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Short communication

Disease control through fertility control: Secondary benefits of animal birth control in Indian street dogs☆

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ABSTRACT

We sought to (1) survey sexually intact street dogs for a wide range of diseases in three cities in Rajasthan, India and (2) evaluate links between the health of non-treated dogs and both the presence and duration of animal birth control (ABC) programs. ABC regimes sterilize and vaccinate stray dogs in an attempt to control their population and the spread of rabies. They are commonly suggested to improve the health of those dogs they serve, but here we provide evidence that these benefits also extend to untreated dogs in the community.

Viral and bacterial disease seroprevalences were assessed in 240 sexually intact street dogs from Jaipur, Jodhpur, and Sawai Madhopur cities in October and September 2011. Those individuals and 50 additional dogs were assessed for the presence of ticks, fleas, fight wounds, and given body condition scores. Dogs in cities with an ABC program had with significantly ($p < 0.05$) higher overall body condition scores, lower prevalence of open wounds likely caused by fighting, flea infestations, infectious canine hepatitis, Ehrlichia canis, Leptospira interrogans serovars, and canine distemper virus antibodies. However, those same dogs in cities with ABC programs had significantly higher prevalence of Brown Dog Tick (Rhipicephalus sanguineus) infestations. Canine parvovirus and Brucella canis prevalences were not significantly different between cities. This study is the first to demonstrate the health benefits of ABC on non-vaccinated diseases and non-treated individuals.

1. Introduction

Street dogs are common in the developing world, and often live with little or no veterinary care, consuming refuse and feces to survive (Butler and du Toit, 2002; Butler et al., 2004; Reece et al., 2008). India's large population of street dogs originates from a unique combination of local tolerance, abundant food, shelter, breeding opportunities, and ineffective dog control policies (Reece, 2007). Compounding the issue, vulture populations on the Indian subcontinent have undergone dramatic (>95%) declines and carcasses that would normally be consumed by vultures now supplement dog diets (Markandya et al., 2008). Surveys of Indian dog population sizes are scarce, but at one rubbish dump in Rajasthan, the population has increased from 60 dogs in 1992 to 1200 individuals nine years later (unpublished results in Prakash et al., 2003). Dog bites account for 90% of the human post exposure rabies treatments and 96.5% of the 20,000 human rabies deaths in India (Knobel et al., 2005; Kale et al., 2006).

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Canine and rabies control are both being addressed by canine animal birth control (ABC) and vaccination programs in urban centers to reduce canine reproductive capability and the progression of rabies (Reece, 2007). Several Indian cities began to use ABC programs in the early 1990s as an alternative to culling strategies (including conscious electrocution, beatings, and strychnine poisoning, Reece, 2007) which may, counter-intuitively, increase rabies incidence. By disrupting canine social structures, culling often leads to increased fighting and rabies transmission opportunities (Donnelly et al., 2006; Reece and Chawla, 2006; Killian et al., 2007). ABC programs seek to produce a socially stable, but declining, street dog population through ovariohysterectomy and castration of a majority of dogs and is advocated by all major international dog control organizations (WHO, 2004; ICAM, 2007). When sterilized in this manner, normal canine hormonal cycling is halted, decreasing conspecific aggression, breeding behavior, and aggregation around bitches in estrus, behaviors that are high-risk factors for disease transmission (Killian et al., 2007). ABC programs in Jaipur and Jodhpur, two cities in the northwestern Indian state of Rajasthan, have been highly effective in reducing the street dog population and rabies incidence (Reece and Chawla, 2006; Totton et al., 2010b). Additionally, dogs which have previously been treated by an ABC program have significantly superior health compared to their sexually intact neighbors in the same city (Totton et al., 2011). This effect was attributed to the behavioral changes and lowered energy requirements of sterilized dogs compared to intact dogs which must care for pups and maintain territories (O'Farrel and Peachey, 1990; Totton et al., 2011).

