PANAMA ROAMING DOG SURVEY: FINAL REPORT

Elly Hiby and Lex Hiby

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EXECUTIVE SUMMARY

A dog population survey of the Panama Metropolitian area was completed by one of the authors (Elly Hiby, independent consultant) and a small team of Spay Panama staff. The method used was direct observation of free-roaming (unconfined owned dogs plus unowned 'roaming' dogs) and tethered dogs whilst driving along four monitoring routes (totalling 93.5km; 3.5% of the streets) that covered the Metropolitan area, confined dogs were not included in the survey. The survey utilised mobile phones for following routes (using Google Maps app) and for recording dogs seen (using OSMtracker app with layout designed specifically for this survey)[1].

The survey established a baseline for monitoring change in roaming dog population density and welfare. The average number of roaming dogs seen per km of street surveyed was 3.60 dogs with 7% of females visibly lactating, 37% of dogs in emaciated or thin body condition and 26% with skin problems; these key indicators can be monitored for change along each of the four routes established by this baseline survey. Extrapolation to the entire Panama Metropolitan area provided an estimate of the total roaming dogs visible at peak roaming time (5-8am) as 9,554 (95% CI 7,663-11,446); this can be corrected for dogs not seen by the surveyors to 21,715 using the 0.44 detectability estimate established in Veracruz, Panama (Boone, 2013[2]). The number of houses with no toilets and route length were found to be significant predicators of dog density and so an alternative extrapolation was made using the coefficients of this significant regression; this provides a similar figure of 9,988 for the Panama Metropolitan area, corrected to 22,701 with the detectability estimate, equating to just under 2 (1.8) roaming dogs for every 100 people.

Further, the survey involved a training session and participation for five staff in the survey, leaving a competent team of surveyors that successfully completed a third replicate of all routes and can indepdently conduct future surveys.

SURVEY OBJECTIVES

Develop a monitoring tool for the free-roaming (owned roaming and unowned 'roaming') dog population in Panama. The monitoring survey needs to have the following characteristics:

- Simple and relatively low-cost to conduct
- Suitable for a local team to carry out on a regular basis, i.e. does not require an outside team other than initial training (although analysis support may be required following the first few surveys, this too should be suitable for in-house processing in the long-term)
- Does not have to lead to a total population estimate, an indication of how the population is changing over time is sufficient

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[1] Survey methodology developed in collaboration with Lex Hiby, Conservation Research Ltd http://www.conservationresearch.co.uk/

[2] John Boone (2013) 'Street Dog Survey & Training in Veracruz, Panama', report to HSI

- National scope (this stage was limited to the Panama Metropolitan area with a focus on areas covered by Spay Panama)
- Baseline completed before end 2013

WHY SURVEY?

Impact assessment tells us whether the change we are aiming to make is happening and whether we can attribute our own efforts to its achievement. It can also tell us when a change is not happening or when progress is slow, highlighting that we need to adjust our work to have the greatest impact possible for our resources; it can help us work faster, smarter and better. Impact assessment may be a prerequisite of donors to establish if their funding is making a difference.

Conducting surveys of roaming dogs on the streets is a method of measuring 'indicators' of whether important changes in dog welfare and density are happening; indicators are those visible/audible signs that tell us whether a change is occurring. In the case of a street survey these indicators will include the proportion of dogs that are emaciated, have skin conditions and visible TVTs as signs of dog welfare; they will also include the percentage of lactating females and puppies as signs of potential population growth and the number of dogs per km of street surveyed as a measure of dog density. By repeating surveys over time we can monitor changes in these indicators and therefore provide evidence that change in important impacts is happening.

ESTIMATE OF ABSOLUTE SIZE VERSUS RELATIVE INDEX

Street surveys of roaming dogs can be conducted following different methodologies. Some of these methods will aim to produce an estimate of total (or 'absolute') dog population size for a given area and some will provide a 'relative index'. An example of a relative index would be the number of dogs per km of street surveyed. The benefit of relative indexes is that they are much quicker to measure as compared to estimates of total population size. This means that larger areas can be covered for the same resources. A relative index is also arguably more meaningful for members of the public; they may have no concept of a total dog population of 2,000 in their city. But they have a very real perception of the number of dogs they encounter as they travel to work or take their children to school and hence the number of dogs per km of street surveyed is more tangible.

Perhaps the best example of where this has been done before is Jaipur in India where every year for 16 years a survey has been conducted over 6 set routes, using the same protocol (e.g. always walking and always at the same time of year and same time of day). These surveys have exposed a consistent decline in the number of roaming dogs seen, the graph that follows displays survey data up until 2012 (data up until 2002 is published in Reece & Chawla, 2006[3]):

