BioOne COMPLETE

PREVALENCE OF BAYLISASCARIS PROCYONIS IN RACCOONS (PROCYON LOTOR) IN PORTLAND, OREGON, USA

Authors: Yeitz, Jennifer L., Gillin, Colin M., Bildfell, Rob J., and DeBess, Emilio E.

Source: Journal of Wildlife Diseases, 45(1) : 14-18

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-45.1.14

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Journal-of-Wildlife-Diseases on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Journal of Wildlife Diseases, 45(1), 2009, pp. 14–18
© Wildlife Disease Association 2009

PREVALENCE OF *BAYLISASCARIS PROCYONIS* IN RACCOONS (*PROCYON LOTOR*) IN PORTLAND, OREGON, USA

Jennifer L. Yeitz,[1,5] Colin M. Gillin,[2] Rob J. Bildfell,[3] and Emilio E. DeBess[4]

[1] College of Veterinary Medicine, Oregon State University, Corvallis, Oregon 97331, USA
[2] Oregon Department of Fish and Wildlife, Corvallis, Oregon 97361, USA
[3] Department of Biomedical Sciences, College of Veterinary Medicine, Oregon State University, Corvallis, Oregon 97330, USA
[4] Oregon State Health Division, Portland, Oregon 97214, USA
[5] Corresponding author (email: yeitz.jenn@gmail.com)

ABSTRACT: We investigated the prevalence of *Baylisascaris procyonis* in raccoons living in the metropolitan area of Portland, Oregon, USA, in order to assess the potential public health risk involved in the transmission of *B. procyonis* to humans and companion animals. Sixty-nine euthanized raccoons were collected from Portland wildlife-control agencies. Infection with *B. procyonis* was determined through the harvesting of adult worms from raccoon intestines during necropsy and by fecal analysis using modified double-centrifugation technique with a sugar-flotation solution. Fifty-eight percent of sampled raccoons were found to be infected with *B. procyonis*. Juveniles represented a greater percentage (64%) of raccoons captured by wildlife-control agents and were found to have the highest prevalence (70%) and heavier adult worm burdens (mean=35 worms). No gender bias was evident. This is one of the few studies of *Baylisascaris* prevalence in the Pacific Northwest, and it demonstrates that there is a high prevalence of *B. procyonis* in raccoons inhabiting the Portland area. This factor should be considered in raccoon relocation and management. The data also suggest that juvenile raccoons are the major potential source of *B. procyonis* contamination in the Portland community and may merit special attention to minimize their interaction with humans.

Key words: *Baylisascaris procyonis*, nematode, Oregon, parasites, Portland, public health, raccoon.

INTRODUCTION

Baylisascaris procyonis (Nematoda:Ascaridoidea) is a roundworm found in the small intestines of raccoons (*Procyon lotor*), and it is a common cause of clinical larval migrans in animals. An adult female worm can produce a prodigious number of eggs (estimates are as high as 115,000 to 179,000 eggs/worm/day), leading to heavy environmental contamination (Gavin et al., 2005). The eggs can infect raccoon kits directly when ingested either from the den bedding or from the contaminated fur of the sow. Adult raccoons appear to be more resistant to direct infection, although they can become infected by *B. procyonis* indirectly when they consume infected intermediate hosts (Kazacos and Boyce, 1989).

Intermediate hosts, including more than 90 species of birds and mammals, commonly become infected by consuming embryonated eggs while foraging for undigested seeds in raccoon scat (Page et al., 1999). However, because *B. procyonis* eggs are sticky and tend to adhere to a number of substances, animals may also become infected through grooming or from areas previously inhabited by raccoons (Kazacos and Boyce, 1989). Outbreaks of neurologic disease in animals housed within wildlife rehabilitation centers (Kidder et al., 1989) and zoological parks (Stringfield and Sedgwick, 1997) have been presumed to be a result of *B. procyonis* infections contracted through contamination of cages with raccoon feces (Kazacos, 2001).

