Potential Impacts of Animal Birth Control On Street Dog Disease: Final Report to the Rufford Grants Foundation

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Executive Summary

The domestic dog (*Canis lupus familiaris*) is the most numerous and ubiquitous carnivore in India and has enormous impacts on the subcontinent's ecology. Predominantly around urban districts, but also extending into rural and forested areas, dog density is inflated by open access to food, shelter, and breeding opportunities. Combined with poor management policies, this, has historically made dogs the main Indian reservoir for rabies, fecal parasites, and numerous other zoonoses. In spite of, or perhaps because of, their commonness, dogs have not been heavily studied and there is little evidence available supporting specific management approaches. We predict that because the sterilization and rabies-only vaccination of a large percentage of dogs in an area decreases their local density as well as improves the health of dogs that have been sterilized, this program will reduce the population's disease transmission potential. Additionally, because the unsterilized dogs will have fewer, more immunocompetent neighbors, their health will be greatly improved. We focus on the effects of differing policies, whether dog population management programs are present and for how long, in three different Rajasthani cities. The vast majority of dogs in the area live with little to no direct human assistance. The "Help In Suffering" program has been running for 15 years in Jaipur and the "Marwar Animal Protection Trust" has been running for 5 years in Jodhpur. There is currently no animal birth control (ABC) program in Sawai Madhopur. We carried out a prevalence survey for canine distemper virus (CDV), canine parvovirus (CPV), infectious canine adenovirus (ICH), canine brucella, leptospirosis, and ehrlichiosis. Dogs were rated on body condition as well as the presence of endo- and ectoparasites, and visible maladies. We surveyed 343 dogs for at least one criteria, 233 fecal samples were surveyed, and 239 blood samples were tested. There were significant differences between cities in the prevalence of CPV, ICH, leptospirosis, ehrlichiosis, fight wounds, lice, ticks, *Toxocara spp., Toxascaris leonia,* Taenid eggs, and low body condition. The prevalence trends for most of the maladies show the longer an ABC program has been implemented in a city, the healthier the cities' dogs will be.

This is the first study of the relationship between ABC and multiple diseases across several locations.

Introduction

The domestic dog (*Canis lupus familiaris*) is the most common large predator worldwide (Daniels and Bekoff 1989) though it is seldom considered when considering wildlife management plans. Unlike dogs in developed nations, dogs in much of the developing world live their lives on the streets with little to no medical care, consuming refuse and feces to survive (Butler & du Toit 2002, Butler et al. 2004, Reece et al. 2008). In India, the dog population is universally considered to be on the rise because of two major factors: human population growth and local ecology changes. (cite a growth) The increase in the human population continues to produce a growing volume of refuse which the dogs use as their main source of food (Butler & du Toit 2002, Vanak & Gompper 2009). The vulture population on the entire subcontinent has undergone dramatic (>95%) crashes, those carcasses that would normally be removed rapidly by vultures now supplement dog food availability allowed for population increase (Oaks et al. 2004, Markandya et al. 2008).

Dog bites account for 90% of post exposure rabies treatments (Kale et al 2006) and 96.5% of Indian rabies fatalities. An estimated 20,000 people yearly die from rabies in India representing almost 60% of the world total (Knobel et al. 2005, Sudarshan et al. 2007). In addition to rabies, dogs are also an important zoonotic pool for forms of leishmaniasis (Quinnell & Courtenay 2009), canine distemper (Harder et al. 1995), hookworms (Traub et al. 2002), some Brucella strains (Renukaradhya et al. 2002), and many others. Spill-over from domestic dogs has already caused large population crashes of Harbor and Caspian seals (Dietz et al. 1989, Kennedy et al. 2000), Ethiopian wolves (Laurenson et al. 1998), spotted hyenas (Haas et al 1996), and Serengeti lions (Roelke-Parker et al. 1996). A steady population increase will only raise the risk from density dependent disorders.

Many diseases can exploit multiple hosts (Goldsmid 2005, Knobel et al. 2005), creating a difficult and complex disease management scenario (Bora 1999, Daszak et al. 2000, Lafferty & Gerber 2002, Kaare et al. 2009). Rabies in particular has been notoriously resilient to eradication and its cost can be measured in the loss of whole wildlife species (Kat et al 1995,), lost human life, and the cost of prevention and treatment (Anderson 1986). Monetary losses in

Africa and Asia alone total US$ 583.5 million annually (Knobel et al. 2005). In India, this economic burden is overwhelmingly borne by the poorest who have the most contact with street dogs. (Sudarshan et al. 2007).