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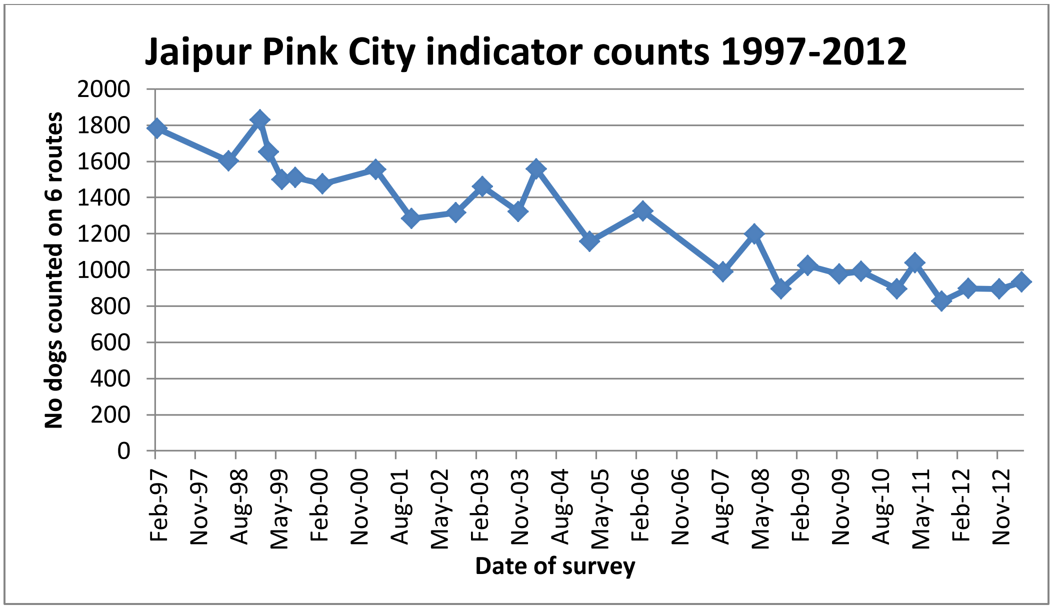
[3] Reece, J. F., & Chawla, S. K. (2006). Control of rabies in Jaipur, India, by the sterilisation and vaccination of neighbourhood dogs. *Veterinary Record*, *159*, 379–383.



A key strength of the Jaipur data is that it is extremely long-term. This was supported by establishing a good set of routes and an achievable protocol at the outset but also by dedication of the local NGO.

For these reasons, a relative index using set routes has been suggested for Panama, allowing a large area to be surveyed in a short space of time. A total population estimate is also calculated; using the measure of dog density along roads (from the current survey), the length of roads across all Panama (calculated using GIS) and the detectability estimate of 0.44 (from Veracruz survey by John Boone). However this estimate would be subject to unknown levels of error, as it relies on the detectability estimate from just one location. Establishing a more accurate detectability estimate for different types of urban and rural areas in Panama is possible but would require significantly more time investment.

SURVEY METHOD IN BRIEF

The detail survey protocol, including procedures for preparing the mobile phones for surveying and downloading data, is included in appendix 1. The following is a description of the methodology in brief:

Four routes were established that cover the urban conurbation of Panama Metropolitan area, these included urban and semi-urban areas and were drawn by someone naïve to Panama to ensure they were unbiased with regards to the roaming dog population. However, one potential bias was to ensure the routes did pass through three areas in which Spay Panama work; Casco Viejo, Kuna Nega and San Miguelito. These routes were between 19 and 26 km each and totalled 93.5 km in length. The routes excluded motorways and trunk roads where it was assumed there would be no roaming dogs, further it excluded paths and steps as the survey was to be done from a car. The total length of roads in the Panama Metropolitan area (with the prior exclusions in mind) is 2,654 km; hence these routes covered 3.5% of the roads. As these routes were drawn using Google Maps by someone naïve of Panama's streets, each route had to be tested and refined ahead of surveying to ensure it was viable (e.g. no dead ends, one-way streets or roads impassable by car), where blocks to the original route was found the shortest possible deviation back to the route was chosen. See figure 1 for an image of all four routes.

A street survey was conducted by driving along these 4 routes to observe and record all dogs on public roads and open private space (unfenced private areas). Dogs that were being walked on a lead or were inside a fenced area (even if gate was open) were excluded from the survey; all dogs that were loose or tethered in an unfenced area were included. Every dog included was categorised into dog type (male/female/female in heat/female lactating/unknown adult/puppy); where possible they were also scored for welfare/ownership attributes (body condition, skin condition, TVT, visibly sick and would benefit from immediate treatment, tethered/collar/no sign of ownership). Note; the presence of open wounds was also initially included as an attribute however only one dog was scored as having an open wound and the category of sick (requires immediate treatment) also encompasses open wounds, hence presence of open wounds was removed from the survey.

Dogs tethered in unfenced areas were included but are presented separately from free-roaming dogs in the results section. Inclusion of tethered dogs was to measure change in this method of restraining dogs, to establish whether any future change in free-roaming dog populations was due to a change in population size or management of dogs by tethering (which has associated welfare problems).

Figure 1 - Four survey routes across the urban conurbation of Panama Metropolitan area, displayed in Google Maps

Each route was surveyed three times on within a period of 17 days (27th Nov - 13th Dec) to establish a measure of day-to-day variance; this variance will be used for distinguishing the extent of actual change in density/welfare when comparing this baseline to subsequent surveys. Initially just two replicates per route was planned, however the day-to-day variation on the two replicates was relatively high and hence a third replicate was recommended.

Two mobile phones were used during the survey; one displaying the route using Google Maps app (version 6.14.4), the second to record observations of dogs using OSMtracker app with button layout design to suit this specific survey. On completion of the survey the data was downloaded from the OSMtracker phone into an Access database for storage and subsequent analysis.

