

## **Domestic Dogs as an Indicator of Tick Density and Diversity in a Semi-rural Area of Northern California**

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**Abstract** Dogs are popular pets all over the world because of the social, health, and companionship benefits they have to offer. Ticks, however, are a well-known pest to humans and animals alike. These parasites pose significant health risks because of the diseases that they can carry. Furthermore, there is evidence of similar causal tick species between canines and humans. If we are able to advance our knowledge on tick distributions, we may be able to improve prediction of patterns of infection and protection against future infestations. With assistance from a veterinary clinic in Danville, California, locations explored by domestic dogs carrying ticks were identified and then sampled for tick density and species diversity. Other areas, not visited by these dogs, were sampled as well for a comparison of tick density and species count. Tick count was low on both dogs and on vegetation due to use of insecticides and presence of vegetation types, respectively. Species diversity of ticks on dogs was not comparable to species diversity in the field, suggesting other target hosts, as well as other sources of infection for the dogs.

## Introduction

Ticks pose a significant health risk to both dogs and humans, as several *Dermacentor* and *Ixodes* species have proven to be vectors of disease, carrying agents of Lyme disease, anaplasmosis, and possibly tularemia in humans (Eisen *et al.* 2006), and causing incidences of tick paralysis in dogs (Lane *et al.* 1984). There have been cases of both human and canine infection from the same causal species – the American dog tick, *Dermacentor variabilis*, and the black-legged tick, *Ixodes scapularis* (Goddard 2002; Lane 1984). American dog ticks are found throughout the United States but are more sparse in the Rocky Mountains, and black-legged ticks are common from the eastern coast to the central states, as well as in the pacific United States (Raghavan *et al.* 2007). Knowledge on tick distributions may be beneficial in predicting the pattern of disease associated with a particular tick species and aiding diagnostic, prevention, and control efforts (Hinrichsen *et al.* 2001).

The tick's life cycle is a fundamental aspect of understanding species distribution and predicting patterns of disease. *D. variabilis* and *I. scapularis* are three-host species, having three parasitic stages (larva, nymph, adult) that each require a different animal host to complete development to the next stage (Lane 1984). This life cycle is dependent upon various factors that are specific to each species, such as environmental characteristics of the habitat and accessibility of vertebrate hosts (Padgett *et al.* 2001). Cilek and Olson (2000) conducted a two-year study in a state park and recreation area to determine tick speciation, seasonal abundance, and spatial distribution, and found several species of ticks in different stages of their life cycles. Within a given area, there was a significantly greater number of ticks gathered from vegetation than from the ground, and there was a majority of ticks recovered that were in the adult and nymphal stages of the life cycle. Vegetation type will affect presence and absence of ticks because of their method of motility. Because ticks are unable to jump or fly, vegetation at a height where animals will pass is ideal. Such research illustrates the specificity of various ticks and its dependency on various factors.

The variety of ticks found in the field requires different methods of tick sampling, as each method will have its own advantages and disadvantages (Ginsberg and Ewing 1989; Kinzer *et al.* 1990; Solberg *et al.* 1992). These methods are generally divided into four categories: flagging or dragging, carbon dioxide traps, direct collection from animals, and human walking model

sampling (Gray 1985; Ginsberg and Ewing 1989). Flagging can be beneficial because it allows the researcher to cover larger areas more rapidly than other methods such as direct collection and human walking model sampling. However, data is affected by factors such as rates of tick drop-off from the flag, which can be dependent on subtransect length and weather conditions. Direct collection can function as a much more thorough method of tick collection but has also proven to be much more time consuming. Although there are multiple approaches to tick sampling, the drawbacks of each method leave room for additional methods that are more efficient or improve accuracy.

