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Survey of *Baylisascaris procyonis* and Canine Distemper Virus in Southern Illinois Raccoons

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ABSTRACT

Although diseases and parasites carried by raccoons (*Procyon lotor*) can have considerable impacts on wildlife populations, little is known about disease prevalence in southern Illinois raccoons. We surveyed raccoon latrine sites for raccoon roundworm (*Baylisascaris procyonis*) and quantified seroprevalence of canine distemper virus (CDV) in raccoons on the Union County Conservation Area (UCCA) during 2004-05. Most latrine sites (97%) were found on either downed logs or at tree bases; 16% of fecal samples at latrine sites exhibited *B. procyonis* eggs. The seroprevalence rate of CDV was 23%, with a slightly higher rate in females than males. Our survey indicates relatively low incidences of *B. procyonis* and CDV on the UCCA, even though raccoon density on the study area is one of the highest reported in the wildlife literature. We conclude it is unlikely that *B. procyonis* or CDV are appreciably affecting raccoons or mammalian species of concern on the UCCA.

Key words: *Baylisascaris procyonis*, canine distemper virus, disease, latrine, parasite, *Procyon lotor*, raccoon, southern Illinois

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INTRODUCTION

Raccoons (*Procyon lotor*) are important as parasite hosts and reservoirs of diseases that are potentially transmissible to other animals (Bigler et al. 1975, Kazacos 1982). Raccoon populations have increased nearly 20-fold during the last 70 years (Zeveloff 2002), heightening concern about potential impacts of raccoon-carried diseases on humans and wildlife. Two of the most important infectious agents associated with raccoons include raccoon roundworm (*Baylisascaris procyonis*; Kazacos 1982, Kazacos 2001, LoGiudice 2003) and canine distemper virus (CDV; Roscoe 1993, Mitchell et al. 1999).

B. procyonis is a well known cause of visceral, ocular, and neural larva migrans in humans and other animals (Sorvillo et al. 2002, Roussere et al. 2003). Fatal or severe central nervous system disease from *B. procyonis* has been reported in >90 species of birds and mammals; 13 known cases of neural larva migrans were reported in humans, primarily in young children (Kazacos 2001, Roussere et al. 2003:1516). Furthermore, *B. procyonis* may have contributed to the historical declines of eastern woodrats (*Neotoma* *floridana*) in southern Illinois (Birch et al. 1994) and Allegheny woodrats (*N. magister*) in New York and New Jersey (LoGiudice 2003).

Raccoon latrine sites can serve as long term sources of *B. procyonis* infection for susceptible animals, especially small vertebrates that forage for undigested seeds in raccoon feces (Roussere et al. 2003). Small vertebrates make use of the high seed content of raccoon feces, especially in times of food scarcity (Page et al. 2001a). Because raccoon latrines are most often found at the base of trees, in tree forks, on large logs, stumps, rocks, tree limbs, or other horizontally oriented structures in forested areas, some small vertebrates are more susceptible to infection than others (Page et al. 2001a, b).

Canine distemper virus is a contagious, incurable, often fatal, multisystemic viral disease that affects the respiratory, gastrointestinal, and central nervous systems (Carmichael 2005). Canine distemper virus can be an important cause of mortality in raccoon populations (Mech et al. 1968, Johnson 1970, Davidson and Nettles 1997, Gehrt 2003) and domestic dogs (Alexander and Appel 1994, Daszak et al. 2000). Infected raccoons can shed CDV via excretions and secretions; the primary mode of transmission is airborne viral particles that animals inhale. Other carnivore species affected by CDV include gray foxes (*Urocyon cinereoargenteus*; Nicholson and Hill 1984) and coyotes (*Canis latrans*; Bekoff and Gese 2003).

The wildlife literature is lacking information about *B. procyonis* and CDV in southern Illinois raccoons. The last study of *B. procyonis* in the region was >10 years ago (Birch et al. 1994). Given recent reintroductions of eastern woodrats in southern Illinois (G. Feldhamer, Southern Illinois University Carbondale, personal communication), an estimate of the prevalence of *B. procyonis* may help understand the likelihood of successful woodrat recovery. Although recent studies of CDV seroprevalence in raccoons have been conducted in west-central Illinois (Mitchell et al. 1999), no current information is available on CDV in southern Illinois raccoons. Our objectives were to (1) determine selected environmental attributes of raccoon latrine sites, (2) survey prevalence of *B. procyonnis* at latrine sites, and (3) determine seroprevalence of CDV in raccoons.

MATERIALS AND METHODS

Study Area

Our study was conducted on the Union County Conservation Area (UCCA), a 2,510 ha wildlife refuge located in southwest Illinois. Raccoons are protected from harvest on UCCA and existed at a population density of 1 raccoon/0.6 ha (Wilson 2005). Acquired by the Illinois Department of Conservation in 1947, UCCA is managed primarily as overwintering habitat for waterfowl. Forested and cultivated bottomlands are interspersed throughout UCCA and account for the 2,165 ha of dry land on the refuge. The temperate, mid-continental climate of southern Illinois is typified by cold winters, wet springs, and hot, humid summers. Annual precipitation for Union County is about 45 cm distributed evenly throughout the year (Illinois State Water Survey 2003).

