

Occurrence of *Baylisascaris procyonis* in Marin, Sonoma, and Alameda Counties in  
Northern California

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**ABSTRACT:** *Baylisascaris procyonis*, a common intestinal parasite of raccoons, *Procyon lotor*, in North America, can cause serious and sometimes fatal larva migrans in humans and many species of mammals and birds. The purpose of this study was to determine the prevalence of infection of *Baylisascaris* adults and eggs in raccoons and raccoon latrines in Marin and Sonoma Counties and at a university student housing facility in Alameda County in northern California. We found that 4 of 6 (67%) and 2 of 4 (50%) raccoons necropsied in Marin and Sonoma Counties, respectively, were positive for *B. procyonis*, with an average intensity of infection of 3 worms (range = 1-10). 13 of 35 (37%) and 5 of 9 (56%) captive raccoons at wildlife centers in Marin and Sonoma counties, respectively, were shedding *B. procyonis* eggs in their feces. 12 of 17 (71%), 1 of 3 (33%), and 13 of 19 (68%) raccoon latrines examined in Sonoma and Marin counties and at the University of California - Berkeley student housing complex in Alameda county, respectively, were positive for *B. procyonis* eggs. These findings, although somewhat limited in scope, indicate that *B. procyonis* is common in these counties in northern California and that appropriate precautions should be taken concerning raccoons and their feces in order to prevent human and animal infection with this parasite.

The large roundworm, *Baylisascaris procyonis* (Ascaridoidea: Ascarididae) is a common intestinal parasite of raccoons, *Procyon lotor*, in North America. Prevalences of infection have ranged from 68% to 82% in the Midwestern and Northeastern United States to 58%, to 100% on the West Coast (Kazacos and Boyce, 1989; Kazacos, 2001). Although the parasite causes little pathology in the raccoon, migrating larvae can cause serious and sometimes fatal central nervous system (CNS) disease in humans and many animals. *B. procyonis* has caused fatal or severe CNS disease in over 90 species of birds and mammals, including humans, in North America (Kazacos 2001).

14 cases of human CNS infection by *B. procyonis* have been diagnosed in the United States from 1975 - 2002 (Kazacos 2000; Kazacos 2001). Four cases occurred in California, three involving severe CNS disease in young children from the San Francisco Bay area (Rowley et al. 2000; Park et al. 2000) and Santa Barbara County (E. Schulman, Santa Barbara County Public Health Department, DCDC California CD Brief CDHS5/ 08/ 02 week 19). The fourth case was diagnosed in a 17 year-old male residing in Los Angeles (W. A. Kennedy, Harbor-UCLA Medical Center, personal communication 2001). In addition, *B. procyonis* is recognized as an important cause of human ocular larva migrans, with cases diagnosed throughout North America, including the San Francisco Bay area (Goldberg et al., 1993). The objective of this study was to determine the occurrence of infection of *B. procyonis* adults and eggs in raccoons

and raccoon latrines in Marin and Sonoma counties and at a university student-housing facility in Alameda County in northern California.

Raccoon feces were collected for examination from: 1) intestinal contents of dead raccoons at necropsy; 2) captive raccoons housed at Marin WildCare, San Rafael, CA and Sonoma County Wildlife Rescue Center, Santa Rosa, CA; and 3) naturally occurring raccoon latrine sites. Raccoons for necropsy were either road-kill specimens (n = 4; Sonoma County) or animals that died or were euthanized while under the care of the wildlife centers (n = 6; Marin WildCare). Necropsies were performed within 48 hours postmortem on fresh or refrigerated raccoon carcasses or within one to two weeks for frozen carcasses. A midline abdominal incision was made, and the small and large intestines were removed and opened. Any *B. procyonis* present were removed and placed into 70% ethanol. Carcasses were incinerated after necropsy.

Fecal samples (approximately 5 grams each) were collected during June 1999- November 2000 from 39 raccoon latrine sites in Sonoma (n = 17) and Marin (n = 3) counties and at the University of California -Berkeley student-housing complex in Alameda county (n = 19). Latrine sites were identified as raccoon feces according to size, coloration and texture consistent with raccoon stool and that these latrines had the common characteristic of being “piled up” in one concentrated area. The distribution of the latrines was highly variable among all three counties. Several sites in Sonoma County were isolated in fields, pastures or along hiking trails with less than 10 separate stools per site. In several urban areas (backyards, garden areas, etc.), the latrines contained substantial amounts of fecal piles with up to 30 separate stool specimen in an

area often less than one square foot. To prevent redundancy, none of the latrine sites were sampled more than once. Fecal samples (n = 44) from raccoons at the wildlife rehabilitation centers were also collected and analyzed for *B. procyonis* eggs prior to the animals' release into the wild (Table 1 ages, sex, etc). Intestinal contents from the 10 necropsied raccoons were also analyzed for eggs and adult worms. 6 out the 10 animals necropsied were adults. The other 4 were identified as juveniles (> 6 months old).

