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Size and spatial distribution of stray dog population in the University of São Paulo campus, Brazil

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ABSTRACT

A longitudinal study was carried out to describe the size and spatial distribution of the stray dog population in the University of São Paulo campus, Brazil from November 2010 to November 2011. The campus is located within the urban area of São Paulo, the largest city of Brazil, with a population over 11 million. The 4.2 km^2 that comprise the university grounds are walled, with 10 access gates, allowing stray dogs to move in and out freely. Over 100,000 people and 50,000 vehicles circulate in the campus daily. Five observations were made during the study period, using a mark-resight method. The same route was performed in all observations, being traveled twice on each observation day. Observed animals were photographed and the sight coordinates were obtained using a GPS device. The estimated size of the stray dog population varied from 32 (CI 95% 23–56) to 56 (CI 95% 45–77) individuals. Differences between in- and outward dog movements influenced dog population estimates. Overlapping home ranges of docile dogs were observed in areas where most people circulate. An elusive group was observed close to a protected rain forest area and the estimated home range for this group did not overlap with the home ranges for other dogs within the campus. A kernel density map showed that higher densities of stray dog sighting is associated with large organic matter generators, such as university restaurants. We conclude that the preferred source of food of the stray dogs on the University of São Paulo campus was leftover food deliberately offered by restaurant users. The population was stable during the study period and the constant source of food was the main reason to retain this population within the campus.

1. Introduction

Stray (free-roaming) dog populations are still an issue in developing and developed countries, causing many problems such as bites in humans and rabies (Rinzin et al., 2008; Dalla Villa et al., 2010). The same is likely to occur in Brazil, although it is uncommon in for stray dogs to be cited in the Brazilian media as a public health concern. Since 2008, the public animal control service was forbidden to promote euthanasia of captured stray animals in São Paulo State, and within the first year of the ban, public animal shelters reached their maximum capacity. In São Paulo the presence of stray dogs has been noted in low-income areas of the major cities, in parks and close to forest protected areas

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(Galetti and Sazima, 2006; Torres and Prado, 2010). There are no published data about the size of stray dog populations in university campi in Brazil. The only related work describes the Animal Control Program at the University of Campinas (Dilly et al., 2005). Few more studies addressed the same problem using mark-resight method, especially in India (Pal, 2001; Hiby et al., 2011).

The University of São Paulo campus is located in the urban area of São Paulo city, the largest city of Brazil with almost 11 million inhabitants (IBGE, 2010). The University community has daily contact with stray dogs particularly those close to buildings, restaurants, cafeterias, streets and open areas. This contact can lead to transmission of zoonosis, bites, and car accidents (by running over) (WHO, 1990; Slater, 2001; Kato et al., 2003; Slater et al., 2008). To the best of our knowledge the exact size of the stray dog population within the University of São Paulo campus has not been measured. Lack of certainty around the numbers of stray dogs makes it difficult to implement appropriate risk management strategies to deal with their presence.

The first attempt to manage the stray dog population inside the University of São Paulo campus was implemented in 2001 based on a capture, neutering and adoption strategy. Although the size of the stray dog population was not estimated at the time, a shelter was built to house captured dogs. All captured dogs were put up for adoption, but no observable decrease in the size of the stray dog population was observed. The shelter reached its full capacity of housing dogs soon after opening, and at the time of writing it houses 120 dogs. When the shelter is full no further dog captures are made and stray dogs are managed by individuals in the University community on a voluntary basis.

In late 2010, a social–environmental service was created by the campus administration to manage food safety, waste disposal, vector-borne disease transmission (particularly dengue fever) and animal health issues. The Animal Population Management Program (ProMAC) is a project subordinated to this administrative organization, and the present work is its first outcome.

Knowledge of the size of the stray dog population inside the campus is a necessary first step toward managing their presence, with a long-term aim to make the coexistence between humans and dogs more harmonious (Beck, 1973; Totton et al., 2010; Galibert et al., 2011). Moreover, this is a pioneer work of this research area in Brazil, since only few published studies only described the impact of predation of wildlife by feral dogs (Galetti and Sazima, 2006) and use of forest areas for unrestricted dogs (Torres and Prado, 2010).

2. Materials and methods

2.1. Study area

The campus of the University of São Paulo (Fig. 1) is surrounded by five different areas: two comprised almost entirely of houses (N1, N4), one an industrial area with few residential buildings (N2), one slum (N3) and one comprised primarily of residential buildings (N5). The campus occupies a land area of 4.2 km^2 divided as follows: 0.7 km^2 built-up area, 0.3 km^2 protected rain forest (F1) and 3.2 km^2 of open garden (including an unprotected forest area, F2). The campus has a total of 60 km of avenues and streets. It has been estimated that approximately 50,000 vehicles and 100,000 people (students, teaching staff and visitors) circulate daily within the campus grounds each day (http://www.usp.br/cocesp/?p=38&f=177). The perimeter of the campus is walled, and there are 10 access gates, five of them exclusively for pedestrians.

Within the campus bondaries there are some fenced areas, but most areas, particularly open gardens, are accessible to stray dogs.

2.2. Estimation of the size of the campus stray dog population

A longitudinal study was carried out to determine the size of the stray dog population within the University of São Paulo campus. Estimates were made on five occasions approximately three months apart, alternating class periods (November 2010; May and November, 2011) with holidays (February and July, 2011), according to the University of São Paulo's official calendar.