There is scant evidence as to the effectiveness of management policies specifically implemented to mitigate the risk of disease in wildlife. Altering the target population's dynamics to better suit disease eradication or limitation may prove to be a good option when other more financial and effort intense options are untenable (Woodroffe 1999). This must be done carefully however, as previous efforts like culling have significantly worsened the problem they are trying to solve (Carpenter et al. 1976, Killian et al. 2007, Breed et al. 2009, Woodroffe et al. 2009). For example, bovine tuberculosis control programs using large scale culling in badgers in Europe are well studied and show a limited, if not harmful net effect on the area's tuberculosis prevalence (Donnelly et al. 2006,Woodruff et al. 2009). In South America, these types of removal techniques lower the street dog density in the short term, but the population quickly rebounds to higher than previous levels with more rabid animals (Beran 1991). In India, dog management policies have historically relied on sporadic culling using ineffective and inhumane techniques like mass electrocution and strychnine poisoning in problem areas (Reece 2007, pers. comm. with A Chhangani).

In response to outcries from the animal welfare and scientific communities, the World Health Organization has released street dog management guidelines calling for the creation of ABC programs to slowly lower the dog population and eliminate rabies (WHO 1990). These methods have been proven effective in India as the dog population has dropped 28% and brought the annual human rabies deaths in the clinic's coverage area to zero (Reece & Chawla 2006). Sterilizing and vaccinating street dogs markedly improves their health and create a more stable, low density, local population (Totton et al. 2011). However, there are many unknowns about the lives of street dogs in India and just how much they influence local ecology. To date, no study has attempted to gather baseline data on multiple diseases simultaneously in several locations. ABC programs in India have been founded sporadically in different cities and have been running for different lengths of time (Reece & Chawla 2006, Totton et al. 2011). This creates a natural observational study to determine the relative effects ABC may have on disease in three different cities. We seek to make recommendations on the most effective population management protocols to limit costs for managers and risk of disease spill-over.

Materials and Methods

Study Area

Dogs were sampled from three different cities, Jaipur, Jodhpur, and Sawai Madhopur. All three cities are within the arid northwestern state of India, Rajasthan. Jaipur is a large city with an estimated 36,580 dogs (Hiby et al. In prep) and has been serviced by the Help in Suffering ABC program since 1994 (Reece & Chawla 2006). Jodhpur is another large city with an estimated 24,853 dogs (Hiby et al. In prep) that has been serviced by the Marwar Animal Protection Trust ABC program since 2005. The third location, Sawai Madhopur, is a smaller city on the edge of Ranthambore National Park and has never had any ABC or rabies vaccination program for street dogs until this study. No estimates of the density of dogs in Sawai Madhopur have ever been made. Dogs in this survey were collected from all areas of the cities of Jaipur and Jodhpur by their respective ABC program's activities. In Sawai Madhopur dogs were collected by luring them with commercially available tea biscuits (Parle-G ™) and then hand restrained while samples were collected. Dogs that were especially violent or wary of humans were considered uncatchable. All possible biometrics were taken on dogs even when they were uncatchable in Sawai Madhopur.

Fig 1 Dogs undergoing ABC at HIS in Jaipur

Dogs

All dogs chosen for this study fell into the loose categories of owned and unowned free roaming street dogs. When the dog's owners were present, permission was secured before handling and rabies vaccination. Unowned dogs were heavily reliant upon humans for food (Butler & Bingham 2000). All owned dogs that were restricted to a confined area were not sampled as they likely have a small role to play in the area's disease epidemiology and this is population is much smaller than those dogs with open access to the street. The dogs on the streets in all three cities were predominantly of the "pariah" type (Oppenheimer & Oppenheimer 1975).

These commonly have muddled ancestry, as various breed pure bred dogs are sometimes released and may mate with a street. All dogs sampled were over 3 months of age and sexually intact, removing the potentially confounding effects of maternal antibodies and sterilization on health.

