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Baylisascaris procyonis in Raccoons (*Procyon lotor*) in Eastern Tennessee

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ABSTRACT: Raccoon (*Procyon lotor*) carcasses ($n=118$) were collected from July through December 2007 throughout eastern Tennessee. Necropsies were performed, and *Baylisascaris procyonis* was collected from the gastrointestinal tract of infected carcasses. Prevalence rates were determined for the overall sample population, males and females, and adults and juveniles. The sample population had a *B. procyonis* prevalence of 12.7%. Males and females had a prevalence of 15% and 11%, respectively; prevalence in adults and juvenile was 13% and 12.6%, respectively. There were no significant differences in prevalence rates between the different groups. *Baylisascaris procyonis* is an ascarid infection of raccoons that can infect humans and over 100 species of other animals. The presence of infection in raccoons, paired with the expansion of human populations in eastern Tennessee, is likely to lead to increased interactions between humans and raccoons and therefore an increased risk of human and domestic animal exposure to *B. procyonis*.

Key words: *Baylisascaris procyonis*, *Procyon lotor*, raccoon, Tennessee.

Raccoons (*Procyon lotor*) are free-ranging animals native to North America, and *Baylisascaris procyonis* infections in raccoons have been reported in numerous geographic regions. The prevalence of infection is reported to be highest in juvenile raccoons, and in the Midwest, Northeast, and West Coast of the United States, with frequencies ranging from 68% to 82% (Jacobson et al., 1982; Evans, 2002; Roussere et al., 2003; Moore et al., 2004; Gavin et al., 2005). Historically, prevalence estimates in the southeastern United States have been low (Harkema and Miller, 1964; Schaffer et al., 1981; Gavin et al., 2005; McCleery et al., 2005). However, a recent study conducted in the Atlanta, Georgia, area found a prevalence of 22% in 50 raccoons, which suggests that *B. procyonis* may be an emerging infectious disease in raccoons in the southeastern United States (Eberhard et al., 2003). Infected raccoons, the definitive host for *B. procyonis*, shed a large number of eggs into the environment, and increased prevalence rates may lead to an increased risk of exposure for intermediate hosts, such as humans and domestic animals.

There have been no recent studies on raccoon infection with *B. procyonis* in Tennessee, but historic studies (Bafundo et al., 1980; Smith et al., 1985) indicate a low frequency. One study conducted in middle Tennessee and western Kentucky found a prevalence of 3.4% (Smith et al., 1985), and the only other study found a prevalence of 7.5% based on samples from across Tennessee (Bafundo et al., 1980). The goal of this study was to determine if *B. procyonis* still occurs in raccoons in eastern Tennessee and to estimate the prevalence of infection in the study population.

Raccoon carcasses ($n=118$) were opportunistically collected from July to December 2007 from 18 counties in eastern Tennessee. Samples included animals that had been: 1) trapped and euthanized, 2) shot by hunters, 3) hit by cars and either found dead or euthanized shortly after collection, or 4) presented to the College of Veterinary Medicine, University of Tennessee, and deemed unsuitable for rehabilitation and then euthanized. Animals were either recently

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euthanized or had been previously frozen. All animals were determined to be negative for rabies virus prior to being included in the study.

Sex, weight, and county of origin were recorded for each animal, which were then determined to be either juvenile or adult based on weight and size. Examination of teeth was not performed. Necropsies were performed, and gastrointestinal contents from the stomach to the rectum were examined. All ascarids were collected and placed in 70% ethanol for identification. Samples were stored, and definitive nematode identification was made by microscopic examination using an identification reference (Anderson et al., 1974).

Prevalence, with 95% confidence intervals, was calculated for the overall population, males, females, juveniles, and adults. Odds ratios (OR) with confidence intervals were calculated to determine if males or females were more likely to be infected and if juveniles or adults were more likely to be infected. An independent *t* test was performed to determine if the weights of the two age classes were different. Significance was set at a level $P<0.05$ for all tests.

