 Km to the south of Coquimbo city and included 2 small towns and 3 rural areas. The second transect ran 40 Km from Ovalle city to the east and included 1 small town and 1 rural zone. Both transects ended at the Fray Jorge National Park. The survey included parameters such as number of people per household, number of dogs per household, age and sex of each dog, number of sterilized animal, free roaming status and other responsible pet ownership parameters. Official household and population data was used to determine the population size and density. The overall dog population size for each site was calculated using the human: dog ratio obtained in the sample. A total of 1325 participated in the survey and 61% of them owned a dog. The higher proportion of dog owners was localized in small towns and rural areas. Besides, the observed human: dog ratio in rural areas was lower (1:1.7) than the observed in small towns (1:4.1) and cities (1:5.2). The highest dog population density was found in Coquimbo (2380 dog Km\(^2\)) followed by that described for a small town named Tongoy (544 dog/Km2). On the other hand, the smallest dog population density was recorded in the rural area named Punillas (1 dog/Km\(^2\)). In addition, there were a higher percentage of males in all of the observed sites. In urban areas, 56% of the dogs were males compared to 74% in towns and 83% in rural areas. The reported average proportion of sterilized animals was 3%. Moreover, 27% of the dogs were allowed to roam free in urban areas, compared to 50% in towns and 67% in rural areas (Acosta-Jamett, et al., 2010).

1.3 Pet Ownership Responsibility and Household Socio Economic Factors.

Factors Related with Pet Ownership Responsibility.- Pet Ownership Responsibility has been a subject of interest for veterinary health agencies, animal welfare agencies and health authorities around the world. The World Organization for Animal Health (OIE) (2013), defines as responsibilities for dog owners the mandatory attention of dog welfare including the respect
for behavioral and physical health needs, prevention of unwanted reproduction, permanent identification/registering where is mandatory and prevention of free-roaming (World Organization for Animal Health, 2013). In addition, the official web site of AVMA define five main parameters for responsible pet ownership: commit, invest, obey, Identify, limit and prepare, subdividing these parameters in recommended practices such as keeping the type and number of pets which care factors could be granted by the owner (American Veterinary Medical Association, n.d.). Besides, the Ordinance 48 of Quito allows the citizens to keep only the number of animals that can be kept within the five freedoms of animal welfare: freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury or disease, freedom to express normal behavior, freedom from fear and distress (Farm Animal Welfare Council, 2009). Likewise, this document prohibits practices such as free-roam of owned dogs and enforces dog owners to provide adequate medical and psychological care to victims of dog bites. Moreover, the ordinance punishes any practice against animal welfare that do not cause extreme suffering or death with a fine that range from 45 to 90% ($153 to $306) of the monthly minimum wage in Ecuador ($340) (El Diario, 2013) and practices that cause death, long term suffering or could cause a big damages to the society with a 10 minimum wages fine ($3400) (Municipio del Distrito Metropolitano de Quito, 2011).

Some health, housing and pet ownership factors have been analyzed in past studies. Margaret Slater et al. (2008) used logistic regression models to investigate variables such as free roaming status, sterilization status, source, indoor/outdoor status, confined to a yard, trained to sit stay or come, trained to walk on a leash, visit to a veterinarian and registration. Slater, et al. (2008) reported that dogs that were trained to a leash were 0.2 (0.05–0.6) times less likely to roam that the ones that were not trained. Besides, the dog size was associated with
indoor/outdoor status. In addition, there was an association between the variable purebred status with use, and training. In addition large dogs were more likely to be outside only and free roam. Likewise, mixed breed dogs were less likely to be purchased than purebred dogs. Nevertheless, purebred dogs were more likely to be working dogs living outdoors. Finally, dogs that were purchased were more likely to be trained than dogs from other sources (Slater, et al., 2008).

Other studies had described other individual factors such as Canine Distemper Virus (CDV), Canine Parvovirus (CPV) vaccination status and feeding regimen. Acosta-Jamett, et al. (2010) described that on average, observed householders reported a vaccination prevalence of 29% for CDV and 30 % for CPV. Towns reported the highest vaccination prevalence (CDV and CPV: 38%) followed by cities (CDV: 23% and CPV: 24%) and rural areas (CDV: 18% and CPV: 19%) (Acosta-Jamett, et al., 2010). Ortega-Pacheco, et al. (2007) reported that commercial dog food was the principal source in Merida, Yucatan (77.2%), followed by family leftovers (19.3%) and butchers' scraps (3.6%). On the other hand, the main source of food in rural areas was family leftovers and scraps followed by a mixture of leftovers with commercial dog food, tortillas or butcher's scraps (14.7%) (Ortega-Pacheco, et al., 2007). Finally, Ratsitorahina, et al. (2009) did a descriptive analysis of factors related to pet ownership including aggressivity (dogs that barks/growl with a history of biting), leash practices (roaming status), guard status, feeding regimen, visits to a veterinarian, and rabies vaccination status. As a result, 2,180 dogs were registered within participant households. Thus, 51.7% of them were considered aggressive, 79.1% were allowed to free roam, 81.1% were considered as guard dogs, 11.7% were fed with commercial dog food, 25.9% of dogs visited a veterinarian at least once a year, and 35.6 % of studied dogs were reported as being vaccinated against rabies (Ratsitorahina, et al., 2009).
Human Living Conditions and Responsible Pet Ownership.- Evaluate the association between socioeconomic factors and public health variables have been described on previous studies. Teresa Gonzalez et al. (2009) used a Living condition index to assess the association between socio-economic factors and nutritional status among Mexican children under 5 years old (Cossío, et al., 2009). A similar approach was used by Carlos Larrea and Wilma Freire (2002) to evaluate the effects of socioeconomic, regional, and ethnic conditions among malnutrition in children under 5 years old in the Andean Region of South America (Larrea & Freire, 2002).

Some researchers had studied the relationship between socioeconomic factors with pet ownership factors. Margaret Slater et al. (2008) analyzed the relationship between participant’s age, gender, education level, marital status and household size with pet ownership related variables. Within observed households, households with three or more people were associated with a bigger number of pets. In addition, Camila Martins et al. (2013) developed a study to analyze the relationship between the number of dogs and cats with the monthly income and number of people in households and age of the householders. As a result, they described that higher income categories were more likely to have at least one dog (Martins, et al., 2013). Ortega-Pacheco, et al. (2007) investigated owner socioeconomic factors including if the household was located in urban or rural area, number of inhabitants on each household, and individual socioeconomic status based upon the electricity consumption. As a result, Ortega-Pacheco, et al. (2007) described that households with medium socioeconomic status had a higher probability to own a dog than those categorized as low or high socioeconomic status. Furthermore, the probability to own a dog was 2.57 times higher in the city than in rural areas.
1.4 Prevalence of Dogs with Gastro Intestinal (GI) Parasites and its Association with Wellness Factors

1.4.1 Description of Common Gastro Intestinal Parasites in the Andean Region

1.4.1.1 Ancylostoma spp.

**Life Cycle.**-The life cycle is direct. Under favorable conditions of heat and moisture, the egg larvates to a L3 in five days. Infection most often occurs via skin penetration of the L3. Once the infective larvae penetrate the skin of young dogs they enter the circulation and migrate to the lungs. Subsequently, they molt to L4 and reach the bronchi and trachea. Next, the L4 is coughed up and swallowed, arriving in the intestine where it continues development into a sexually mature adult. In susceptible bitches and older dogs, the infective larvae migrate to the skeletal muscles and remains in a dormant, or hypobiotic state, until pregnancy when it is reactivated and can then be transmitted transplacentally or lactogenically to the litter. Literature describes that one infection of a bitch could produce transmamary infection in at least three consecutive litters. Arrested L3 has also been described in males and could mature and reinfect the host with the presence of stress factors, disease and large doses of Corticosteroids (Urquhart, et al., 1996). On average, eggs appear in the feces 4-5 weeks after percutaneous infection (Georgi & Georgi, 1992).

**Diagnosis.** - Fecal flotation is used to diagnose this parasite (University of Pennsylvania, 2004). However, presence of eggs in the patient is not indicative of clinical disease. Eggs of *A. caninum* are ellipsoidal, thin shelled, contain an eight cell morula and average in size between 28-58 µm by 52-59 µm. if samples are allowed to stand for several hours at room temperature the larvated egg or L1 stage larvae instead of eggs may be recovered via fecal flotation. For identification purposes, *Ancylostoma caninum* L1 larvae are longer than *Strongyloides*
stercolaris, another canine intestinal nematode, and presents a smaller genital rudiment. (Georgi & Georgi, 1992).

**Treatment.** - Pharmaceutical products composed by pyrantel pamoate, febantel, fenbendazole, milbemycin oxime and moxidectin (Bowman & Georgi, 2009).

**Public health aspects.** - Often, *Ancylostoma* spp is the most frequent parasite found in studies in the Andean Region (Gingrich, et al., 2010) (Ramírez-Barrios, et al., 2004) (Tortolero-Lou, et al., 2008). This could be understandable since the geographic distribution of this parasite is related to the temperature of the location and some species of *Ancylostoma* spp are frequently found in places with a temperature higher than 20°C (Overgaauw & Van Knapen, 2000). Besides, only two species of *Ancylostoma* are considered zoonotic: *A. ceylanicum* and *A. caninum*. The first is often successful instead of the second that has that behavior occasionally. On the other hand, *A. braziliense* is mainly responsible for the “creeping eruption” or cutaneous larva migrans which is the percutaneous infection of L3 in humans (Overgaauw & Van Knapen, 2000). Human infections with *Ancylostoma* spp. are more common in children and adults that spent time barefoot in areas with warm and moist weather. Besides, professionals with more risk are construction workers and gardeners since their job put them on direct contact with dirt which could be contaminated with L3. Clinical manifestations involve skin, blood and intestine. The infection by skin of the infectious third-stage larvae of *A. caninum* or *A. braziliense* will cause skin lesions. Eosinophilic enteritis has been reported in infections with *A. caninum*. *A. ceylanicum* infection occurs mainly peroral and cause abdominal symptoms and anemia (Overgaauw & Van Knapen, 2000).

1.4.1.2 *Toxocara canis*

**Life cycle.**-*Toxocara canis* has a complex life cycle. Under favorable conditions of moisture, temperature and oxygen tension, the larva molts to the infective L2 within the egg.
Dogs become infected with *Toxocara canis* by ingesting infective eggs or tissues of animals that serve as paratenic hosts, harboring hypobiotic L3 larvae (Georgi & Georgi, 1992). Once ingested by a young dog, the L2 larva is digested out of the egg in the stomach, penetrates the intestinal wall and enters the circulation, migrating through the liver and lungs. Once in the lungs, the larvae are coughed up and swallowed, making their way to the intestine where they become sexually mature adults; this is known as tracheal migration. If the host is an older dog, somatic migration occurs, and the larva is more prone to remain in the circulation and it migrates to the kidney or other somatic tissues where it will encyst as hypobiotic larvae (Bowman & Georgi, 2009).