This study seeks to demonstrate if treated dog's behavioral changes, reduction in dog density, and lowered energy requirements caused by sterilization substantially affect the cycling of common canine diseases. The ABC programs in this survey vaccinate solely against rabies, so our reported disease prevalences are not affected by direct vaccination or treatments of these diseases. Since this work only examines sexually intact dogs that have not been through an ABC program, it highlights the benefits of having sterilized neighbors where other investigators report the benefits to the individual dog that is sterilized (Totton et al., 2011). This also illustrates health benefits for proximate humans and wildlife susceptible to similar disease pressures. Additionally, this study is the first to survey multiple diseases over several different localities with large numbers of dogs.

2. Materials and methods

2.1. Study area

A cross-sectional survey of canine disease was performed in three different Indian cities: Jaipur (26°55′ N, 75°49′ E), Jodhpur (26°17′ N, 73°01′ E), and Sawai Madhopur (25°59′ N, 76°22′ E) in September–October of 2011. All three cities are within Rajasthan, an arid, northwestern state of India. Jaipur is a large city (pop. 3.1 million) with an estimated 36,580 dogs (Hiby et al., 2011) and has been served by the Help In Suffering ABC program since 1994 (Reece and Chawla, 2006). Jodhpur is another large city (pop. 1 million) with an estimated 24,853 dogs (Hiby et al., 2011) that has been served by the Marwar Animal Protection Trust ABC program since 2004. Although the proportion varies yearly, roughly 80% of bitches are sterilized in these cities (Hiby et al., 2011). The third location, Sawai Madhopur, is a smaller city (pop. 120,000) on the edge of Ranthambore National Park and has never had any ABC or large-scale rabies vaccination program. No scientific estimate of the dog population size in Sawai Madhopur has been made. However, if estimates of dog/human ratios from another similarly sized Rajasthani city, Jaisalmer, holds, a rough estimate of ~4500 dogs is produced (Census, 2012; Hiby et al., 2011).

2.2. Survey procedures

Dogs in Jaipur and Jodhpur were collected by their respective ABC programs, Help In Suffering and the Marwar Animal Protection Trust, and blood was taken immediately prior to sterilization while under anesthesia. In Sawai Madhopur, resting dogs were hand caught in the early morning and restrained for sampling and rabies vaccination. All dogs were selected solely based on unrestricted movement (unchained/unfenced) on the streets. Blood samples were taken from the cephalic vein and stored in EDTA blood collection tubes.

Blood was tested for the presence of immunoglobulin G for canine distemper virus (CDV) (IgM sensitivity of 93.1%, IgG sensitivity of 95%, IgM specificity of 95.5%, IgG specificity of 100%), canine parvovirus (CPV) (IgM sens. of 91.4%, IgG sens. of 97%, IgM spec. of 90.8%, IgG spec. of 100%), Leptospira interrogans serovars (IgG sens. of 80%, spec. of 60%), Brucella. canis (IgG sens. of 98%, spec. of 93%), Ehrlichia canis (IgG sens. of 100%, spec. of 94.1%), and infectious canine hepatitis (ICH) (IgG sens. of 98%, spec. of 86%) using commercially available ELISA testing kits (Immunocomb® kits, BioGal Labs, Kibbutz Galed 19240, Israel). The L. interrogans test indicates the presence of the serovars canicola, icterohemorrhagiae copenhagi, icterohemorrhagiae RGA, pomona, and grippotyphosa but did not differentiate between them. Additionally, IgM values were gathered for CDV and CPV, providing information about what disease stage an individual dog was experience during the time of sampling (susceptible, infected, immune).

Dogs were given a brief physical examination during which a body condition score (based off a simplified scale from Totton et al., 2011) and checked for the presence of ticks, fleas, and open wounds. The body condition scores (1–4) correspond to weight classes of emaciated (1), underweight (2), healthy weight (3), and obese (4). Before release, Sawai Madhopur dogs were vaccinated against rabies (ImRab 3®, Merial Ltd., Duluth, GA 30096).

