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Original Article

Evaluating the movement of free-roaming dogs using georeferencing and the photographic capture-recapture method

Avaliação da movimentação de cães soltos nas ruas por meio de captura-recaptura fotográfica e georeferenciamento

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ABSTRACT

This work proposes to use the photographic capture-recapture technique associated with the GPS positioning (Global Positioning System) to estimate the population and to evaluate the movement of free-roaming dogs in public spaces. An observer on a motorcycle traveled all the streets of Jardim Ipanema and part of Dona Amelia neighborhoods in Araçatuba, SP, totaling a 1.3 Km² area covered on two days, with a one-week interval between them. The free-roaming dogs were photographed and their geographical locations were determined using GPS, and this geographic record was then used to estimate the spatial and temporal distribution of free-roaming dogs in the neighborhood. A total of 77 dogs were found on the streets, 21 of which were photographed more than once (photo-recaptured). The number of free-roaming dogs was estimated from the capture rate using a linear regression model, revealing a population of 76 animals, corresponding to 7.5% of the canine population living in the neighborhood. The results indicated a higher concentration of free-roaming dogs in a certain neighborhood region that has unpaved streets and most houses had no walls. Furthermore, the highest number of dogs was observed early in the day (between 7 and 9 a.m.) and that, among the dogs observed moving through the neighborhood streets, the longest distance traveled was 520m. It is concluded that the proposed methodology is an efficient tool and can be used when planning public health activities.

Palavras-chave:

Cães de rua

Captura fotográfica

Estimativa populacional

Deslocamento

GPS

RESUMO

Este trabalho propõe o emprego da técnica de captura-recaptura fotográfica associada ao registro de posicionamento geográfico obtido por GPS (Global Positioning System) para estimar a população e avaliar a movimentação de cães encontrados soltos em espaços públicos. Utilizando-se uma motocicleta e um observador, todas as ruas do bairro Jardim Ipanema e parte do Bairro Dona Amélia, de Araçatuba-SP, com área total de 1,3 Km2, foram percorridas durante dois dias, com uma semana de intervalo entre eles. Os cães encontrados soltos foram fotografados e suas localizações geográficas foram determinadas por meio de GPS. Com este registro geográficos foi possível estimar a concentração espacial e temporal dos mesmos nas ruas do bairro. Foram observados 77 cães soltos nas ruas, sendo que 21 destes foram fotografados mais de uma vez (foto-recapturados). A estimativa do número de cães soltos, realizada a partir da taxa de captura, por meio de um modelo linear de regressão, revelou uma população de 76 animais, correspondendo a 7,5% da população canina domiciliada do bairro. A metodologia permitiu observar que houve maior

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concentração de cães sem supervisão encontrados nas ruas em determinada região do bairro, onde as ruas eram não pavimentadas e a maioria das casas não possuía muros; que o maior número de cães foi observado nos horários do início do dia (7 a 9 horas) e que, dentre os cães que se deslocaram pelas ruas do bairro, a maior distância percorrida foi de 520m. A metodologia proposta é uma ferramenta eficiente e pode ser utilizada em planejamento de atividades de saúde pública.

INTRODUCTION

Although healthy, the close interaction between humans and domestic animals may result in public health risks and environmental problems (SOTO et al., 2006). Dogs are more numerous and, therefore, more capable of disseminating zoonoses, particularly when not adequately supervised while, sometimes, their aggressive behavior can cause great economic losses (BELOTTO, 2004).

In order to prevent risks to the population, when adopting control measures, dogs are classified according to the degree of supervision and restriction: domiciliary or controlled, when they have restricted access to the streets; family or half-domiciliary, when they have free access to the streets; community, neighborhood or free-roaming, when they have no owner or shelter; and, wild or feral dogs, when humans have no control over them (BECK, 1975; REICHMANN et al., 2000; WHO/WSPA, 1990).

The planning and monitoring strategies for the control and welfare of canine populations in urban areas, the management of risks associated with their presence, such as bites and other aggressive behaviors, the quantifying of zoonoses and other dog-related diseases require an appropriate estimate of the number and characteristics of the free-roaming dog populations (BELO et al., 2015; SHIMOZAKO et al., 2018). However, obtaining information on the number of animals living on the streets is not so simple and can result in distorted estimates as well as inadequate planning of measures to prevent and control dog-borne zoonoses (LIMA JUNIOR, 1999; MATOS et al., 2002).

