Raccoon Roundworm in Raccoons in Central West Virginia

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Abstract - We investigated the occurrence of raccoon roundworm (*Baylisascaris procyonis*) in common raccoons (*Procyon lotor*) in the Allegheny Mountains of West Virginia during spring (n = 9, April–June) and fall (n = 5, August–October) 2001 and spring (n = 7) and fall (n = 4) 2002. We found no evidence of *B. procyonis* infection in 25 raccoons sampled by fecal floatation and necropsy methodologies. However, we did detect *Capillaria* sp. eggs in 28% and *Strongyloides* sp. eggs in 64% of individual raccoons, respectively. *Baylisascaris procyonis* has been implicated in population declines of the Allegheny woodrat (*Neotoma magister*) in the northeastern United States. The low prevalence of *B. procyonis* in an area inhabited by what is believed to be a stable population of Allegheny woodrats supports conservation measures to continue to monitor anthropogenic activities that potentially may increase the prevalence of *B. procyonis* or raccoon interaction with Allegheny woodrats in the region.

Introduction

The common raccoon (*Procyon lotor*) is the definitive host for *Baylisascaris procyonis*. Because *B. procyonis* is asymptomatic in raccoons and is a low pathogenic risk, the roundworm is not considered a limiting factor in raccoon populations (Davidson and Nettles 1997). However, *B. procyonis* larvae can infect and cause serious central nervous system disease in > 90 wild and domestic birds and mammals (Evans 2002, Kazocos 2001), including the Allegheny woodrat (*Neotoma magister*) (Kazacos and Boyce 1989).

The Allegheny woodrat is found in the central and southern Appalachians and Interior Low Plateau of the eastern United States in close association with rocky habitats such as cliff lines, rock-outcrops, and caves (Castleberry et al. 2001, Hall 1981). It is considered by the Natural Heritage Program (Association for Biodiversity Information 1999) as rare in parts of its range but overall is thought to be globally secure. At the state-level, the Allegheny woodrat is endangered in New York, threatened in New Jersey, Massachusetts, and Vermont, and a Species of Concern in Virginia and West Virginia (Castleberry 2002). Many woodrats in the

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genus *Neotoma* display caching behavior, including feces of other animals; they often consume the seeds and plant material contained in the feces. Adult *B. procyonis* reside in the small intestine of raccoons where eggs are transported in the feces to the environment allowing the life cycle to reinitiate in a new host. Accordingly, Allegheny woodrats are particularly susceptible to *B. procyonis* infection when they collect infected raccoon feces (LoGuidice 2003, Page et al. 1998).

Increased urbanization and habitat modification and fragmentation have resulted in higher raccoon densities, which have altered patterns of habitat use at the regional scale (Hoffman and Gottschang 1977, Riley et al. 1998). These changes in raccoon spatial distribution and increased densities may have increased interactions with Allegheny woodrat populations in the central Appalachians via altered spatial movements and den-site selection, thereby elevating the risk of *B. procyonis* infection. Researchers in the northeastern United States have attributed population declines of the Allegheny woodrat in part to fatal exposure to *B. procyonis* (Birch et al. 1994, LoGiudice 2003). Information on the geographic distribution and prevalence of *B. procyonis* is important in relation to the parasite epizootiology and woodrat conservation.

Although research has been conducted to determine the ecology and conservation status of the Allegheny woodrat in the central Appalachians (Castleberry 2000, Castleberry et al. 2001), only two studies have investigated the presence of *B. procyonis* within West Virginia; one of 58 raccoon scats collected from occupied woodrat habitat in Monongalia and Preston Counties contained nematode eggs compatible with *B. procyonis* (pers. comm., J. Wright, Carlisle, PA), and two of five raccoons examined at necropsy from a suburban environment (Ohio County) in an area of no known woodrat occurrence were infected with *B. procyonis* (Schaffer et al. 1981). Our objective was to determine the prevalence of *B. procyonis* in an area of known Allegheny woodrat and raccoon sympatry in West Virginia.