Baylisascaris procyonis larvae embark on an aggressive migration through the intestinal wall of an intermediate host into somatic tissues, which may include the central nervous system (described as cerebrospinal nematodiasis). Unlike other migrating ascarid larvae, *B. procyonis* larvae continue to grow rapid, to a length of up to 1.9 mm, causing severe neuro-

Downloaded From: https://bioone.org/journals/Journal-of-Wildlife-Diseases on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

logic damage through a strong inflammatory reaction to larval secretory products, in addition to mechanical damage to neural tissue (Kazacos, 2001). The incapacitated and/or dead intermediate hosts become easy prey for raccoons, and, once ingested, *B. procyonis* is liberated from the intermediate host and remains in the raccoon's small intestines, thus completing its life cycle.

Humans are an accidental host for *B. procyonis*. Fourteen human cases of *Baylisascaris*-associated encephalitis have been documented in a number of states, including Oregon (Wise et al., 2005). The majority of reported cases involved children between the ages of one and four years old and special-needs adults suffering from pica. The most significant form of neural larva migrans from *B. procyonis* results in an eosinophilic meningoencephalitis, and clinical symptoms are dependant on the number of infective eggs ingested and the severity of damage from migration. Clinical signs may include: sudden onset of lethargy, irritability, loss of motor coordination, and generalized ataxia, which can progress to opisthotonus, coma, and death. Signs can develop as early as 2–4 wk postinfection (Park et al., 2000).

The high pathogenicity of *B. procyonis* larvae and the ability of raccoons to thrive in urban developments have resulted in concern as to the prevalence of the infection in different raccoon populations. Studies of the prevalence of *B. procyonis* throughout the US have revealed a higher distribution of *B. procyonis* in raccoons from the Northeast, Midwest, and Western US states (72–82%) and a much lower prevalence in the Southeast US (0–22%; Murray and Kazacos, 2004). However, local variations in the prevalence of *B. procyonis* may be influenced by raccoon population density and the availability of resources (Kidder et al., 1989). This variability identifies a need for more local investigations of infected raccoons in order to document the risk of transmission to humans and domestic animals living in a region. This especially holds true for areas like Portland, Oregon, USA, in which rapid urban expansion has amplified interactions between raccoons and people. The goal of this study is to determine the prevalence of *B. procyonis* in a population of raccoons in the greater Portland metro area in order to assess the risk of transmission to the local community.

MATERIALS AND METHODS

Raccoons used in this study were obtained through three organizations responsible for the trapping and relocation of nuisance and injured raccoons in Portland, Oregon, USA. These included the Audubon Society of Portland, Critter Control, and Critter Gitter. Raccoons admitted into this study were euthanized based on the criteria of the Oregon Department of Fish and Wildlife (ODFW), which were completely independent of the objectives of this inquiry. All raccoons were stored in individual garbage bags within freezers at each facility until transported to Oregon State University Veterinary Diagnostic Laboratory (OSU VDL) for processing. Personnel at each facility attached premade tags to each bag indicating the date, location of capture, and the number of raccoons obtained at each location.

At the time of necropsy, each raccoon was sexed, weighed, and age was determined. Body weight, the condition of the baculum in males and teats in females, tooth eruption, and wear of teeth were used to distinguish the juveniles from the adult raccoons. *Baylisascaris* is unlikely to have achieved oocyst patency in directly infected animals less than 2 mo of age (Kazacos and Boyce, 1989). Since fecal flotation was one of the assays employed in the study, raccoons less than 2 mo of age were excluded from the study.