The data was analysed to present the average and standard error for each individual route and the total for the four routes combined. The indicators used were total number of free-roaming and tethered dogs seen and number of free-roaming dogs per km of street surveyed. Sex, age, welfare and ownership attributes are presented as percentages of dogs scored for those attributes (i.e. not including dogs that were not scored for those attributes) both for individual routes and the four routes combined.

The results were also used to estimate the total roaming dog population (visible at peak roaming time 5-8am) for the Panama Metropolitan area and the total dog population using the detectability estimate established in Veracruz (Boone, 2013), and subsequently represented as the number of dogs per 100 people (using 2010 census data on human population). For corregimientos where the survey route covered at least 3.5% of the streets a total roaming dog population was estimated and presented as number of dogs per 100 people against human density (using 2010 census data) to establish whether roaming dog populations varied with human density in some predictable way.

RESULTS

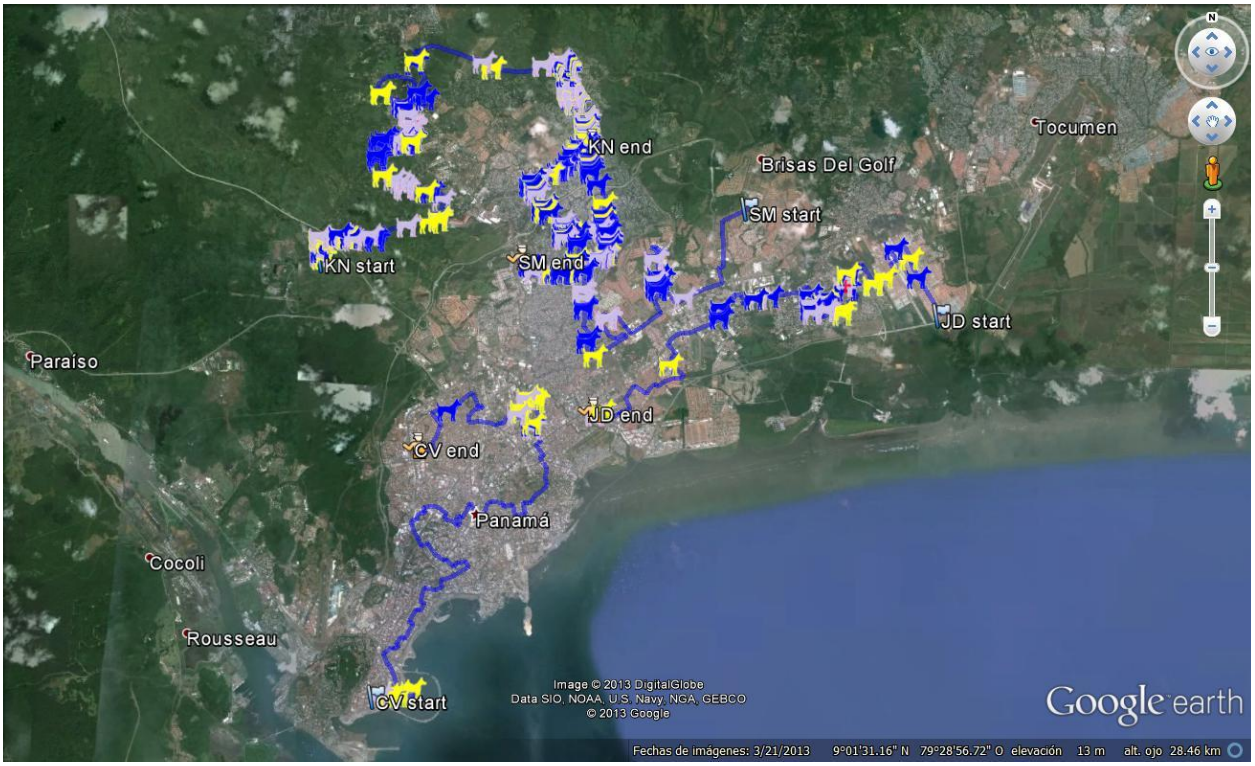
ROAMING AND TETHERED DOGS

The total number of adult dogs recorded on the 12 surveys (3 replicates over 4 routes) was 1227 of which 84% were roaming and the remaining tethered in unfenced areas (i.e. accessible to other dogs). This can also be expressed as an average of 3.60 roaming dogs per km of street surveyed; table 1 presents this data broken down by each of the four routes and figure 1 is an image of the routes plus icons for all the dogs seen on the 1st survey of each route.

Table 1 - Roaming and tethered dog total and roaming dogs per km of street surveyed split by route and survey

Route	Survey date	Total dogs	Roaming dogs	Tethered dogs	Roaming dogs per km street	Tethered dogs per km street
Juan Diaz	27 November 2013	47	47	0	2.48	0.00
	28 November 2013	42	37	5	1.91	0.26
	13 December 2013	27	25	2	1.29	0.10
	Average (SE)	**39 (6.01)**	**36**	**2**	**1.89 (0.34)**	**0.12 (0.08)**
Casco Viejo to Bethania	29 November 2013	21	21	0	0.83	0.00
	30 November 2013	27	26	1	1.03	0.04
	10 December 2013	36	34	2	1.35	0.08
	Average (SE)	**28 (4.36)**	**27**	**1**	**1.07 (0.15)**	**0.04 (0.02)**
Kuna Nega to Torrijos Carter	02 December 2013	166	131	35	5.84	1.56
	03 December 2013	191	146	45	6.51	2.01
	09 December 2013	160	115	45	5.13	2.01
	Average (SE)	**172 (9.49)**	**131**	**42**	**5.83 (0.40)**	**1.86 (0.15)**
Brisas del Golf to San Miguelito	01 December 2013	155	135	20	5.10	0.76
	04 December 2013	167	150	17	5.67	0.64
	12 December 2013	188	161	27	6.09	1.02
	Average (SE)	**170 (9.64)**	**149**	**21**	**5.62 (0.29)**	**0.81 (0.11)**
All Routes	**Total/Average (SE)**	**Total = 1227**	**Total = 1028**	**Total = 199**	**Average = 3.60 (0.31)**	**Average = 0.71 (0.56)**