Methods

We conducted this study on the MeadWestvaco Ecosystem Research Forest (MWERF) located in the Allegheny Plateau physiographic province in Randolph County, WV, from August 2000 through March 2003. The MWERF has elevations ranging from 700 to 1,200 m with steep side-slope mountains, broad ridge tops, and narrow valleys (Fenneman 1938); annual precipitation averages between 170 and 190 cm (Smith 1995). The MWERF is a 3,600-ha, managed forest devoted to the study of the interaction of industrial forestry with Appalachian ecosystems. The MWERF is a 40–80 year old, second-growth or newly regenerating Allegheny-northern hardwood forest dominated by black cherry (*Prunus serotina*), sugar maple (*Acer saccharum*), red maple (*A. rubrum*), yellow birch (*Betula alleghaniensis*), American beech (*Fagus* *grandifolia*), and northern red oak (*Quercus rubra*). The MWERF is characterized by a cool, moist climate (Smith 1995). Allegheny woodrats are abundant in rocky areas and outcroppings on the MWERF and the population appears to be stable (Castleberry 2000).

We estimated raccoon population density during fall 2001 (September) by live trapping a 3-km^2 sampling area within our study area that was representative of the macrohabitat across the study area. We checked 50 live traps for 10 consecutive nights (500 trap nights). Each animal was given a uniquely numbered ear tag and released. The resulting number of individual raccoons captured/3-km^2 was used as a crude density/km^2 index (USDA/APHIS Wildlife Services, unpublished protocol).

Raccoon fecal samples were collected from trapped individuals (25 x 25 x 81 cm Havahart cage traps; Woodstream Corp., Lititz, PA) during spring (n = 9, April–June) and fall (n = 5, August–October) 2001 and spring (n = 7) and fall (n = 4) 2002, packaged in plastic bags, and refrigerated until analysis. We used a fecasol® (use of tradenames does not imply endorsement by the federal government) solution (1.2 specific gravity) and fecalyzer® (EVSCO Pharmaceutacals, Buena, NJ) to identify endoparasite eggs via the fecal floatation technique described in Sloss (1970). We also investigated the presence of adult roundworms in the small intestine of road-kill raccoons on or adjacent to our study area.

Results and Discussion

We found no evidence of *B. procyonis* eggs from 16 adult raccoons (9 male, 7 female) during the spring of 2001 (n = 6) and 2002 (n = 10). We also found no *B. procyonis* from two adult raccoons (1 male; 1 female) and four juvenile raccoons (3 male, 1 female) sampled by fecal flotation during fall 2001. We also found no evidence of adult *B. procyonis* in the small intestine of one juvenile, male and of two, adult, male road-kill raccoons via necropsy during fall 2002. However, *Capillaria* sp. eggs were detected in 28% (n = 7) and *Strongyloides* sp. eggs were detected in 64% (n = 16) of the individual raccoons. We estimated the raccoon population on our study area to be approximately 54 individuals (1.5 raccoons/km^2 x 36 km^2). Because *Baylisascaris* ova output is seasonal, *Baylisascaris* eggs are likely to be observed during fall (Kidder et al. 1989); therefore, we did not pool our samples and calculated separate prevalence estimates for spring and fall.

On the basis of our 16 negative spring cases and at a 95% confidence level, the estimated maximum prevalence rate was 13%, and the maximum number of detectable cases within the population of 54 raccoons was seven. Likewise, on the basis of our nine negative fall cases and at a 95% confidence level, the estimated maximum prevalence rate was 26%, and the maximum number of detectable cases within the population of 54 raccoons was 14 (Corn and Nettles 1995). However, we believe that this elevated prevalence rate in fall was due to our small sample size, which resulted from the low raccoon density and our limited trap success, and likely does not indicate a high occurrence of *Baylisascaris*.

