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# Prevalence of *Baylisascaris procyonis* and Implications for Reintroduced Woodrat Populations in Southern Illinois

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## ABSTRACT

The roundworm *Baylisascaris procyonis* (Nematoda: Ascaridae) is carried and spread by raccoons (*Procyon lotor*). In intermediate hosts the parasite can cause brain damage and death. The prevalence of *B. procyonis* in raccoon populations is a concern in areas where the state-endangered eastern woodrat (*Neotoma floridana*) occurs or has been reintroduced because the foraging and hoarding strategies of woodrats ("packrats") make them particularly susceptible to infection. To determine the prevalence of this parasite and the possible implications for reintroduced eastern woodrats, we established 10 transects from Garden of the Gods (Saline County) east to Rim Rock/Pounds Hollow (Gallatin County) where woodrats have been reintroduced in Illinois. Raccoon latrine sites were visually located along these transects and scat piles sampled and analyzed using Fecalyzer flotation kits. Of 79 total fecal samples, only 1 tested positive for *B. procyonis*. This low prevalence (1.3%) for *B. procyonis* suggests that it likely poses little risk to the reintroduced woodrat populations within the study area.

Key words: *Baylisascaris procyonis*, eastern woodrats, raccoons, reintroductions

## INTRODUCTION

Raccoons (*Procyon lotor*) have a wide geographic distribution in North America and population densities are often quite high (Gehrt 2003). They thrive in proximity to humans and low pelt prices and reduced trapping effort have increased their abundance. Their large population sizes and ubiquitous distribution make raccoons an important vector for parasites and diseases including distemper, rabies, and the roundworm *Baylisascaris procyonis* (Mitchell et al. 1999).

Raccoons develop communal latrine sites used by various individuals (Gehrt 2003, Page et al. 2009a, b). Rodents often forage on scats at latrine sites for undigested seeds (LoGiudice 2001). This behavior presents a strong potential method of transmission of *B. procyonis* (Page et al. 1998). The parasite has little to no effect on the raccoon host and is rarely fatal except in cases of severe infection (Kazacos 2001, Gehrt 2003). In an accidental host infected with the parasite, the larvae migrate to ocular and brain tissue, encyst there and can cause listlessness, emaciation, loss of motor skills, coma, and ultimately death (Kazacos et al. 1984).

The prevalence of raccoons and their latrine sites may have a direct impact on other wildlife species, including woodrat populations. Whereas eastern woodrats (*Neotoma floridana*) once ranged throughout much of southern Illinois, today only four remnant populations remain. These show evidence of inbreeding (Monty et al. 2003) and the species is listed as endangered in the state. Reintroduction efforts in the Shawnee Hills region began in 2002 (Feldhamer and Poole 2008), with woodrats from Arkansas and Missouri released in formerly occupied sites at Garden of the Gods, Buzzard's Point, High Knob, and Pounds Hollow/Rim Rock. Reasons for the decline of woodrats in Illinois are unknown, but may have included habitat loss, degradation, and fragmentation; predation; competition; and mortality due to parasitism from *B. procyonis* (Birch et al. 1994; Feldhamer and Poole 2008). A high incidence of *B. procyonis* could have a negative impact on population viability of reintroduced woodrats in Illinois because the foraging strategies of eastern woodrats make them particularly susceptible to infection. Woodrats routinely collect and store items from their habitat, including raccoon scat. Consumption of fresh *B. procyonis* eggs is not harmful because they are not infective until they embryonate in 2 to 4 weeks. Woodrats, however, store scats and may not eat the seeds, giving eggs time to become infective (Page et al. 1999). Furthermore, the eggs remain viable for several years, creating the possibility for increased risk of infection as the bank of eggs increases.

The primary objective of this study was to determine the prevalence of *B. procyonis* in the local raccoon population inhabiting areas of woodrat reintroductions. The secondary objective was to determine significant microhabitat variables associated with location of raccoon latrines.

## MATERIALS AND METHODS

### Study Area

Between 2002 and 2009, 422 woodrats were reintroduced into 4 sites within the Shawnee National Forest, from Garden of the Gods (Saline County) east to Buzzard's Point, High Knob, and Rim Rock (Gallatin County) (Figure 1). These sites were selected for reintroduction based on documented past presence of the species and their bluff escarpments that provide rocky habitat (see Novosak 2004). Dominant overstory is oak (*Quercus* spp.)-hickory (*Carya* spp.) forest, although Rim Rock is primarily beech (*Fagus* spp.)-maple (*Acer* spp.) forest. The forest above the bluffs is xeric, while below the bluffs the habitat is more mesic. Self-sustaining populations of woodrats have been established at these sites (Feldhamer and Poole 2008, Ing 2008).