Figure 2 - Google Earth image of all the dogs seen on the four survey routes. Blue icons are male dogs, yellow icons are female dogs and grey dog icons are adult dogs of unknown sex and grey icons with red 'P's are pups



SEX, WELFARE AND SIGNS OF OWNERSHIP

The female to male ratio of dogs observed was 1:2.7. Puppies comprised only 5% of all dogs seen, 7% of females were lactating and 3% were observed to be in heat. Most adult dogs were visible long enough to be scored for welfare state (table 2 provides the *n* values); of those that were scored 37% were judged to be emaciated or thin (scoring 1 or 2 body condition score), 28% were seen to be suffering from some kind of skin condition, 4% were visibly sick (would benefit from immediate veterinary care) and only 1% had a visible TVT. Of the roaming untethered dogs 15% were wearing a collar.

Table 2 – Sex, welfare and owner status for all (roaming and tethered) dogs observed (all 12 surveys), grouped by route.

	Dog type				Welfare and ownership status (of adult dogs only)				
Route	Female: Male	% Heat (*n*)	% Lactating (*n*)	% Pups (*n*)	% Emaciated or thin; BCS 1-2 (*n*) *	% Skin problem (*n*)	% Sick (*n*)	% TVT (*n*)	% Collared (*n*) **
Juan Diaz	1 : 2.0	4% (25)	0% (25)	1% (74)	22% (59)	23% (57)	5% (56)	0% (56)	7% (75)
Casco Viejo to Bethania	1 : 0.9	0% (25)	8% (25)	0% (45)	16% (44)	12% (34)	3% (30)	0% (31)	18% (60)
Kuna Nega to Torrijos Carter	1 : 2.2	1% (87)	5% (87)	10% (298)	19% (298)	15% (314)	4% (310)	1% (310)	19% (314)
Brisas del Golf to San Miguelito	1 : 4.5	7% (72)	11% (72)	2% (344)	38% (289)	28% (297)	11% (247)	1% (310)	7% (330)
TOTAL	**1 : 2.7**	**3% (209)**	**7% (209)**	**5% (761)**	**37% (690)**	**26% (702)**	**7% (643)**	**1% (630)**	**15% (779)**

* Lactating females (*n* = 8) excluded from this body condition score summary, on the assumption that lactation and body condition is not independent

** Tethered dogs not included, % of roaming dogs only.

RELATIONSHIP WITH SOCIOECONOMIC FACTORS

The four routes included streets falling within 21 of the 33 corregimientos that comprise Panama and San Miguelito Districts; however for 5 of these corregimientos, less than 3.5% of the streets were covered by the routes and hence they were excluded from the following analyses. For the remaining 16 corregimientos an estimate of the roaming dog population size was calculated from the roaming dogs per km of street surveyed and the total street length (excluding trunk roads, motorways, paths and steps) for the corregimientos (table 3), the total estimated roaming dog population during the survey period for these 16 corregimietos is 3,964.

Using linear regression, the dog count in each of the 16 surveyed corregimientos could be explored for its relationship with covariates obtained from the 2010 census (data available from www.arcgis.com under the name GEORED 507 - Corregimientos - Censo Nacional de Población y Vivienda 2010[4]). Significant relationships could then be used to estimate the number of dogs on the streets at any one time during the survey period in the remaining 14 unsurveyed corregimientos (or surveyed to a limited extent, i.e. only along < 3.5% of roads).

The potential covariates considered were human population size, total number of houses and data relating to housing infrastructure. During the surveys dog density appeared high in areas where properties lacked fences, the census did not include information about property boundaries however we searched the census data for other signs of infrastructure limitations that we hypothesised could

[4] http://www.arcgis.com/home/webmap/viewer.html?webmap=09a8abd85ac2435bb5f6a5d0e01204fd

indicate a house that might also lack a surrounding fence. The characteristics identified including the number of houses with no toilet, number of houses without mains water and number of improvised houses. The data for households without mains water showed limited variation between the corregimientos (12 of the corregimientos reported no houses without mains water) and so was not suitable for further analysis. The number of improvised houses and houses without a toilet were correlated with each other, presumably these were often the same household, however the number of houses without a toilet explained a greater proportion of the variation (R^2 = 0.34) in dog density than improvised houses (R^2 = 0.30) and so this covariate was used in subsequent analysis.

Repeat counts along the standard routes suggest that the count variance increased in proportion to the average count. For the regression we therefore chose to model the count in each corregimiento as having a negative binomial distribution about the expected count with variance a multiple of that expectation which was estimated along with the regression coefficients.