Fecal floatation to detect *B. procyonis* is a reliable indicator of infection, with approximately 25,750 (± 3,912) eggs per gram of feces reported (Jacobson et al. 1976). Therefore, we are confident that the prevalence of *B. procyonis* on our study area is below our fall estimate of 26%. Nonetheless, *Baylisascaris procyonis* is known to occur to the north in Ohio County, WV (Schaffer et al. 1981), and neurological disease from *Baylisascaris* sp. larval migrans has been reported in woodchuck (*Marmota monax*) from Marion County, WV (unpubl. data, 1985, J. Crum, Elkins, WV), although both locations are a considerable distance from our study area (> 50 km)

The geographic distribution of *B. procyonis* is sympatric with that of raccoons in the continental United States (Kazacos 2001). However, researchers have reported various prevalence rates of *B. procyonis* throughout the range and have found higher prevalence rates in juvenile than adult raccoons in the northeastern and mid-western United States (Ermer and Fodge 1986, Kazacos 1983). Infection rates of 80%, 43%, and 20% have been reported in Iowa (Kazacos 1983), Kentucky (Cole and Shoop 1987), and West Virginia (Schaffer et al. 1981), respectively. Direct transmission between raccoons, prolonged viability of shed eggs, and infection of intermediate hosts by *B. procyonis* may contribute to its ability to persist at low population densities of raccoons (Loguidice 2003). *Baylisascaris procyonis* abundance is believed to be more dependent on raccoon density than on the density of intermediate hosts because of the number of potential intermediate hosts. Therefore, raccoons can serve as a disease reservoir, continuously reintroducing the parasite to intermediate hosts and young raccoons (LoGiudice 2003).

Recent declines of Allegheny woodrat populations in the northern and western peripheries of its range have been attributed in part to the fatal exposure to *B. procyonis* and to habitat loss from forest fragmentation (Balcolm and Yahner 1996, Birch et al. 1994). Current land-use practices have altered raccoon spatial distribution and movements and have increased raccoon abundance. Therefore, land-management practices may have forced or expanded raccoon populations into habitats occupied by Allegheny woodrats (Balcolm and Yahner 1996). This increased association may elevate parasite contamination and thus increase the possibility of woodrat infection with *B. procyonis*. LoGuidice (2003) reported 100% mortality of Allegheny woodrats experimentally released at sites infested with *B. procyonis* in the Kittatinny Range of northwestern New Jersey and in the Shawangunk Mountains of southeastern New York. Because the MWERF is an intensively managed forest, habitat fragmentation and the reduction in cavity trees may result in increased raccoon and woodrat interaction through den site competition. Owen et al. (unpubl. data, 2003, S. Owen, Morgantown, WV) via telemetry found raccoons denning in six rock outcrops that contained Allegheny woodrats or exhibited evidence of past use. Even where tree cavities are not limited, raccoons appear to select rock outcrops to den during certain seasons (Endres and Smith 1993).

The likelihood of woodrats encountering infected raccoons or raccoon feces is greater where raccoon densities are high (Castleberry 2000). Habitat quality for raccoons in the high Allegheny Mountain region of West Virginia is considered poor to fair (Rogers 2000), and the raccoon rabies epizootic advance west of the Allegheny Mountains in the past 5 years may have depressed raccoon populations. Low density and spatial dispersion of raccoons on the MWERF may reduce the likelihood of direct and indirect interactions between raccoons and woodrats, and therefore *B. procyonis* infection.

Raccoon resistance to *B. procyonis* infection is hypothesized to increase with age, however, direct transmission is possible in young raccoons (Davidson and Nettles 1997). Natal dispersal of raccoons introduces a possible mechanism of infecting new raccoons and woodrat populations in distant geographic locations. Moreover, the anthropogenic translocation of raccoons (interstate or intrastate transport) from areas of high *B. procyonis* prevalence may pose threats to Allegheny woodrat populations. Our findings support conservation measures to monitor anthropogenic activities that may increase the prevalence of *B. procyonis* or raccoon interaction with Allegheny woodrats.

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Literature Cited

Association for Biodiversity Information. 1999. Downloadable data sets. http://www.abi.org/. Natural Heritage Central Databases. Association for Biodiversity Information, Arlington, VA.

Balcom, B.J., and R.H. Yahner. 1996. Microhabitat and landscape characteristics associated with the threatened Allegheny woodrat. Conservation Biology 10:515–525.

Birch, G.L., G.A. Feldhamer, and W.G. Dyer. 1994. Helminths of the gastrointestinal tract of raccoons in Southern Illinois with management implications of *Baylisascaris procyonis* occurrence. Transactions of the Illinois State Academy of Science 83:165–170.