Among the various methods used to estimate this population (BELO et al., 2015), the photographic capture-recapture method, which was initially used for mammals, consists of photographing individuals within a population and photographing them again after a predetermined time interval. The animal is individually identified by its natural marks and, thus, the photo-capture history is analyzed through the estimated probability of being captured at least once (DIAS et al., 2013; SHIMOZAKO; COUTO, 2010; SILVER et al., 2004; SRBEK-ARAUJO; CHIARELLO, 2007).

Using the photographic capture-recapture method is efficient for estimating the abundance and population density of free-roaming dogs, those living in the public roads without supervision while the geographical positioning obtained by a GPS (Global Positioning System) allows determining the animal exact location when the photograph was taken (DIAS et al., 2013, KOTVISKI; BURGARD, 2014) and how these spaces are used (GUILLOUX et al., 2018; LIMA JUNIOR, 1999; SHIMOZAKO; COUTO, 2010) to adopt measures for controlling zoonoses such as rabies (WHO, 1987), and managing the canine populations (ICAM, 2015).

Thus, the objective of this study is to answer a few questions regarding the stray dog populations, such as places and hours of higher animal concentration, the distance they travel based on the locals where they were photographed, and the ratio between the free roaming dog population and the neighborhood dog population. In order to do so, it is proposed to use the photographic capture-recapture technique associated with the GPS positioning record to evaluate the movement of dogs found in public spaces.

MATERIAL AND METHODS

The study area included two neighborhoods located in the urban area of Araçatuba, SP, totaling 1.3 km^2 and a population of 5,211 inhabitants distributed in 1,829 households (IBGE, 2010). These neighborhoods were chosen for convenience since the Zoonoses Control Center (CCZ) had previously seized the highest number of street dogs on these public streets between 2003 and 2007. The study was conducted in March 2011.

The studied neighborhoods (Jardim Ipanema and part of Dona Amélia) are located in the northern part of the city, surrounded by avenues with heavy traffic (Av. 2 de Dezembro, Av. Prestes Maia, and Av. José Ferreira Batista) and a walled small urban forest where the Municipal Zoo is located (Figure 1). The altitude is 400m and the streets are flat, with few open green areas and some empty land either between houses or covering entire blocks. About 70% of the streets are paved, facilitating the access and displacement of the motorcycle used for photographing the free-roaming dogs, thus increasing the chances of photographing a large number of animals.

The domestic canine population in the study area was estimated based on the (1: 5.1) dog street inhabitant ratio calculated considering the number of dogs in the municipality obtained in the 2010 census of the CCZ of Araçatuba (unpublished data) and the human population given by the IBGE (2010).

To increase the chances of photographing all free-roaming dog population, an observer/photographer traveled all the streets of the neighborhoods with a motorcycle at approximately 20 km/h, taking pictures of

free-roaming dogs all over the area without having to get off the vehicle every time a dog was observed. The photos were taken from approximately 6 meters, a distance considered safe for people approaching foreign animals (FOX et al., 1975).

Figure 1 – Map of the urban area of Araçatuba, SP, Brazil, emphasizing the Ipanema neighborhood and part of the Jd. Dona Amélia where the movement of free-roaming dogs was evaluated in March 2011.

Source: Map built using the Qgis 2.18.28 software.

The area traveled was covered twice during two days with a week interval between them from 7 a.m. to 5 p.m., considering that dogs are generally more active in the cooler times of the day, usually early morning and late afternoon (BEAVER, 2009; DIAS et al., 2013). To observe the dynamics of dogs on the streets throughout the day, the neighborhood was covered six times, totaling 18 km. The displacement was performed in such a way that the streets were traversed in the same sequence and in the same time period (90 min). On the first day, the routes were made in odd hours, starting at 7 a.m. and on the second day in even hours, starting at 8 a.m.

A Reflex Digital CANON® EOS 450D 12Mp was used to photograph all the free-roaming dogs found in the neighborhood unsupervised. At each meeting, the same animal was photographed 03 to 05 times in different positions to facilitate recognizing them through their natural or other marks that may help to identify them later. Each photograph was labeled with a sequential number of the photographed animal, followed by date and time that the photograph was taken. The observer/photographer analyzed the captures and recaptures to ensure that the photos showing the characteristics and anatomical peculiarities of each dog were not lost during the analysis (SHIMOZAKO; COUTO, 2010).