Fig 2 Biogal kits and fecal floatation materials

Collection

In Jaipur and Jodhpur, dogs were sedated with Ketamine/Xylazine mixture and 3-6 ml of blood was collected in EDTA tubes through the saphenous vein before surgical sterilization. Fecal samples were taken directly by probing the anus. In Sawai Madhopur, dogs had blood taken in the same manner, were vaccinated for rabies, and then immediately released. All dogs were collected in the early hours of the day between 3 and 6 am when they are known to be more sedentary and docile. Fecal samples in Sawai Madhopur were more difficult to collect because dogs were not sedated and the presence other coprophagous animals (feral pigs, other dogs) removing feces from the ground rapidly, so fewer samples were taken. All dogs were rated on their parasite loads, including various ticks and lice, as well as the dog's prevalence for fight wounds, and low body conditions. In Jaipur, dogs that died while being held at the ABC center were autopsied and grossly examined for internal parasites.

Testing

Blood samples were tested for disease using commercially available ELISA testing kits (Immunocomb kits, BioGal Labs, Kibbutz Galed, Israel). For CDV and CPV, both immunoglobulin G (IgG) and immunoglobulin M (IgM) values were available, but for ICH, brucella, leptospira, and ehrlichia only IgG tests are available. Having both immunoglobulin values provides information about what stage of the disease a particular dog is currently experiencing (active infection, gaining immunity, immune) but with only IgG alone, only exposure status can be determined. These tests are very accurate for dogs (Waner et al. 2003) and have been used effectively in the field (Vanak & Gompper 2007). For further description of test analysis see Vanak and Gompper's methods (2007).

To ensure accurate internal parasite identification fecal samples were tested within 12 hours of collection using direct smear and fecal flotation techniques. The floatation suspension used was the commercially available sodium nitrate solution (Fecatect, Butler Animal Supply, Dublin, Ohio, USA) brought to a specific gravity of 1.27. Slides were scanned on low (40x) power and individual eggs checked on high (100x) power. Any unknown eggs were photographed and submitted to The Ohio State Veterinary College's diagnostic laboratory.

All testing for all diseases was performed by A.J. Yoak.

Analysis

To evaluate the differences between locations, the categorical data was analyzed using JMP ® version 9.0.0 . Odds ratios were derived from the results of a nominal logistic regression.

Results and Discussion

Canine Distemper Virus

CDV is an acutely contagious febrile virus that can cause acute multi-systemic failure (Appel 1995). Disturbingly, it has original host range has been expanding in recent years, and now can be found in most families of *Carnivora* (Deem et al. 2000). CDV has caused massive die offs in wild populations of seals (Kennedy et al 2000), lions (Roelke-Parker et al. 1996), and numerous captive animals (Appel et al 1994). Notably, several important Indian fauna have established susceptibilities (Blythe et al. 1983, Durbin et al. 2010)

CDV Status	Jaipur	Jodhpur	Sawai Madhopur	Nannaj, Maharashtra (Vanak & Gompper 2007)
Susceptible	34.0% (34)	33.3% (26)	15.0% (9)	6.7% (5)
Active Infection	15.0% (15)	20.5% (16)	23.3% (14)	4.0% (3)
Infected Gaining Immunity	13.0% (13)	10.3% (8)	13.3% (8)	13.3% (10)
Immune	34.0% (34)	32.1% (25)	41.7% (25)	60.0% (45)
Immune Re-exposed	4.0% (4)	3.9% (3)	6.7% (4)	16.0 (12)

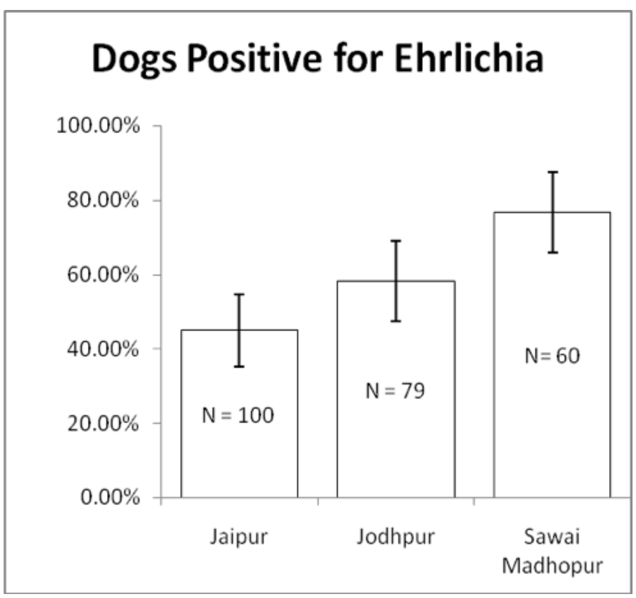
Canine Parvovirus

CPV is also a contagious virus though it is almost entirely a disease of puppies. Pup symptoms commonly express as gastroenteritis and cardiac failure leading to a very high mortality rate. Adult dogs are often unaffected because of immunity or they are asymptomatic (Merck 2005). In India, it is considered to be a significant driver of young dog fatalities (Pers Obs).