*Toxocara canis* can also be transplacentally transmitted to future litters via hypobiotic larvae encysted in tissues of pregnant females (Bowman & Georgi, 2009).

**Diagnosis.**- Fecal flotation is used to diagnose this parasite (University of Pennsylvania, 2004). Severe infections can show clinical signs beginning at the second week of life, including anappetence, listlessness and a pot-bellied appearance. Their coat becomes lusterless and unkempt. Eosinophilia in infected puppies could appear as early as 1 week after birth. The non embryonated egg of *T. canis* is yellow-brown in color, thick shelled and has a suppshereical to ellipsoidal shape. Average size is 70x90 µm (Georgi & Georgi, 1992).

**Treatment.**- For 2 week old puppies the labeled treatment is pyrantel pamoate. The treatment should be repeated each two weeks until the age of three months. Sometimes, puppies are also treated with piperazine. Nevertheless, some labels do not recommend the use of piperazine in puppies under 6 week. A commercial product with febantel, praziquantel and pyrantel pamoate is labeled for 3 weeks of age if dogs weight at least 2 pound. Products with Milbemycin oxime are labeled for puppies of at least 4 weeks and two pounds of weight. A drug
composed by fenbendazole or ivermectine with pyrantel can be used in puppies over 6 weeks. A topic treatment with imidacloprid or moxidectin could be applied in puppies over 7 weeks. Finally, the formulation with fenbendazole, ivermectine and pyrantel is labeled for puppies of at least 8 weeks old (Bowman & Georgi, 2009).

**Public health aspects.** *Toxocara canis* is probably the most common GI helminth of dogs worldwide. The reported infection rates in domestic dogs vary from 3.5% in adults to 79% in puppies. The mode of transmission in humans is ingesting eggs from contaminated soil, hands and raw vegetables or by the consumption of undercooked meat of a paratenic host. Direct contact with infected dogs is not considered a transmission risk since the parasite ova requires a period of three weeks to embryonate and become infective (Overgaauw & Van Knapen, 2000).

In humans, the literature reports that infections in children are more frequent. Severe Visceral Larva Migrans is mainly found in children between 1-3 years of age. Geophagic pica is described as a major risk factor to be infected with *T. canis*. This behavioral disorder may affect a range of 2 to 10% of children between 1 and 6 years old (Overgaauw & Van Knapen, 2000).

**1.4.1.3 Trichuris spp**

**Life Cycle.** Environmentally resistant, non-embryonated eggs are passed in feces and the infective L2 larvae develop within the egg in approximately 1 month. Once the infective egg is ingested by the definitive host, the L2 larva is digested out and develops to a sexually mature adult in the cecum and colon within 3 months (Bowman & Georgi, 2009).

**Diagnosis.** *Trichuris* spp. is diagnosed using fecal flotation (University of Pennsylvania, 2004). Eggs of *Trichuris* spp. are symmetrical, have a smooth shell and bipolar plugs and average greater than 75µm (Georgi & Georgi, 1992).

**Treatment.** The preferred drugs for *Trichuris* spp infection treatment are fenbendazole, milbemycin oxime, febantel and moxidectin (Bowman & Georgi, 2009).
1.4.1.4 *Cystoisospora* spp

**Life Cycle.** - The infective, sporulated oocyst is ingested by a canine host. Thereafter, sporozoites are released from the oocyst in the small intestine where they invade the intestine epithelial cells and develop into trophozoites that in the next few days develop into a schizont (meront) which starts a multiple fission process named schizogony (merogony). The schizont, asexual reproduction (schizogony) produce multiple merozoites. Each first generation merozoite has the potential to invade a new cell and give rise a second generation schizont. The second generation of Merozoites (telomerozoites) are then released, invade intestinal epithelial cells where they develop into male (microgamete) and female (macrogamete) gametes. Sexual reproduction, or gametogony, occurs when the macrogamete is fertilized by the microgamete forming a diploid zygote. The zygote matures into an oocyst that is then released in the feces. The oocyst will sporulate within 4 days and become infective to the next host. Additionally, dogs may also become infected when rodents serving as paratenic hosts are ingested (University of Pennsylvania, 2004) (Georgi & Georgi, 1992).

**Diagnostic.** - *Cystoisospora* spp. is diagnosed by fecal flotation. The oocyst size is dependent upon the species of *Cystoisospora*, ranging 10-33 x 10-42um (University of Pennsylvania, 2004) (Georgi & Georgi, 1992).

**Treatment.** - At least 4 daily doses of sulfadimethoxime is recommended for the treatment of *Cystoisospora*. Therefore, 55 mg/kg is applied the first day and 27.5 mg/kg the following days until the patient is free of signs for two days. Another option is the use of toltrazul in a dosis of 10-30 mg/kg for one to three days (Bowman & Georgi, 2009).

1.4.2 Prevalence Studies in the Andean Region

There are limited published studies related to prevalence of dog with parasites in Ecuador and the Andean Region. Gingrich E. et al. (2010) analyzed the prevalence of parasites in
Galapagos, Ecuador, using a convenient sample of 97 owned dogs that were presented to temporary spay neuter clinics in Isabela, Santa Cruz and San Cristobal (Gingrich, et al., 2010). At least 2g of fecal sample were collected during the neutering process and processed using the Sheather Sugar flotation method. Morphological analysis was used to determine the presence of gastrointestinal parasites. In addition, they used a commercially available immunofluorescence assay for analysis of Cryptosporidium spp. and Giardia spp. As a result, the prevalence of infected dogs for the whole sample population was 71.4%. The most commonly detected parasites were Ancylostoma caninum (57.7%) and Toxocara canis (16.5%) (Gingrich, et al., 2010).

María Giraldo et al. (2005) collected 324 samples from randomly selected dogs in Quindío, Colombia, during rabies vaccination campaigns in the second semester of 2003 and 2004 (Giraldo, et al., 2005). Morphological characteristics were used to determine the presence of infecting organisms. A prevalence of 22% within observed dogs were reported in this study. The most prevalent parasite was Ancylostoma caninum (13, 9%), followed by Trichuris vulpis (4, 3%). Toxocara canis was the fourth more frequent (2, 5%) (Giraldo, et al., 2005).

Between January and December 2001, Roger A. Ramirez-Barrios et al. (2004) examined presence of parasites in fecal samples from 614 owned dogs that were presented for attention at the Veterinary Policlinic of the University of Zulia, Venezuela. The samples were processed using flotation with sodium chloride solution and diagnosed based upon morphological characteristics. A prevalence of 33.5% were reported in this study. Ancylostoma spp. was the most prevalent parasite (24.5%) followed by T. canis (11.4%) and Cystoisospora spp. (8.1%) (Ramírez-Barrios, et al., 2004).
Finally, Tortolero Low et al. (2008) described prevalence of dogs infected with GI parasites in La Vela, Venezuela. Fecal samples from 225 dogs were collected and analyzed by direct smear, Willys Molloi and Faust Technique. Morphological characteristics were used to determine the presence of infecting organisms. The overall prevalence was 76.47% being *Ancylostoma* spp. (45.88%) the most frequent parasite followed by *Toxocara canis* (31.77%). *Cystoisospora* spp. was the third most prevalent parasite (14.90%). Finally, Tortolero Low et al. (2008) found associations between presence of some studied parasites (*Toxocara canis* (OR 6.79), *Ancylostoma* spp, *Uncinaria* spp (OR 7.64) and *Cystoisospora* spp (OR 5.91)) with low socioeconomic conditions. The Graffar method was used to classify households assigning categories starting with I (1) for that households with the highest income to V (5) for that households with the lowest income (Banco Central de Venezuela, 2007). The application of this method within the owners of 255 participant dogs showed that 29.80% of dogs with a positive diagnostic of GI parasites belonged to owners within the level III and the other 70.20% belonged to owners within the levels IV and V of the Graff Scale. (Tortolero-Lou, et al., 2008).
CHAPTER 2
INTRODUCTION AND METHODS

2.1 Introduction

Canine overpopulation, risk of dog bites, transmission of gastro-intestinal parasites from
dogs to humans, pet owner responsibility and lack of animal shelter programs are emerging
public health issues of concern in Quito, the capital city of Ecuador. The current populations of
free-roaming dogs and owned dogs in Quito are not known, although previous studies have
estimated human-to-dog ratios of 7:1 for the city of Guayaquil (the largest city of Ecuador)
(Beran & Frith, 1988) and for Ecuador—as part of a report of the rabies situation for Latin
America (Pan American Health Organization, 2005). More recently, in September 2013, the
Ecuadorian Ministry of Public Health published in its official web site a national human:dog
ratio of 8:1). Nevertheless, the information generated from these studies could not be useful as a
baseline for planning a program in Quito. The information produced in these three studies has
limited health policy applications for management of dog populations in Quito. The study in
Guayaquil was conducted in the 1980s, and the geography and climate in Guayaquil and Quito
are different. The canine population data produced by PAHO in 2005 and the Ecuadorian
Ministry of Public Health in 2013 do not explain the methodologies used in these studies.
Moreover, the studies do not publish a specific demographic parameter for Quito.

The city of Quito has a history of fatal dog bites in people. In August 2004, three
different dogs evaded a fence and killed an elderly woman in Tumbaco, a rural sector of Quito
(Universo, 2004). Later, in September 2008, a 7 years old boy was killed by a dog owned by his
parents in Carcelén bajo (El Universo, 2008). This event triggered the debate and pass of The
Dog Responsible Ownership National Rule in 2009. Although this rule banned the tenancy of
Rottweiler and Pit Bulls, it also prohibited cruelty practices against dogs such as torture and
massive culling as dog population control method (Derecho Ecuador, 2009). Finally, in January 2013, the death of a two-year old boy who was attacked and killed in his house by an adult dog sparked a national debate on dog population management and responsible pet ownership (El Universo, 2013).

Health authorities in the city of Quito have identified a high gastro-intestinal parasite burden in dogs as a potential public health issue of concern. In Ecuador, knowledge about the prevalence of and exposure factors associated with a positive diagnosis of gastro-intestinal (GI) parasite infection in dogs is limited to one published study. In a study conducted on the Galapagos, 65 of 97 dogs presented to a spay-neuter clinic in Isabela, San Cristobal, and Santa Cruz were classified as infected with one or more GI parasites. *Ancylostoma caninum* was the most common GI parasite (56/65) identified in tested dogs (Gingrich, et al., 2010).