2.3. Statistical analysis

We utilized generalized linear models (GLM) in SPSS 19 (IBM SPSS Statistics) to determine the effects ABC programs have on the prevalence of disease. The binomial data (sick or not sick) utilized a binary logistic response, binomial probability, and a logit link function. The three ordinal data categories (body condition score, CPV, and CDV infection class) used an ordinal logistic response, multinomial probability, and a cumulative logit link function. In analysis, body conditions of 3 and 4 were combined because of the absence of obese body condition dogs. A model for each disease was built using location, body condition, age, and sex as fixed effects. For all models, location was the only significant contributing factor, so the others variables were removed from the final model. For each disease, we used Wald likelihood ratios to determine significant differences between cities for all pairwise comparisons of means. Using the p-values derived from these initial pairwise comparisons between cities for single diseases, we applied the Holm–Bonferroni correction (Holm, 1979) to determine corrected significance of pairwise comparisons accounting for testing of multiple diseases on individual dogs. Using an initial significance at $p = 0.05$, after accounting for our 10 diseases, we assessed significance at $p = 0.005$.

3. Results

The prevalence of diseases and body condition scores, the significance of the pairwise comparisons between cities, and the total effect of location in predicting disease prevalence are shown in Table 1. There were significant effects of location on body condition scores, tick, flea, fight wound, *E. canis*, *Leptospira* serovars, and infectious canine hepatitis presence. In the case of each of these diseases, with the exception of ticks, the direction of the effect showed a positive influence of ABC on dog health.

Location had a significant effect ($p = 0.0001$) on the proportion of dogs currently infested with ticks (all identified to be in the R. sanguineus species complex). In pairwise comparisons for ticks, Jaipur and Jodhpur differed significantly from Sawai Madhopur (both $p = 0.0001$) but did not differ from each other ($p = 0.131$).

We found similar results for body condition, with the fewest number of low body condition dogs (emaciated) and the highest body condition (healthy weight) dogs in the ABC cities compared to the non-ABC city. For each of the other diseases for which location was a significant predictor, significant pairwise comparisons show lowered disease prevalence as the duration of ABC increased.

Other conditions important to dog health were observed but not comprehensively evaluated because of their rarity. Several dogs presented with suspected Babesia canis/gibsoni and Leishmania sp. infections but no confirmatory test was locally available. Some dogs presented with canine transmissible venereal tumors, however as many early stage tumors can easily go undiagnosed, it was not recorded for this survey.

4. Discussion

We found that ABC areas exhibited lower prevalence of disease in unsterilized and untreated dogs for seven

Table 1
Prevalences of canine diseases in three Rajasthani cities.

Disease	More ABC→Less ABC		
	Jaipur	Jodhpur	Sawai Madhopur
Body condition score*	$n = 106^{A}$	$n = 83^{AB}$	$n = 101^{B}$
Emaciated	22.65%	42.17%	45.54%
Low weight	48.11%	45.78%	37.62%
Healthy	29.95%	12.05%	16.83%
CPV	$n = 100$	$n = 78$	$n = 60$
Susceptible	14.00%	24.36%	18.33%
Infected	1.00%	3.85%	6.67%
Immune	85.00%	71.79%	75.00%
CDV	$n = 100$	$n = 78$	$n = 60$
Susceptible	34.00%	33.33%	15.00%
Infected	28.00%	30.77%	36.67%
Immune	38.00%	35.90%	48.33%
Ticks*	$n = 120^{A}$	$n = 83^{A}$	$n = 48^{B}$
	53.33%	63.85%	25.00%
Fleas*	$n = 120^{A}$	$n = 83^{A}$	$n = 64^{B}$
	4.17%	1.20%	25.56%
Fight wounds*	$n = 153^{A}$	$n = 88^{A}$	$n = 102^{B}$
	3.92%	6.83%	25.49%
*E. canis**	$n = 100^{A}$	$n = 79^{B}$	$n = 60^{C}$
	45.00%	58.23%	76.67%
Leptospira serovars*	$n = 100^{A}$	$n = 77^{A}$	$n = 58^{B}$
	12.00%	7.79%	39.66%
Infectious canine hepatitis*	$n = 100^{A}$	$n = 78^{A}$	$n = 60^{B}$
	74.00%	92.31%	96.67%
B. canis	$n = 100^{A}$	$n = 79^{A}$	$n = 58^{A}$
	10.00%	5.06%	3.45%

Notes: Cities are arranged by the degree of ABC use (Jaipur – 17 years, Jodhpur – 7 years, Sawai Madhopur – 0 years). Diseases with * indicate statistically significant effects of location in a generalized linear model. Values with differing superscripts (A–C) indicate statistically significant differences in the three pairwise comparisons between two individual cities.