Dogs are popular pets all over the world because they can offer companionship, as well as health and social benefits (Cutt *et al.* 2007). Evidence of similar causal species between humans and dogs implies potential transfer of infestation from canine to owner and vice versa. Determining if dogs are effective measures of tick density and diversity will provide enhanced understanding of tick distributions and dynamics, and aid in protecting ourselves and companion friends from an existing form of infection. This study examines whether or not canines function as proxies of tick distribution in a given area and, consequently, as possible vectors of disease. In addition to observation of tick density in a particular area, species diversity of ticks found on dogs at a veterinary practice in northern California was compared to species of ticks collected in the field where the owners claim to run their pets. My research follows two questions: How does tick density vary in a semi-rural area of northern California? This question will focus on presence or absence of dogs and distance from residential areas. The second research question is: Can tick diversity on domestic dogs function as an indicator of tick diversity in a semi-rural area? I hypothesize that tick density will vary according to distance from residential areas and the presence of dogs because of tick preference for particular vegetation types and presence of potential hosts. Furthermore, I hypothesize that dogs should be an accurate measure of tick density because public open space is one of the key motivators for owners to walk their dogs (Cutt *et al.* 2008), and if the owners are running their dogs in open vegetation, it is likely that they are picking up many of the ticks in the area due to exposure.

## Methods

To test the feasibility of using tick density from dogs as a measure of tick density in a given area, I conducted an observational field study examining the species count of ticks found on dogs

and comparing this to tick species diversity in semi-rural areas, some explored and some unexplored by the dogs. Dr. Elisa Dowd of the Tassajara Veterinary Clinic of Danville, California preserved the ticks she found and distributed my survey to clients according to the methods I outlined. My research was limited to a single veterinary clinic in one city due to availability and proximity. For my data collection, I flagged for ticks in March and April, one to two times a week to produce sufficient data for comparing tick diversity on dogs and the areas they explore to tick species in other unvisited areas. Dr. Dowd preserved any ticks removed from canines for the entire duration of this study.

**Study Design** I requested that veterinary staff preserve any ticks that they find on canines. Ticks were removed and stored in vials of 70 percent isopropyl alcohol in order to prevent desiccation and degradation of tick morphology for species identification at a later date. All ticks from an individual host were placed in a single vial of ethanol and those numbers were recorded.

I administered a questionnaire to the owners of dogs carrying ticks, asking where they run their dogs, how long they run the animal, whether the animal is on or off leash, and the general activities of the animal during the run (i.e. exploring vegetation, rolling on the ground). This questionnaire allowed me to determine the most common sites where owners like to bring their pets, and pinpoint locations for flagging. (Appendix A) The questionnaires produced three feasible flagging locations and I randomly selected three additional sites for comparison, not visited by the same dogs, for a total of six flagging sites. (Appendix B) These three sites were in the city of Danville as well, maintaining comparable distance from the veterinary clinic as the former three locations.

Ticks were collected in the field by dragging a 1 m × 1 m white cotton cloth along dense, low-level vegetation. Numbers of ticks on the flag were checked and the ticks were removed every 4.57 meters (15 feet, subtransect length) to reduce the effect of tick drop-off. I took three 45.72-meter (150-foot) transects, 5 meters apart and each composed of five subtransects. Transects were taken getting progressively further from residential areas, with initial transects 20 to 50 meters away from housing, depending on placement of fencing and open space availability. All initial transects were collectively labeled *A*; second transects were labeled *B*; and transects furthest from residential areas were labeled *C*. This position of transects allowed for observation of several variables, covering areas on and off the path as well as several vegetation types including mowed areas, low-level grasses and weeds, and tall seasonal bushes. I recorded

location of flagging, date, temperature, and numbers of ticks obtained at each subtransect on data sheets I prepared beforehand. (Appendix C) Visual observations at each site were also recorded. Ticks obtained from flagging were preserved in the same manner as those extracted from dogs.

