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An epidemiologic survey of raccoon(procyon lotor) latrine sites

Gabriel Paul Roussere
San Jose State University

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AN EPIDEMIOLOGIC SURVEY OF RACCOON (*PROCYON LOTOR*) LATRINE SITES

A Thesis

Presented to

The Faculty of the Department of Biological Sciences

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

Gabriel Paul Roussere

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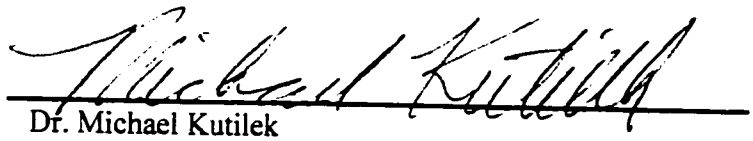

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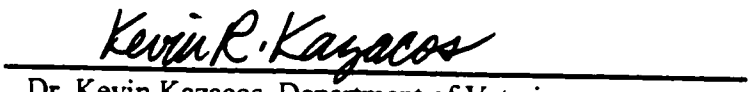

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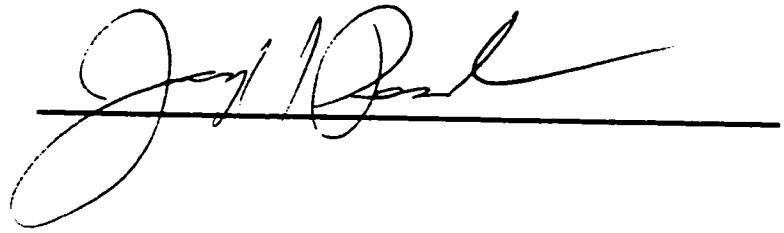

ABSTRACT

AN EPIDEMIOLOGIC SURVEY
OF RACCOON (*PROCYON LOTOR*) LATRINE SITES

By Gabriel Paul Roussere

I conducted a systematic survey of raccoon latrines and *Baylisascaris procyonis* eggs at private residences in two Monterey, CA cities. There was a mean of 1.6 latrines/property (8.7/hectare) in Pacific Grove and 1.7 latrines/property (21.7/hectare) in Carmel, considerably higher than densities previously reported in the literature. Latrines were found on the roofs of houses and sheds, on open ground, on tree stumps, near fences or walls, on wood piles, at the base of trees, and in the forks of trees. I collected fecal samples from 169 latrines, analyzed them for *B. procyonis* eggs, and found that 52.1% of the latrines examined contained *B. procyonis* eggs, with 26.6% containing infective stage eggs. For the properties surveyed, 48.3% contained at least one latrine that was positive for *B. procyonis* eggs. These results indicate that raccoon fecal contamination and *B. procyonis* eggs are common and widespread in communities on the Monterey Peninsula.

DEDICATION

This thesis is dedicated to my family.

Thank you for all your love and support.

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INTRODUCTION

The raccoon, *Procyon lotor*, is a free-ranging mammal found throughout urban and rural areas of North America. Like all free-ranging wildlife, raccoons harbor a wide variety of parasites, some of which are zoonotic. One of these, the raccoon roundworm, *Baylisascaris procyonis* (Nematoda: Ascaridoidea), is a well-known cause of visceral, ocular, and neural larva migrans (VLM, OLM, and NLM) in other animals, including humans (1,2). Fatal or severe central nervous system disease due to *B. procyonis* has been reported from over 90 species of birds and mammals (2). There are 13 known cases in humans, occurring primarily in children under two years of age (2-6, Gavin et al., unpubl.).

Raccoons habitually defecate in preferred sites, termed latrines, and a number of different raccoons may visit latrines over time, leading to large accumulations of feces at these sites (7,8). Latrines are commonly found at the base of trees and in the crotches of trees. They are also found on raised stumps, logs, rocks, tree limbs, and other horizontally oriented structures (2,7). In urban and suburban areas, raccoons establish latrines on the rooftops of garages and houses, in attics and chimneys, on woodpiles, decks, and other areas of high human activity (1,2). In areas where raccoon densities are high, substantial amounts of feces and *B. procyonis* eggs accumulate at latrines, which then become long-term sources of infection for humans and animals (2,8,9). Infected raccoons shed millions of *B. procyonis* eggs daily in their feces, and infective eggs survive for years depending on environmental conditions (1,2). Young children 1-4 years old are especially at risk for

heavy infection, since they frequently exhibit pica or geophagia, and handle and mouth objects contaminated with soil.