As each count was obtained along a measured length of survey route one of the predictors was the route length. The other predictors provided by the census data related to the entire corregimiento (e.g. there are 206 houses without a toilet in the corregimiento Arnulfo Arias) and so needed to be transformed before testing for their relationship with the dog count; the transformation was to multiple them by route length/total road length for the corregimientos (e.g. again for Arnulfo Arias 206 houses with no toilet X 2.58km route/39.23 km road length = 13.5 houses without toilets estimated to be associated with the route). The regression constant also therefore fixed at zero (forcing the regression line through the origin when plotted), giving a zero expected dog count for a zero length survey route.

Table 3 – Roaming dogs (adults only and excluding tethered dogs) seen in total across 3 surveys and average, route length, dogs per km of street and estimated dog population and human population by corregimientos

Corregimiento	Area (km²)	Stray dogs				Roads (km)			Human population (2010 census)		
		Dogs per km street surveyed	Popn estimate	Popn estimate *	Dogs per 100 people	Covered by routes	Total	% Roads covered by routes **	Total	Density km²	Number of houses without a toilet
Arnulfo Arias	7.3	10.97	430	978	3.09	2.58	39.23	6.58	31,650	4,356	206
Belisario Frías	4.3	12.85	606	1378	3.09	3.68	47.18	7.81	44,571	10,359	101
Belisario Porras	4.0	8.53	303	688	1.39	5.78	35.49	16.30	49,367	12,294	222
Bella Vista	4.8	0.00	0	0	0.00	5.33	57.77	9.22	30,136	6,229	0
Betania	8.3	0.23	29	65	0.14	5.72	123.60	4.63	46,116	5,559	0
El Chorrillo	0.6	12.78	128	291	1.59	0.55	10.02	5.47	18,302	29,363	0
José Domingo Espinar	7.1	1.93	209	474	1.07	10.87	107.98	10.07	44,471	6,265	44
Juan Díaz	34.0	1.96	530	1205	1.20	16.32	270.48	6.03	100,636	2,960	32
La Exposición O Calidonia	1.6	0.28	9	20	0.10	2.35	30.64	7.66	19,108	12,001	0
Las Cumbres	27.8	4.91	1308	2974	9.05	20.09	266.40	7.54	32,867	1,180	163
Parque Lefevre	6.8	1.20	97	221	0.60	4.15	80.70	5.15	36,997	5,408	7
Pueblo Nuevo	2.9	1.67	65	148	0.78	1.99	38.90	5.12	18,984	6,626	5
Río Abajo	3.9	4.95	221	503	1.89	2.02	44.69	4.52	26,607	6,892	4
San Felipe	0.3	1.90	15	33	1.02	1.58	7.72	20.45	3,262	11,005	0
San Francisco	6.4	0.00	0	0	0.00	3.04	74.68	4.07	43,939	6,856	4
Santa Ana	0.8	1.08	14	32	0.08	0.93	13.07	7.09	18,210	21,728	0

* Estimated roaming dog population including correction factor of 0.44 for detectability from 'Street Dog Survey & Training in Veracruz, Panama' (Boone, 2013)

** Highlighted cells are corregimientos where less than 3.5% of roads were covered by routes, these were excluded from subsequent analyses with socioeconomic factors

Stepwise regression gave a coefficient of 3.54 for expected count against length of survey route only (corresponding to an overall average of 3.54 dogs per km; note this is a slightly lower average to the 3.60 dogs per km provided earlier, this is because the previous average was based on all survey routes and this current average of 3.54 is based on only those routes falling within the selected 16 corregimientos). When combining route length and number of houses with no toilet the coefficient was 0.99 for route length and 2.25 for number of houses with no toilet, this combination was a significantly better fit at $p < 0.005$ as compared to the regression on route length only.

Adding human population size to the regression on route length only, or to the regression on route length and number of houses with no toilet, failed to produce a significant improvement in fit; the relationship between dogs per 100 people and human density was also analysed separately and found to not be significant ($R^2 = 0.0758$, p = 0.302; see figure 3). The regression on route length and number of houses with no toilet was therefore used to predict the number of dogs that would have been seen along the total road length in each of the unsurveyed corregimientos (table 4).

Table 4 – Estimated roaming dogs per unsurveyed corregimientos produced by applying the linear regression coefficients to the census data and route length.

Corregimientos	Estimated roaming dog population	Estimate roaming dog population *	Total 'dog' road length	Estimated dogs per km of street surveyed
24 de Diciembre	562	1277	175.94	3.19
Amelia Denis de Icaza	187	425	46.52	4.02
Ancón	1071	2434	388.68	2.76
Chilibre	284	645	97.39	2.92
Curundú	132	300	17.55	7.52
Las Mañanitas	294	668	92.91	3.16
Mateo Iturralde	98	223	13.30	7.37
Omar Torrijos Herrera	179	407	61.73	2.90
Pacora	340	773	108.24	3.14
Pedregal	281	639	85.51	3.29
Rufina Alfaro	396	900	136.11	2.91
San Martín	118	268	18.48	6.39
Tocumen	382	868	135.88	2.81
Victoriano Lorenzo	190	432	26.83	7.08
TOTAL	6024	10259		

* Estimated roaming dog population including correction factor of 0.44 for detectability from 'Street Dog Survey & Training in Veracruz, Panama' (Boone, 2013)

Fixing the route length coefficient to reduce the maximised log likelihood to 1.92 less than its full model maximum value provided 95% confidence limits on the point estimate of 6024 dogs in the unsurveyed corregimientos from 4,700 to 7,830. Using the detectability estimate of 0.44 increased the estimate for the unsurveyed corregimientos to 10,259.