**Analysis techniques** Ticks were identified to species and gender, recognizable by patterns and coloring of the body. Tick species from dogs were compared to those found in the field. A Wilcoxon rank sum test was used to compare transects A, B, and C in pairs. This test was used to account for the non-normal distribution due to high volume of zeroes in the data (ticks found at each subtransect) and to test for significant differences between transects. A linear regression of tick density from both methods of data collection was also performed in order to analyze the strength of the relationship between tick density on dogs and in the field.

## Results

The Wilcoxon rank sum test provided  $p$ -values for the comparison of paired transects. If we set a standard of  $p < 0.1$ , there is an observed statistically significant difference between transects A and C.

Transects	$p$ -value
A and B	0.2987
B and C	0.3172
A and C	0.0799

Table 1: Wilcoxon rank sum test  $p$ -values for comparison of transects in pairs

Flagging at the six sites in the field, provided very limited diversity of tick species. Of the nineteen ticks that were obtained from flagging, only one was a black-legged tick (*Ixodes scapularis*), and the rest were American dog ticks (*Dermacentor variabilis*). The single black-legged tick was obtained at the site furthest west, and it is an owner-designated site. With these tick count data, I conducted a regression analysis between numbers of ticks on dogs to the numbers of ticks found on vegetation. This analysis, illustrated in Figure 1, will provide a means to observe how tick density on dogs fluctuates in relation to numbers of ticks found on plants, as well as test the strength of that relationship:

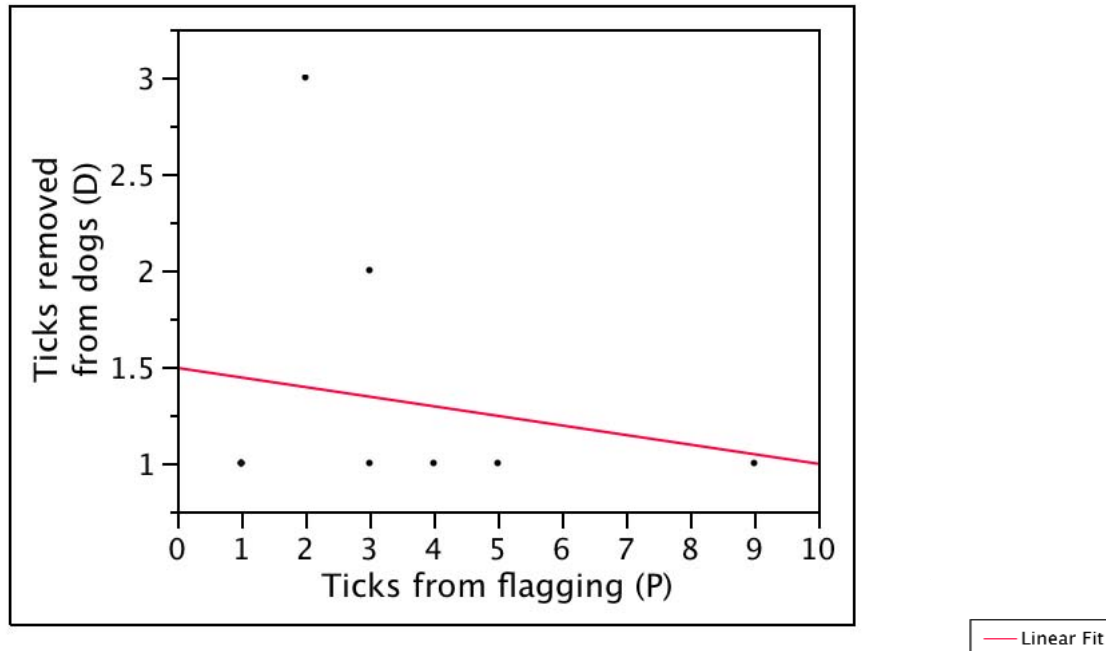


Figure 1: Regression analysis between numbers of ticks on dogs to ticks on plants using a line of best fit.