On each observation day members of the research team moved through the university grounds collecting details of sighted dogs. Four people formed the research team, one person exclusively photographing the dogs, one making notes and marking spatial coordinates with GPS, one counting missing dogs and one driving (WHO, 1990). The route consisted of stretches performed on foot (6.5 km) and by car (19.8 km) at a constant speed of 30 km/h (Fig. 2). This route was taken twice on each observation day (the first time from 7:00 h to 9:00 h and the second time from 16:00 h to 18:00 h), maximizing dog sight probability by concentrating on areas where dogs congregate such as trash bins and places where food is for sale (Berman and Dunbar, 1983; WHO, 1990). The route included only open areas. Fenced areas within the campus were not considered, even if dogs were observed inside. Food sale points and trash bins located inside fenced areas were excluded from the analysis.

A two-sample method was used to estimate the size of the stray dog population on each observation day (Sutherland, 2006). This method is appropriate only for closed populations and involves one session of (photographic) marking and a single resight session. After being observed by binoculars, dogs were photographed on their best possible angles, on various positions, prioritizing physical signals that helped subsequent identification of each photographed ("captured") animal. A Canon Rebel XT digital camera with a Canon 35–80 mm lens was used.

A single observer was responsible for all photographs, maintaining a minimal distance of six meters from subjects, in order to avoid triggering of agonistic territorial, defensive or predator behaviors (Fox et al., 1975; Jensen, 2007). All observed dogs were photographed, even if they were recounted. Physical characteristics such as coat color, size and gender were recorded. For males, reproductive status (neutered, entire) was documented. Weather conditions on each observation day were recorded.

The point location of each sighting was registered using a Garmin 60CS GPS device. Dogs that were observed in at least three counts had their home-range determined using

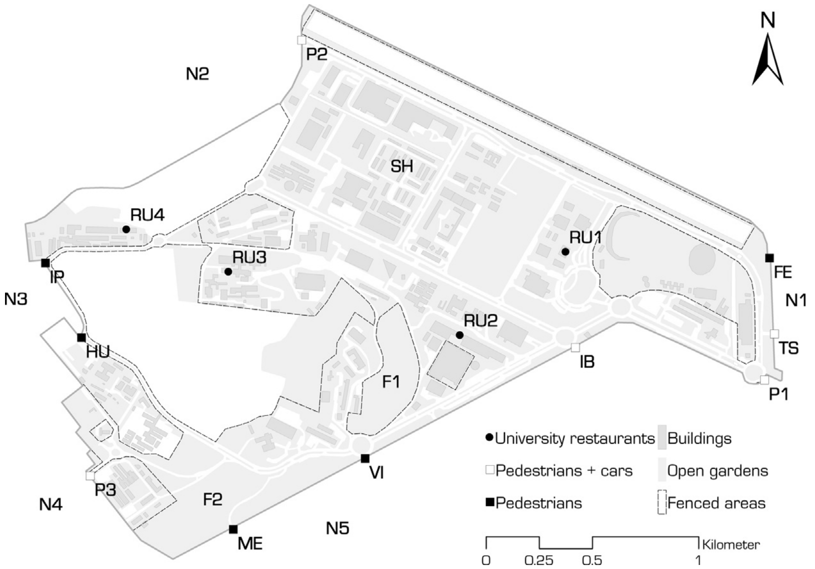

Fig. 1. Thematic map of the University of São Paulo campus showing location of access gates, restaurants, forest areas and neighborhoods.

the minimum convex polygon method, implemented in the Home Range Tools package for ArcGIS (Rodgers et al., 2007).

At the end of each observation day, members of the research team discussed and agreed on the number of observed (n) and re-observed dogs (m). The size of the stray dog population (N) was then estimated using Eq. (1), proposed by Sutherland (2006):

$$N = \left(\frac{(n_1 + 1) \times (n_2 + 1)}{(m_2 + 1)}\right) - 1 \quad (1)$$

where n_1 is the total number of dogs photographed on the first occasion (7:00–9:00 h); n_2 is the total number of dogs photographed on the second occasion (16:00–18:00 h) and m_2 is the number of already photographed dogs found on the second occasion.

The upper (UCL) and lower (LCL) 95% confidence limits for N were calculated using Eqs. (3) and (4), respectively, proposed by Sutherland (2006):

$$W_1, W_2 = \frac{m_2}{n_2} \pm \left(\frac{1}{2n_2} + 1.96\sqrt{\frac{P \times (1 - P) \times (1 - m_2/n_1)}{(n_2 - 1)}}\right) \quad (2)$$