The location on the streets where the dogs were observed and photographed was recorded by a GPS Data Longer Waypoints I-goTU® GT-120 that used the SIRGAS2000 (Geographic Reference System for the Americas) geographical coordinates as a reference. These data were plotted on a map showing the routes traveled, the times, distances and meeting locations with their respective photos, using the GPS I-goTU® software with a 3m precision. Therefore, a straight-line measurement between at least two locations allowed to calculate the distance traveled by the dogs that were photographed at different sites.

To evaluate the concentration of dogs at specific points in the study area, the map was divided into nine geographical regions of 25 hectares (500 x 500m), using the official city map on a 1: 12,000 scale and considering that half-domiciliary dogs travel up to 500m from their homes (WANDELER et al., 1993).

The schedules and the neighborhood regions where the dogs were photographed were compared by the chi-square test, at 5% significance level. Statistical tests were performed in the BioEstat 5.3 software (AYRES et al., 2007). The total population of free roaming dogs was estimated from the capture rate, using a linear regression model (WHO/WSPA, 1990).

RESULTS AND DISCUSSION

The 120 photographs obtained allowed to identify 77 unsupervised dogs that were observed in public spaces in the studied districts. The rest of the photos (43/120) corresponded to 21 dogs photographed more than once during the two study days. It was possible to determine the dog gender in 72.7% (56/77) of the photographed animals, of which 67.9% (38/56) were males compared to 32.1% (18/56) of females, as it has already been reported by other authors in similar studies (DANIELS, 1983; DIAS et al., 2013; SALLUM; RIBAS; MASSAD, 2015;

WANDELER et al., 1993). In contrast to our results, the national literature reports only one study conducted at the Ivarana Campus in Ponta Grossa, PR, Brazil, in which a largest number of female stray dogs was observed in two distinct periods (KOTVISKI; BURGARD, 2014). No specific research was found to explain the higher number of male free-roaming dogs, however, Wandeler et al. (1993) reviewed data on canine populations in urban and rural areas in Nepal, Sri Lanka, Switzerland, and Tunisia and reported that male dogs tend to travel longer distances than females to search for food, interactions with other dogs, and with females in estrus. Shimozako; Couto (2010) also reported similar results in the municipalities of Ibiúna, Guarulhos and São Paulo.

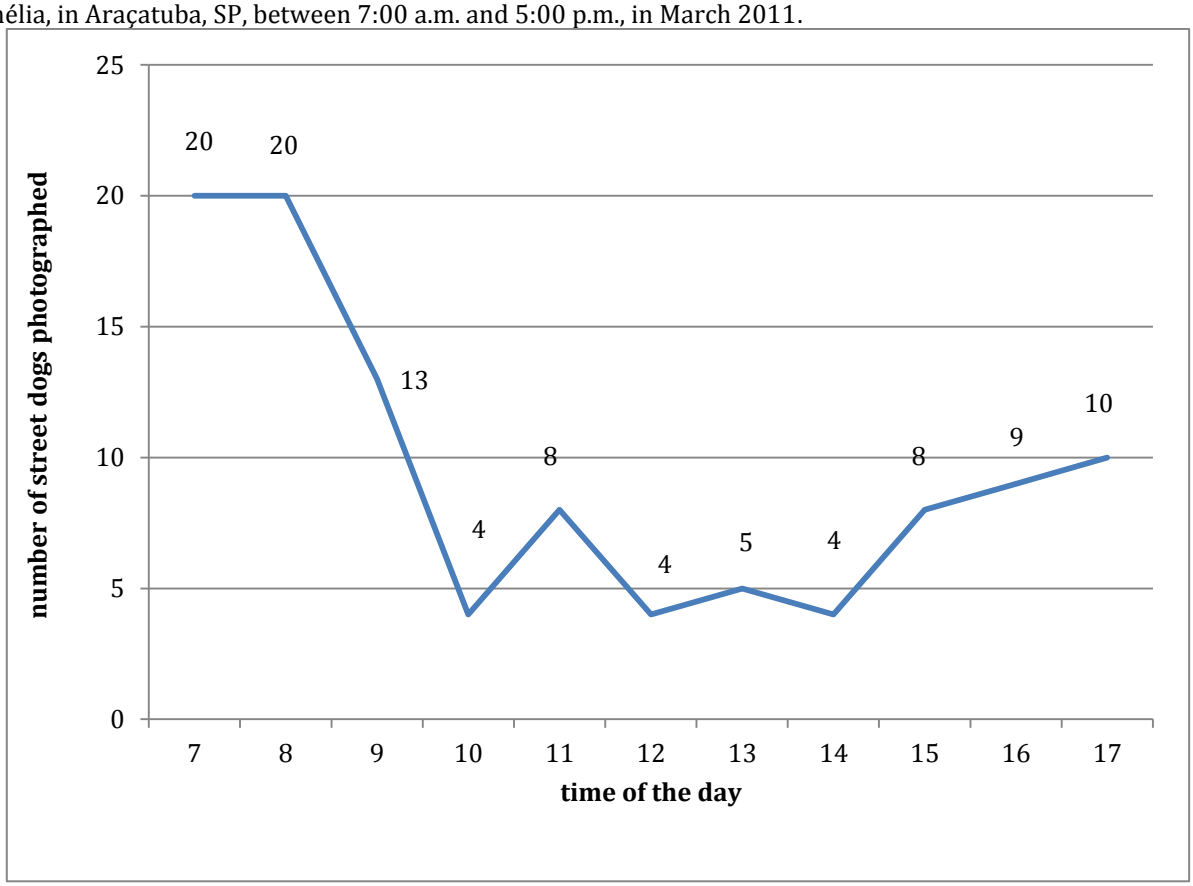
Of the 21 photo-recaptured dogs, nine (42.9%) did not travel any distance during the study period and were assumed as probably belonging to the residences in the area, since no evidence to determine permanence such as food, shelter or sex partners was identified (FOX et al., 1975). Other studies also describe the fact that domiciliary dogs with unrestricted access to the street may go out in the mornings to extend their territory and to interact with other animals (MATOS et al., 2002; SHIMOZAKO; COUTO, 2010).