Baylisascaris procyonis were found in raccoons from eight counties (Table 1), including the two counties with the greatest human population density in eastern Tennessee, Knox and Hamilton. Fifteen raccoons were positive for *B. procyonis* infection (prevalence=12.7%; 95% confidence interval [CI] 6.7–18.7%). Infected animals had between one and 15 worms (mean=6.8), all collected from the small intestine. Males and females had a prevalence of 15% (9/60; 95% CI 6–24%) and 11% (6/57; 95% CI 3–19%), respectively. Sex was not recorded for one adult that was not infected, so these calculations are based on 117 animals. Statistically, males were equally likely to be infected as females (1.5 odds ratio; 95% CI 0.5–4.5). Adults and juveniles had a prevalence of 12.6% (13/103; 95% CI 6.2–19.0) and 13% (2/15; 95% CI 0–31%) respectively. Juveniles and adults were equally likely to be infected (0.9 odds ratio; 95% CI 0.2–4.6) based on this sample. The mean weight (±SD) for the juveniles was 1.42±0.48 kg, and mean weight for the adults was 4.54±1.34 kg. The weights of the two age classes were significantly different ($P<0.001$).

With most ascarid infections, including *B. procyonis*, juveniles typically have a higher prevalence than adults and are therefore more likely to contaminate the environment with eggs (Snyder and Fitzgerald, 1985). Of the 118 raccoons sampled, only 15 were classified as juveniles, and juveniles were not more likely to be infected than adults. However, the subjective method of aging animals used in our study may lead to inaccurate estimates of prevalence within the two age groups. Additionally, the time of year of collection may contribute to less objective measures of age such as weight and size because there may be more overlap between age classes. Animals in this study were collected between summer and late fall. The use of objective methods, such as examining teeth and ossification of epiphyseal cartilage (Sanderson, 1961; Johnston et al., 1987), would have improved our age determination but were beyond the time and financial constraints of this study.

Raccoons are well adapted to living in close proximity to people, and their populations are often dense near suburban and urban parks and residences (Gavin et al., 2005). Raccoons use gardens, garbage, bird feeders, and pet food as food sources. Although the number of infected raccoons was small in this study, animals with *B. procyonis* infections were collected across the region and from the two most densely populated counties in eastern Tennessee. Increased interactions with raccoons are likely as human populations continue to expand into previously undisturbed natural habitats and naïve humans are unaware of the risks associated with interacting with wildlife. Additionally, with a general decrease in hunting, trapping, and preda-

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TABLE 1. Raccoons (*Procyon lotor*) were collected from 18 counties in eastern Tennessee from July through December 2007. Animals infected with *Baylisascaris procyonis* were present in eight counties. Counties are listed geographically (north to south).

Counties in eastern Tennessee	No. of samples positive/No. of samples examined
Sullivan	2/2
Johnson	1/2
Grainger	0/1
Hamblen	0/10
Greene	0/9
Cumberland	1/5
Anderson	0/3
Knox	6/24
Jefferson	2/9
Cocke	0/1
Roane	0/5
Loudon	0/6
Blount	1/9
Meigs	0/1
McMinn	0/1
Monroe	1/8
Marion	0/11
Hamilton	1/11
Total	15/118

tion, it is estimated that the raccoon population of the United States will double over the next 10 yr (Gavin et al., 2005).

Baylisascaris procyonis may be an emerging zoonotic infectious disease in the southeastern United States. The morbidity and mortality associated with human infections of *B. procyonis* can be significant. Although the observed prevalence is lower than in reports from regions of the country where human cases have been reported, the presence of *B. procyonis* in the most densely populated counties in eastern Tennessee provides reason to educate the public about risks associated with interacting with raccoons. The most efficient way to educate the public about the risks of *B. procyonis* would be to combine this information with current raccoon rabies education efforts. Periodic studies should be performed to determine if the prevalence of *B. procyonis* in raccoons in eastern Tennessee is changing. Additionally, because of the increased prevalence of *B. procyonis* in raccoons in areas such as eastern Tennessee and Georgia, studies should be conducted in other regions of the southeastern US to determine current prevalence rates.

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