$$\mathrm{LCL} = \frac{n_1}{W_1} \quad (3)$$

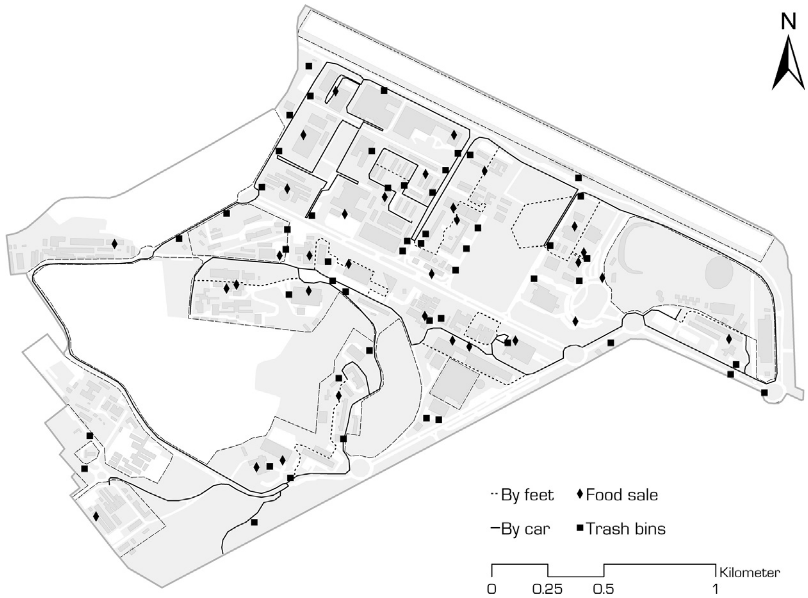

Fig. 2. Map of the University of São Paulo campus showing the route traveled to sight dogs on each observation day, November 2010–2011.

$$\mathrm{UCL} = \frac{n_1}{W_2} \quad (4)$$

The same method was applied to estimate the gender (male and female) populations.

To determine if there were significant changes in the size of the dog population over time, a linear regression analysis was performed. There, calendar date was the predictor variable and estimated population size, the outcome. Under the null hypothesis of population stability, the slope of the line of best fit β should be zero. To test this hypothesis, the 95% confidence limits of β were calculated in the software SPSS 9.0. The same method was applied to determine if there were changes in the size of gender (male and female) populations.

2.3. Assumptions

Because the two sightings necessary to estimate N occurred on the same day (i.e. 7:00–9:00 and 4:00–6:00 h) it was reasonable to assume that there would be little change in the size of the population during the 9 h interval between the start of the first and second sightings. This assumption was particularly valid for dogs since in the early morning they are active searching for food and, for most of the day (around 18 h), they sleep (Font, 1987).

The research team did not interact or intervene with the dogs throughout the study period.

2.4. Estimating the number of dog movements through campus access gates

After prior contact with the campus security authority, staff stationed at each of the University gate was trained to register the movement of each dog that was observed to move through campus access gates each day. In- and outbound movements of dogs were recorded, even if the same dog was observed more than once.

Data collection forms were distributed to gate staff and they were instructed to start recording dog movements seven days before each observation day. Forms were collected on the day after each observation day. When changing shift, gate staff were instructed to hand their forms over to the next-shift person.

Frequency histograms were constructed to identify movement peaks and to compare counts across campus access gates. Spearman's correlation coefficient was calculated to quantify the association between dog population estimates and net dog movements (supervised and unsupervised) in and out of the campus.

Gate staff was not instructed to register any dog being abandoned. Despite being a federal crime in Brazil, gate staff was not properly trained to prevent or register events of this type.

2.5. Environment analysis and determination of preferred food source

All changes to campus buildings and facilities were recorded for the period November 2010–2011. This included details of building renovations, demolitions, construction of new buildings and siding installations. Changes in services (such as waste collection) provided by the campus administration authority (COCESP) were recorded for the same period.

The point location of trash bins and food sale points (cafeterias, restaurants and hot dog stands) within the campus were also determined using the Garmin 60CS GPS device.

On each observation day, trash bins were inspected and the presence of litter recorded. The trash collection schedule was also recorded.

2.6. Spatial analysis

Kernel smoothing techniques were applied to describe the spatial distribution of dog sights (across all observation days), expressed as the number of dog sights per km^2. These analyses were based on a regular grid of 300×200 cells ($10\,\mathrm{m} \times 10\,\mathrm{m}$ each) calculated using the *spatstat* package (Baddeley and Turner, 2005) implemented in R (R Development Core Team, 2012). The bandwidth parameter for the kernel function (used to control the amount of smoothing of the estimated density surface, σ) was fixed at 75 m and was calculated using the normal optimal method (Bowman and Azzalini, 1997).

To determine preferred food sources, the dog sight distribution (across all observation days) was compared with the location of trash bins and food sale points. To visualize this relationship the point locations of trash bins and food sale points were superimposed on the raster surface of the number of dog sights per km^2, described earlier. A second approach was to plot the number of dog sights per km^2 as a function of Euclidean distance from each trash bin and food sale point, using the rhohat function in *spatstat* (Baddeley et al., 2012). The resulting functions were compared to determine preferred sources of food.

3. Results

Throughout the study period, 87 individual dogs were photographed (51 males, 30 females and 6 with indeterminate gender). Of the total number of photographed dogs, 32 (19 males and 13 females) were sighted on more than one occasion. The stray dog population estimates varied from 32 (95% CI 23–56) to 56 (95% CI 45–77). The count schedule, weather conditions and population estimates (with corresponding confidence intervals) are presented in Table 1. In general, weather conditions were optimum for dog sight during each observation day (sunny, few clouds). During the first observation day the weather was overcast with light rain. Minimum temperatures varied from 15 to 22 °C and maximum temperatures varied from 25 to 30 °C during the five observation days. Selected pictures were posted to the address http://www.flickr.com/photos/ricardodias1/.

Although there was no significant change in estimated total population size over time ($P = 0.21$), during University class periods (May and November, 2011) estimates were slightly less than at other times of the year.

The size of the estimated male dog population varied from 19 (95% CI 14–36) to 35 (95% CI 26–65), but there was no significant difference between observation days

Table 1
Stray dogs within the University of São Paulo campus, Brazil, November 2010–2011. Count schedule, weather conditions and estimates of the size of the stray dog population for each of the five observation days.

