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ENVIRONMENTAL IMPACTS CAUSED BY THEFECES OF THE *Canis lupus familiaris*IN SAN ANTONIO DE PICHINCHA PARISH –ECUADOR

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SUMMARY
In order to ascertain the negative effects produced in the environment of San Antonio de Pichincha Parish due to the uncontrolled amount of dog feces on public roads, the population density of stray dogs found on the roads was estimated through direct observation of 6 streets within the parish, 3 are locatedin urban areas and 3 in peripheral areas. With a simple methodology and low cost, taking into account the presence of dogs and keeping a photographic record of each dog, it was determined that the total density of stray dogs is 880 dogs per km^2, in addition, dogs were found in 100% of the area, both urban and peripheral. The population density was established in the different streets sampled, thus verifying a high prevalence of stray dogs in the peripheral areas of the parish, with a density of 586 dogs per km2.Furthermore, a study was made to ascertain the impact of canids in connection with the feces they produce through a weekly count, both the amount they produce per day and the number of bowel movements per day as well as the counting and weighing of dog feces found in the sidewalks of the streets chosen to estimate of population density.
Key Words: Stray dogs, density, feces, environment, impact

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INTRODUCTION
The dog, *Canis lupus familiaris*, is one of the domestic animals that has the most contact with humans [1]. Seventy-fivepercent (75%) of existing dogs are estimated notto be purebred and neither are they crosses of races having pedigree [2].
It is stated that customarily, stray dogs in a high percentage, belong or belonged to someone, but they are allowed to wander freely [1, 3].
In the ethological field, dogs are considered animals that take part of a herd to survive [4]. Notwithstanding, the social structure of stray dogs does not have the same dynamics as that of urban dogs; as Kerkhove [5] shows, the structures of the social groups of stray dogs are different fromthat of dogs in general, since the former lack structured groups and in the course of time they form amorphous associations, recruiting more street partners as a social method for their survival, where the hierarchy granted by the alpha male qualities prevail over time [5].
In Ecuador there is a large number of stray dogs, which is a problem that directly affects public health, the ecosystem and the embellishment of cities [6]. The statistics carried out by the National Institute of Statistics and Geography (Inegi–*Spanish Acronyms*), in Mexico, reveal that the annual population growth rate of dogs is 20%, while the rate of human reproduction does not even approach 1%, thus indicating that the growth of these animals is 19% more than the human population growth [7].

Studies proposed by international universities such as UNAM, Mexico, show that the presence of dog feces in the streets cause serious ailments to human beings, because if dog feces impact on their health, zoonotic diseases will pose greater threats in the population, both human and animal; dogs' owners have an erroneous belief that "only fresh and odorous feces maypose a health risk", but the truth is that waste is consumed over time due to its exposure to the sun and other environmental factors, until they become bioparticles; subsequently the waste remains in the environment circulating in the air, which are breathed by people and they can easily adhere to various foods sold in the streets [8], or can disintegrate, generating pollutants in the earth, hence originating the ideal means for the proliferation and exposure of parasites, since a large part of their eggs remain on land for a long time, causing not only oral infection to people but also to other animals [7].

In general, more than 140 diseases transmitted by the contact with dogs, mainly stray dogs, have been counted [7]. The fecal matter of the dog in the street can potentially transmit parasites that cause Toxocariasis, Ancylostoma, *Trichuris*, Cenurosis, Ascaridiasis, Leptospirosis and other diseases that may lead to death [8];in addition tocausingharm to the digestive system and discomfort in the respiratory system, these parasites are even likely to result inabortions in pregnant women [9], a clear example of serious diseases caused by these parasites is the total loss of vision produced by the parasite *Toxacara canis* [10].

This is a problem that leads to consider several factors, because as discussed, dog feces in the environment includes negative impacts in the socio-environmental and health areas [11], therefore, the proper management of the dog population is a subject of interest for several public entities, which have developed some techniques and methods for a proper management [12].The purpose of this study is to learn the degree of negative impacs that stray dogs and their waste have on the community, through a methodology that allows to estimate the population density of these animals in San Antonio de Pichincha as well as the estimated amount of stools in relation to the number of dogs found, with the purpose of contributing to a real knowledge of the urban fauna in the area and the seriousness of the current situation caused by the organic waste of these dogs. This study aims to perform an analysis through direct observation, establishing more accurately the number of non-domestic dogs in the urban area and part of the peripheral area, and the amount of feces they are capable of evacuating according to the size of the animal in the San Antonio de Pichincha Parish.