A modified necropsy was performed on each raccoon by exposing the abdominal cavity through a midline incision from the xiphoid process to the pubis bone. The gastrointestinal tract was removed between the colon just proximal to the rectum and the gastric cardia. Fecal samples were collected into a labeled plastic bag by emptying the contents of the colon directly into the bag. The gastrointestinal tract was then cut open with a longitudinal incision and examined for the presence of adult ascarid worms. Adult *B. procyonis* worms were identified and counted before being placed in a labeled plastic bag. Pre-

Downloaded From: https://bioone.org/journals/Journal-of-Wildlife-Diseases on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

TABLE 1. Prevalence of *Baylisascaris procyonis* adults and/or ova in respect to total population of sampled raccoons, according to age and gender.

	Total population of raccoons (n=69)	Gender of raccoons		Age of raccoons	
		Male	Female	Adults	Juveniles
		52%	48%	36%	64%
Infection with *B. procyonis*[a]	58%	56%	61%	36%	70%
Average *B. procyonis* adult worm burden[b]	24 (0–344)	20 (0–344)	28 (1–195)	4 (0–46)	35 (0–344)

[a] Ova or adults detected.

[b] Indicates range of worm burdens.

sumptive identification as *B. procyonis* adults was based on morphologic features, such as range in size of approximately 12–23 cm, tan color, and general ascarid characteristics.

Fecal analysis was performed on 1 g of feces using the modified double-centrifugation technique with a sugar solution (specific gravity=1.27; Foreyt, 2001). Slides were examined at 100× (×10 ocular, ×10 objective) for the presence of *B. procyonis* eggs and quantified by counting ova present within the limits of the cover slip, up to 500 eggs. Egg counts greater than 500 eggs were denoted as too numerous to count.

Statistical analysis of the prevalence of *B. procyonis* in the sampled raccoons was done using Fisher's exact test (Ramsey and Schafer, 1997). A P-value of <0.05 was used to determine significance of 2×2 tables of prevalence between adult and juvenile raccoons, male and female raccoons, the presence of ova and adult worms in each of these parameters, as well as seasonal variation. Statistical comparison of the parasitic burden of adult and juvenile raccoons was also performed using Student's t-test.

RESULTS

From June 2005 to June 2006, 87 raccoons were collected from the Portland area. Most of the samples were obtained in August at the height of an ODFW-mandated ban on the relocation of raccoons. This ban was precipitated by a canine distemper outbreak in the local raccoon population. Eighteen individuals were eliminated from the study either due to lack of information on location of capture or because they were less than 2 mo of age. Similar numbers of male and female raccoons were collected (52% and 48%, respectively), with juveniles comprising 64% of the sampled population.

The prevalence of *B. procyonis* in the 69 raccoons sampled is summarized based on overall prevalence, prevalence between sexes and age groups, as well as by the presence of adult *B. procyonis* at necropsy (Table 1). The overall prevalence of *B. procyonis* infection was 58% (eggs and/or adult worms detected). Analysis of parasitic burdens showed that infected juveniles had a significantly higher number of *B. procyonis* worms than did infected adult raccoons (35 vs. 4 for average worm count, P=0.013, Student's t-test) Juveniles also provided the majority (83%) of fecal samples with egg counts greater than 500 eggs/slide.

Significantly higher numbers of juvenile raccoons (70%) were infected with *B. procyonis* when compared to adults (36%) (P=0.006, Fisher's exact test). There was no implication that gender was a factor in prevalence: 52% of males vs. 48% of females (P=0.4, Fisher's exact test). In a comparison of prevalence between summer (July–September) and winter (December–March) seasons, there appeared to be no significant change (P=0.5 Fisher's exact test), indicating that the time of year was not a factor. However, the power of this test was severely limited due to the small size of the winter sample group.