Observation day	Date	Temperature (°C)		Weather condition	Photographed on the 1st occasion	Photographed on the 2nd occasion	Re-photographed	Population estimate (*N*)	95% confidence interval
		Minimum	Maximum						
1[a]	11/23/10	17	26	Drizzle	31	29	16	56	(45, 77)
2[b]	02/23/11	22	28	Sunny	20	21	10	41	(31, 68)
3[c]	05/02/11	22	25	Sunny	16	16	8	32	(23, 56)
4[d]	07/28/11	15	29	Sunny	26	21	13	42	(33, 59)
5	11/24/11	17	30	Sunny	24	23	15	37	(31, 48)

[a] Interventions occurred between 1st and 2nd observation days. December 2010: trash bins emptied at least once daily; university restaurant RU1 partly closed for refurbishment; university restaurant RU3 completely closed for refurbishment. January 2011: beginning of the campaign against abandonment of dogs inside the campus.
[b] Interventions occurred between 2nd and 3rd observation days. February–March 2011: demolishing of abandoned sheds in SH area.
[c] Interventions occurred between 3rd and 4th observation days. May 2011: end of the campaign against abandonment of dogs inside the campus.
[d] Interventions occurred between 4th and 5th observation days. August 2011: university restaurants RU1 and RU3 re-opened.

($P = 0.09$). Estimates for female by neuter status were not done but for males were. Observed neutered male dogs varied from 5 to 11 and entire male dogs from 8 to 13.

The estimated female population varied from 10 (95% CI 7–19) to 19 (95% CI 14–31), but there was no significant difference between observation days ($P = 0.87$) (Table 2).

Throughout the study, most dogs were friendly, approaching the field team during photography sessions and allowing contact. This group of tolerant dogs was referred to as the "docile group". Another group of dogs did not tolerate human presence, fleeing whenever the field team approached. This group was referred to as the "elusive group". The home-ranges for 17 docile dogs and for a group of elusive dogs ($n = 13$) were obtained (Fig. 3). Docile dogs showed overlapping home ranges but the elusive dogs showed a distinct home range. One docile dog that had a home range that overlapped the elusive group was attacked between the 4th and 5th observation days.

The University of São Paulo campus has 10 access gates, five of them that permit the entry and exit of cars and pedestrians while five are exclusively for pedestrians. The gates are open from 5:00 h to 20:00 h from Monday to Friday and from 5:00 h to 14:00 h on Saturday. The gates are closed on Sundays, except for the university community.

The net dog movement through the campus access gates indicated a daily surplus of animals inside the campus on all observation days. The mean daily surplus was +2.9 for unsupervised dogs and +3.5 for supervised dogs (Table 3). A single access gate (VI) was the entry and exit point for most dogs. Two peaks of dog movements were observed: from 7:00 h to 9:00 h in the morning and from 16:00 h to 18:00 h in the afternoon (Fig. 4).

The Spearman correlation coefficients for the dog population estimates along with net supervised and unsupervised dog movement in and out of the campus were 0.67 ($P = 0.22$) and 0.87 ($P = 0.05$), respectively.

University restaurants serve an approximate total of 14,150 meals (breakfast, lunch, dinner) daily. RU1 serves 7550, RU2 serves 3600, RU3 2000 and RU4 serves 1000 meals daily. In 2011, the campus produced approximately 3450 tons of common waste, 720 tons of recyclable waste, 2.5 tons of used batteries and 27 tons of chemical waste. The main producers of common waste were the university restaurants and the university hospital. Up until December 2010 there was no common system of waste collection on the campus. In 2011, all trash bins were emptied by contract cleaners at least once daily.

A campaign against animal abandonment in the campus was held between January and May, 2011, using banners distributed close to the campus access gates. Animal abandonment is a federal crime in Brazil and the communication material of this campaign emphasized the law and that the campus administration authority was aware of the problem.

The group of elusive dogs was observed in all observation days around the forest fragment area F1. On all five observation days leftover food was observed inside this area.

On all observation days it was noted that leftover food and water for dogs was left close to most of buildings,

Table 2
Stray dogs within the University of São Paulo campus, Brazil, November 2010–2011. Counts of the number of dogs observed and estimates of the stray dog population for each of the five observation days, by gender.

Count	Observation day				
	1	2	3	4	5
Observed					
Males (intact) (%)	13 (29.54)	11 (35.48)	8 (33.33)	8 (23.53)	8 (25.00)
Males (neutered) (%)	11 (25.00)	5 (16.13)	5 (20.83)	6 (17.65)	6 (18.75)
Males (indeterminate) (%)	2 (4.55)	1 (3.23)	2 (8.34)	2 (5.88)	4 (12.50)
Males (total) (%)	26 (59.09)	17 (54.84)	15 (62.50)	16 (47.06)	18 (56.25)
Females (total) (%)	15 (34.09)	13 (41.93)	9 (37.50)	16 (47.06)	14 (43.75)
Indeterminate gender (total) (%)	2 (4.55)	1 (3.23)	–	2 (5.88)	–
Puppies (total) (%)	1 (2.27)	–	–	–	–
Total (%)	44 (100)	31 (100)	24 (100)	34 (100)	32 (100)
Estimated					
Males (CI 95%)	35 (26, 65)	23 (16, 60)	21 (13, 78)	19 (14, 36)	21 (16, 31)
Females (CI 95%)	17 (13, 27)	16 (11, 34)	10 (7, 19)	19 (14, 31)	15 (12, 21)
Total (CI 95%)	56 (45, 77)	41 (31, 68)	32 (23, 56)	42 (33, 59)	37 (31, 48)