CPV Status	Jaipur	Jodhpur	Sawai Madhopur	Nannaj, Maharashtra (Vanak & Gompper 2007)
Susceptible	14.0% (14)	24.4% (19)	18.3% (11)	9.3% (7)
Active Infection	1.0% (1)	1.3% (1)	6.7% (4)	25.3% (19)
Infected Gaining Immunity	0.0% (0)	2.6% (2)	0.0% (0)	18.7% (14)
Immune	85.0% (85)	65.4% (51)	75.0% (45)	22.7% (17)
Immune Re-exposed	0.0% (0)	6.41% (5)	0.0% (0)	24.0% (8)

Ehrlichiosis

The rickettsial bacteria *Ehrlichia canis* causes canine monocytic ehrlichiosis and is passed by transfer of *E. canis* by the brown dog tick, *Rhipicephalus sanguineus,* from infected individuals. Generally, symptoms are mild but dogs occasionally present as lethargic and bleed excessively (Waner 2004).

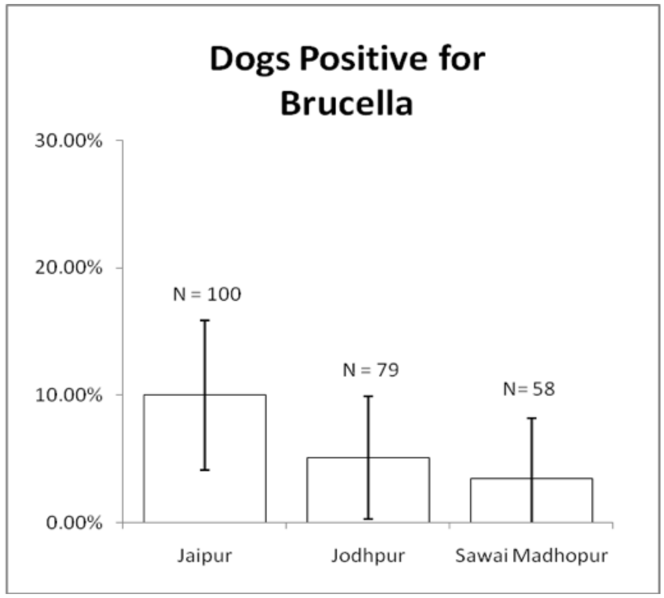


Dogs from each ABC city, Jaipur and Jodhpur, are significantly less likely to have a past exposure to erhlichia than Sawai Madhopur. Sawai Madhopur dogs are 4.02 times more likely (CI = 2.00-8.44, $p < 0.001$) than Jaipur dogs and are 2.36 times more likely (CI = 1.13-5.09, $p < 0.021$) than Jodhpur dogs to have past exposure to erhlichia. There are not significant differences between Jaipur and Jodhpur.

Canine Brucellosis

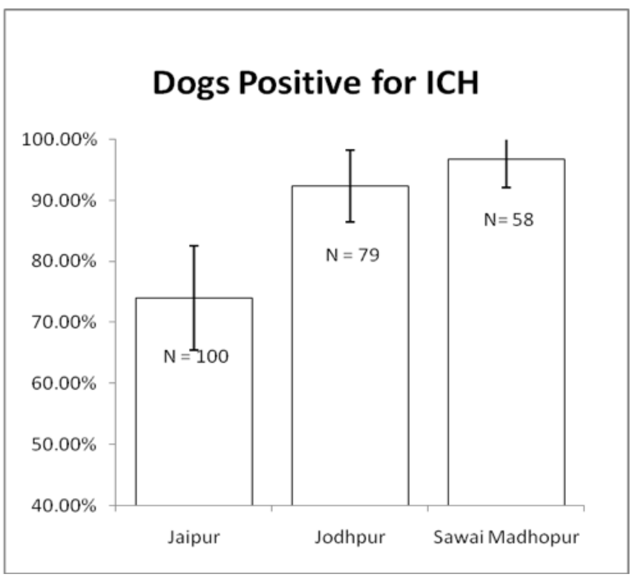
Canine brucellosis is caused by the *Brucella canis* bacterium and is transfered either sexually or by ingesting aborted material. Infected dogs generally do not have any major negative symptoms other than infertility (Wanke 2004).