DISCUSSION

The zoonotic potential of *Baylisascaris procyonis* is a serious public health

Downloaded From: https://bioone.org/journals/Journal-of-Wildlife-Diseases on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

concern in Portland because raccoons are often found inhabiting areas with high human population densities. A 58% prevalence of *B. procyonis* in raccoons within the area confirms that there is a risk of zoonotic transmission in areas with dense raccoon populations. The prevalence of *B. procyonis* in Oregon has rarely been studied. The prevalence reported in this study adhered closely to the findings of some other investigations in the Pacific Northwest, specifically 61% prevalence in British Columbia (Ching et al., 2000) and 79% in Washington (cited by Kazacos, 2001). However, the prevalence in one necropsy-based study in southwestern Washington was reported as only 3% (McNeil and Krogsdale, 1953).

The higher prevalence of *B. procyonis* in juvenile raccoons (70%) found in this study is similar to trends found in other *B. procyonis* studies within the US, and it can be partly explained by the direct life cycle of the parasite, which specifically targets young juveniles. The lower prevalence in adult raccoons (30%) may also be a consequence of age-related immunity to *B. procyonis*. In addition, juvenile raccoons demonstrated a higher average number of eggs shed and number of adult worms, signifying a greater link to the spread of *B. procyonis* into the environment. It is therefore of particular concern that the juvenile raccoons in this study made up 64% of the total number of captured raccoons, suggesting a greater level of activity around human dwellings for this age group.

Anomalies in the data included the finding of two male raccoons (one adult, one juvenile) in which ascarid eggs were found in the absence of adult worms. Contamination of the fecal samples (false positive) was considered in reviewing this discrepancy. However, precautions were taken to avoid such occurrences by preparing each fecal sample independently. A more logical explanation is that some adult worms were not identified during the examination of the intestinal contents, which was limited to visual identification without aids such as screens or a dissecting scope. Conversely, four raccoons were found to be positive for the presence of worms and were negative for ova. Irregular production of eggs is a recognized feature of *Baylisascaris* infections. It is also possible that these worms had not yet reached sexual maturity.

The effects of seasonality on the prevalence of *B. procyonis* could not be adequately determined by this study due to the termination of the ODFW relocation ban in November. This allowed wildlife-control agents to relocate many of the raccoons and considerably limited the number of raccoons available for sampling. It should be noted, however, that the month of August showed a prevalence of 78%, which was significantly higher than the overall prevalence and which had the largest sample of raccoons. This supports the conclusion that late summer and early fall pose the best environmental conditions for the shedding and transmission of the infective larvae (Kazacos and Boyce, 1989) Additionally, the environmental hardiness of *B. procyonis* eggs provides ample opportunity for the spread of the parasite via water sources such as rivers, rain gutters, and reservoirs used for community drinking during Oregon's wet fall season.

Although relatively few human cases of baylisascariasis have been reported, the prevalence of *B. procyonis* found in Portland, Oregon, USA, raccoons suggests that the likelihood of exposure and infection is higher than previously suspected. Because *B. procyonis* infections are difficult to accurately diagnose and treat, prevention is critical in the control of baylisascariasis (Park et al., 2000; Wise et al., 2005). Public health education regarding the transmission of *B. procyonis* from raccoons to intermediate hosts should be delivered to the Portland community, especially to families with small children or special-needs adults. Citizens should be discouraged from feeding raccoons around their houses or pro-

Downloaded From: https://bioone.org/journals/Journal-of-Wildlife-Diseases on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

viding a food source, such as pet food, that will attract hungry raccoons.

Although there is much debate about the efficacy of relocating nuisance raccoons, the potential to spread *B. procyonis* to less severely infected areas is a major concern. Antihelminthic treatment of raccoons at the time of capture, especially juveniles, should be considered prior to relocation. In areas with high numbers of raccoons, a baiting system with antihelminthics may significantly reduce *B. procyonis* infections in juvenile raccoons, further diminishing the risk of transmission.

Veterinarians and wildlife rehabilitators play a crucial role in the prevention of *B. procyonis* transmission to intermediate hosts such as domestic animals and wildlife. Wildlife rehabilitation facilities should have designated isolation areas for raccoons, and it is suggested that an antihelminthic protocol be adopted at these facilities for incoming raccoons to further eliminate the risk of transmission.