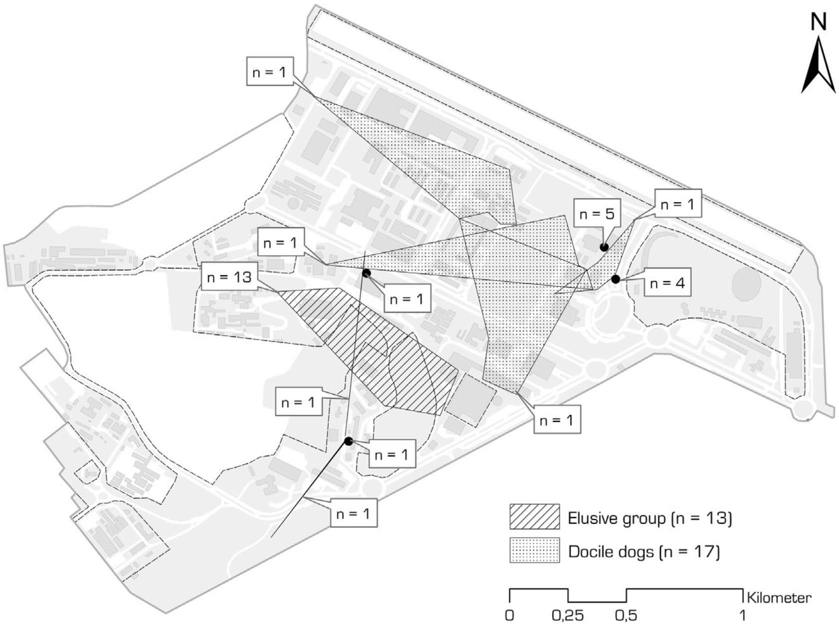

Fig. 3. Map of the University of São Paulo campus showing the number (n) and home-range of dogs observed more than three times during the five observation days carried out from November 2010 to November 2011.

Table 3
Stray dogs within the University of São Paulo campus, Brazil, November 2010–2011. Mean number of dogs entering and exiting the campus access gates over the seven days prior to each observation day.

Category	Type	Observation day					Mean
		1	2	3	4	5	
Unsupervised	Enter[a]	11.6	9.7	9.0	8.0	10.1	9.7
	Exit[b]	7.6	6.6	6.6	4.7	8.7	6.8
	Net change	+4.0	+3.1	+2.4	+3.3	+1.4	+2.9
Supervised	Enter[a]	33.7	38.1	33.4	37.0	33.1	35.1
	Exit[b]	29.3	34.7	33.1	31.6	29.3	31.6
	Net change	+4.4	+3.4	+0.3	+5.4	+3.8	+3.5

[a] Mean number of dogs entering the university campus per day.
[b] Mean number of dogs exiting the university campus per day.

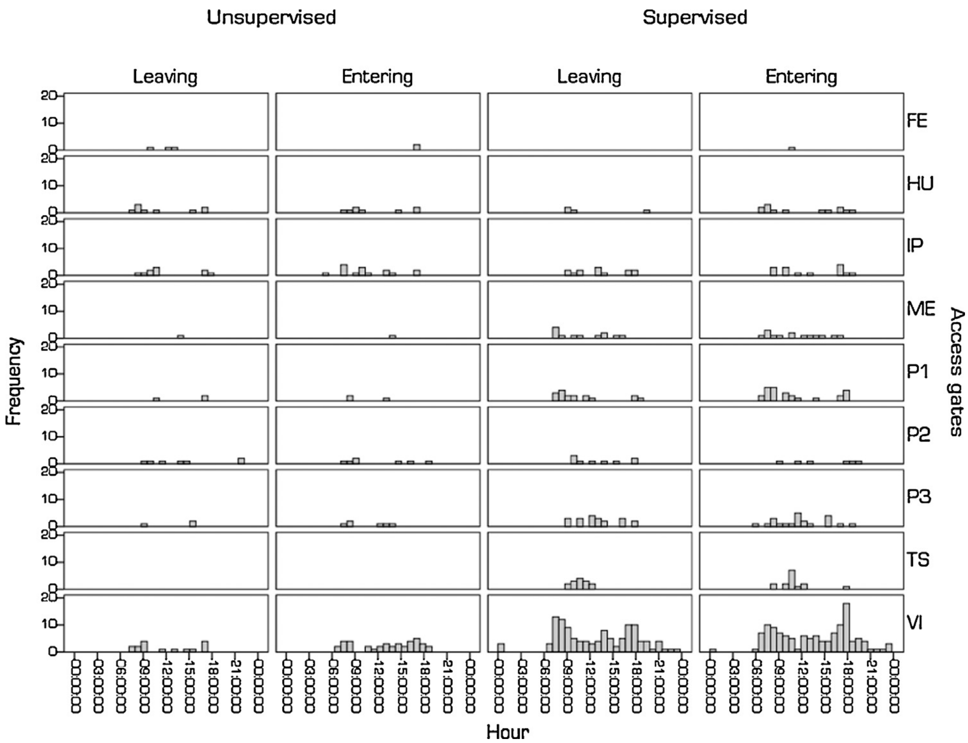

Fig. 4. Frequency histograms showing counts of supervised and unsupervised dogs entering and exiting the University of São Paulo by access gate, November 2010–2011.

especially those close to the RU1 restaurant, which is adjacent to a student residential complex.