The several photographs showing identical characteristics, when observed only from a single angle, were useful since they increased the chance of correct identification of these animals (SHIMOZAKO; COUTO, 2010).

The photographic capture-recapture method conducted in two research days with six replicates in each of them is indicated for dimensioning the street dog population, corroborating the recommendations of Wandeler et al. (1993) and Sallum; Ribas; Massad (2015) stating that observations should be carried out in at least two periods. Similarly, six observations carried out in three days in a neighborhood of Ibiúna, SP, resulted in 65 street dogs (SHIMOZAKO; COUTO, 2010) while two observations on five different occasions in the University of São Paulo (USP) Campus indicated 87 street dogs (DIAS et al., 2013).

The number of street dogs photographed on the streets was significantly different at different times of the day ($p < 0.05$) (Figure 2), with the highest number being recorded in the first hours of the day (7 and 8 a.m.).

Figure 2 – Number of free-roaming dogs photographed, unsupervised, in the Ipanema neighborhood and part of the Jd. Dona Amélia, in Araçatuba, SP, between 7:00 a.m. and 5:00 p.m., in March 2011.



The times during which the highest number of free-roaming dogs was observed corroborates the results of other authors (DANIELS; BEKOFF, 1989; DIAS et al., 2013; FONT, 1987). The close coexistence with humans may explain certain behaviors of the dog so that the schedules of some activities performed by the animal may coincide with those performed by the man (BEAVER, 2009; FOX et al., 1975), thus explaining the fact that few dogs were observed in the streets between 10 a.m. and 3 p.m. This fact suggests that most of the

dogs that were on the streets earlier in the day returned to their homes at lunchtime, where their owners also meet, a characteristic of semi-domiciliary dogs (WHO/WSPA, 1990).