MATERIALS AND METHODOLOGY

The data collection was carried out betweenApril 10 and 16, 2017 in the San Antonio de Pichincha Parish, Pichincha Province, Quito Canton, which has rural and urban areas [13].Six (6) streets were selected for sampling in this study, three are located around the parish and three crosses it. To obtain the information, the data collection was carried out through direct observation through linear transects [14] in the urban area and part of the peripheral area of San Antonio de Pichincha Parish, in streets 13 de Junio, Pucará, Lulumbamba, Museo Solar, Equinoccial and Manuel Córdova Galarza, each street being a sampling unit. Observations were made at an approximate distance of 5m on each side of the selected streets. Once the dogs were recorded as well as their respective perpendicular distance of observation in each transect, we proceeded to analyze them with the King's variable width transect methodology [15], to estimate the population density, in which the total number of individuals, the average of the perpendicular distance and the total length of each transect were related; the population density of each transect was compared in the peripheral and the urban areas and one in the entire sampled area. For comparison purposesbetween areas, 6 transects were divided into 3, corresponding to the peripheral area and 3 to the urban area, thus adding their lengths and grouping the observations with their respective perpendicular distances (Figure 1).

A weekly count was made to learn the impact of canids in relation to the feces they evacuate, both the amount they produce per day and the number of bowel movements per day. The data of 11 domestic dogs were stored in Excel tables, where the different sizes of the canids (large, medium and small) were taken into consideration.Furthermore, on November 18, 2017 for approximately 8 hours, each fecal sample found in the sidewalks of each selected street, where the observation of the canids was recorded previously,was weighed in gramsby means of the sample collection and weighing procedure, using 3 manual, calibrated weights, and 9" x 12" plastic bags; prior to the collection, the current physical state of the animal waste, namely, the color and appearance was taken into account. A total of 3 groups were distributed per street, they were given a map, highlighting the routes they had to travel and sample. Each volunteer was equipped with gloves and a mask to safeguard their health. Once the sample was weighed, it was separated into a larger plastic bag for later disposal in garbage cans found in each sidewalk. Finally, the recorded data were separated per streets and added to the original database, where an estimate of the amount of dog feces to be produced in one year was obtained according to the estimated number of dogs found, both domestic and non-domestic.

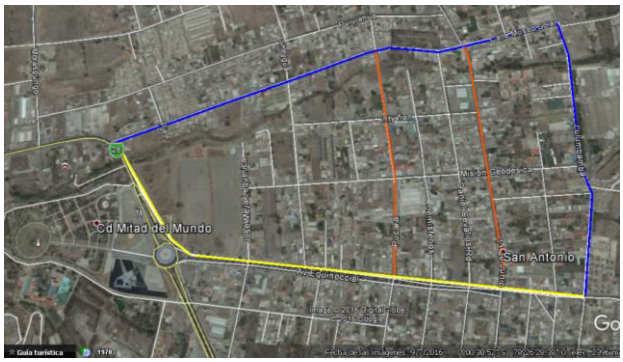

Fig. 1Area of study, San Antonio de Pichincha

RESULTS

The results show that stray dogs can be found in 100% of the sampled area, being the peripheral areas the places with the highest concentration of dogs (Figure 2).

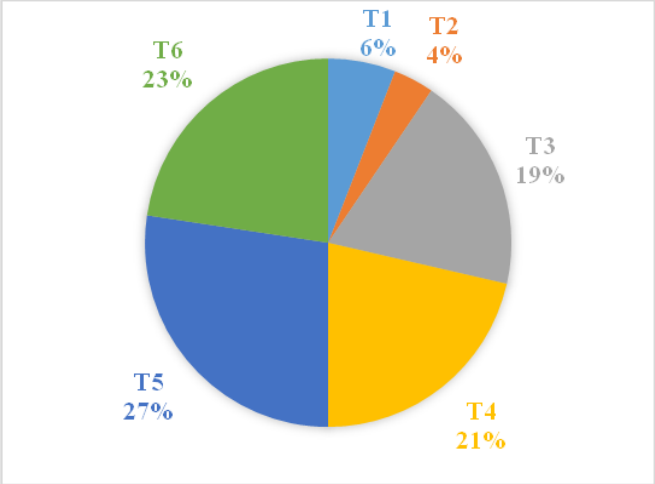

Fig. 2 Distribution of stray dogs per transect

The values were obtained through direct observation and the density values were determined through the King method (variable width transect D=n/2*x*L).