In 1998, an 11-month-old boy from Pacific Grove, CA became infected with *B. procyonis*, which caused severe neural larva migrans and unilateral ocular disease (6). Infective *B. procyonis* eggs were found in raccoon latrines on the patient's property and an adjacent area, and the local raccoon population density was judged to be much higher than anything previously reported in the United States. Further investigation indicated apparent high raccoon populations in other communities on the Monterey Peninsula, based on sightings, homeowner complaints, and the presence of raccoon latrines in residential areas. Because of the potential for transmission of *B. procyonis* to both humans and animals in the area, I chose to investigate this situation further by systematically examining raccoon latrines in two cities on the Peninsula. The purpose of the present study was to determine the density and location of raccoon latrine sites and the prevalence of *B. procyonis* eggs in those latrines in Pacific Grove and Carmel, CA, in order to assess the potential risk of transmission of this parasite to humans and animals in the area.

MATERIALS AND METHODS

Field Methods

I obtained access to private properties within the cities of Pacific Grove and Carmel, CA using a newspaper advertisement and a telephone messaging system, in which residents called in and volunteered their properties for study. I assigned unique identification codes to the properties, corresponding to the city and the numerical order in which they were surveyed. I measured the total area of each property in square meters, and then systematically surveyed each site for the presence of raccoon latrines.

I identified latrines by the presence of raccoon fecal matter, which has a characteristic size, shape, odor, and other physical characteristics; typically they are dark, attenuated scats approximately 7-15 cm long by 2 cm in diameter, containing a variety of seeds and other food items (2,10). Fecal piles less than one meter apart were considered to be from the same latrine. I mapped the location of each latrine, measured its diameter, and counted the number of scats it contained. I collected fecal samples from each latrine and examined them for the presence of *B. procyonis* eggs.

Laboratory Methods

I determined the presence of *B. procyonis* eggs in fecal samples by centrifugal flotation using Sheather's sugar solution, specific gravity 1.25-1.27 (11). *B. procyonis* eggs have a characteristic size and morphology and can be identified with a standard light microscope using 200X magnification (1,2). Once identified, the eggs were classified as either undeveloped (containing a developing embryo) or embryonated (containing a fully formed infective larva).

RESULTS

I found 127 raccoon latrines on 80 property sites in Pacific Grove and 64 latrines on 38 property sites in Carmel, for a total of 191 latrines. There were 1.6 ± 1.6 (mean ± standard deviation) latrines/property in Pacific Grove and 1.7 ± 2.0 latrines/property in Carmel. The property size was much more variable in Pacific Grove than Carmel. The property size in Pacific Grove was 1828 ± 6023 m^2, while in Carmel it was 777 ± 1263 m^2. The density of raccoon latrines was 8.7 latrines/hectare (3.5/acre) in Pacific Grove and 21.7 latrines/hectare (8.8/acre) in Carmel. The majority of latrines were found on the roofs of houses and sheds (40.3%). The remaining latrines were found on open ground (17.8%), on tree stumps (7.3%), near a fence or wall (6.8%), on wood piles (6.3%), at the base of trees (5.2%), in the forks of trees (5.2%), and at other locations (11.1%).

Of the 191 latrines found, 22 were not accessible due to their unsafe locations. The remaining latrines were examined for *B. procyonis* eggs. Over half of the latrines examined were positive for *B. procyonis* eggs and latrines in both cities contained many infective eggs (Fig 1). Approximately half of the properties surveyed contained at least one latrine that was positive for *B. procyonis* eggs (Fig 2). Most of the properties surveyed contained from 0 to 3 latrines (Fig 3).