Pet ownership responsibility is important for pets, pet owners, and society. It demands pet owners to provide their pets with basic needs of food, water, shelter, health, and welfare. In addition, it requires pet owners to be informed on the public health consequences of poor pet ownership responsibility (e.g., dog bites, gastro-intestinal parasite contamination of private and public spaces). Previous studies (Slater, et al., 2008) (Acosta-Jamett, et al., 2010) (Ratsitorahina, et al., 2009) have identified socio economic factors such as household location (rural/urban) associated with individual pet ownership responsibility components. In Ecuador, no studies have identified factors associated with pet ownership responsibility. However, we speculate that years of education of the household’s chief and poverty are two broad factors that can influence pet ownership responsibility in the capital city of Quito.
On April 14th, 2011, authorities in the City of Quito approved an Ordinance that advocates animal welfare (to prevent cruel treatment of animals) and pet ownership responsibility (to reduce the risk of dog bites and to enhance awareness of zoonotic diseases that can be transmitted from companion animals to people). The Ordinance considers implementing initiatives to educate the general public on animal welfare and pet ownership responsibility, as well as a Trap Neuter Return (TNR) program for free-roaming dogs and free, high-quality high-volume spay-neuter (HQHVSN) clinics for owned dogs in parishes with low income economies. Health authorizes in Quito have requested assistance in formulating, implementing, and evaluating a population study to estimate canine population and to measure the level of pet ownership responsibility in the capital city of Quito. The goal is to produce baseline data and information for a better formulation and implementation of proposed education, TNR and HQHVSN programs.

The objectives of this study are the following:

- To estimate the population of free-roaming dogs and owned dogs in the metropolitan area of Quito.
- To examine relationships between household factors (geographic zone, human population in the parish, number of people in the household, and living condition index) and Pet Ownership Responsibility in study households.
- To estimate the prevalence of and to identify household factors associated with a positive diagnosis of gastro-intestinal parasites in owned dogs.

The overall purpose of this cross-sectional study is to generate a baseline composed by demographic, health and pet ownership responsibility indicators, that that can be used to formulate, implement, and evaluate the efficacy and efficiency of future trap-neuter-return, animal welfare and public health education program to reduce the burden of gastrointestinal parasites in companion animals and people in Quito.
2.2 Methods

2.2.1 Study site

This study was conducted in the Metropolitan District of Quito, the capital city of Ecuador. The population is about 2.3 million people who live in 634,611 households (INEC, n.d.). Quito is officially divided into 65 parishes (32 are located in urban areas and 33 in rural areas). The median age is 29 years old (INEC, n.d.).

2.2.2 Definitions

2.2.2.1 Free roaming dogs

In this study, free roaming dogs were defined as dogs not under direct control by a person (dog owner) or that were not prevented from roaming during study period observations from 4.00 to 6.00am (World Organization for Animal Health, 2013).

2.2.2.2 Owned dogs

In this study, owned dogs were defined as dogs claimed as owned by a household chief or a family member during house-to-house personal interviews.

2.2.2.3 Household

In this study, a household is a basic social unit composed by those living together in the same house (INEC, n.d.).

2.2.2.4 Urban and rural parishes

The selected parishes were classified as urban or rural according the official Political and Administrative Division of Ecuador.

2.2.3 Estimating the Population of Owned and Free Roaming Dogs in Quito

2.2.3.1 Sampling of free roaming dogs

The city of Quito is divided in 65 parishes. First, Working outwards from one parish roughly located in the center, each parish was identified with 1 of 4 colors (avoiding to assign the
same color to adjacent parishes) using procedures recommended by the World Society for the Protection of Animals (WSPA) (Figure 2-1) (World Society For The Protection of Animals, 2008). This approach identified three groups of 16 parishes and one group of 17 parishes (with 1 color for each group). Next, 1 of 4 colors was randomly selected to identify 16 parishes that were included in the study. Eight urban parishes (Rumipamba, Mariscal Sucre, La Magdalena, La Ecuatoriana, Carcelén, San Isidro del Inca, Puengasí, Solanda) and eight rural parishes (La Merced, Nanegalito, Chvezpamba, Yaruquí, Conocoto, Calderón, Nayón) were included in the study. Second, within each selected parish, Sections were created using Google Earth®. Each Section had a walking distance of approximately 3.2 miles in public routes and was identified with a unique number. Each parish had a median of 25 Sections (90 maximum). Next, 2 Sections were randomly selected using a computer software program ‘Research Randomizer’ available at http://www.randomizer.org.

Counting of free roaming dogs was conducted by the same investigator (JG) on a total of 32 Sections (2 selected Sections x 16 parishes = 32 Sections). Each Section was walked at 2.5 MPH twice (i.e., Monday and Tuesday) and dog data were collected from 4 to 6 am (at dawn). This time period was selected to avoid morning car traffic (World Society For The Protection of Animals, 2008). A tally counter was used to count dogs each day (Captured dogs). An Earthmate ® PN 60 GPS devise was used to record the track followed the first day, and the same track was followed the second day. Dogs that were counted were registered on a digital photographic archive using a Canon® PowerShot D20 camera equipped with a GPS devise. The photographic archive and a second tally counter were used to identify dogs observed on both observation days (Recaptured dogs).
2.2.3.2 Sampling owned dogs

Within each selected parish (n=16) and each selected Section (n=32), all Blocks (approximately 14 Blocks per Section) were considered for inclusion, but only 1 Block was randomly selected and included in the study. All Households in selected Blocks were visited for a personal interview with the household chief. Participation in the personal interview was voluntary, and only household chiefs who approved and signed a consent form were included in this study. Within rural parishes, all households in the Section were included in places where blocks were not clearly defined.

2.2.4 Pet Ownership Responsibility Index (PORI)

An instrument was prepared to measure and calculate a PORI (Table 2-1). The instrument included 8 factors (i) spayed/neuter status, (ii) use of leash, (iii) dog shelter conditions, (iv) food, (v) veterinary care, (vi) rabies vaccination compliance, and (vii) deworming (viii) allowance to free roam. Scores of 0 to 1 or 0 to 2 were assigned to each element for a maximum score of 8 in each household.

2.2.5 Living Condition Index (LCI)

An instrument was prepared to measure and calculate a LCI (Table 2-2). The instrument included 2 factors (i) accumulated wealth (PC, e-mail account, TV, cars) and (ii) education (elementary school, middle school, high school, university). Scores of 0 to 4 were assigned to selected factors with the exception of the number of cars, for a highest score of 8 or more, depending on the number of cars in each household.

2.2.6 Collection of Fecal Samples from Owned Dogs

During house-to-house visits, each household chief was instructed to collect one fecal sample from her/his dog(s) from the ground, after normal defecation. On a first home visit (day 1), the household chief was provided with two pairs of gloves, a disposable tongue depressor and
two sterile plastic specimen containers (100 ml) labeled with the dog’s name and the date the sample was collected. In addition, she/he was instructed in sanitary collection procedures of dog-fecal samples after normal defecation. The fecal sample was collected the following day (day 2). He/she was instructed to put on a pair of gloves and remove the screw cap to collect the fecal by “scooping” the fecal sample with the tongue depressor into the specimen container before replacing and securing the screw cap. He/she was instructed to avoid touching the feces with the gloves to prevent unnecessary contamination of other objects. The specimen container with the fecal sample was placed in a plastic bag “zip-lock” to reduce the risk of contamination. Next, he/she was instructed to remove one glove at the time by pulling them off from the proximal end with the opposite hand, entirely exposing the inner side of the glove. Both gloves were placed in a paper or plastic bag for disposal with other waste produced in the household. In addition, he/she was instructed to wash her hands with soap immediately after the sample was collected. Finally, if canine fecal samples were visible in the home backyard, he/she was provided with zip-lock bags and instructed to collect a dog fecal sample from the ground safely by turning the bag inside out. All fecal samples were submitted to a laboratory at the University of San Francisco de Quito for identification of gastro-intestinal parasites.

2.2.7 Identification of GI parasites

Fecal samples were processed and analyzed for diagnosis of GI parasites in a laboratory at the Universidad de San Francisco de Quito. The parasitological exam consisted in identification of morphological characteristics of parasite eggs, cysts and oocysts using a Sheather’s sugar centrifugational flotation and sedimentation techniques (Stockdale Walden, 2013). Samples diagnosed with parasite eggs were classified as positive, and a quantitative exam was conducted using the McMaster’s technique in Sheather’s sugar solution with a specific gravity of 1.25 when more than 25 eggs, cysts or oocysts per slide were found. The microscope
was equipped with a portable digital camera to take photos of parasites observed during the parasitological exam. The photographs were stored in electronic files and were sent to one of the co-investigators (HW) of this project at the University of Florida for confirmation.

2.2.8 Data Analysis

Data was recorded in Microsoft Excel files and analyzed using Microsoft Excel 2013 (Microsoft, Redmond, WA, USA) Statistix 9 (Analytical Software, Tallahasee, FL, USA) and SAS 9.3 (SAS Institute Inc., Cary, NC, USA)

2.2.8.1 Counting free-roaming dogs

Within each Section, the proportion of observed free-roaming dogs in the first and second observation (recaptured animals) was calculated using the information collected with the second tally counter and GPS camera (World Society For The Protection of Animals, 2008) (Dias, et al., 2013). Equation 1-1 was used to calculate the estimate number of dogs (Greenwood & Robinson, 2006). In equation 1-1, n1 is the number of dogs observed in the first observation (captured animals), n2 is the number of observed dogs in the second observation, m2 is the number of dogs observed in the first and the second observation (recaptured animals) and N is the estimated number of animals in each section. Confidence intervals using the two-sample method (Greenwood & Robinson, 2006) were not determined because only 4 of 32 study Sections had the required number of ≥ 8 recaptured dogs. The idea of using this method for counting dogs is to estimate the proportion of “recaptured” dogs within the second count (m2/n2), since it is a reasonable assumption that this proportion is the same as that in the population at large (n1/N).

To estimate number of dogs in each selected parish, the estimated numbers of dogs on Sections 1 and 2 were averaged, then multiplied by the total number of Sections in each selected parish.
To calculate the human: free-roaming dog ratio per parish, the estimated dog population on each parish was divided by the official census data stratified by parishes published by the City Institute of Quito (Instituto de La Ciudad, 2012). In addition, the median free-roaming dog ratio was calculated for all studied parishes.