### Latrine/Scat Analysis

We established 10 1-km transects between Garden of the Gods and Pounds Hollow to sample raccoon latrine sites. Five transects were on the upland slopes of the bluff line, where reintroduced woodrats may have dispersed, and 5 were below the bluff line in areas known to harbor reintroduced woodrats. Transects were unbounded and all latrines that could be located visually were sampled. Likely sites for raccoon latrines (downed logs and prominent rocks) were examined along the route, flagged, and a GPS location determined. Each identified site constituted an individual sampling unit. Size of latrines was classified as small (1 scat), medium (2 scats), or large (≥3 scats) based on amount of

scat. Number of samples taken was dependent upon the size of each scat pile—small piles were sampled once, medium piles twice, and large piles three times. Sampling began March 2008, and a circuit of all 10 transects was made monthly for 20 months except August 2008. Different transects were visited weekly, with even effort among all transects. During June and July 2008, transects were walked twice each month. Checking continued through October 2009 for a total of 210 km monitored.

A sample of about 3 g was collected from individual scats in each latrine. Samples were stored at -70º C. Presence/absence of *B. procyonis* ova was determined by flotation using sodium nitrate and the Fecalyzer system (Evsco Pharmaceuticals, Bueno, NJ) following manufacturers recommendations. Eggs were identified using guidelines for morphology and size from Page et al. (2005). Eggs of *B. procyonis* are oval-shaped, generally between 65 and 80 $\mu$m in length, and have thick, granulated shells. They differ from eggs of *Toxocara* spp. in shape, membrane thickness and appearance (Kazacos and Boyce 1989).

**Habitat Measurements**

Microhabitat variables were measured at each latrine site and included: number of downed trees (coarse woody debris) in a 5-m radius surrounding the latrine, substrate (bare stone, log, or soil), and distance to nearest tree > 30 cm diameter at breast height (DBH). These habitat variables were also collected at random sites by choosing a cardinal direction at each latrine site and pacing 50 steps in that direction.

**Statistical Analyses**

We used a 1-tailed, paired t-test to determine differences in the amount of coarse woody debris and distance to the nearest tree at latrine sites vs. random sites. Chi-square analyses were used to test for differences in location of latrine sites above or below bluff line, and on substrate types. Level of significance was $\alpha = 0.05$.

## RESULTS

We collected 79 fecal samples from 54 latrine sites. Most of the scat found was in single piles. However, raccoons used several latrine sites repeatedly during the course of the sampling period. Thus, there were only 40 unique latrine sites, or 1 for every 5.25 km monitored. Of the 79 samples, only 1 (1.3%)—from Garden of the Gods—contained eggs of *B. procyonis*.

Four substrate types contained latrines: rock (n = 18), downed log (n = 13), leaf litter (n = 8), and live tree (n = 1). There was a significant difference among substrate types for occurrence of latrines ($\chi^2 = 15.8$, df = 3, $P < 0.05$). Essentially the same substrate types occurred on the 40 randomly selected sites as the identified latrine sites, with the exception of one random site with grass substrate. The mean amount of coarse woody debris at latrine sites (28.12%) was greater ($t_{39} = 2.46$, $P < 0.009$) than at random sites (16.62%). The mean distance to a tree > 30 cm DBH was 5.08 m at the latrine sites and 5.05 m at the random sites; these were not significantly different ($t_{39} = 0.72$, $P = 0.473$).

Considering location of the 40 latrines with respect to the bluff line, there were 20 above and 20 below. However, when each woodrat release site was considered independently, there were significant differences. At Garden of the Gods, there were 13 latrine sites

above the bluff line and only 3 below ($\chi^2 = 6.5$, df = 1, $P < 0.05$). At Rim Rock, there were 3 latrine sites above the bluff line and 10 below ($\chi^2 = 3.76$, df = 1, $P < 0.05$). Sample sizes at High Knob (3 above and 4 below) and Buzzard's Point (2 above and 2 below) were too small to test statistically.

Seasonal variation in scat presence was apparent. Scat was most frequently detected in autumn [Sep.-Nov.] ( $\bar{x} = 4.2$ scats/month), winter [Dec.-Feb.] ( $\bar{x} = 6.3$ scats/month), and spring [Mar.-May] ( $\bar{x} = 5.3$ scats/month), while an average of only 0.6 scats/month was found during June, July, and August.