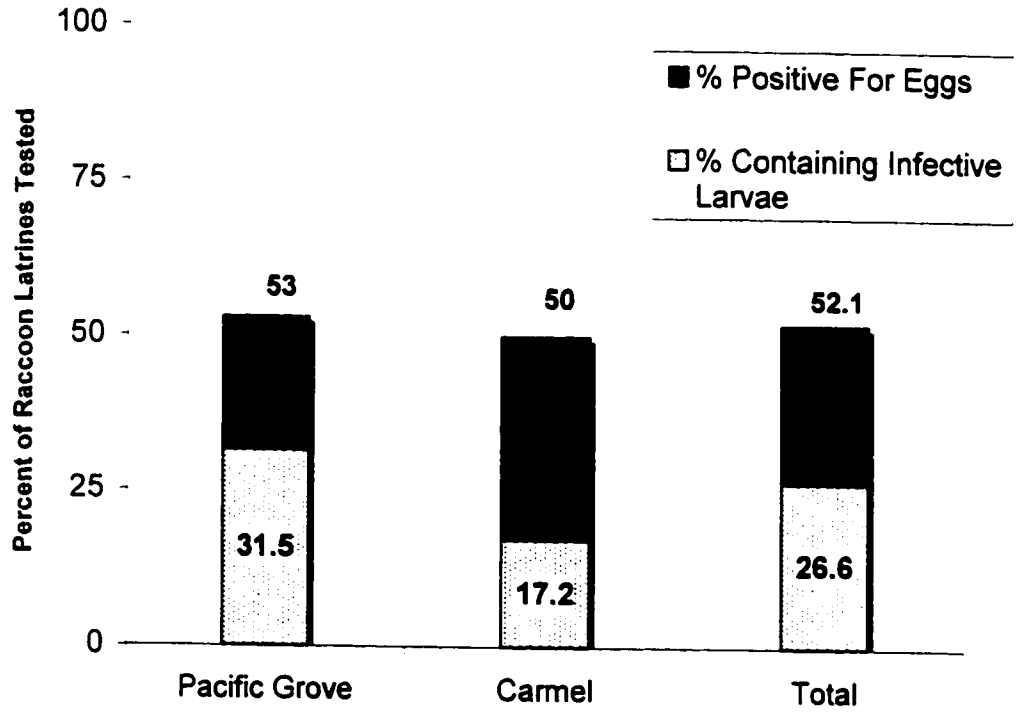

Figure 1. Percentage of raccoon latrines on the Monterey Peninsula, CA, that tested positive for *B. procyonis* eggs and eggs with infective larvae (number of latrines = 169)

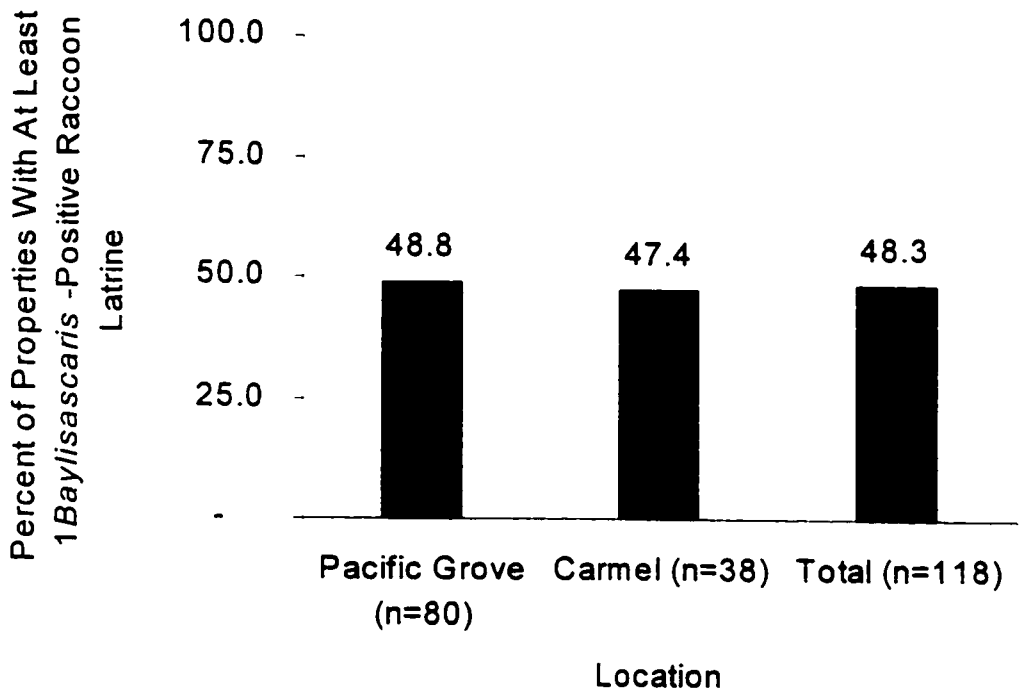

Figure 2. Percentage of properties on the Monterey Peninsula, CA, that contained at least one raccoon latrine positive for *B. procyonis* eggs.