The estimated population density of free-roaming dogs per parish was calculated by dividing the estimated dog population per parish by the official area (Km$^2$) of each parish. (Secretaría de Territorio, Habitat y Vivienda, n.d.). In addition, to calculate the population density of free-roaming dogs in Quito, the total estimated dog population in all 65 parishes was divided by the by the official total area of Quito (Km$^2$).

Finally, three simple linear regression models were constructed to analyze the relationship between the human:free-roaming dog ratio as dependent variable and the officially reported poverty rates within each study parishes (Instituto de la Ciudad, 2012a). The two variables were analyzed for normality using Statistix 9 (Analytical Software, Talahasee, FL, USA) and transformations were done when necessary. First, a simple linear regressions model was used to analyze overall human:free-roaming dog ratio with poverty rates. Second, two similar models were used to analyze the same variables stratified by Zone (urban and rural parishes).

2.2.8.2 Counting owned dogs

To calculate the human:owned-dog ratio, simple linear regression was used to quantify the relationship between the observed human population and the observed number of dogs in selected Blocks in each study parish.

Since socioeconomic differences has been described between zones (Instituto de La Ciudad, 2013a) (Instituto de la Ciudad, 2013b) the following calculations were performed to estimate the population density of owned dogs in urban and rural parishes. First, a simple linear
regression model where: \( Y_1 = \text{the number of observed dogs in each urban parish} + X_1 = \text{the number of observed people in each urban parish} \). A similar model was constructed using data from rural parishes. The estimated dog population was calculated by multiplying the officially estimated human population in each study parish by the Beta coefficient obtained using the two linear regression models. Next, the dog population density was obtained by dividing the estimated dog population by the area (Km\(^2\)) in each study parish. Finally, to calculate the population density of owned dogs in Quito, the total estimated dog population in all 65 parishes was divided by the by the total area (Km\(^2\)).

### 2.2.8.3 Pet Ownership Responsibility Index (PORI)

Unconditional logistic regression was used to model the odds of a household with a low PORI. Households were assigned into one of two groups (high PORI, score 6 to 8; low PORI, score 0 to 5) based on the median distribution. In the univariable analysis, explanatory variables with a p value ≤ 0.20 were considered eligible for multivariable analysis. Associations between exposure variables (p ≤ 0.20) were examined, and when a pair of variables was associated by use of a chi-square test (two tailed), the exposure variable judged as most biologically plausible was used as a candidate in the multivariable analysis. To determine the best fitting model, the variable with the smallest p value in the univariable analysis was entered into the model first. Thereafter, each of the remaining variables was added to the model containing the first variable to test whether its addition significantly improved the fit of the model. The variable with the highest likelihood ratio statistic (chi-square test with one degree of freedom) was selected for addition to the model and the process was then repeated; variables had to have a p value ≤ 0.05 to be retained in the model. Explanatory variables retained in the model were examined for confounding and interaction by adding each of the variables to the model and assessing the changes in the odds ratios (i.e., > 10%) of the remaining variables in the model, as well as the
observed and expected effects between two explanatory variables on the outcome of interest (e.g., pet owner responsibility).

In addition, the expected combined effect of number of dogs in the household (≥ 2) and a low living condition index (score 1 to 5) of household chiefs with a low pet owner responsibility index (score 0 to 6) was calculated as follows:

Additive Model

- Observed OR for number of dogs in the household (≥ 2) + OR for a low living condition index (score 1 to 5) – 1 (additive model)

- or observed OR for number of dogs in the household (≥ 2) × OR for a low living condition index (score 1 to 5) (multiplicative model) (Szklo & Nieto, 2000).

2.2.8.4 Gastro-intestinal (GI) parasites

Prevalence of households with ≥ 1 dogs with a positive diagnosis of GI parasites was calculated as the number of households with a positive diagnosis divided by the total number of households with dogs sampled and tested. Similarly, prevalence of dogs with a positive diagnosis of GI parasites was calculated as the number of dogs with a positive diagnosis divided by the total number of dogs sampled and tested. Ninety-five percent confidence intervals were calculated for each calculated prevalence estimate.

Logistic regression procedures described above were used to identify factors associated with households with dogs a positive diagnosis of GI parasites (2.8.2). The unit of analysis was the household. Explanatory variables included in the analysis were: parish’s zone (rural, urban), Parish human population (low = < 41,169; high = ≥ 41,170), dogs in household (1, ≥ 2), people in household (low = 1 to 4; high = 5 to 12), dog(s) dewormed in the last 6 months (no, yes), living condition index (high = score 6 to 8; low = score 1 to 5), and pet ownership responsibility index (high = score 6 to 8; low = score 1 to 5).
Table 2-1 Parameters included in the Pet Ownership Responsibility Index (PORI)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Spayed/Neuter</th>
<th>Free Roaming</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of leash: Yes</td>
<td>Yes</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Housing (shelter) conditions are appropriate</td>
<td>Yes</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Food (commercial or prepared)</td>
<td>No</td>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>Visit veterinarians in last 12 months: Yes</td>
<td>No</td>
<td>Yes</td>
<td>0</td>
</tr>
</tbody>
</table>

Maximum score: 8

Table 2-2 Parameters included in the Living Conditions Index (LCI)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accumulated wealth</td>
<td>PC</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Car(s)</td>
<td>≤ 2</td>
</tr>
<tr>
<td>Education</td>
<td>Primary</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>High school</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>University</td>
<td>4</td>
</tr>
<tr>
<td>Sum of Scores</td>
<td></td>
<td>≤ 9</td>
</tr>
</tbody>
</table>
Figure 2-1 Geographic location of 65 parishes in the metropolitan area of Quito. Each parish was assigned to 1 of 4 colors (blue, yellow, green orange). Base map by (Hflopez2000, 2009)
CHAPTER 3
RESULTS

3.1 Estimated Abundance of Dogs in Quito

3.1.1 Abundance of Free Roaming Dogs

3.1.1.1 Abundance of free-roaming dogs in all study parishes

The overall median human:free-roaming dog ratio was 49:1 and the free-roaming dog population density was 11 dogs/Km\(^2\).

Using linear regression, the human:free-roaming dog ratio was associated with official poverty rates of people (rank data) in study parishes (\(\beta=-0.77\); \(r=0.77\); \(R^2=0.59\); \(p<0.01\)). (Figure 3-1)

3.1.1.2 Abundance of free-roaming dogs in urban parishes

The estimated human:free-roaming dog ratio (Table A-1) varied from 24:1 in the parish of San Isidro del Inca to 998:1 in the parish of Mariscal Sucre (Figure 3-2)

The dog population density (Table 3-1) varied from 3 dogs/Km\(^2\) in Rumipamba to 279 dogs/Km\(^2\) in San Isidro del Inca (Figure 3-3).

Using linear regression, the human:free-roaming dog ratio was associated with official poverty rates of people (rank data) in urban parishes (\(\beta=-0.69\); \(r=0.82\); \(R^2=0.67\); \(p<0.05\)).

3.1.1.3 Abundance of free-roaming dogs in rural parishes

The estimated human:free-roaming dog ratio (Table A-1) varied from 5:1 in the parish of La Merced to 99:1 in the parish of Conocoto (Figure 3-2)

In addition, the dog population density (Table 3-1) varied from 1 dog/Km\(^2\) in Yaruquí and Chavezpamba to 59 dogs/Km\(^2\) in Calacalí (Figure 3-3)
No association was found between the human:free-roaming dog ratio and poverty rates of people in rural parishes.

3.1.2 Abundance of Owned Dogs

3.1.2.1 Abundance of owned dogs in all study parishes

Among the 32 selected blocks, 232/998 (23%) households voluntarily participated in this study. A total of 194/232 or 84% household chiefs reported having one or more dogs for a total of 318 dogs. Thirty eight (16%) households had no dogs, 114 (49%) had 1 dog only, and 80 (34%) had ≥ 2 dogs. The median age of dogs = 2 years (minimum= 6 weeks, first quartile = 1 year; third quartile = 4 years, maximum=16 years). A total of 195 dogs (61%; 95% CI = 56, 67%) were classified as males, and 44 dogs (14%; 10, 18%) were classified as spayed or neutered. Finally, 71 dogs (22%; 18, 27%) were reported as dogs allowed to roam in public spaces.

Using linear regression, the frequency of observed owned dogs increased by 29 for every 100 people in study households (Y = 1.09 + b = 0.29; r = 0.94; R² = 0.89; 95% CI = 0.23, 0.34; p <0.01) (Figure 3-4). Based on these calculations, the overall human:dog ratio in study households = 100/29= 3.48:1.

The overall dog population density = 152 owned dogs/Km².

3.1.2.2 Abundance of owned dogs in urban and rural parishes

In urban parishes, the median human:owned-dog ratio = 3.28:1 (Y = 0.48 + b = 0.31; r = 0.93; R² = 0.96; p<0.01). In rural parishes, the median human:dog ratio = 3.85:1 (Y =2.11 + b = 0.26; r =0.92; R2 = 0.85; p<0.01) (Figure 3-5) (Figure 3-6).

In urban parishes, the dog population density ranged from 789 dogs/Km² (La Ecuatoriana) to 5430/Km² dogs (Solanda). In rural parishes, the dog population density ranged from 3 dogs/ km² (Chavezpamba) to 498 dogs/ km² (Calderón) (Table 3-2).
In urban parishes the proportion of dogs allowed to roam on public spaces = 11% (95% CI = 7, 17%). In rural parishes, proportion of dogs allowed to roam on public spaces = 36% (95% CI = 28, 44).

3.2 Factors Associated with Households with a Low Pet Ownership Responsibility Index (PORI)

In the univariable analysis, the variables for zone, human population in a parish, number of dogs in a household, and living condition index had a p value < 0.01 (Table A-2). The variable for living condition index in a household was associated (p < 0.01) with the variables for zone and human population in the study parish. In addition, the variable for zone was associated with that for human population in a study parish (p < 0.01). Thus, in this study, the explanatory variables for number of dogs in a household and living condition index were further examined.

In the multivariable analysis, the variables for number of dogs in the household and living condition index were associated with a low PORI score. The odds of a household with a low PORI were 2.77 times higher in households with ≥ 2 dogs, after controlling for living condition index (Adjusted OR = 2.77; 95% CI = 1.43, 5.36 p < 0.01). In addition, the odds of a household with a low PORI were 5.75 times higher in households with a low LCI, after controlling for number of dogs in the household (Adjusted OR = 5.75; 95% CI = 2.97, 11.15; p < 0.01).