Figure 3 - Estimated roaming dogs (adults only and excludes tethered) per 100 people and human population density (2010 census) by corregimientos (where > 3.5% of streets were surveyed)

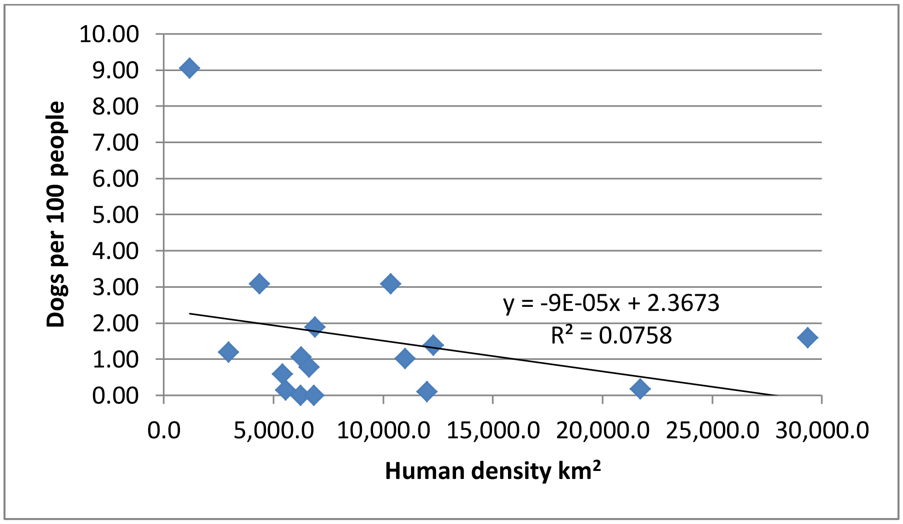
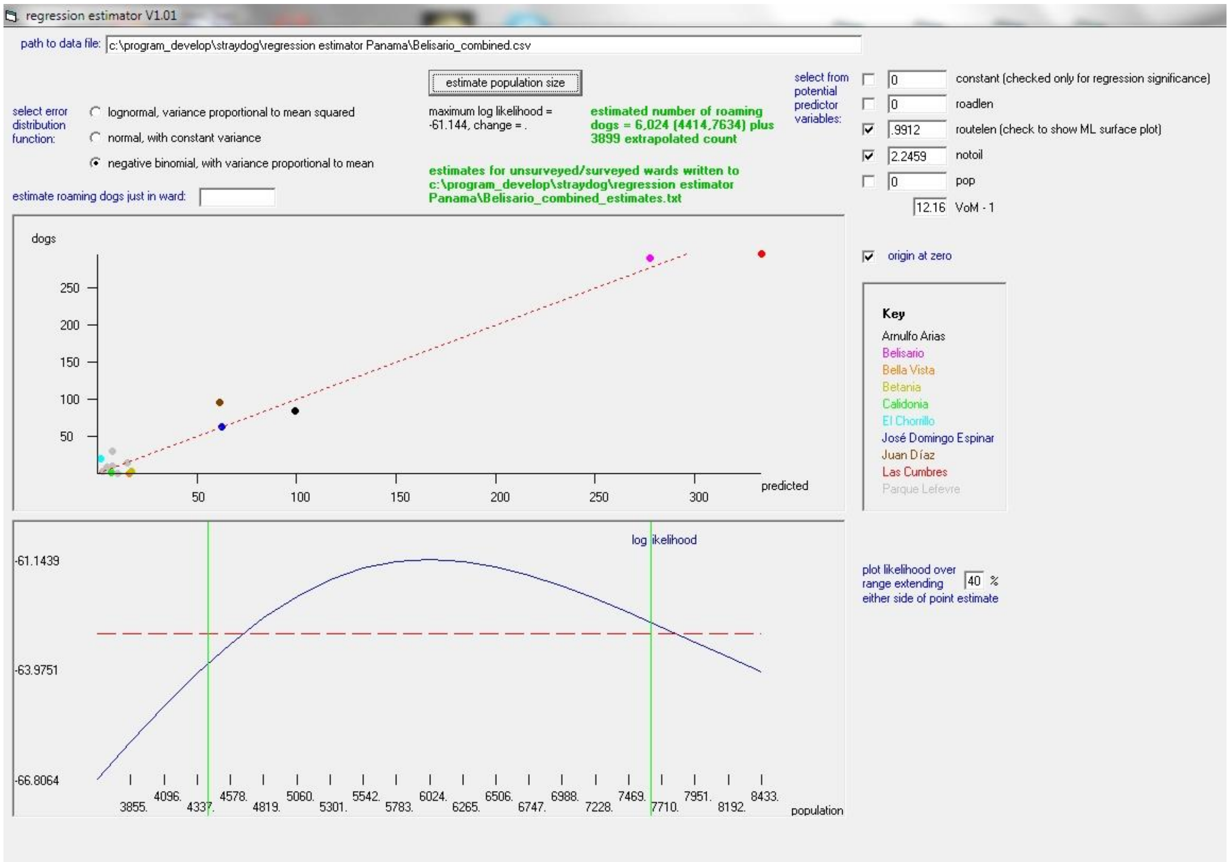


Figure 4 shows output of the code used to derive the regression estimates and illustrates a comparison of observed counts in each surveyed corregimiento to the count predicted by the regression equation.