It can be observed that the transect with the highest density was found on Equinoccial street, while the one with the lowest density was the transect on 13 de Junio street (Table 1, 2).

Table 1. Total Population Densityof non-domestic dogs

Area	Length(km)	# of Observations	Density (ind/km2)
Total	7,59	84	880

Table 2. Population density of dogs in each street (transect)

Street name (transect)	Length. Km (L)	No. Observations(n)	Density (ind/km2)
13 de Junio	1.05	5	14
Pucará	1	3	38
Museo Solar	1.45	18	72
Lulumbamba	1.14	16	52
Manuel Córdova Galarza	1.5	23	93
Equinoccial	1.45	19	107

The values were obtained through direct observation and the density values were determined through the King method (variable width transect D=n/2*x*L). There is a notable difference between the urban area (Pucará, June 13 and Equinoccial streets) and the peripheral area (Museo Solar, Lulumbamba and Manuel Córdova Galarza streets), as the urban area has the lowest density of dogs (Table 3).

Table 3. Comparison of the canids' population densitybetween the urban and the peripheral areas

Area	Length(km)	# ofObservations	Density (ind/km^2)
Urban	3.55	31	295
Peripheral	4.04	53	586

Although no marked difference was found between dogs of different breeds and the amount of feces produced in one day, mainly among medium and big dogs, the biggestdogs were those that evacuated a higher amount of feces in comparison with the dogs of small race. On the other hand, the amount of fecesper dog showedno significant differences amongthe dogs (Table 4).

Table 4. Comparison of the dog size and the amount of dog feces produced

Dog Size	#Feces per day	Times the dog defecated
Small	190	65
Medium	206	61
Big	208	60

Dogs of different breeds and sizes are estimated to generate a disproportionate number of feces per week, according to the high number of stools calculated per week, taking into account an estimate of the average number of times they perform their bowel movements per day (Table 5).

The dogs with the largest breed are those that showed a higher average daily fecal samples compared to dogs of medium and small breeds, taking into account that they were fedon a daily basis and in proportional amounts (Table 5).

Table 5. Average of total dog feces

Size of the dog	Average of daily dog feces	Average of weekly dog feces	#of weekly dog feces
medium	3,857142857	27	23760
small	3,571428571	25	22000
big	8,571428571	60	52800
TOTAL	**5,333333333**	**37,3333333**	**32853,33333**

There was a noticeable difference between the urban area and the peripheral area, being the urban area the one that showed a greater quantity of dog feces in both crowded and little traveled streets,and a greater weight of all the fecal samples found, which provided a significant total weight in kilograms of heavy dog feces along all the selected streets (Table 6).

Table 6. Total of fecal samples found in the street (transect)

	Name of Street	#Feces	Total weight (kg)
Peripheral area	Lulumbamba	460	11100
	Museo Solar	1307	9525
	Manuel Córdova G.	110	956
	Subtotal	1877	21581
Urban area	13 de Junio	216	20970
	Equinoccial	2139	23214
	Pucará	340	6050
	Subtotal	2695	50234
	TOTAL	**4572**	**71, 815**

DISCUSSION

The existence of stray dogs can be explained by the union of several factors such as irresponsible pet ownership, manifested in allowing their free and uncontrolled movement, resulting in an unwanted reproduction of dogs [16]. There is no real data on the number of stray dogs in Quito, sinceno thorough study has taken place to estímate how many dogs wander in the streets of the city [17].

The methodology employed in this research was able to carry out a field study in San Antonio de Pichincha Parish to estimate the population of stray dogs; previous works estimate the existence of 221 to 265 non-domesticdogs per km^2[17], a figure that is lower than that determined by our study, which affirms an approximate existence of 880 stray dogs per km^2, possibly this is due to the difference in the method applied by Cadena's study [17] where the sampling unit comprises several municipal markets of the Metropolitan District of Quito, Ecuador, where several visits were carried out to each selected sampling unit and means were calculated to determine the population densities of non-domestic dogs.