Also, we examined the observed combined effect of number of dogs in the household and living condition index on low pet ownership responsibility index, and the analysis revealed that households with ≥ 2 dogs and with a low living condition index were 16.71 times more likely to have a low pet ownership responsibility index, compared to households with 1 dog only and with high living condition index (OR = 16.71; 95% CI = 5.90, 47.37; p < 0.01) (Table 3-3). This observed combined effect for low pet ownership responsibility index (OR = 16.71) was higher
than the expected combined effect based on adding (OR = 7.37), and multiplying (OR = 11.91) absolute independent excesses due to living condition index (OR = 2.39) or (OR = 4.98) number of dogs in the household.

3.3 Gastro-Intestinal Parasites in Owned Dogs

A total of 110 of 194 (57%) households with one or more dogs returned a dog fecal sample. Thirty-one of 110 or 28% (95% CI= 21, 37%) study households had one or more dogs classified as infected with one or more GI parasites. At the dog level, 39 of 154 or 25% (95% CI=19,33%) observed dogs were infected with one or more GI parasites. *Ancylostoma* spp. was the most frequent parasite diagnosed in sampled and tested dogs (18/39) followed by *Toxocara canis* (11/39) (Table 3-4). Using logistic regression, no investigated factors were significantly associated with a positive diagnosis of gastrointestinal parasites in owned dogs (Table A-3)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Parish</th>
<th>Estimated number of dogs</th>
<th>Km² ††</th>
<th>Dogs/Km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>Rumipamba</td>
<td>36</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Mariscal</td>
<td>13</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>La Ecuatoriana</td>
<td>1628</td>
<td>24</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Carcelén</td>
<td>488</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Solanda</td>
<td>501</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Puengasí</td>
<td>1548</td>
<td>11</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>La Magdalena</td>
<td>435</td>
<td>3</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>San Isidro del Inca</td>
<td>1727</td>
<td>6</td>
<td>279</td>
</tr>
<tr>
<td>Rural</td>
<td>Chavezpamba</td>
<td>30</td>
<td>69</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Yaruquí</td>
<td>200</td>
<td>153</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Nanegalito</td>
<td>311</td>
<td>125</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Conocoto</td>
<td>832</td>
<td>91</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>La Merced</td>
<td>1542</td>
<td>47</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Calderón</td>
<td>2682</td>
<td>79</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Nayón</td>
<td>684</td>
<td>16</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Calacalí</td>
<td>219</td>
<td>4</td>
<td>59</td>
</tr>
</tbody>
</table>

†† Data were obtained from official records of the City of Quito
Table 3-2 Estimated owned-dog population density (dog/Km$^2$) in each parish

<table>
<thead>
<tr>
<th>Zone</th>
<th>Parish</th>
<th>No. of observed dogs</th>
<th>No. of people observed</th>
<th>Beta$^b$</th>
<th>Human pop’n$^c$</th>
<th>Dog pop’n$^d$</th>
<th>Km$^e$</th>
<th>Dogs/Km$^f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>La Ecuatoriana</td>
<td>29</td>
<td>97</td>
<td>0.31</td>
<td>62313</td>
<td>19020</td>
<td>24.1</td>
<td>789</td>
</tr>
<tr>
<td></td>
<td>Rumipamba</td>
<td>28</td>
<td>70</td>
<td>0.31</td>
<td>31300</td>
<td>9554</td>
<td>10.3</td>
<td>928</td>
</tr>
<tr>
<td></td>
<td>Mariscal Sucre</td>
<td>1</td>
<td>8</td>
<td>0.31</td>
<td>12976</td>
<td>3961</td>
<td>2.8</td>
<td>1415</td>
</tr>
<tr>
<td></td>
<td>Puengasí</td>
<td>50</td>
<td>160</td>
<td>0.31</td>
<td>62628</td>
<td>19117</td>
<td>11.3</td>
<td>1692</td>
</tr>
<tr>
<td></td>
<td>San Isidro del Inca</td>
<td>13</td>
<td>50</td>
<td>0.31</td>
<td>42071</td>
<td>12842</td>
<td>6.2</td>
<td>2071</td>
</tr>
<tr>
<td></td>
<td>Carcelén</td>
<td>13</td>
<td>42</td>
<td>0.31</td>
<td>54938</td>
<td>16769</td>
<td>5.7</td>
<td>2942</td>
</tr>
<tr>
<td></td>
<td>La Magdalena</td>
<td>20</td>
<td>48</td>
<td>0.31</td>
<td>30288</td>
<td>9245</td>
<td>2.9</td>
<td>3188</td>
</tr>
<tr>
<td></td>
<td>Solanda</td>
<td>22</td>
<td>89</td>
<td>0.31</td>
<td>78279</td>
<td>23894</td>
<td>4.4</td>
<td>5430</td>
</tr>
<tr>
<td>Rural</td>
<td>Chavezpamba</td>
<td>12</td>
<td>38</td>
<td>0.26</td>
<td>801</td>
<td>208</td>
<td>69.3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Nanegalito</td>
<td>11</td>
<td>34</td>
<td>0.26</td>
<td>3026</td>
<td>785</td>
<td>125.1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Yaruquí</td>
<td>39</td>
<td>111</td>
<td>0.26</td>
<td>17854</td>
<td>4634</td>
<td>153.1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>La Merced</td>
<td>4</td>
<td>3</td>
<td>0.26</td>
<td>8394</td>
<td>2179</td>
<td>46.5</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Conocoto</td>
<td>26</td>
<td>119</td>
<td>0.26</td>
<td>82072</td>
<td>21303</td>
<td>90.7</td>
<td>235</td>
</tr>
<tr>
<td></td>
<td>Nayón</td>
<td>8</td>
<td>37</td>
<td>0.26</td>
<td>15635</td>
<td>4058</td>
<td>15.7</td>
<td>258</td>
</tr>
<tr>
<td></td>
<td>Calacalí</td>
<td>21</td>
<td>62</td>
<td>0.26</td>
<td>3895</td>
<td>1011</td>
<td>3.7</td>
<td>273</td>
</tr>
<tr>
<td></td>
<td>Calderón</td>
<td>21</td>
<td>78</td>
<td>0.26</td>
<td>152242</td>
<td>39517</td>
<td>79.3</td>
<td>498</td>
</tr>
</tbody>
</table>

$^a$Data were obtained during personal interviews with dog owners in selected parishes, Sections, and Blocks.

$^b$Y$_1$ = Number of observed dogs in each urban parish + X$_1$ = Number of observed people in each urban Parish.

$^c$Y$_2$ = Number of observed dogs in each rural parish + X$_2$ = Number of observed people in each rural Parish.

$^d$Data were obtained from official records from the government of Ecuador (census data from year 2010).

$^e$Human population x 0.31 (in urban parishes) or x 0.26 (in rural parishes).

$^f$Data were obtained from official records of the City of Quito.

Table 3-3 Observed and expected effects of number of dogs in household and living condition index on households with low Pet Ownership Responsibility Index

<table>
<thead>
<tr>
<th>Dogs in household</th>
<th>Living Condition Index</th>
<th>Odds ratio</th>
<th>95% CI*</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High</td>
<td>1.00</td>
<td>Reference</td>
<td>NA</td>
</tr>
<tr>
<td>1</td>
<td>Low</td>
<td>2.39</td>
<td>1.00, 5.74</td>
<td>0.05</td>
</tr>
<tr>
<td>≥2</td>
<td>High</td>
<td>4.98</td>
<td>2.09, 11.87</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>≥2</td>
<td>Low</td>
<td>16.71</td>
<td>5.90, 47.37</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

$^*95\%$ confidence interval

Table 3-4 Frequency of observed gastro intestinal parasites in owned dogs

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ancylostoma spp.</em></td>
<td>18</td>
</tr>
<tr>
<td><em>Toxocara canis</em></td>
<td>11</td>
</tr>
<tr>
<td><em>Cystoisospora spp</em></td>
<td>1</td>
</tr>
</tbody>
</table>
Table 3-4 Continued

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Trichuris</em> spp</td>
<td>1</td>
</tr>
<tr>
<td>Co-infections:</td>
<td>8</td>
</tr>
</tbody>
</table>

Figure 3-1 Relationship between human:free-roaming dog ratio and poverty rates per parish (Ranked Data)
Figure 3-2 Human: Free-roaming dog ratio by parish. Map by Lenin Vinueza (USFQ)

Figure 3-3 Free-roaming dog Population density (dog/Km²) by parish. Map by Lenin Vinueza (USFQ)
Figure 3-4 Relationship between human and owned dog abundance per parish

\[ Y = 1.09 + 0.29 \]
\[ r = 0.94 \]
\[ R^2 = 0.89 \]
\[ p < 0.01 \]

Figure 3-5 Human: owned dog ratio by parish. Map by Lenin Vinueza (USFQ)
Urban owned dogs = 0.48 + 0.31 n-people; r = 0.93; R² = 0.96; p<0.01
Rural owned dogs = 2.11 + 0.26 n-people; r = 0.92; R² = 0.85; p<0.01

Figure 3-6 Relationship between human and owned dog abundance per parish stratified by zone
CHAPTER 4
DISCUSSION

This study has created a baseline to help the City of Quito in planning and evaluation processes during the implementation of the Ordinance that regulates the tenancy, protects and control the urban fauna of the capital city of Ecuador. In summary, first, the median human: free-roaming dog ratio was higher than that assumed for the city officials during the Ordinance discussion process. Second, the human: owned dog ratio was smaller than that assumed by the city officials at that time. Also, the proportion of owned dogs allowed to roam was smaller than that expected by the city officials (Zaldumbide, 2011). Likewise, the prevalence of dogs with GI parasites was smaller than that described before in the study in the Galapagos Islands (Gingrich, et al., 2010). On the other hand, this study has analyzed some parameters related to dog demography, pet ownership responsibility and socioeconomic aspects that were correctly assumed before by the city officials in Quito. In fact, the data showed an association between abundance of free-roaming dogs and pet ownership responsibility with socioeconomic factors as expected.

4.1 Estimated Abundance of Dogs in Quito

4.1.1 Abundance of Free Roaming Dogs

4.1.1.1 Abundance of free-roaming dogs in all study parishes

The overall median human:free-roaming dog ratio was 49:1 and the free-roaming dog population density was 11 dogs/Km². This results are translated in less abundance of free roaming dogs than that expected by the city official during the approval process of Ordinance 48 (human:free-roaming dog ratio 19:1 and dog population density 28 dogs/Km²). (Diario Hoy, 2010) (Zaldumbide, 2011). This difference could be explained since the assumptions made by
the city officials were based upon data published from other Latin American cities since previous studies for Quito were not available (Jacome, 2013).