Although this study investigated the prevalence of *Baylisascaris procyonis* in raccoons in Portland, Oregon, USA, the population of raccoons sampled came from wildlife-control agencies that were providing a paid service to people with nuisance raccoons. Therefore, an unbiased distribution of infected raccoons could not be adequately investigated. A more active sampling program may reveal local variations in prevalence in the Portland, Oregon, USA, area and provide more insight into local factors that may be influencing infection rates, such as land use, water sources, and biodiversity.

ACKNOWLEDGMENTS

Distinctive recognition is bestowed on the Oregon Department of Health Services, Acute and Communicable Disease Section for their financial support. Special gratitude is also extended to all the wildlife-control agencies in Portland, Oregon, USA, and the Pathology Department at Oregon State University College of Veterinary Medicine for their contributions in the collection of samples for this study.

LITERATURE CITED

CHING, L. H., B. J. LEIGHTON, AND C. STEPHEN. 2000. Intestinal parasites of raccoons (*Procyon lotor*) from southwest British Columbia. Canadian Journal of Veterinary Research 64: 107–111.

FOREYT, W. J. 2001. Veterinary parasitology. 5th Edition. Iowa State University Press, Ames, Iowa, p. 5.

GAVIN, P. J., K. R. KAZACOS, AND S. T. SHULMAN. 2005. Baylisascariasis. Clinical Microbiology Reviews 18: 703–718.

KAZACOS, K. R. 2001. *Baylisascaris procyonis* and related species. Parasitic Diseases of Wild Mammals. 2nd Edition. Iowa State University Press, Ames, Iowa, pp. 301–341.

———, AND W. M. BOYCE. 1989. *Baylisascaris* larva migrans. Journal of the American Veterinary Medical Association 195: 894–903.

KIDDER, J. D., S. E. WADE, M. E. RICHMOND, AND S. J. SCHWAGER. 1989. Prevalence of patent *Baylisascaris procyonis* infection in raccoons (*Procyon lotor*) in Ithaca, New York. Journal of Parasitology 75: 870.

MCNEIL, C. W., AND J. T. KROGSDALE. 1953. Parasites of raccoons in southwest Washington. Journal of Mammalogy 34: 123–124.

MURRAY, W. J., AND K. R. KAZACOS. 2004. Raccoon roundworm encephalitis. Emerging Infections 39: 1484–1492.

PAGE, K. L., R. K. SWIHART, AND K. R. KAZCOS. 1999. Implications of raccoon latrines in the epizootiology of balisascariasis. Journal of Wildlife Diseases 35: 474–480.

PARK, S. Y., C. GLASER, W. J. MURRAY, K. R. KAZACOS, H. A. ROWLEY, D. R. FREDRICK, AND N. BASS. 2000. Raccoon roundworm (*Baylisascaris procyonis*) encephalitis: Case report and field investigation. Pediatrics 106: 56–60.

RAMSEY, F., AND D. SCHAFER. 1997. Fisher's exact test: The randomization (permutation) test for 2×2 tables. *In* The statistical sleuth. Wadsworth Publishing Co., Pacific Grove, California, pp. 548–552.

STRINGFIELD, C. E., AND C. J. SEDGWICK. 1997. Baylisascaris: A zoo-wide experience. *In* Proceedings of the American Association of Zoo Veterinarians meeting, Los Angeles Zoo, Los Angeles, California. 2004 Collected Proceedings, CD ROM.

WISE, M. E., F. J. SORVILLO, S. C. SHAFIR, L. R. ASH, AND O. G. BERLIN. 2005. Severe and fatal central nervous system disease in humans caused by *Baylisascaris procyonis*, the common roundworm of raccoons; a review of current literature. Microbes and Infection 7: 317–323.

Received for publication 27 July 2007.

Downloaded From: https://bioone.org/journals/Journal-of-Wildlife-Diseases on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use