$r^2$	0.033
Root mean square error	0.74
$p$ -value	0.64

Table 2: Summary of values from regression analysis between numbers of ticks on dogs to ticks on plants using a line of best fit ( $D = 1.494 - 0.050 \cdot P$ ).

## Discussion

Tick density both on the dogs and on vegetation was low. As a result, ticks found on dogs were a poor predictor of tick density in the areas that they visit. Although dogs often explore semi-rural areas and would seem capable of functioning as indicators of tick density, my research did not return such results. The low number of ticks collected from the animals was a direct effect of a low number of dogs actually carrying ticks. Such insufficient data can cause statistical analysis results such as those illustrated in Table 2, with a very low  $r^2$  value, high root

mean square error, and a high  $p$ -value. The low  $r^2$  value and high root mean square error indicate that canine tick density is a poor predictor of tick density in a given area, and the low  $p$ -value indicates that a statistically significant relationship between these two densities cannot be proven. These results strongly suggest the presence of confounding factors, one of which I was able to identify with the help of the veterinarian at the assisting clinic. Because so many dog owners enjoy walking their dogs in public open spaces (Cutt *et al.* 2008), it has now become common practice for them to use insect preventatives containing Fipronil, more commonly known as Frontline, which specifically targets fleas and ticks. The use of such products will cause ticks to bite but then detach immediately from the animals, which would make it difficult, if not impossible, to make a correlation between canine tick density and tick density on vegetation.

Previous studies have examined the efficacy of different methods of tick sampling, such as flagging, carbon dioxide traps, and human walking model sampling (Gray 1985; Ginsberg and Ewing 1989; Kinzer *et al.* 1990; Solberg *et al.* 1992). In my research, dogs function as a modified version of the direct collection sampling method. My research aimed to take this method a step further and have them function as a measure of tick density. However, just as it was discovered that each method has its disadvantages, my proposed method is at a major disadvantage due to the usage of insecticides. Consequently, canine tick density cannot function as a measure of tick density in corresponding areas of vegetation.

Although my research did not provide the results that I expected, it still provides an important piece of a broader perspective. The errors in my research can be used to extend my study in the future. A prominent error in my research was overlooking the use of Frontline, which consequently made it difficult to find veterinary clinics with sufficient numbers of tick removals. In the future, this study could be extended to animals that are not protected by pest preventatives such as wildlife, including deer and squirrels.

I am aware of the risk of potential pitfalls in my research. For example, a student conducting a previous study collected ticks directly from animals and found an extremely low percentage of ticks on the animals (less than 0.5 percent). I am also aware of the presence of various confounding variables that may affect how useful my research conclusions may be, such as the specific activities of each dog when they are in the field or the amount of time between the dog's recreation and their visit to the veterinarian. I am unsure how this time period will affect my data

if the ticks do not attach to the skin of the animal. Different canine breeds will also have longer, shorter, curlier, or straighter fur, and this may or may not affect the numbers of ticks that attach to each individual.

My research was dependent on tick collection on dogs and consultation of their owners for the areas they have visited. I offered as incentive to these participants an opportunity to advance knowledge on tick distributions and aid in protecting their pets against future tick infestations. Although my study may not have turned out the way I planned, these pet owners will be happy to know that their pets are better protected than we have realized all along.