Using linear regression, the human:free-roaming dog ratio was associated with official poverty rates (rank data) of people in study parishes ($\beta=-0.77; r = 0.77; R^2 = 0.59; p<0.01$). This could explain that the rural parish of La Merced that has the lowest human:free-roaming dog ratio (5:1) has a higher poverty rate (60.7 %) compared to the urban parish of Mariscal Sucre which is the parish that has the highest human:free-roaming dog ratio (998:1) and a lower poverty rate (16.9%) (Instituto de la Ciudad, 2012a). In addition, Ortega-Pacheco, et al described that 77% of the households in rural villages did not have adequate fences to prevent the dogs from roaming (Ortega-Pacheco, et al., 2007). Although the proportion of inadequate fences was not registered in the study in Quito, inadequate fences were observed within the two selected sections of La Merced. This could be related with higher poverty rates described in La Merced since people could not have enough money to afford a fence to protect their property and prevent dogs from roaming or could be using dogs as guardians to protect their property as described for Guayaquil, Ecuador by Beran & Frith in 1988.

### 4.1.1.2 Abundance of free-roaming dogs in urban parishes

In urban parishes, the estimated human:free-roaming dog ratio varied from 24:1 in San Isidro del Inca to 998:1 in Mariscal Sucre. This should be related with socioeconomic factors since an association of a lower human:free-roaming dog ratio and higher poverty rates was found. Thus, San Isidro del Inca is also the urban studied parish with the highest rates of poverty (29.5%) compared to Mariscal Sucre that has a lower rate (16.3%) (Instituto de la Ciudad, 2012a). Likewise, the free-roaming dog population density in urban parishes ranged from 3 dogs (Rumipamba) to 279 (San Isidro del Inca) per Km². Although, Rumipamba is 1.7 times bigger than San Isidro del Inca, it is not the biggest urban parish included in this study. Nevertheless,
Rumipamba has the lowest poverty rate within urban studied parishes (15%) compared to San Isidro del Inca that has the highest (29%).

Using linear regression, an inverse relation was found between human: free-roaming dogs and poverty rates (rank data) ($\beta = -0.69; r = 0.82; R^2 = 0.67; p<0.05$). This finding agrees with the common rule suggested by Alan Beck (2000) which states that free roaming dogs are more frequent in low to middle income neighborhoods. Moreover, Beck (2002) in the second edition of the book that relates his study of the ecology of stray dogs in Baltimore in the 1960s and 70s, he conclude that free-roaming dogs were closely correlated with low income areas of Baltimore which had the vast majority of free roaming dogs compared to high income areas that were relatively free of loose dogs (Beck, 2002).

### 4.1.1.3 Abundance of free-roaming dogs in rural parishes

In rural parishes, the observed abundance of free roaming dogs was between 2682 in Calderón to 30 in Chavezpamba. This should be related with the abundance of people living in poverty since Calderón has the highest abundance (42138) within all the studied parishes and Chavezpamba the lowest (532). In addition, the estimated human: free-roaming dog ratio varied from 5:1 in the parish of La Merced to 99:1 in the parish of Conocoto. In addition, the dog population density varied from 1 free-roaming dogs/Km$^2$ in the parishes of Yaruquí and Chavezpamba to 59 free-roaming dogs/Km$^2$ in Calacalí. In this case, the difference could be based mainly on the area and human population density of the parishes. Calacalí is the smallest (4 Km$^2$) rural parish in the study compared to Yaruquí that is the largest (153 km$^2$). However, the low free-roaming dog population density in Chavezpamba could be explained since it is the selected parish with the lowest human population density (2810/Km$^2$) and the lowest abundance of people living under poverty levels (Instituto de La Ciudad, 2012) (Instituto de la Ciudad, 2012a)
4.1.2 Abundance of Owned Dogs

4.1.2.1 Abundance of owned dogs in all study parishes

The median age of owned dogs was 2 years. The age distribution of owned dogs in Quito is lower than that reported by Acosta-Jamett, et al., (2010) in Coquimbo, Chile (3 years) and by Slater, et al., 2008 4-1-2-1 central Italy (4 years), but similar to that reported by (Ortega-Pacheco, et al., 2007) in a study a rural community in Yucatan, Mexico (average = 2.5 years). This finding can be related with two aspects: the level of progress of Veterinary Medicine in the European Country and the higher frequency of spay and neuter in Italy compared to the Latin American Countries. Since more technical recourses are available for veterinarians in Italy, the patient has better chances to extend its life compared to South America. Also, according to the World Bank, the GDP per capita in Italy was of $33,072 in 2012 compared to the same parameter in Ecuador that was $5,425 (The World Bank, n.d.). This means that on average, people in Italy have more money that could be invested in veterinary care compared to Ecuador. On the other hand, since more proportion of dogs have been spayed neuter in Italy, the chances to the born of new litters is reduced and the average age could increase.

In this study, 61% of owned dogs were classified as males. This finding is similar to previous studies conducted in Guayaquil, Ecuador (61%) (Beran & Frith, 1988), Isabela, Ecuador 1980’s (70%) (Barnett & Rudd, 1983), Isabela, Ecuador 2011 (Herrera, et al., 2012), in rural areas of Yucatan (58 %) (Ortega-Pacheco, et al., 2007) and in Central Italy (62%) (Slater, et al., 2008). In the region of Coquimbo, Chile, the proportion of male dogs were 56% in urban areas, 74 % in small towns and 83% in rural areas (Acosta-Jamett, et al., 2010) . This could be explained since people tend to prefer males than females as property guardians. Also, the owners prefer females to avoid the consequences of unwanted mating. (Overgaauw & Van Knapen, 2000).
In addition, 14% of owned dogs were classified as spayed or neutered. This frequency of spayed/neutered dogs is considered very low and lower than the 27% reported for Isabela, Ecuador (Herrera, et al., 2012) and similar (<20%) to that reported in previous studies in Italy (16%) (Slater, et al., 2008), in Yucatan, Mexico (1.8 to 3.1%) (Ortega-Pacheco, et al., 2007) in Coquimbo, Chile (3%) and Iringa, Tanzania (0%). This could be related with emotional reasons, lack of awareness of spay neuter programs, lack of knowledge about minimum age to spay neuter and others (Miller & Zawistowski, 2013) (Ortega-Pacheco, et al., 2007). Since 22% of the dogs are reported to roam, the consequence of not spay and neuter could be related with the increase of the population of dogs (including free roaming-dogs) in Quito. Undesirable mating could occur in the streets and when owners have dogs of both sexes without spay or neuter (Ortega-Pacheco, et al., 2007).

Next, 22% of study dogs were allowed to free-roam in public spaces. In rural areas, this proportion was higher (36%) compared to urban areas (11%). Also, households that allowed to free-roam at least one dog were 4.47 times higher in households with a low LCI. In 2011, the city officials of Quito expected a proportion of 32% owned dogs allowed to roam (80% of the 40% expected free-roaming dogs) which means a minor proportion but a higher number of dogs since the human dog ratio expected at that time was higher than the described in this study (Diario Hoy, 2010). Overall, the frequency of owned dogs allowed to freely roam in public spaces in Quito is similar (< 50%) to that reported in other studies in Yucatan (7%) (Ortega-Pacheco, et al., 2007), and lower than that in urban areas (50%) and rural areas (57%) in Coquimbo, Chile (Acosta-Jamett, et al., 2010), and in Antananarivo, Madagascar (79%) (Ratsitorahina, et al., 2009). Owned dogs allowed to roam free in public spaces could increase the problem of free-roaming dogs since free-roaming dogs need from owned dog sources to
counter the effects of high puppy mortality (Overgaauw & Van Knapen, 2000). Moreover, this owned free-roaming dog population could be overlapped with the free roaming dog population described in this study. Further, since in this study, the sterilized dog proportion was 14%, roaming un-sterilized dogs will be an excellent source to increase this problem (Overgaauw & Van Knapen, 2000). In addition, owned free-roaming dogs could be a health risk for their owners since in the streets they can be contaminated with zoonotic pathogens (Overgaauw & Van Knapen, 2000). Moreover, free roaming dogs could cause nuisances to neighbors or being victims of cruelty (Zaldumbide, 2011). Furthermore, OIE recommends a legislative instruments and education in Responsible Pet Ownership to prevent roam of owned dogs (World Organization for Animal Health, 2013).

Using linear regression, the human: owned-dog ratio in selected study households was 3.48:1. This finding differs from the described for Guayaquil by Beran & Frith in 1988 (7.1:1) and the reported for Ecuador by Pan American Health Organization in 2005 (7:1) and by the Ecuadorian Ministry of Public Health in 2013(8:1) (Beran & Frith, 1988) (Pan American Health Organization, 2005) (Ministerio de Salud Publica de Ecuador, 2013). In addition, the observed human: owned dog ratio is smaller than that assumed by City Officials in Quito in 2010 and 2013 (12:1) (Diario Hoy, 2010) (Jacome, 2013). This finding is significant because it shows evidence that more resources would be needed to control dog populations when the human:owned-dog ratio is 2.86 versus 12:1. One explanation for the observed difference between the human:owned-dog ratio estimated in this study (3.48:1) and that estimated by City Officials is that City Officials extrapolated data from published reports for the capital cities of Santiago (Chile) (UNIVERSIA Chile, n.d.), Buenos Aires (Argentina) (Atlas Ambiental de Buenos Aires, 2010) and other Latin American capitals. Ortega-Pacheco, et al., (2007) described
a similar human: dog ratio (3.4:1) within observed households in Merida, Yucatan. As well, Ratsitorahina, et al., (2009) described a human:owned dog ratio of 4.5:1 within the observed dogs in Antananarivo, Madagascar. However, the official page Atlas Ambiental de Buenos Aires (2010) published that according to a census developed in 2003, there was 1534 owned dogs for each 10000 people (human: owned dog ratio=6.5:1) (Atlas Ambiental de Buenos Aires, 2010). Finally, Acosta-Jamett, et al., (2010) described a human: dog ratio of 5.2:1 for Coquimbo and 6.2:1 for Ovalle, two cities in the region of Coquimbo, Chile.

4.1.2.2 Abundance of owned dogs in urban and rural parishes

Although the median human:owned-dog ratio in urban parishes (3.28:1) was slightly higher than in rural parishes (3.85:1), the proportion of dogs allowed to roam was three times higher (36%) in rural parishes compared to urban parishes (11%). This could add an explanation for the difference of human:free-roaming dog ratio between rural and urban parishes since rural studied parishes had a lower ratio (more dogs) than urban parishes.

The dog population density differences between urban and rural parishes could be related with human population densities (urban parishes are more dense than rural) since rural areas has less inhabitant/ha than urban areas.