## DISCUSSION

**Occurrence of *Baylisascaris procyonis***

Previous studies have determined the prevalence of infection of *B. procyonis* among raccoon populations in southern Illinois. Birch et al. (1994) found only 5.0% prevalence of *B. procyonis* among a sample of 60 raccoons in southern Illinois. This was much lower than the 64% prevalence found by Barnstable and Dyer (1974) in a sample of 36 raccoons. A more recent study by Nielsen et al. (2007) at Union County Conservation Area (UCCA)—with a very high density of raccoons—found *B. procyonis* at 16% of latrine sites. Prevalence of *B. procyonis* is positively correlated with the density of raccoons (Gompper and Wright 2005) and increased raccoon contact rates lead to increased rates of internal parasitism (Wright and Gompper 2005). Anthropogenic impacts that increase resources also can increase parasite prevalence, as can age structures of raccoon populations (Prange et al. 2003, Page et al. 2009b).

Given the well-documented ubiquitous nature of raccoons (Gerht 2003, Nielsen et al. 2007), we expected that scat would be abundant and easy to find on our study area. The number of scats we found was much lower than expected, however, and may indicate a low density of raccoons. The study area is removed from most development and the sites generally have little human use. Garden of the Gods is the only site that permits camping; Rim Rock has extensive hiking and picnic use, whereas High Knob and Buzzard's Point are more remote and less accessible to people with only hiking and equestrian use permitted. Locations of scats relative to the bluff line paralleled human activity. At Garden of the Gods most use is above the bluff line, whereas at Rim Rock picnic tables are only below the bluff line. High Knob has mostly equestrian use below the bluff line, whereas few people visit Buzzard's Point.

Raccoons are well known for their tendency to gravitate toward urban and suburban areas for easier access to food, with densities often higher than in rural areas (Prange et al. 2003). The study site at Garden of the Gods had the highest number of latrines and also the most human use. Likewise, UCCA experiences higher human use for camping, boating, fishing, and hiking, and high densities of raccoons; Nielsen et al. (2007) reported 1.67 raccoons/ha there. The apparent seasonal variation in scat prevalence we found, with fewer scats during summer, also was unexpected. Whether this was because of seasonal variation in raccoon habitat, increased decomposition rate, increased scat foraging by rodents, or some other factor is unknown.

**Site Selection of Latrines**

Raccoons choose specific latrine sites, often rocky, open areas (Page et al. 1998). Our results found 18 of the 40 unique latrines (45%) were on rocky locales. However, we did not determine relative availability of substrates or selection by raccoons. Latrines on our study area may have been deposited in proportion to available substrate without regard to selection—particularly because proportion of substrates at random sites was similar. The amount of coarse woody debris was significantly related to the occurrence of latrines, but unexpectedly, the distance to a large tree had no significant bearing on selection of sites. This is in contrast to Nielsen et al. (2007), who found that 61% of latrine sites were deposited at the base of large trees. Also contrary to most accounts in the literature, there was little proclivity for raccoons on our study area to form large communal latrine sites. We found only one large communal latrine at Garden of the Gods, located near a campsite, which had the only sample to test positive for *B. procyonis*.

**Management Implications**

Periodic monitoring of eastern woodrat and raccoon populations in southern Illinois should continue. Control of raccoon populations that are near reintroduction sites may be necessary should their numbers significantly increase. Raccoon populations state-wide have remained stable for the past 15 years (Bluett 2010), but as noted, they attain their highest densities in proximity to humans and/or agricultural land, where food is easy to obtain. It is in the best interest of the reintroduced woodrat populations if human impact remains at current low levels. Increased camping and recreational use may lead to increases in litter and garbage, resulting in increased raccoon abundance. The rarity of scat (and tracks) on our study area suggests a low density of raccoons and corresponding low occurrence of *B. procyonis*. The reintroduced woodrat populations in this area appear to be expanding, with documented reproduction and dispersal (A. K. Poole, SIUC, unpublished data), which is further indicative of low levels of *B. procyonis*. As such, we conclude that *B. procyonis* is not now a major threat to the population of woodrats in the study area.

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Figure 1. Location of eastern woodrat (*Neotoma floridana*) reintroduction sites (*) in southern Illinois. The 4 sites studied for *Bayliascaris procyonis* prevalence were Garden of the Gods, Buzzard's Point, High Knob, and Rim Rock. Woodrats were also introduced to Lusk Creek but that area was not included in this study. Previous extant woodrat populations (●) are at Pine Hills and Fountain Bluff.