## Appendix A

### Survey

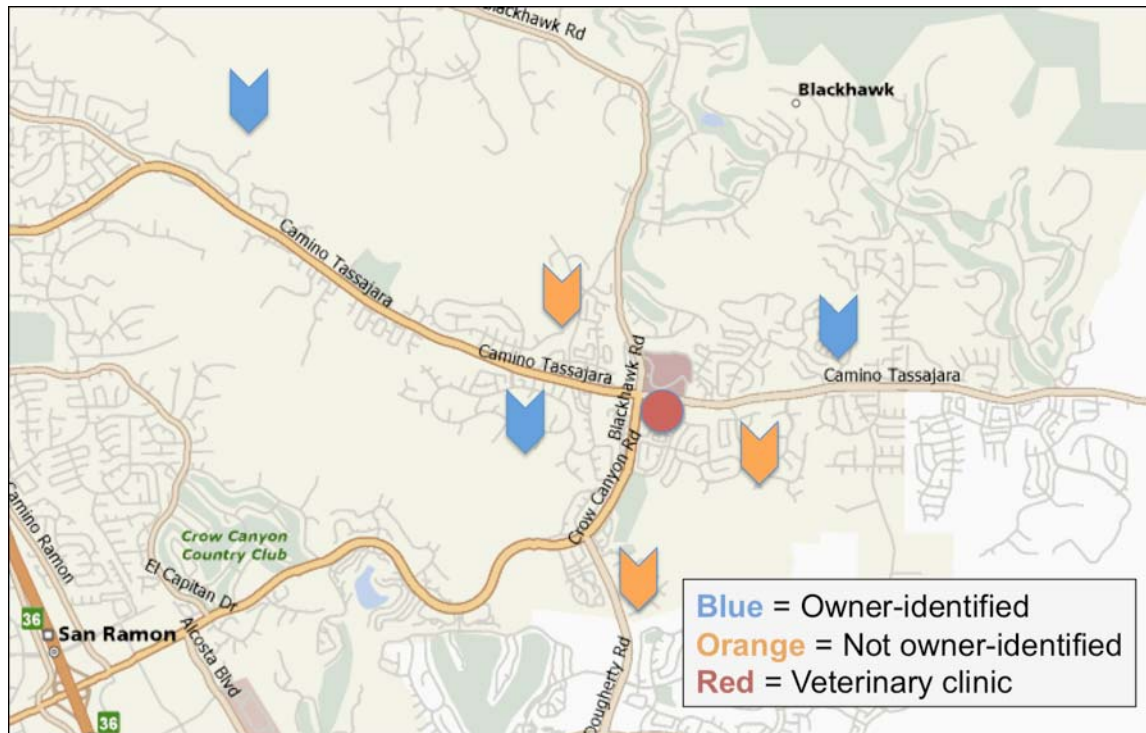
Hello, my name is Barbara Novero. I am a fourth-year Environmental Science student at UC Berkeley working on a research project examining whether tick density on dogs can be used as a measure of tick density in a semi-rural area. I would greatly appreciate it if you could take a few minutes to answer these short questions. You will be providing information that is crucial to my research, which could advance knowledge on tick distributions and aid in protecting your pet from future tick infestations. If you have any questions please feel free to e-mail me at [barbaranovero@berkeley.edu](mailto:barbaranovero@berkeley.edu).

- 1. Where do you run your dog(s)? If it is not at a park, please give a very short description, sufficient enough that it can be easily located.**

**What is the vegetation like there? (i.e. low-level, shrubs, grass, trees)**

- 2. How long do you generally run your dog(s)?**
- 3. Is your dog on or off leash for the duration of activity?**
- 4. Please describe briefly the general activities of your dog(s) during the run. (i.e. exploring vegetation, rolling on the ground)**

**Appendix B**



**Appendix C****Tick Data**

Flagging site: \_\_\_\_\_ Date: \_\_\_\_\_

RH before flagging (%): \_\_\_\_\_ Temp. before flagging (°C): \_\_\_\_\_

After flagging (%): \_\_\_\_\_ After flagging (°C): \_\_\_\_\_

Number of ticks found at each 5-meter subtransect, with *A* = *uphill side of path* and *B* = *downhill side of path* (where applicable)

1A =

6A =

11A =

1B =

6B =

11B =

2A =

7A =

12A =

2B =

7B =

12B =

3A =

8A =

13A =

3B =

8B =

13B =

4A =

9A =

14A =

4B =

9B =

14B =

5A =

10A =

15A =

5B =

10B =

15B =

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