The kernel-smoothed intensity of dog sight points showed that denser areas were associated with the university restaurants, particularly the RU1 restaurant (Fig. 5). The distribution of dog sight points, food sale points and trash bins are shown in Fig. 6. The spatial covariate function, showing the density of dog sight points as a function of Euclidean distance from trash bins and food sale points are shown in Fig. 7.

4. Discussion

Out of 87 different dogs sighted during the five observation days, 32 (36.8%) dogs were sighted on more than one occasion. These dogs formed a "core population", responsible for maintaining a stable population, even when there are numerous dogs entering the campus each day. No significant differences between population estimates were observed throughout the study period.

During the first observation day, cloud cover and light rain was observed, in contrast with sun and high temperatures observed in the four remaining observation days. According to Daniels (1983), dog activity increases with the increasing cloud cover regardless of season (summer or winter). The higher dog population estimate for the first observation day may have been associated with weather condition.

On all observation days, dogs were observed moving around during the mornings and were asleep in the afternoons, as expected (Rubin and Beck, 1982; Berman and Dunbar, 1983; Font, 1987), particularly close to university restaurants and buildings. This characteristic made it easy to identify and count dogs on each observation day.

The assumption of closed population is a prerequisite for the two-sample method. Dog movement through campus gates, particularly stray dogs, was low, as shown in Fig. 4. Although a correlation between unsupervised dog movements in and out of the campus and the population size was observed, the limitations of using such a small sample size, and having a possible lack of independence in the data points should be considered. Low numbers of dogs entering and leaving the campus meant that for all practical purposes the stray dog population within the campus on each observation day was closed (Sutherland, 2006). For this reason we believe the results presented in this study are an unbiased estimate of campus stray dog population size.

Higher population estimates during vacation periods, even though not significant, may be a consequence of: (1) the abandonment of owned dogs inside the campus, since the lower circulation of people during this period facilitate this practice, or (2) owned dogs that are allowed to roam freely from nearby homes.

Almost a third of the males were sterilized in all counts and the (male and female) population was almost entirely comprised of adults. Moreover, a single female (from the elusive group) was observed to be in standing estrus during the fourth observation day and a single pup was observed during the first observation day.

Population dynamics could not be assessed in this study because birth (and death) rates could not be determined

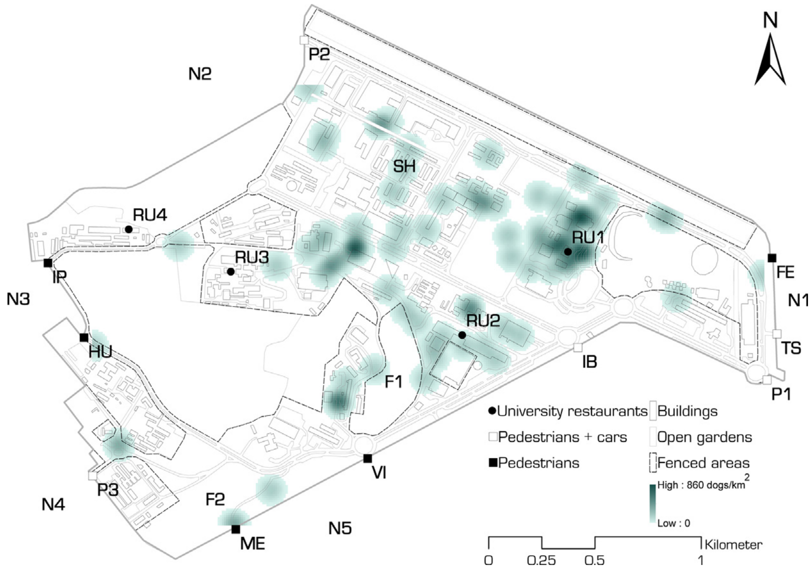

Fig. 5. Map of the University of São Paulo campus showing the density of dog sight points across the five observation days from November 2010 to November 2011. Densities are expressed as the number of dog sightings per km^2.

with certainty. Although a single pup was observed on a single observation day we were unable to locate dens where pups were hidden, which meant that we were unable to estimate average litter size or the age of females at the time of parturition. Furthermore, the relatively short length of the study period meant that estimation of age-specific survival probabilities was impossible. Carrying out a study similar to the one described in this paper over a much longer period of time would provide the opportunity to estimate age-specific survivorship. In the same study, the application of radio tracking collars to females would allow us to record average litter sizes and estimate the age of individual females at the time of birth. In turn, this would provide information that would allow development of models of stray dog population dynamics. Such models could then be used as a tool to assess likely responses to various interventions to reduce the overall size of the campus stray dog population.

Peaks of animal movements, especially supervised dogs, through University access gates were observed before people leave home for work and after they return home. These peaks did not influence the population estimates, since dogs on a leash or dogs accompanied by an owner were not included in the population size estimates. A single gate (VI) was responsible for most movements. This gate is adjacent to a residential neighborhood comprised primarily of apartment buildings with no suitable nearby area for dog walking apart from the university campus. Abandonment discouragement measures must be focused around this gate.