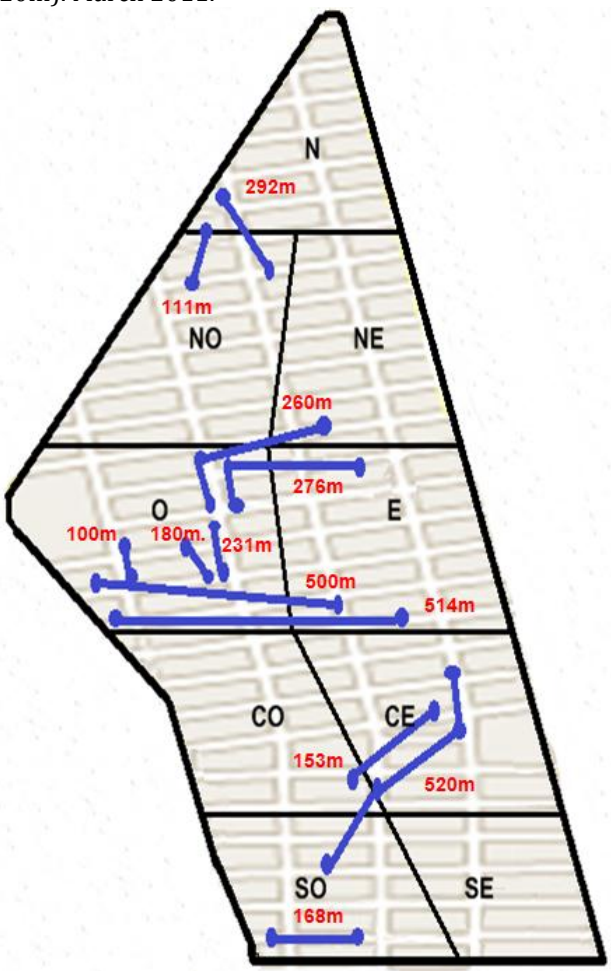
According to the population size estimation model from the capture rate (WHO/WSPA, 1990), the animals photographed for the first time were considered as "tagged and removed from the population". When correlating the number of dogs previously photographed with those photographed for the first time in each period, the population of free-roaming dogs in the study area was estimated by a linear regression ($y = -0.2059x + 15.684$; $R^2 = 0.5468$) as being 76 dogs (58.5/Km^2), like that observed through the photographs (77 dogs). However, this number was lower than the population density of 232 stray dogs per km^2 reported by Beck (1975) and was close to the 73.9 free-roaming dogs/Km^2 observed by Shimozako; Couto (2010).

The domiciliary dog:inhabitant ratio in the neighborhood was 1:5.1 according to the human population informed by the IBGE and the domiciliary canine population obtained via the CCZ census in the city. Considering that the total population in the study area was 1022 dogs, the number of animals found without supervision in public spaces corresponded to 7.5% of the domiciliary canine population. Wandeler et al. (1993) reviewed the literature on dog ecology and described several studies showing that the percentage of street animals ranges from 7.0% to 8.3% in urban, peri-urban and rural areas, exceeding 10% only in areas with a higher accumulation of resources. Studies in São Paulo state showed that this percentage ranged from 28.1 to 31.1% in Ibiúna (SOTO et al., 2006) and was 36.1% in Guarulhos (SALLUM; RIBAS; MASSAD, 2015).

Among the dogs that were photographed more than once at different locations on the neighborhood streets (12/21), the distance traveled between the first and last meeting places of each photo-recaptured dog was 100m (minimum) and 520m (maximum) (Figure 3). The mean distance traveled was 275.5m and 67% of the dogs moved between 101m and 300m. These data agree with observations by Wandeler et al. (1993) where 57.7% of the dogs studied in Tunisia moved less than 500 m from their homes. In Brazil, this is the first description of the displacement distance of street dogs in urban areas.

One of the limitations of this study is the fact that only one area of the urban zone was evaluated, which may have particularities that influenced the results. In addition, this is an area not totally isolated, since the great avenues may not have restricted the movement of dogs from one neighborhood to another. Guilloux et al. (2018) conducted a similar study in six districts of São Paulo city, SP, and also highlighted the same fact. Furthermore, we could not determine the seasonal influence on the population variation during the year since the study was carried out in a single month (only in March).

Figure 3 – Distances traveled by free-roaming dogs in Jardim Ipanema and part of Dona Amélia neighborhood, Araçatuba, SP, Brazil, according to the region. 275.5±154.7m Average (Minimum: 100m, Maximum: 520m). March 2011.