There are not significant differences between the three different locations for canine brucella.



Infectious Canine Hepatitis

ICH is a contagious disease causes by canine adenovirus type-1 (CAV-1) that generally presents as mild nasal and febrile involvement. Sometimes, more often in younger dogs, acute fever and gastrointestinal symptoms appear and more frequently so when interacting with secondary co-infection (Merck).

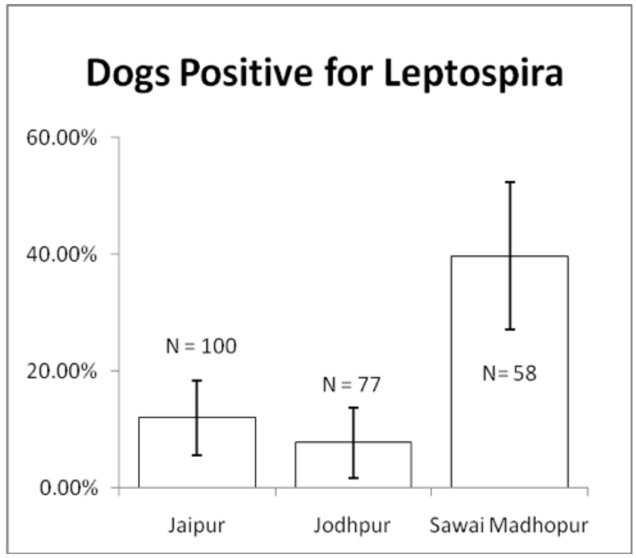


Dogs from Jaipur are significantly less likely to have a past exposure to ICH than both other cities. Jodhpur dogs are 4.22 times more likely (CI = 1.74-11.86, $p < 0.001$) and Sawai Madhopur dogs are 10.19 times more likely to have past exposure than Jaipur dogs. (CI = 2.88-64.85, $p < 0.001$). There are not significant differences between Jodhpur and Sawai Madhopur.

Leptospirosis

Leptospira is a spirochaete bacteria and is passed when infected urine enters through skin wounds or mucous membranes. The epidemiology is poorly understood because of the numerous strains (serovars), that dogs are not the only species involved in sustaining its transmission

(Chaudry et al. 2004), and the existence of long-term carrier states (Kuriakose et al. 1997). Symptoms of leptospirosis range from subclinical to acutely fatal liver and kidney failure (Kuriakose et al 1997).



Dogs from each ABC city, Jaipur and Jodhpur, are significantly less likely to have a past exposure to various leptospira serovars than Sawai Madhopur. Sawai Madhopur dogs are 4.82 times more likely (CI = 2.20-11.03, $p < 0.001$) than Jaipur dogs and 7.78 times more likely (CI = 3.07-22.64, $p < 0.001$) than Jodhpur dogs to have past exposure to leptospira. There are not significant difference between Jaipur and Jodhpur.

Intestinal Parasites

There are many gastrointestinal parasites affecting the dogs of Rajasthan. All those presented in this survey are passed by the fecal-oral route or, in the case of hookworms, by penetrating the skin (Traub et al. 2005). Dogs are a large source of GI parasites in India and while none of these conditions carry significant mortality, their negative effects are additive as make dogs more susceptible to other conditions (Traub et al. 2002, Hotez et al. 2004, Traub et al. 2005).

There are significant differences between Jaipur and Jodhpur's intestinal parasites but no significant differences between any city and Sawai Madhopur. Jodhpur dogs are 9.88 (CI = 1.96-179.85, $p<0.003$) times more likely to carry any intestinal parasites than Jaipur dogs. This does not highlight the fact that all dogs in Sawai Madhopur carried parasites of some kind because of a low sample size (n=7).