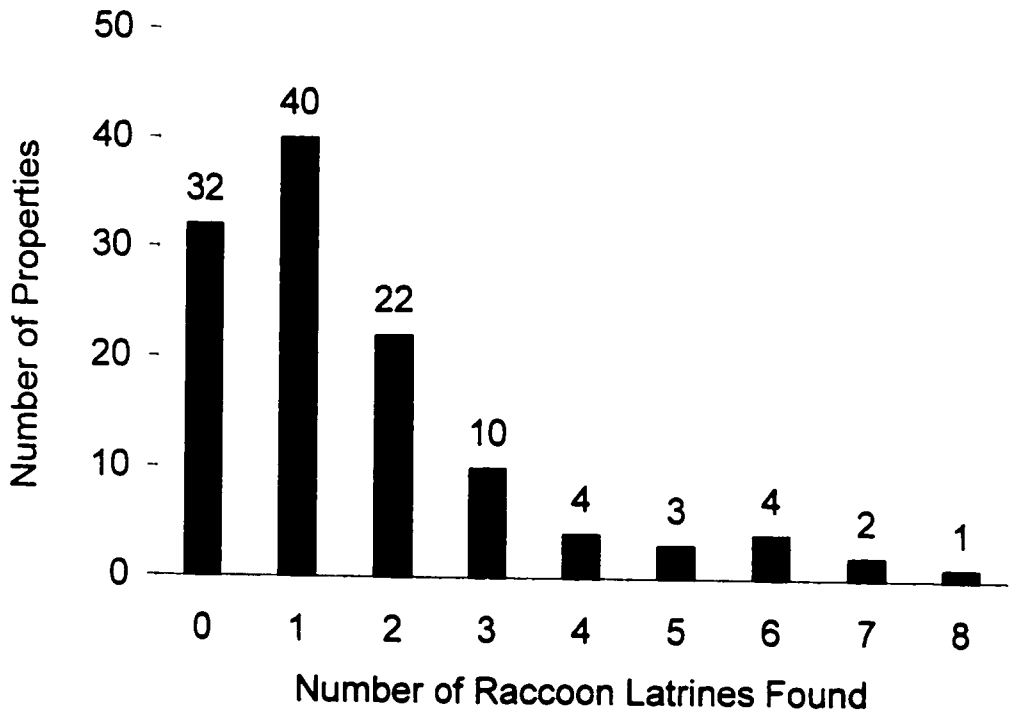

Figure 3. Frequency distribution for the number of raccoon latrines found on properties on the Monterey Peninsula, CA (number of properties = 118).

DISCUSSION

The widespread distribution and high density of raccoon latrines suggests that human and animal contact with raccoon feces and *B. procyonis* eggs is a common occurrence on the Monterey Peninsula. These latrine densities and the percentage of latrines containing *B. procyonis* eggs are the highest yet reported from North America. Page et al. (7) found 42 latrines in an 8.2 hectare woodlot (5.5 latrines per hectare) and *B. procyonis* eggs in 14% of the latrines sampled. Jacobson et al. (12) found 97 raccoon scats in a 280 hectare urban study area and 121 raccoon scats in a 230 hectare rural study area (0.35 and 0.53 latrines per hectare, respectively). In their study, 27% of the urban scats and 31% of the rural scats contained *B. procyonis* eggs (12).

The high raccoon latrine density on the Monterey Peninsula suggests a high raccoon population density in this area, which allows for both intra and interspecific density-dependent disease transmission. Intraspecific transmission occurs when *B. procyonis* eggs are passed from one raccoon to another through social interactions, such as denning, grooming, and visits to raccoon latrines. Interspecific transmission occurs when intermediate hosts ingest eggs at raccoon latrines (8). Latrines are visited routinely by small granivorous rodents and birds, which forage for seeds contained in the feces (2,8,9), and the possibility of transmission increases with latrine density. It is likely that raccoon latrines are also attractive to inquisitive young children, thereby posing a direct risk of pediatric infection.