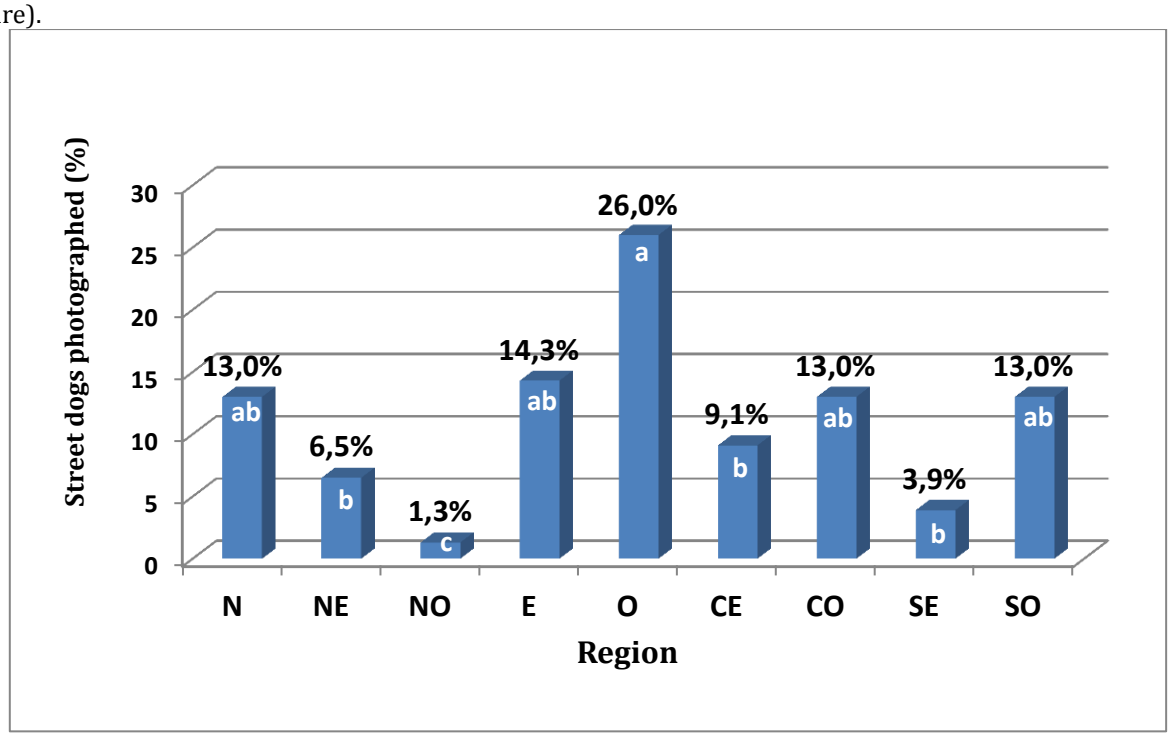


North (N), Northeast (NE), Northwest (NO), East (E), West (O), Central-east (CE), Midwest (CO), Southeast (SE) and Southwest (SO).

Several zoonoses can be transmitted and disseminated by street animals very easily, therefore, the present method applied to determine the distance traveled by each photo-recaptured dog in public roads, can be an important tool to aid the planning of preventive actions against the spread of diseases, such as vaccination in areas at risk for canine rabies, as recommended by the Ministry of Health (BRASIL, 2017)

There was a statistically significant difference ($p = 0.0003$) in the number of street dogs observed in the neighborhoods (Figure 4), which was higher in the western region compared to other regions. This neighborhood area has no commerce, parks or large circulation of people, and part of the streets is not paved, with low house density and frequent empty land. Most of these lands are not fenced in or walled, allowing free access to street animals that may use them as shelters.

Figure 4 – Percentage of dogs observed on the streets of Jardim Ipanema and part of Dona Amélia neighborhoods in Araçatuba, SP, Brazil, according to the region. March 2011. Same letters in the columns indicate non-significant differences (Chi-square).



North (N), Northeast (NE), Northwest (NO), East (E), West (O), Central-east (CE), Midwest (CO), Southeast (SE) and Southwest (SO).

In addition to Araçatuba, the photographic capture-recapture method using GPS has already been used in several other cities of different sizes such as Ibiúna, SP (SHIMOZAKO; COUTO, 2010), Guarulhos, SP (SALLUM; RIVA; MASSAD, 2018), in six distinct neighborhoods (GUILLOUX et al., 2018), and restricted to the campus area of the University of São Paulo, in São Paulo city (DIAS et al. 2013), and also restricted to the area of the Uvaranas campus of the Ponta Grossa State University, in Ponta Grossa, PR (KOTVISKI; BURGARD, 2014). Therefore, this method can be applied to both small and large cities to assist in managing the canine populations and providing indicators to evaluate the adopted measures (ICAM, 2015).

CONCLUSION

The photographic capture-recapture methodology associated with GPS for georeferencing allowed to determine the spatial distribution of the free-roaming dog population present in the studied public space; to estimate the ratio between street and domiciliary dogs; to determine whether they were more concentrated in certain neighborhood regions; and to determine the temporal distribution throughout the day of the dogs that moved through the streets of the neighborhood. The results indicate that the longest distance traveled was 520m.

The present methodology was proven to be an efficient tool requiring few people for its execution that can be used as an additional resource for planning the actions required to prevent and control urban zoonoses.

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