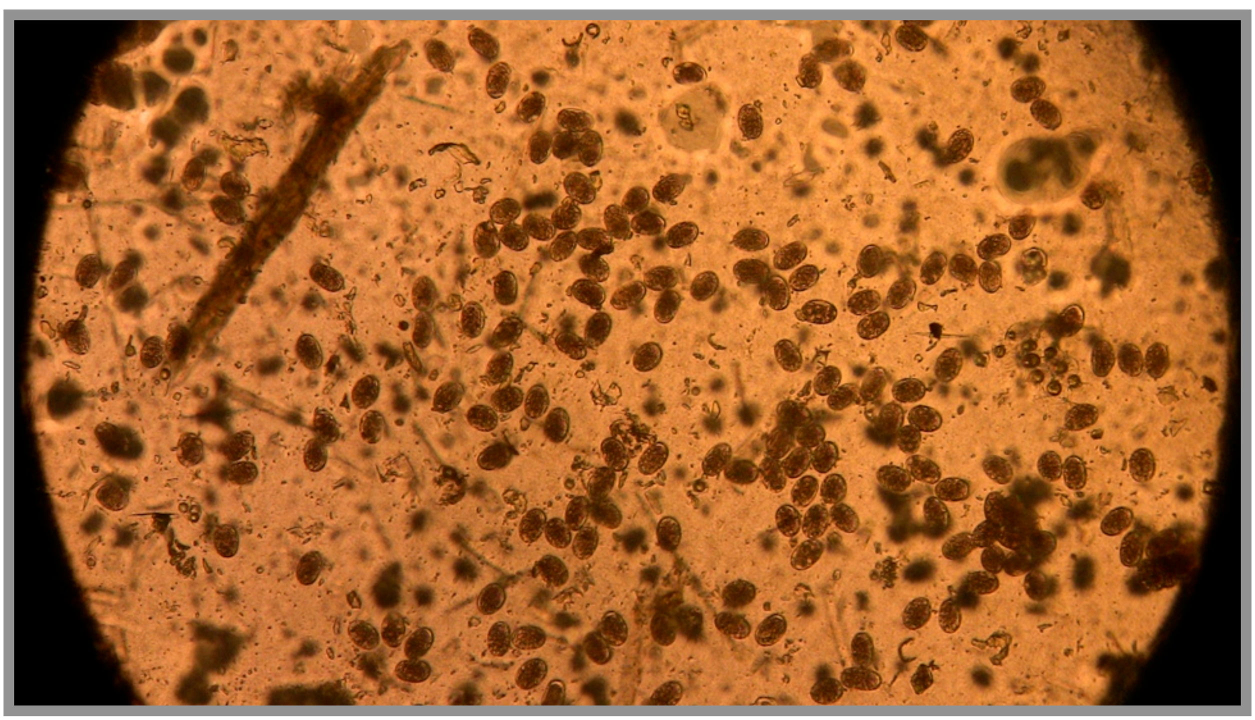
Fig 3.A fecal sample showing a heavy hookworm infestation

There are not significant differences between cities' prevalences of hookworms.

Dogs from the two ABC cities are significantly less likely to have taenid egg infestations than dogs from Sawai Madhopur. Sawai Madhopur dogs are 5.69 times (CI = 1.0489-28.01, $p<0.045$) more likely than Jaipur dogs and 11.25 times (CI = 1.83-67.43, $p<0.011$). There are no significant differences between Jaipur and Jodhpur.

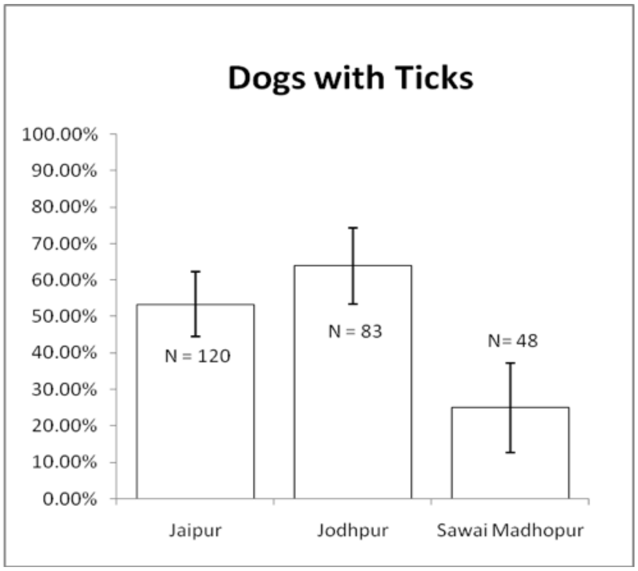
Positive % (total N)	Jaipur	Jodhpur	Sawai Madhopur
Any Parasites	88.89% (144)	98.75% (80)	100% (7)
Hookworm sp.	87.50%	95.00%	100%
Toxocara sp.	6.95%	0.00%	14.29%
Toxascaris leonia	1.37%	30.00%	0%
Taenid	11.64%	6.25%	42.86%

Dogs from Jodhpur are significantly more likely to have a *Toxascaris leonia* infection than dogs from Jaipur ($p<0.001$) or Sawai Madhopur ($p<0.029$). There is no difference between Jaipur and Sawai Madhopur. This is skewed somewhat as Jodhpur has an unusually high number (30% of n=80) of *T. leonia* infested dogs compared to the other two cities combined (1.3% of n=153).