The reasons for the relative stability of the campus dog population can be attributed to either one or a combination of: (1) a high mortality rate (due to dogs being run over by cars or by disease), (2) dogs being rescued by individuals and re-homed, and/or (3) dogs being captured and maintained in the university animal shelter. To the best of our knowledge no data exists to allow each of these three mechanisms to be quantified with any certainty. No carcasses were found in the campus during the observation days and dogs going in or out of the shelter were not registered during the study period. Based on the findings presented in this study, campus authorities have been advised to implement systems that will allow information on these three areas of dog loss to be collected on an on-going basis.

A constant source of food may be the main reason for stray dogs to remain resident within the campus. Even though immigration or emigration were not evaluated in this study, the existing population may prevent outside or abandoned dogs to settle inside the campus.

It is known that university employees have regularly provided food for the elusive black dog population inside the protected forest area F1 for at least 10 years. Elusiveness is a behavioral characteristic arising from low socialization (isolation) during puppyhood (Pal, 2005; Miklósi, 2007). As a result of this isolation, and the absence of the necessity to beg for food (like the docile dogs that circulate near the university restaurants) this group of dogs showed a high level of aggressiveness and territorialism toward people and non-familiar dogs (Font, 1987). Although Fox et al. (1975) state that there is a high probability that these dogs likely to become feral, this group within the São Paulo University campus cannot be classified as feral. This is because they do not forage or hunt (Berman and Dunbar, 1983), they have a large home range, are hard to track (Fox et al., 1975; Rubin and Beck, 1982; Berman and Dunbar, 1983; Daniels, 1983; Font, 1987) and their body condition is generally good due to their regular food supply. This group is cohesive and stable (consistent with the findings of Pal et al., 1998) and on the first observation day a group of five elusive dogs (four entire males and one female) were seen greeting another elusive dog, which seemed to be an alpha-male, under a tree shade. This alpha-male had a “magnetic” effect over the group. They were observed

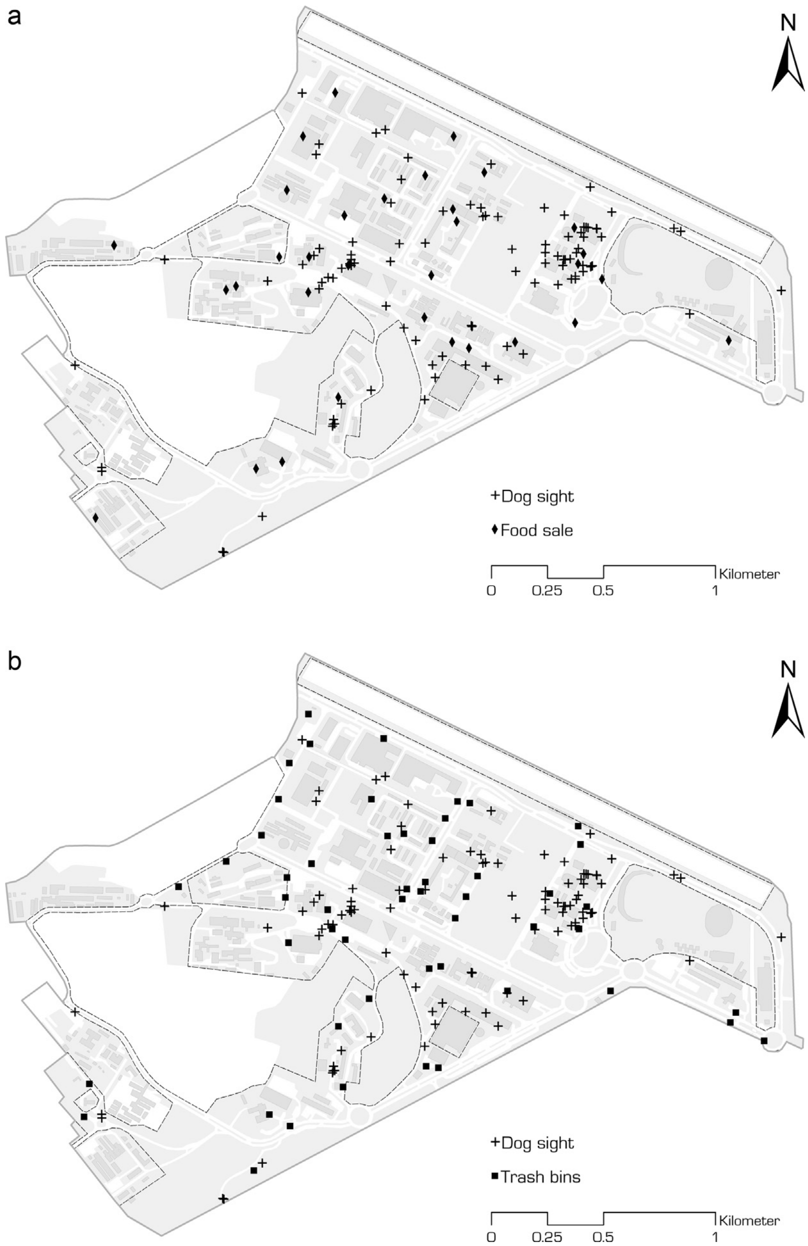

Fig. 6. Map of the University of São Paulo campus showing dog sight points from the five observation days carried out between November 2010 and November 2011 and (a) the location of food sale points and (b) trash bins.

together for 15 min, a cohesion behavior not commonly observed in a non-estrous group (Daniels, 1983a). Groups of greater than four dogs are not often observed (Berman and Dunbar, 1983). The home range of the elusive dog group is predicted, and is probably determined by the existence of food and shelter provided inside the F1 area. If the regular food source were to be broken, it is likely that the elusive group would disperse. In turn, this would probably lead to disputes with docile dogs (Pal et al., 1998a).