(body condition score, fleas, fight wounds, CDV, E. canis, Leptospira serovars, and ICH) of the ten conditions. CPV and B. canis seroprevalence did not differ significantly among cities. The E. canis prevalences in Jaipur differed significantly from both Jodhpur and Sawai Madhopur. The ABC program in Jaipur has operated for 17 years, in contrast to 7 years in Jodhpur and not at all in Sawai Madhopur. Thus, for these conditions, prevalence is also affected by the duration of ABC. The association between the presence of ABC programs and a lower prevalence of infection may result from the ABC-driven decline of the dog population size as well as the behavioral and immunological changes. Importantly, ABC programs appear to influence disease dynamics in the entire dog population, and not just treated dogs, since this survey only included sexually intact dogs who had not undergone sterilization and vaccination. We argue that untreated dogs were less likely to be exposed to infection because neighboring ABC-treated dogs were healthier (Totton et al., 2011), more capable of resisting infection, and less likely to transmit disease.

While most of the disorders in this survey are unlikely to be affected by climatic conditions, leptospirosis in India is one that may be heavily influenced by the availability of other principal hosts (particularly rodents) and high rainfall levels (Venkataraman and Nedunchelliyan, 1992). The yearly average rainfall for Jaipur, Jodhpur, and Sawai Madhopur is 60, 30, and 75 cm, respectively (Singh et al., 1974). While all three cities had experienced a moderately heavy monsoon season in the months prior to this survey, the mildly damper conditions in Sawai Madhopur may cause higher numbers of Leptospira infections, unrelated to ABC coverage. Therefore, we recommend additional investigation with methods that differentiate between Leptospira serovars.

We found significantly fewer open wounds in the cities with ABC coverage. Based on concurrent behavioral observations and wound morphology (A.J. Yoak and J.F. Reece, pers. obs.), we suggest that the majority of these are received by fighting with other dogs. As the sterilization programs in Jaipur and Jodhpur halts hormonal cycling in bitches, they do not enter estrus and thus do not elicit competition and congregation over breeding opportunities. Breeding associated fighting was seen nearly every day of the week-long survey in Sawai Madhopur and never in the other cities (surveys were performed during the established breeding season (Totton et al., 2010a)). This decrease in incidental biting may substantially lower the rabies transmission rate by reducing pre-symptomatic transmission, benefiting dogs, humans, and wildlife (Killian et al., 2007).

Dogs from ABC cities had higher prevalences of R. sanguineus ticks. This may be because ABC centers facilitate the transfer of ticks by housing dogs in close contact and there may be differences in the availability of alternate hosts or environmental conditions between cities. Protocols to mitigate the risk of tick spread (use of cypermethrin spray) should be implemented in ABC programs as suggested by Totton et al. (2011). Nevertheless, dogs in ABC cities still had significantly lower prevalence of infection by the tick-borne spirochaete bacterium E. canis, which suggests that factors other than tick density influence ehrlichiosis in these dogs.

The dogs sampled here may represent a subset of the more catchable dogs, although this is difficult to assess. As our study cities are not perfectly comparable with respect to their dog population size, human demographics, or environmental conditions, the claim that ABC will lower the prevalence of non-targeted diseases in street dog populations must be tempered. However, we would predict that many of the differences between cities would expect to result in greater disease prevalences in ABC cities (e.g., greater dog populations mean a larger pool of susceptible individuals), in contrast with our findings. We suggest that by sterilizing and vaccinating against rabies, ABC programs yield a healthier and more stable street dog population with lowered disease prevalence. This has significant impacts for developing nations like India, where dogs live in close contact with both humans and endangered wildlife.

5. Conclusion

Dogs in cities with ABC programs showed a significantly lower prevalence of several diseases important to both dog and wildlife health. Only tick prevalence was higher in ABC cities; and we echo others' calls to include an ectoparasite control procedure in ABC program design (Totton et al., 2011). Even so, untreated dogs in these ABC cities were still significantly healthier than those in the city not undergoing ABC.

Conflict of interest statement

AJY, IMH, and SDG have no conflicting interests with this paper's subject material. JFR is employed by the ABC program in Jaipur, Help in Suffering. This work's sponsors played no role in this study other than financial support.

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