Ticks

The higher prevalences of ticks in the two ABC cities may be an artifact of the manner in which dogs go through the program. Dogs are rounded up and placed into the caged bed of a converted truck and are then placed in concrete cages with multiple other dogs. Totten (2011) has suggested this close contact may be the cause of increased rates of the skin mite infestation mange and the reasons would explain the tick prevalences. It should be noted however, that even with the higher rates of tick infestation, the dogs in ABC cities show a lower prevalence of the tick-bourne Ehrlichia bacteria.

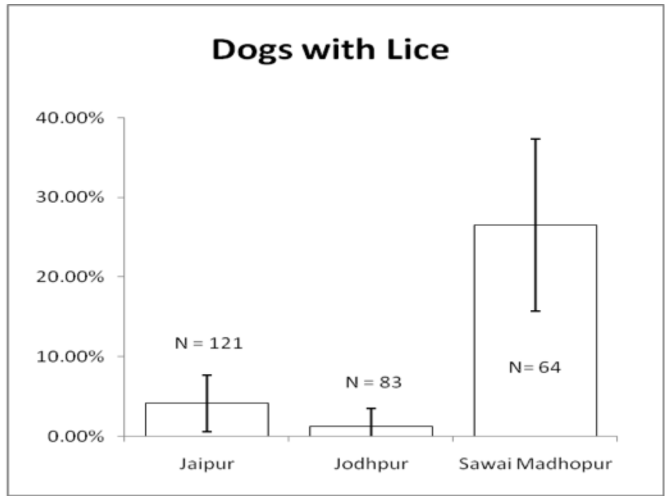


Jaipur dogs are 3.43 times more likely (CI = 1.67-7.47, $p < 0.001$) and Jodhpur dogs are 5.3 times more likely (CI = 2.46-12.08, $p < 0.001$) to have a current tick infestations than Sawai Madhopur dogs. There are not significant differences between Jaipur and Jodhpur.

Lice

Sawai Madhopur dogs are 8.39 times more likely (CI = 3.12-26.72, $p < 0.001$) than Jaipur dogs and are 29.66 times more likely (CI = 5.80-542.65, $p < 0.021$) than Jodhpur dogs to a current lice infestation. There are not significant differences between Jaipur and Jodhpur.

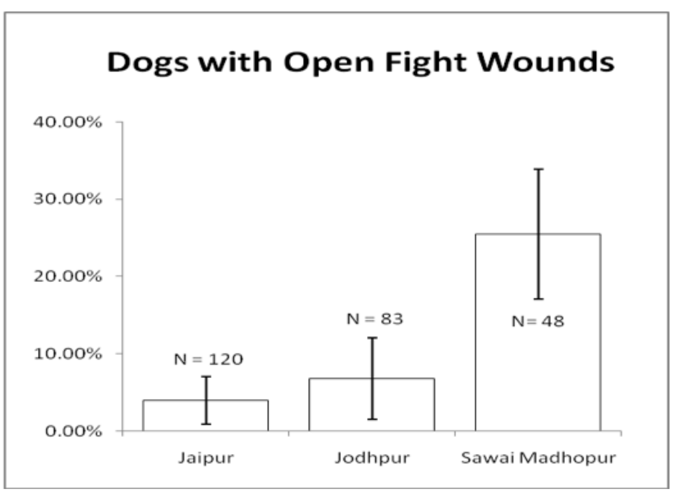
Interestingly this inclination for higher contact mediated disease does not hold for lice. In the two ABC cities, lice are rarely seen and when they are, the dog is almost invariably exceptionally sick (Pers Comm. w/ J Reece). The ABC center dogs that did have lice in this study rarely had more than a few, which may be indicative of recent infestations that have not been cleared yet. In Sawai Madhopur, the majority of lice infected dogs had a very heavy load some even visible several feet away.



Fight Wounds

Dogs from each ABC city, Jaipur and Jodhpur, are significantly less likely to have current fight wounds than those in Sawai Madhopur. Sawai Madhopur dogs are 8.38 times more likely (CI = 3.51-23.39, $p < 0.001$) than Jaipur dogs and are 4.68 times more likely (CI = 1.94-13.11, $p < 0.004$) than Jodhpur dogs to a current fight wounds. There are not significant differences between Jaipur and Jodhpur.