4.2 Factors Associated with Households with a Low Pet Owner Responsibility Index

Using multivariable logistic regression analysis, the variables for number of dogs in the household and living condition index were associated with a PORI that is considered unacceptable. This is understandable since owners have to divide their time and recourses for the number of dogs that are kept. The AVMA in the “Guidelines for Responsible Pet Ownership” recommends to keep the number of pets that can be provided with an appropriate environment and care. (American Veterinary Medical Association, n.d.) Besides, the Ordinance 48 of Quito
encourage the citizens to keep only the number of animals that can be kept within the five freedoms of animal welfare (Municipio del Distrito Metropolitano de Quito, 2011).

It was also expected that householders with a higher income and education treat better their animals since their higher monetary capacity and access to knowledge. The World Society for the Protection of Animals (2013) includes ignorance and poverty as one of the causes for lack of animal welfare in an educational tool developed for Veterinary Medicine students (World Society for the Protection of Animals, 2013). The AVMA suggest that pet owners should recognize that companion animals require investment of time and money. Finally, it was expected that owners with a high LCI have more access to information about responsible pet ownership than those with low LCI.

Households with ≥ 2 dogs and with a low living condition index were 16.71 times more likely to have a low pet ownership responsibility index, compared to households with 1 dog only and with high living condition index. Within the observed households, data supports the logic assumption that a better wealth help to keep better the animals. However, if the number of animals increases, the recourses are distributed to more subjects and some of the pet ownership responsibility parameters could not been satisfied. It is important to notice the big increase of the odds ratio when ≥ 2 dogs and low living condition index are included in the model. The combination of a low level of wealth and a high number of dogs could be an indicator of bad conditions of the dogs in a household. For the same reason, areas with more dogs and low income should be the priority in the implementation of the Ordinance 48 in Quito.

4.3 Gastro-Intestinal Parasites in Owned Dogs

A total of 110 of 194 (57%) households with one or more dogs returned a dog fecal sample. This could be related with lack of interest in participate, veterinary care provided a short time before the survey or other factors. Thus, thirty-one of 110 (28%; 95% CI= 21, 37) study
households had one or more dogs classified as infected with one or more GI parasites. At the dog level, 39 of 154 (25%; 95% CI=19.33) observed dogs were infected with one or more GI parasites. Other prevalence studies in the North Andean Region have shown diverse results. Giraldo, et al., (2005) reported a prevalence of 22% within observed dogs in Quindio, Colombia. In addition, Ramírez-Barrios, et al., (2004) described a prevalence of 35.5 % in observed dogs under veterinary care. Nevertheless, results reported by Gingrich, et al., 2010 in Galapagos, Ecuador and Tortolero-Lou, et al., (2008) in La Vela, Venezuela described prevalence higher than 50%.

_Ancylostoma_ spp. was the most frequent parasite diagnosed in positive sampled and tested dogs (18/39) followed by _Toxocara canis_ (11/39). A similar finding was described in similar studies in the north Andean Region (Ramírez-Barrios, et al., 2004), (Tortolero-Lou, et al., 2008) (Gingrich, et al., 2010). _Trichuris vulpis_ was the second most observed parasite in dogs in Quindio, Colombia (Giraldo, et al., 2005)

Nevertheless, one of the limitations of this study was that the collection of samples was limited to the dry season in Quito. Ponce-Macotela, et al., (2005) described that the overall prevalence of GI parasites in a sample of dogs in Mexico D.F. during the warm season was higher than the prevalence in the cold season (Ponce-Macotela, et al., 2005). In addition, a higher prevalence of _Ancylostoma_ spp. during rainy seasons and as the temperature and humidity increased has been described (Hernández Merlo, et al., 2007) (Andresiuk, et al., 2007 ). However, Quito does not have meaningful variations of the temperature during the year. According to the National Institute of Meteorology and Hydrology or Ecuador (INAMHI), the mean temperature of Quito for year 2011 was 14.7 °C (58.5°F), with a minimum temperature of 10.2 °C (50.4 °F) and a Maximum of 22.3 °C (72.1 °F). On average, the minimum temperatures
were registered in March and November (9.8°C, 48.6°F) and the maximum in August (22.4 °C, 72.3°F). These temperatures are constant during the whole year. Nevertheless, on average, the dry season of the year in Ecuador goes from June to September which could be biasing the obtained results (INHAMI, 2011). To avoid this bias, more than one sample should be taken from each studied dog and sampling should be also developed during the rainy season.

Using logistic regression, no investigated factors were significantly associated with a positive diagnosis of gastrointestinal parasites in owned dogs. However, Tortolero-Lou, et al., 2008 described a higher prevalence of *Toxocara canis*, *Ancylostoma* spp and *Cystoisospora* spp in households with lowest socioeconomic conditions according to the Graffar method. The Graffar method classifies households assigning categories going from I for that households with the highest income to V for that households with the lowest income (Banco Central de Venezuela, 2007). The application of this method within the owners of 255 participant dogs showed that 29.80% of dogs with a positive diagnostic of GI parasites belonged to owners within the level III and the other 70.20% belonged to owners within the level IV and V of the Graff Scale (Tortolero-Lou, et al., 2008).
CHAPTER 5
LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Study Limitations

5.1.1 Objective one

Since funding and time available limitations to execute this study, only one count of free-roaming dogs was developed on each day and only one “recapture” count per section was performed. More counts are recommended for more precise results (Beck, 2002) (Greenwood & Robinson, 2006). In addition, only two of the 25 sections available on average in each parish were randomly selected. A sample size was calculated using the software available in the website http://www.winepi.net/sp/index.htm. First, The number of possible sections were calculated dividing the total longitude of public routes in Quito in Km by 5 Km (3.2 miles) that is the measure assumed for each section (8734.46 Km/5 Km) 1. Using this information 1746 possible sections as study population we used the standard deviation observed between the estimated average of observed dogs between the two studied sections (16) with 95% of confidence and 5% of absolute error. The calculated sample size was 39 sections. Only 32 of the 39 calculated sections were included in this study.

Likewise, 232 households were included for the owned dog demographic and pet ownership responsibly studies. For these studies, a sample size was calculated using Epi Info 7 (Center for the Disease Control and Prevention, Atlanta, GA, USA). Using as study unit the household, the official number of households reported by the City of Quito (634,611) was used as study population (Secretaria de Territorio Habitat y Vivienda, n.d.). We used the observed frequency of 86% of households with at least one dog with 5% of confidence limit. Also, we

1Personal communication, Walter Enriquez Ulloa, General Director of the Transit Control Agency of Quito.
plugged in the 32 clusters (blocks) that were randomly included in this study. The calculated sample size with 95% Confidence level was 192 households, 6 households for each one of the 32 selected clusters. Nevertheless, in this study each cluster (block) did not have the same amount of households since it depended on the zone (urban or rural), availability and will of the householders to participate in the study.

5.1.2 Objective two

The observation bias that exists when we estimated the Pet Owner Responsibility Index and Living Condition Index is not known since the study depends on the participant honesty when answering the questions.

5.1.3 Objective three

The prevalence of GI parasites was based on one sampling only. It is possible that more dogs could have been classified as infected if dogs had been sampled and tested two or more times. Besides, the study was developed during the dry season in Quito, which can reduce the number of *Ancylostoma* spp diagnosed since the parasite could be more prevalent during humid seasons (Hernández Merlo, et al., 2007).

Finally, 110 households with dogs participated in the study to describe the prevalence of dogs infected with parasites in Quito. Using as study unit the household, the official number of households reported by the City of Quito (634,611) was used as study population (Secretaria de Territorio Habitat y Vivienda, n.d.). We used the observed prevalence of 28% households with at least one dog infected with 10% of confidence limits. Also, we plugged in the 32 clusters that were randomly included in this study. The calculated sample size with 95% Confidence level was 96 households, 3 households for each one of the 32 selected clusters.
5.2 Conclusions

- The population estimate of free-roaming dogs was lower than that previously assumed by City officials (Human:free-roaming dog ratio=49:1 compared to 19:1)

- There was an inverse relationship between human:free-roaming dog ratio with poverty rates (β= -0.77; r = 0.77; R2 = 0.59; p<0.01).

- The population estimate of owned dogs is higher than that previously assumed by City officials (Human: Owned Dog Ratio= 3.48:1 compared to 12:1)

- Number of dogs and living conditions (poverty) are associated with a low Pet Ownership Responsibility Index

- Prevalence of households with dogs infected with GI parasites = 28%

- Anclylostoma spp was the most common GI parasite in owned dogs

- A local, canine demographic (baseline) data that City officials in Quito can use to prepare a budget to implement and evaluate the proposed pet ownership responsibility and dog population control policies have been produced.

- This study has created a relatively low cost and valid method to perform further evaluations in Quito.

5.3 Recommendations

- Since the population estimate for owned dogs was higher than the expected by the city officials, and 22% of these dogs were allowed to free-roam, it is important to continue with free high volume high quality spay neuter clinics to reach the highest number of owned dog possible.

- In addition, it is important to implement the educational policies established by Ordinance 48 such as educational programs for the community and the inclusion of contents related with pet ownership responsibility and animal welfare in the schools curricula (Municipio del Distrito Metropolitano de Quito, 2011).

- Also, the Trap Neuter Return program should be implemented with the community participation since according to the data presented, a proportion of free-roaming dogs have an owner.

- Additionally, these policies should be implemented prioritizing low income zones since poverty and low levels of wellness was associated with higher abundance of free-roaming dogs and low PORI
• If funding is limited, study results can be used to identify parishes with a low or high burden of free-roaming dogs, or households with a low or high pet ownership responsibility index.

• Further studies to determine the proportion of owned and un-owned free-roaming dogs are needed. Moreover, further studies to determine the burden of dogs infected with GI parasites in different times of the year are needed.