In regard to the quantity of stools found and of which their approximate weight was recorded, it is easy to conclude that there are highly negative environmental repercussions, since the dogs' wastes that were found, were mostly in a decomposition and deterioration state, namely, the bioparticles generated by the stools are being breathed by the entire community of San Antonio de Pichincha and are part of the environment of the area, a fact of utmost sanitary importance since studies conducted worldwide, in cities mainly in Latin America, such as Chile , Mexico and Ecuador (Gingrich *et. al.* [18], Luzio*et. al.* [19]) and in European cities of countries such as Russia and Spain [20, 21], state that the sampled areas of each publication were contaminated with parasitic forms of zoonotic importance that come in contact with the population because dog feces contain eggs of the parasites, in different stages of development, thus bringing about potential risks of contaminación and of infectious and zoonotic diseases [21].

Using data from Delgado's study [21], which states that a dog evacuates a daily amount of approximately 500 g of dog feces and uponrelating it to the data collected by this study obtained throughthe calculation of the total population density of dogs in the area, it is possible to say, that nearly 440 kg of dog stools are being produced perday in the Parish of San Antonio de Pichincha, without taking into account descriptive characteristics of the dog such as its size, breed and amount of ingested food; a fact that demonstrates once again that the irresponsible possession of dogs, in addition to increasing the number of stray dogs, enormously increases the probability of contracting parasitic diseases causedby microorganisms such as *Toxocara canis*, the same that was found and described in most microbiological studies such as those carried out by Gingrich *et al*. [18] and Luzio *et al*. [19], and in studies mentioned by Delgado [21] in Ecuador, in two regions of the country: the city of Huaquillas (el Oro) and the area of Carapungo (Quito); where the prevalence of the parasite was more than 50%, in a smaller number of dogs found in comparison with the study performed;these data allow to affirm that the presence of zoonotic gastrointestinal parasites will be much greater in the San Antonio de Pichincha Parish because the proportion of dogs found in this area in comparison with the 291 dogs of the area of Los Angeles, Chile, was approximately 90 in 90 dogs.

All scientific articles focused on the work with dog feces in various countries of the world, such as those mentioned in this study, have submitted, without exception, results that show that although dogs are domestic, the feces they produce are contaminated by some parasitic form, as proven by Gorman *et. al.* [22] whose work showed that one third of the 582 healthy dogs examined, namely, 30.24%, had infectious microorganisms in their waste; these values aresimilar to other studies around the world; for this reason, although in this case a microbiological study of each waste found has not been carried out, it is possible to assert and affirm that the excrements in all the found conditions contained parasites of zoonotic importance, which over time affects in a highly negative way upon the population of San Antonio de Pichincha, because by estimating the amount of stools that were obtained forthe purposes of this article, it will be possible to find about 32,853 stools per week, in which each stool will have the presence of infectious microbiological organisms, being fecal waste a determinant factor of zoonotic parasites contamination [23] in this study area, where it is shown that the areas with the highest prevalence of parasites are those with human concentrations such as tourism, recreational and housing places [23].

Although the largest population of dogs in San Antonio de Pichincha Parish was found in the peripheral area, the greatest amount of bowel movement occurred in the urban area, as explained by Vélez-Hernández *et. al*. [23], inthe case of domestic dogs, the owners who take their pets for a walk do not collect, nor do they discard the droppings dogs produce, in addition, as evidenced in the sampling areas, the employees of garbagecollection companies, do not perform the cleaning of this type of organic waste in the sidewalks, so the excrement will decompose in these highly populated areas, causingcontamination by parasites to be much more likely than in other areas of study. In the case of non-domestic dogs, we must take into account their territorialist behavior, because when dogs' bowel movementoccur, they mark their territory due to anal secretions expelled voluntarily by them, which will intensify due to the fact that this species scrapes the earth where itevacuated, thus encouraging other dogs to evacuatein the same land [23], this was verified because the greatest concentration of feces was found in places with soil or grass, in this case parterresas well asfloral and bushy decorations found in the sidewalks of some streets, mainly the most crowded avenue, Calle Equinoccial.

CONCLUSIONS AND RECOMMENDATIONS

To conclude, the study area has a very strong environmental problem in terms of the factor described as fecal wasteproduced by domestic and non-domestic dogs, so it is imperativefor both the authorities and the dwellers of the areato carry out some control concerning the responsible possession of pets and waste produced by these animals, as they pose an ongoing risk to their health, which can be affected by a numberof parasites with zoonotic potential.

It could be affirmed that once the control over the possession of this animal in the study area has been carried out, not only the population's health will improve, but also the aesthetics of this tourist area, which gives rise to an increase in the economic sector, sincetouristsmay visit, not only the most referenced and emblematic places, but also remote and little crowded ones.

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