Urban environments typically provide increased food sources and den sites and reduced hunting and predation, leading to higher densities of raccoons (13,14).

Anthropogenic food sources, some inadvertent and others purposefully provided by residents, are important contributing factors for high raccoon populations. Pet food, which is high in protein and fat content, is an important food source for raccoons in urban areas. In addition, urban raccoons may forage on fruits and vegetables from gardens and on food wastes from garbage cans and dumpsters (14). Numerous den sites exist in urban areas, including ground-based decks, culvert pipes, chimneys, and other accessible portions of buildings. On the Monterey Peninsula, I observed that tall Monterey pine trees appear to be commonly used as daytime resting sites for urban raccoons.

In rural environments, raccoons tend to prefer raised horizontal surfaces, such as logs, stumps, and the limbs and forks of trees, as well as the base of trees, as latrine sites (1,2,7). My results show that accessible roofs of houses and sheds are commonly used latrine locations in urban areas. Roof latrines may be used for years without a homeowner's knowledge, and substantial amounts of fecal matter accumulate during this time. During periods of rainfall, fecal matter from roof latrines is washed into rain gutters, which then empty into areas around residences. Young children who frequent these areas may then come into contact with infective *B. procyonis* eggs, which may be inadvertently ingested. Ground latrines, which were also common, may be important foci of *B. procyonis* eggs due to their location and accessibility. Young children who frequently exhibit pica or geophagia, or who frequently mouth objects that have fallen on the ground are especially at risk for accidental ingestion of *B. procyonis* eggs, possibly leading to heavy infection (2). Moreover, fecal matter on the ground may decompose into

the surrounding soil, leaving no sign of its presence, but infective eggs released from the feces may remain viable for years (1,2).

Since 1998, Pacific Grove has had an ongoing program of trapping and euthanizing nuisance raccoons in response to citizens' complaints. They have also increased educational efforts aimed at reducing anthropogenic food sources and shelter for these animals. Carmel has had no such programs, which may be the reason for the difference in latrine densities between the two cities.

B. procyonis can produce devastating neurologic disease in humans, especially young children (2-6). *B. procyonis* is much more pathogenic than the dog roundworm, *Toxocara canis*, the more frequently encountered cause of larva migrans in humans (1). There have been 13 cases of *Baylisascaris* encephalitis in humans in the United States, four of which were eventually fatal (2-6, Gavin et al., unpubl.). Except for 2 cases in adults, all occurred in very young children with heavy infections. Diagnosis commonly occurs only after clinical symptoms become pronounced and considerable tissue damage has already occurred (1,2). A number of human cases of *B. procyonis* OLM have also been recognized, related to general exposure of the population to the parasite (2).

Public education about this parasite and its potential health effects is essential for limiting human exposure to *B. procyonis* eggs, especially in urban areas where humans and raccoons coexist. Special care should be taken to limit raccoon activity near human habitations by eliminating raccoon attractants such as food and denning sites. Also, common sense precautions should be taken to prevent the accidental ingestion of *B. procyonis* eggs. Hands should be washed with hot, soapy water after coming in contact

with potentially contaminated materials, such as soil or firewood, and young children should be closely supervised when playing in areas raccoons are known to frequent. Property owners should remove fecal matter from latrine sites and dispose of it in a safe manner. Decontamination of latrine sites is best accomplished using heat, such as from a portable propane flame gun (1,2). In areas where the raccoon density is high, trapping and removal of raccoons may be necessary to decrease the prevalence of *B. procyonis* in the environment (2,8).

Finally, municipalities should increase their efforts to educate the public about this parasite and the negative effects of providing feeding opportunities for raccoons and other wildlife. A reduction in available anthropogenic food sources is an important step in reducing the population densities of urban raccoons, which, in turn, may lead to a reduction in latrine sites and *B. procyonis* eggs. Through these and other measures limiting human interactions with raccoons and their latrines, it is hoped that additional human cases of *B. procyonis* infection can be prevented.

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