The marked decrease in the presence of recent fight wounds on dogs in the two ABC cities is a clear indication that they are in fact changing the local populations social dynamics as predicted (Reece & Chawla 2006). As more bitches are prevented from entering estrus, fewer males will actively pursue and fight over her. This behavior change, in addition to the concurrent vaccination program, creates a mutually beneficial method of stabilizing and aging the population (Killian et al. 2007). In Jaipur, there has been a marked decrease in the per capita dog bite



rate, even when the dog density decrease is accounted for. This supports others assertion that the sterilization is influencing behavior bite dynamics on a wide scale (Reece & Hiby unpublished results)

Body Condition Scores

Dogs from the city with the longest running ABC program, Jaipur, are 3.01 and 2.04 times more likely to have high body condition scores (3 or 4 out of 4) than dogs from the short running ABC city, Jodhpur (CI = 1.42-6.89, $p < 0.004$), and the city lacking a program entirely, Sawai Madhopur (CI = 1.06-4.05, $p < .033$), respectively. Dogs from Jaipur are also 2.49 and 2.86 times less likely to have a low body condition score (1 out of 4) compared to dogs from Jodhpur (CI = 1.33-4.72, $p < .004$) or Sawai Madhopur (CI = 1.58-5.27, $p < .001$). There are not significant differences between the dogs of Jodhpur and Sawai Madhopur for either grouping.

Dog body condition is a indicator of gross overall health, but is not as specific as the previous tests. Totton et al. (2011) demonstrated a correlation between higher body condition and sterilization when comparing sterilized to sexually intact dogs.

The capture protocols for the three cities were not uniform due to the difficulties of capturing feral street dogs in an urban environment. The two ABC cities, Jaipur and Jodhpur, have similar methods, as the Jodhpur program was modeled off of the Jaipur one. All sexually intact dogs available were captured though there was a mild bias towards females. In Sawai Madhopur, as there is no ABC program for dogs and all were hand caught, there exists a fairly large amount of selection bias for catchable dogs. However, we contend that this is does not diminish our results as the dogs that will accept hand capture, are likely to be those that have more human contact/assistance and subsequently be healthier than the uncatchable dogs. The bias that exists in this study trends towards making our results less significant so it is not a serious issue here.

Conclusions and Recommendations

This study finds a marked decrease in the prevalence of disease in unsterilized dogs for most of the diseases tested when the area has undergone ABC treatment. This decrease in the rate of infection should be attributed to the ABC associated decline of the dog population as well as the behavioral and immunological improvements such a program provides. Perhaps most importantly, because this survey only included dogs that were sexually intact, the known immunologic benefits to dogs that go through these programs (Totton et al. 2011) are affecting the disease dynamics in the entire dog population. It would appear that because their neighbors have gone though ABC, the sexually intact dogs are less likely to be exposed likely because healthier individuals are more capable of resisting initial infection and thus transmission. Additionally, even when they succumb to infection, ABC dogs may shed less infectious material. (need citation)

We found some troubling results however, as even in the city with the longest ABC program, no disorders have been extirpated entirely. For some, like ICH and erhlichia, the prevalence in Jaipur is quite high even though it is significantly lower than the other cities. To encourage complete eradication, we suggest implementing an ABC program combined with simultaneously administering multiple disease vaccines. This has proved effective at controlling rabies in Jaipur (Reece & Chawla 2006), and using government subsidies to do so could be justified by the decrease in healthcare costs from those zoonotic diseases.

We echo the call for additional vaccine use from many others (Reece & Chawla 2006, Killian et al. 2007, Vanak & Gomper 2007). The expansion of a vaccination program is only limited by the funding of cash-strapped local governments. Currently, the Animal Welfare Board of India provides funding to existing ABC programs on a per-dog basis to subsidize the various costs of sterilization and care. This funding level is sufficient for well established programs, but newer programs may not be able to sterilize dogs even at this subsidized rate (Perss Comm. B Singh, J Reece). Therefore, we recommend the expansion of the government subsidies provided to ABC centers to cover current costs as well adding the use of non-rabies vaccines.

Direct action as a result of this study

This study provided the pilot dog disease survey for all three cities and is the first to cover such a large area. We have provided the results and recommendations to all three local partners. In the city with no history of any dog ABC program, Sawai Madhopur, we vaccinated 120 dogs for rabies and provided the local veterinarians with an additional 180 doses to hand out free of cost.

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