Figure 4 – Output of the regression model



Note that data for Bellisario Frias and Belisario Porras were combined in the analysis because the survey route ran along the border between the two regions and dogs could not be reliably allocated to each corregimientos. Further Las Cumbres in this analysis represents Las Cumbres in its present form plus Ernesto Cordoba Campos and Alcalde Díaz combined; this combination had to be used because there was no total street length available for the 3 corregimientos separately.

ROAMING DOG POPULATION ESTIMATE FOR PANAMA METROPOLITAN AREA

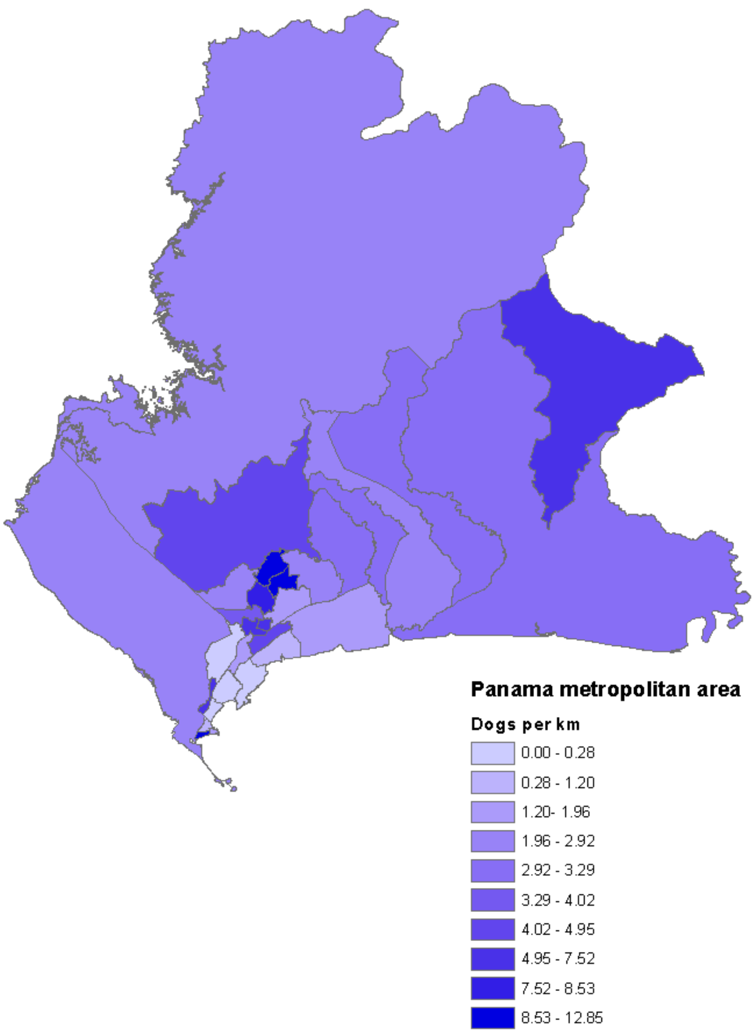
The significant linear regression between the dog count and the number of houses with no toilet combined with route length was used to estimate the dogs per km of street for the 14 corregimientos that were not included in the survey, this was then multiplied by the road length to estimate the total roaming dogs for each corregimientos (see table 4). This came to a total of 6,024 dogs for the 14 unsurveyed corregimientos and 3,964 for the 16 corregimientos that were surveyed along at least 3.5% of their streets; hence a total of 9,988 roaming dogs for the whole Panama Metropolitan area during peak roaming time (5-8am). This estimate can be corrected for dogs that were not visible to the surveyors by using the detectability estimate for free-roaming dogs of 0.44 from the 'Street Dog Survey

& Training in Veracruz, Panama' (Boone, 2013); this brings the total estimated roaming dog population for the Panama Metropolitan area to 22,701. The Panama Metropolitan area has a human population of 1,272,672 (2010 census) which equates to 1 roaming dog for every 56 people or just under 2 roaming dogs for every 100 people.

Interestingly, this is not dissimilar to the estimate of 9,554 (95% CI 7,663-11,446[5]) roaming dogs at peak roaming time estimated through the simple application of the average roaming dogs seen per km of street surveyed (3.60) and the total road length (2,654km); this is increased to 21,715 when considering the detectability estimate.

The dogs per km of street by corregimientos is displayed in figure 5 as a thematic map of the Panama Metropolitan area.

Figure 5 - Dogs per km of street for all corregimientos in Panama Metropolitan area



[5] Confidence interval estimated using within route survey to survey variation

DISCUSSION

They key indicator for monitoring change in the dog population is the number of roaming dogs seen per km of street surveyed for each of the four routes; this was highest on the Brisas del Golf to San Miguelito (5.62 dogs per km) and Kuna Nega to Torrijos Carter (5.83 dogs per km) routes. The number of tethered dogs per km should also be monitored to establish whether any reduction in roaming dogs is due to an increase in tethering in unfenced areas (which suffers from associated welfare problems), or some other factor such as a reduction in the overall dog population or an increase in fenced areas for confining dogs.