Castleberry, S.B. 2000. Conservation and Management of the Allegheny Woodrat in the Central Appalachians. Ph.D. Dissertation, West Virginia University, Morgantown, WV. 166 pp.

Castleberry, S.B., W.M. Ford, P. Bohall Wood, N.L. Castleberry, and M.T. Mengak. 2001. Movements of Allegheny woodrats in relation to timber harvesting. Journal of Wildlife Management 65:148–156.

Cole, R.A., and W.L. Shoop. 1987. Helminths of the raccoon (*Procyon lotor*) in Western Kentucky. Journal of Parasitology 73:762–768.

Corn, J.L., and V.F. Nettles. 1995. Disenfection in Wildlife. Revue scientifique et technique: Office International des Epizooties 14:455–468.

Davidson, W.R., and V.F. Nettles. 1997. Field Manual of Wildlife Diseases in the Southeastern U.S. Southeastern Cooperative Wildlife Disease Study. 417 pp.

Emer, E.M., and J.A. Fodge. 1986. Occurrence of the raccoon roundworm in raccoons in Western New York. New York Fish and Game Journal 33:58–61.

Endres K.M., and W.P. Smith. 1993. Influence of age, sex, season and availability on den selection by raccoons within the Central Basin of Tennessee. American Midland Naturalist 129:116–131.

Evans, R.H. 2002. *Baylisascaris procyonis* (Nematoda: Ascarididae) larva migrans in free-ranging wildlife in Orange County, California. J. of Parasitology 88:299–301.

Fenneman, N.M. 1938. Physiography of the Eastern United States. McGraw-Hill, New York, NY. 691 pp.

Hall, E.R. 1981. The Mammals of North America. John Wiley, N.Y., NY, 1181 pp.

Hoffman, C.O., and J.L. Gottschang. 1977. Numbers, distribution, and movements of a raccoon population in a suburban residential community. Journal of Mammalogy 58:623–636.

Jacobson, H.A., P.F. Scanlon, V.F. Nettles, and W.R. Davidson. 1976. Epizootiology of an outbreak of cerebrospinal nematodiasis in cottontail rabbits and woodchucks. Journal of Wildlife Disease 12:357–360.

Kazacos, K.R. 2001. Baylisascaris procyonis and related species. Pp. 301–341, *In* W.M. Samuel, M.J. Pubus, and A.A. Kocan (Eds.). Parasitic Diseases of Wild Mammals. 2nd Edition. Iowa University Press, Ames, IA. 568 pp.

Kazacos, K.R. 1983. Raccoon roundworms (*Baylisascaris procyonis*): A cause of animal and human disease. Station Bulletin 442. Purdue University Agricultural Experiment Station. 25 pp.

Kazacos, K.R., and W.M. Boyce. 1989. Zoonosis update: *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 75:870–874.

LoGiudice, K. 2003. Trophically transmitted parasites and the conservation of small populations: Raccoon roundworm and the imperiled Allegheny woodrat. Conservation Biology 17:258–266.

Page, L.K., R.K. Swihart, and K.R. Kazacos. 1998. Raccoon latrine structure and its potential role in transmission of *Baylisascaris procyonis* to vertebrates. American Midland Naturalist 140:180–185.

Riley, S.P., D.J. Hadidian, and D.A. Manski. 1998. Population density, survival, and rabies in raccoons in an urban national park. Canadian Journal of Zoology 76:1153–1164.

Rogers, R. 2000. West Virginia raccoon field trial survey 1999–2000. West Virginia Division of Natural Resources, Romney, WA. 11 pp.

Schaffer, G.D., W.R. Davidson, V.F. Nettles, and E.A. Rollor III. 1981. Helminth parasites of translocated raccoons (*Procyon lotor*) in the Southeastern United States. Journal of Wildlife Diseases 17:217–227.

Sloss, M.W. 1970. Clinical Veterinary Parasitology. Iowa State University Press. Ames, IA. 450 pp.

Smith, D.Wm. 1995. The southern Appalachian hardwood region. Pp. 173–225, *In* J.W. Barrett (Ed.). Regional Silviculture of the United States. John Wiley & Sons, Inc. New York, NY. 643 pp.