The elusive dogs had a larger home range compared with docile dogs. The proportion of sterilized animals, higher in the docile group, can explain this. According to Berman and Dunbar (1983), the home range decreases 90% after sterilization.

Figs. 2 and 6(a, b) show that the locations of trash bins and food sale points were in close proximity, making it difficult to separate the spatial effects on the distribution of the dogs. However, the density of dog sightings at distances of 0–200 m from food sale points, including university restaurants, was greater than the density of dog sightings at the same distance from trash bins (Fig. 7). Our interpretation of this finding is that the preferred food source for dogs was leftover food offered by people and volunteers around university restaurants. The disinterest of dogs for garbage was

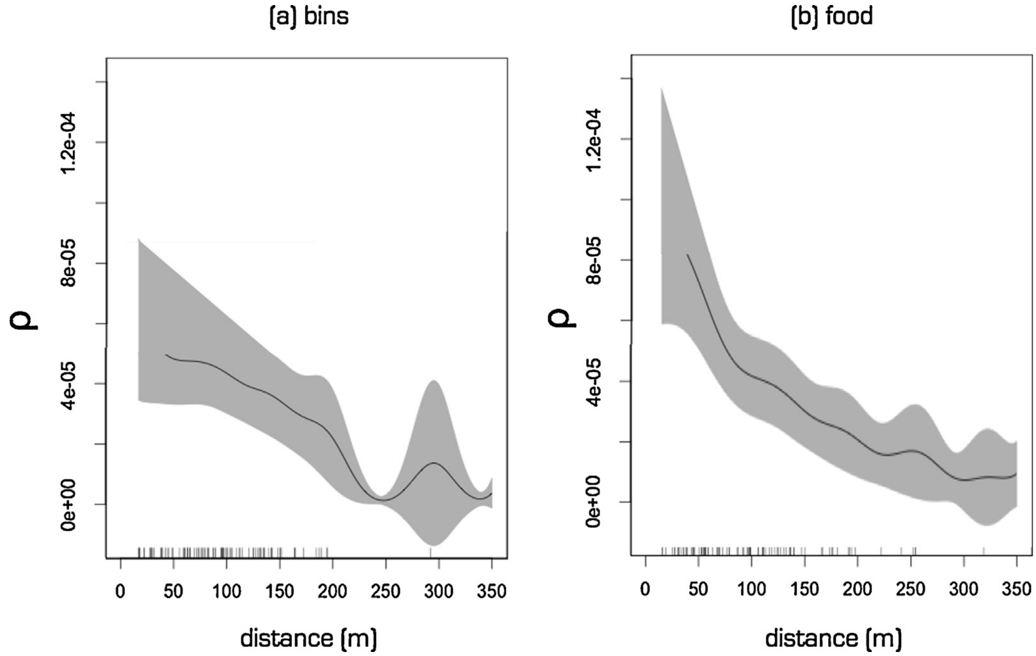

Fig. 7. Density of dog sight points as a function of Euclidean distance from: (a) trash bins and (b) food sale points. In each plot the gray-shaded areas indicate the uncertainty around the point estimates of dog sight density, as indicated by the solid black line.

explained by Daniels (1983). According to this author, the influence of garbage in social patterns is negligible, since sociality is not resource-centered. In this study, dogs were not seen to congregate around garbage, and it seemed that the presence of a single dog around a trash bin discouraged other dogs to approach, as seen once, during the second observation day. A group of dogs was seen playing, not eating, garbage only once during the first observation day.

Trash bins were more numerous than restaurants. A greater number of trash bins means that there are smaller numbers of dogs per bin, leading to smaller density estimates at given scales of distance. Although it was official University policy that all trash bins were to be kept in a locked concrete dispenser, throughout the study period none were found to be closed and therefore easily accessed by dogs.

Interventions occurred throughout the campus during the study period, and the effect of these activities on the size of the dog population is difficult to quantify. Dispersive behavior of some dogs, as shown by their home-ranges (Fig. 3) may be a result of the reorganization of occupation territory. Despite their dispersive behavior, free-roaming dogs do not isolate themselves from other dogs, leading to an increase in the likelihood of the spread of skin diseases, mites, intestinal parasites, leptospirosis and even rabies (Rubin and Beck, 1982).

5. Conclusion

The assessment of the size of the stray dog population in the University of São Paulo campus elucidated some of the key parameters for its control. The population was stable during a one-year period and the consistent and constant source of food was the main reason for persistence of the population within the campus boundaries. Interventions should therefore focus on this issue.

People should be discouraged to provide leftover food to stray dogs. Abandonment should also be addressed within the campus, perhaps by closer monitoring of people bringing dogs in. If it is considered acceptable for stray dogs to remain on the campus then food (presumably waste food from campus restaurants) should be made regularly available in specified sites. From an animal welfare and (human) public health perspective it would be prudent that stray dogs within the campus had their health status monitored systematically.

To achieve these goals, volunteers, visitors, the university community and researchers should be involved with the problem, supported by public policies.

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