The percentage of puppies seen was highly variable across survey because puppies usually appeared with their litter mates, hence if a litter was seen this equated to several puppies. On other surveys of the same route a litter may not be spotted and hence the number of puppies seen was much lower. With this in mind, it is recommended that % of females observed to be lactating be used as a more reliable indicator of reproductive activity.

In addition, there are several welfare related indicators that would be ideal to also monitor by route, including the % of thin or emaciated dogs, % of dogs with visible skin conditions and % of sick dogs. Currently the Brisas del Golf to San Miguelito route showed the highest % of these welfare problems. The percentage of dogs with collars may also be relevant to monitor as a reflection of perceived owner responsibility.

Only 1% of dogs were observed to have a visible TVT. The actual prevalence of TVT is far higher, as recorded by Spay Panama during their spay/neuter work, but these tumours are rarely visible during street surveys. This suggests that TVTs may not be worth recording during street surveying in future as it will not be possible to show any decline in TVTs over time with such a low starting prevalence. However, they should still be recorded during Spay Panama's spay/neuter work; the prevalence of TVTs per month could be plotted over the years to establish if there is any change over time.

Using the data available for 16 corregimientos where sufficient streets had been surveyed allowed for exploration of the relationship between dog density and socioeconomic factors. The number of people, number of households and human density by area were found to have non-significant relationships with dog density. However the number of houses with no toilet was found to have a significant positive relationship with dog density. One suggestion for why this relationship exists is that houses with no toilet also tend to have no fence and it is the absence of fencing that allows dogs to roam. The socioeconomics of householders and their inability to afford reproduction control for their dogs may also be a contributing factor.

The significant regression of route length and houses with no toilets on dog count was used to estimate the number of roaming dogs in unsurveyed corregimientos, with a total of 6,024 estimated for all 14 corregimientos. Combined with the estimated dog population for the surveyed corregimientos (3,964) provides a total of 9,988 for the Panama Metropolitan area. Interestingly, this is not dissimilar to the estimate of 9,554 (95% CI 7,663-11,446[6]) roaming dogs estimated through the simple analysis of the average roaming dogs seen per km of street surveyed (3.60) and the total road length (2,654km).

However these estimates are for the number of dogs seen at peak roaming time (5-8am) and do not account for roaming dogs not seen by the surveyors. This can be corrected using the detectability estimate of 0.44 from the 'Street Dog Survey & Training in Veracruz, Panama' (Boone, 2013); providing an estimate of 22,701 based on the socioeconomic relationship and 21,715 using the more simple average dogs per km metric and total street length. These corrected figures should be treated with caution as it uses a detectability estimate from a town outside of the Panama Metropolitan area.

RECOMMENDATION FOR FUTURE SURVEYS

This survey approach establishes a baseline for monitoring, as such it is meaningless as a single event; the survey needs to be repeated at regular intervals to expose any change in the dog population. The survey was completed within a 17 day period and required 12 mornings of actual surveying. The consultant conducted a short training course for all Spay Panama staff and also involved five staff in the survey itself alongside one taxi driver. This established a core survey team that successfully completed a third replicate of all routes after the consultant had left Panama and hence can competently complete further surveys in future.

I recommend that the survey is completed once every six months, with three replicates of each four routes, totalling 12 mornings of surveying twice per year. If this level of investment is not possible a reduction to an annual survey but retaining three replicates of all four routes is advised.

It is essential that the survey protocol (e.g. counting each route more than once, always travelling in the same way i.e. by car, same time of day when the counts are conducted and same effort put into searching for dogs) and routes are kept consistent over time to ensure the data is comparable (see further recommendations on how to maintain survey protocol in the final section of appendix 1).

As future surveys are conducted the data can be analysed for change over time and explored for correlation with efforts made by Spay Panama, such as number of spay/neuter surgeries per six months. I further recommend that Spay Panama spay/neuter data is aggregated according to species, sex, and pregnancy status (i.e. dog castrate/dog spay/pregnant dog spay/cat castrate/cat spay/pregnant cat spay) to provide more detailed records of Spay Panama work when exploring correlations with population changes and to establish the existence of breeding seasons.

If Spay Panama are interested in exploring further the owned dog population including confined dogs (our survey captured only roaming owned dogs and some, presumably small, number of unowned dogs) a house-to-house questionnaire could be conducted. This could be done along the same routes for surveying and could explore the number, sex, reproductive status, source and care (including confinement) provided to dogs. However, if Spay Panama would like to establish a detectability estimate for Panama (or indeed a range of detectability estimates dependent on socioeconomic status) this would need to utilise 'blocks' as described in the methodology used in Veracruz (Boone, 2013), and would require a combination of a questionnaire of a sample of households and an exhaustive street survey of roaming dogs. A questionnaire along the routes would not be sufficient as there are

[6] Confidence interval estimated using within route survey to survey variation

households not directly associated with roads that are only accessible by paths/steps and will contribute to the roaming dog population. Blocks could be selected with routes running through them so comparisons could be made between the resulting dogs per km of street surveyed and owned dog population from the block surveys and the dogs per km of street from the monitoring surveys. It would be ideal to select blocks from different socioeconomic areas as the level of confinement of owned dogs clearly varied significantly.

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Dr Elly Hiby

Independent Consultant,

Cambridge,

UK

Tel: 44 (0) 7818098131

Email: ellyhiby@gmail.com

Skype: ellyhiby

Mr Lex Hiby

Conservation research Ltd,

Cambridge,

UK