• Finally, it is important to repeat similar studies within the next few years to evaluate the policy implementation and after at least 5 years to evaluate if the policy objectives have been achieved.
Table A-1 Estimated population of free roaming dogs in the metropolitan area of Quito

<table>
<thead>
<tr>
<th>Zone</th>
<th>Parish</th>
<th>Section 1 (A)</th>
<th>Section 2 (B)</th>
<th>Average of dogs in Sections 1&amp;2 (C)</th>
<th>No. Sections in parish (D)</th>
<th>Total dogs in parish (E)</th>
<th>Official Human Pop’n in parish (F)</th>
<th>Estimated Human: Free-Roaming Dog Ratio in Parish</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n1</td>
<td>n2</td>
<td>m2</td>
<td>NS1</td>
<td>n1</td>
<td>n2</td>
<td>m2</td>
</tr>
<tr>
<td>URBAN</td>
<td>San Isidro del Inca</td>
<td>14</td>
<td>16</td>
<td>8</td>
<td>27</td>
<td>11</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>La Ecuatoriana</td>
<td>23</td>
<td>28</td>
<td>15</td>
<td>43</td>
<td>30</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Puengasí</td>
<td>9</td>
<td>13</td>
<td>3</td>
<td>34</td>
<td>14</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
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<td>3</td>
<td>0</td>
<td>15</td>
<td>16</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
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<td>14</td>
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<td>0</td>
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<td>31</td>
<td>10</td>
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<td>2</td>
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<tr>
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<td>Rumipamba</td>
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<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Mariscal</td>
<td>0</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>RURAL</td>
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<td>3</td>
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<td>6</td>
<td>2</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Calacalí</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>17</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>52</td>
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<td>18</td>
<td>6</td>
</tr>
<tr>
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<td>Chavézpamba</td>
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<td>8</td>
<td>4</td>
<td>15</td>
<td>5</td>
<td>2</td>
<td>2</td>
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<td>27</td>
<td>13</td>
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<td>7</td>
<td>4</td>
</tr>
<tr>
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<td>Yaruquí</td>
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<td>14</td>
<td>6</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Conocoto</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

n1= dogs observed in the first count ("captured" dogs)
n2= dogs observed in the second count.
m2= dogs observed in both counts ("recaptured"dogs)
NS(n)=[(n1+1)(n2+1)/(m2+1)−1]
Table A-2 Univariable logistic regression analysis for identification of factors associated with a low Pet Ownership Responsibility Index (PORI) (n = 194)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>High PORI (Score 6-8) N = 116 (100%)</th>
<th>Low PORI (Score 0-5) N = 78 (100%)</th>
<th>OR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban Parishes</td>
<td>Rumipamba</td>
<td>16 (100%)</td>
<td>2 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Mariscal Sucre</td>
<td>1 (100%)</td>
<td>0 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>La Magdalena</td>
<td>5 (100%)</td>
<td>3 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>La Ecuatoriana</td>
<td>9 (100%)</td>
<td>8 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Carcelén</td>
<td>6 (100%)</td>
<td>2 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>San Isidro del Inca</td>
<td>10 (100%)</td>
<td>9 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Puengasí</td>
<td>14 (100%)</td>
<td>2 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Solanda</td>
<td>16 (100%)</td>
<td>2 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Rural Parishes</td>
<td>La Merced</td>
<td>0 (100%)</td>
<td>2 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Nanegalito</td>
<td>1 (100%)</td>
<td>5 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Chvezpamba</td>
<td>0 (100%)</td>
<td>7 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Yaruquí</td>
<td>6 (100%)</td>
<td>15 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Conocoto</td>
<td>17 (100%)</td>
<td>3 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Calderón</td>
<td>6 (100%)</td>
<td>10 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Nayón</td>
<td>5 (100%)</td>
<td>1 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Calacalí</td>
<td>3 (100%)</td>
<td>9 (100%)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Zone</td>
<td>Urban</td>
<td>78 (67)</td>
<td>26 (33)</td>
<td>1.00</td>
<td>Reference 2.23-7.55</td>
<td>NA &lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>38 (33)</td>
<td>52 (67)</td>
<td>4.11</td>
<td>NA</td>
<td>ND</td>
</tr>
<tr>
<td>Parish Human Pop’n</td>
<td>High (≥ 41,170)</td>
<td>95 (82)</td>
<td>36 (46)</td>
<td>1.00</td>
<td>Reference 2.76-10.10</td>
<td>NA &lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Low (&lt; 41,170)</td>
<td>21 (18)</td>
<td>42 (54)</td>
<td>5.28</td>
<td>NA</td>
<td>ND</td>
</tr>
<tr>
<td>People in household</td>
<td>Low (1 to 4)</td>
<td>68 (60)</td>
<td>39 (51)</td>
<td>1.00</td>
<td>Reference 0.80-2.58</td>
<td>NA 0.24</td>
</tr>
<tr>
<td></td>
<td>High (5 to 12)</td>
<td>46 (40)</td>
<td>38 (49)</td>
<td>1.44</td>
<td>NA</td>
<td>ND</td>
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<tr>
<td>Dogs in household</td>
<td>1</td>
<td>79 (68)</td>
<td>35 (45)</td>
<td>1.00</td>
<td>Reference 1.45-4.75</td>
<td>NA &lt;0.01</td>
</tr>
<tr>
<td></td>
<td>≥2</td>
<td>37 (32)</td>
<td>43 (55)</td>
<td>2.62</td>
<td>NA</td>
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<tr>
<td>LCI*</td>
<td>High (6 to 10)</td>
<td>81 (75)</td>
<td>28 (36)</td>
<td>1.00</td>
<td>Reference 2.84-10.11</td>
<td>NA &lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Low (1 to 5)</td>
<td>27 (25)</td>
<td>50 (64)</td>
<td>5.36</td>
<td>NA</td>
<td>ND</td>
</tr>
</tbody>
</table>

*Living Condition Index
Table A-3 Univariable logistic regression analysis for factors associated with a positive diagnosis of gastro-intestinal (GI) parasites at the household level (n=110)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>GI parasites not observed N=79</th>
<th>GI parasites observed N=31</th>
<th>Odds ratio</th>
<th>95% CI*</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Parishes</td>
<td>Rumipamba</td>
<td>12</td>
<td>0</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Mariscal Sucre</td>
<td>1</td>
<td>0</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>La Magdalena</td>
<td>1</td>
<td>3</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Ecuatoriana</td>
<td>4</td>
<td>6</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Carcelén</td>
<td>4</td>
<td>1</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
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<td>1</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Puengásí</td>
<td>11</td>
<td>0</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Solanda</td>
<td>5</td>
<td>4</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
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<td>Rural Parishes</td>
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<td>ND</td>
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<td>ND</td>
</tr>
<tr>
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<td>Nanegalito</td>
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<td>Chavezpamba</td>
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<td>4</td>
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<td>ND</td>
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<tr>
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<td>ND</td>
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<td>ND</td>
</tr>
<tr>
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</tr>
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<td>16 (52)</td>
<td>1.00</td>
<td>Reference 0.71-3.81</td>
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<td>Urban</td>
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<td>15 (48)</td>
<td>1.65</td>
<td>Reference 0.21-1.18</td>
<td>NA 0.12</td>
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<tr>
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<td>14 (45)</td>
<td>1.00</td>
<td>Reference 0.21-1.18</td>
<td>NA 0.12</td>
</tr>
<tr>
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<td>High (≥41,170)</td>
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<td>0.50</td>
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<td>NA 0.29</td>
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<td>15 (48)</td>
<td>1.00</td>
<td>Reference 0.49-2.72</td>
<td>NA 0.83</td>
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<tr>
<td></td>
<td>2+</td>
<td>31 (39)</td>
<td>16 (52)</td>
<td>1.65</td>
<td>Reference 0.58-27.47</td>
<td>NA 0.23</td>
</tr>
<tr>
<td>People in household</td>
<td>Low (1 to 4)</td>
<td>47 (60)</td>
<td>17 (57)</td>
<td>1.00</td>
<td>Reference 0.49-2.72</td>
<td>NA 0.83</td>
</tr>
<tr>
<td></td>
<td>High (5 to 12)</td>
<td>31 (40)</td>
<td>13 (43)</td>
<td>1.16</td>
<td>Reference 0.58-27.47</td>
<td>NA 0.23</td>
</tr>
<tr>
<td>Dog(s) dewormed in the last 6 months</td>
<td>No</td>
<td>13 (16)</td>
<td>2 (6)</td>
<td>1.00</td>
<td>Reference 0.52-2.79</td>
<td>NA 0.83</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>66 (84)</td>
<td>29 (94)</td>
<td>2.86</td>
<td>Reference 0.90-4.86</td>
<td>NA 0.09</td>
</tr>
<tr>
<td>LCI**</td>
<td>High (6 to 10)</td>
<td>42 (55)</td>
<td>15 (50)</td>
<td>1.00</td>
<td>Reference 0.52-2.79</td>
<td>NA 0.83</td>
</tr>
<tr>
<td></td>
<td>Low (1 to 5)</td>
<td>35 (45)</td>
<td>15 (50)</td>
<td>1.2</td>
<td>Reference 0.90-4.86</td>
<td>NA 0.09</td>
</tr>
<tr>
<td>PORI***</td>
<td>High (6 to 8)</td>
<td>50 (63)</td>
<td>14 (45)</td>
<td>1.00</td>
<td>Reference 0.90-4.86</td>
<td>NA 0.09</td>
</tr>
<tr>
<td></td>
<td>Low (1 to 5)</td>
<td>29 (37)</td>
<td>17 (55)</td>
<td>2.09</td>
<td>Reference 0.90-4.86</td>
<td>NA 0.09</td>
</tr>
</tbody>
</table>

*95% confidence interval
**Living condition index
*** Pet owner responsibility index
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BIOGRAPHICAL SKETCH

Since 2004, Jaime Grijalva Rosero has been involved in the discussion and development of policies related to animal welfare and public health in his country, Ecuador. As student of the College of Veterinary Medicine at the University of San Francisco de Quito, he participated in the technical committee that elaborated the rule to apply the Ordinance 128 in the city of Quito. Between 2007 and 2008, during his last year in veterinary school, he was part of the process to advocate for the inclusion of animal welfare in the new Constitution of Ecuador. In 2008, he was part of the national committee that worked with the Ministry of Health and the Ministry of Agriculture of Ecuador and the Pan American Health Organization, to elaborate the project for The National Rule for Dog Responsible Ownership. In 2009 he graduated from the College of Veterinary Medicine at University of San Francisco de Quito and later on that year, he was invited to participate as advisor of the Health Commission of the City of Quito in the formulation of a new ordinance to promote animal welfare and public health in the city. In 2010, he started to volunteer with Project HEAL, a group of students and faculty from the College of Veterinary Medicine at the University of that travel each year to Ecuador to give preventive veterinary care in poor communities of Quito. After the Ordinance approval, he participated in the beginning of the implementation of the High Quality High Volume Spay Neuter Clinics and was part of the first team of forensic veterinarians in Quito. In 2011 he was awarded with the SENESCYT scholarship to start graduate school in the College Of Veterinary at University of Florida. At UF, Jaime’s major was veterinary medical sciences focusing his coursework and research in epidemiology and shelter medicine graduating with a Master of Science in Veterinary Medical Sciences in May 2014.