Fecal specimens were analyzed for *B. procyonis* eggs by standing flotation using Fecalyzer® kits (Evsco Pharmaceutical Corp., Oceanside, NY) and sodium nitrate flotation solution (specific gravity 1.25 – 1.30). After 10-15 minutes, cover slips were removed, placed on glass slides and examined microscopically at 100x magnification. *B. procyonis* eggs were identified based on their size, ellipsoidal shape, brown color, and finely granular surface (Kazacos, 2000; Kazacos, 2001).

In Marin and Sonoma counties, 4 of 6 (67%) and 2 of 4 (50%), respectively, of necropsied raccoons contained *B. procyonis* adult worms, with a mean intensity of infection of 3 worms (range 1-10). Necropsied raccoons checked for fecal samples indicated that intestinal feces were present when adult worms were present in the intestine. Fecal samples of 5 of 9 (56%) captive raccoons at Sonoma County Wildlife Rescue center were positive for *B. procyonis* eggs, while 13 of 35 (37%) fecal samples collected from raccoons at Marin WildCare were positive.

In Sonoma County, 12 of 17 (71%) latrine samples were positive for *B. procyonis* eggs and 1 of 3 (33%) latrines in Marin County contained eggs. The U.C. Berkeley student-housing complex in Alameda County had 13 of 19 (68%) latrine sites containing

*B. procyonis* eggs. These findings constitute new county records for Sonoma and Alameda counties.

Ingestion of infective *B. procyonis* eggs can have severe neurological consequences, with one to four year old children being at particular risk of infection due to their propensity for pica and geophagia (Kazacos, 2000; Kazacos, 2001; Park et al., 2000). Larvae hatch from ingested eggs in the intestine and migrate via portal and systemic circulation to various tissues including the musculature, heart, lungs, eyes, and brain. Migrating larvae induce a strong host inflammatory response in which eosinophils predominate. In heavy infections, larval migration within the CNS may result in major damage leading to loss of motor and visual function, muscle weakness, ataxia, decreased head control, and other abnormalities that may progress to coma and death (Kazacos, 2000). Because ante mortem diagnosis is difficult and often delayed, and anthelmintics given during the clinical disease are often ineffective, prevention of infection is essential. Information regarding the prevalence of infection and degree of environmental contamination in a particular area facilitate prevention.

Based on a combination of raccoon necropsy and fecal data, we found *B. procyonis* infections occurring in raccoons in Marin and Sonoma counties at the rates of 42% (17 of 41) and 54% (7 of 13), respectively. In these counties, 33% and 71% of raccoon latrines, respectively, were found to contain *B. procyonis* eggs. We also found 68% (13 of 19) of latrines contained *B. procyonis* eggs at the U.C. Berkeley housing site an area with a playground frequented by children. In a previous study conducted in

Marin County the prevalence of infection of *B. procyonis* in raccoons was 67% (8 of 12), similar to our findings in necropsied raccoons from this county.

*Baylisascaris procyonis* was first reported from northern California in raccoons from Monterey County in 1956 (Voge, 1956), and subsequently from Los Angeles (Overstreet, 1970). More recent studies, including this survey, indicate that *B. procyonis* is probably common in raccoons throughout California and that raccoon fecal contamination containing *B. procyonis* eggs is widespread (Kazacos, 2001). In Monterey County, where an 11-month old boy contracted severe CNS disease due to *B. procyonis*, all latrine sites on the patient's property and adjacent lot were positive for eggs, and 12 of 27 (44%) of latrines sampled elsewhere in the community were positive (Park et al., 2000). The numerous reportings of the presence of *B. procyonis* eggs in areas with the potential for human contact make it prudent to alert the public about the risk of infection with this parasite and appropriate precautions.

In our study, 68% of the raccoon feces found on the grounds at the U.C. Berkeley student-housing facility were positive for *B. procyonis* eggs. Many of the fecal samples were concentrated on lawns near the children's play areas, in a community garden site, or on the stairwells of the apartments. Upon further investigation, we determined that local residents were feeding commercial cat food to this urban raccoon population. Because of the high potential for zoonotic transmission of this parasite to children living at that housing complex, public health brochures and posters were circulated and displayed. The information provided in the brochures included suggestions of ways to discourage raccoons and other wildlife from frequenting the area, e.g. placing all

garbage in cans with tight lids and preventing access of wild animals to pet food left outdoors. Both the information and suggestions were well-received by the residents of the complex.

We also found a risk of infection for animal handlers at wildlife rehabilitation centers in both Marin and Sonoma counties, because both facilities held captive raccoons that tested positive for *B. procyonis*. Brochures and suggested precautions were also provided to these wildlife centers informing personnel of preventative measures and risks of handling raccoons and other animals housed in these facilities. Because of the probable high prevalence of infection of *B. procyonis* in raccoons in northern California, public education remains one of the most important aspects of preventing infections with this parasite.

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