Latrine Site Characteristics

We sampled 3 bottomland hardwood forest patches for raccoon latrine sites on UCCA during January-April 2004. We walked transects, spaced 20 m apart, and looked for fresh raccoon latrine sites until each forest patch had been surveyed. A latrine site was defined as an area with ≥2 fresh (i.e., relatively intact and not yet disintegrated) raccoon scats. Each latrine site substrate was recorded as (1) on top of a downed log, (2) inside a downed log, (3) on a stump, (4) at the base of a tree (within 1 m), or (5) on the ground. If the latrine site was at the base of a standing tree, dbh (diameter at breast height) of the tree was recorded. If the latrine site was on a downed log, log diameter at the latrine site was measured, and an estimate of log length was recorded to the nearest 5 m. We then used correlations ($\alpha = 0.05$ throughout) to assess relationships between: (1) number of latrine sites per downed log and log length, (2) number of latrine sites per downed log and diameter of downed logs, and (3) number of latrine sites per standing tree base and tree dbh.

Prevalence of *B. procyonis*

During February-March 2005, we sampled raccoon latrine sites for *B. procyonis* on the UCCA. We used Jacobson et al. (1982) as a guide to scat sample collection and used fecal flotation to assess prevalence of *B. procyonis* eggs in raccoon feces. We collected fecal matter (≥3 g) estimated to be <1 week old and included a small amount of soil with each sample. Fecal samples were then stored in 10% formalin. Samples were analyzed by using the Fecalyzer® flotation method and floated in Fecasol® solution (EVSCO Pharmaceuticals, Newington, New Hampshire, USA) with a specific gravity of 1.200. We then assessed specimens for *B. procyonis* eggs using a microscope.

Seroprevalence of Canine Distemper Virus

We captured raccoons as part of a larger study of raccoon ecology on UCCA (Wilson 2005, Wilson and Nielsen 2007). Raccoons were live-trapped during 4 periods: 6 October-4 December 2003, 8 March-16 April 2004, 26 September-10 December 2004, and 2 March-10 April 2005. Each trapping period, 40 wire cage traps (30x30x70 cm) were set along linear transects adjacent to water or field edges, and spaced at 100 m intervals. Trap density averaged 1 trap/0.6 ha of forested land. Traps were baited with commercial cat food and checked each morning from 0700-1100 hr. Live trapped raccoons were anesthetized with an intramuscular injection of Telazol (5mg/kg) based on an initial estimation of the animal's weight (Gehrt et al. 2001). Blood (5-10 ml) was collected from the femoral vein of selected raccoons to test for CDV (Yabsley et al. 2001). Blood samples were allowed to clot at room temperature and then centrifuged and separated. Serum was removed from each sample and aliquotted into cryovials and immediately frozen at -10^{o} C until tested at the Animal Health Diagnostic Center at Cornell University, Ithaca, New York. Similar to Mitchell et al. (1999), a CDV serum neutralization test was used with a starting dilution of 1:4; raccoons were considered negative if no antibody was detected at this dilution. Individuals with higher titers (≥1:8) were considered exposed to CDV. Research was conducted in adherence with a university-approved animal care and use protocol.

RESULTS

We found 276 latrine sites; of these, 61% (n = 168) were located at tree bases, 36% (n = 99) on downed logs, 2% (n = 5) on the ground, and 1% (n = 4) on stumps. Because downed logs and tree bases made up the vast majority of substrates used, further analysis was only conducted on these 2 substrates. Downed logs with larger diameter ($r = 0.219$, P

= 0.029) and greater length ($r = 0.435$; $P < 0.001$) contained more latrine sites. As dbh of tree bases used as latrine sites increased, the number of latrine sites at tree bases also increased ($r = 0.246$, $P < 0.002$).

We collected 100 fecal samples at latrine sites; of these, 16 samples (16%) exhibited *B. procyonis* eggs. Other parasites, such as whipworms (*Trichuris spp.*) and hookworms (*Ancylostoma spp.*), were observed in 28% of the samples. We collected blood from 35 raccoons (26 M, 9 F); 8 (23%) were seropositive for CDV. Four of the 9 F sampled (44%) were seropositive, while 4 of 26 M (15%) were positive.

DISCUSSION

We report relatively low prevalence of *B. procyonis* (16%) and CDV (23%) in raccoons on the UCCA in southern Illinois. We expected slightly higher prevalence rates given that raccoon density on our study area was one of the highest reported in the literature at 1 raccoon/0.6 ha (range = 1 raccoon/0.4 ha to 1 raccoon/17.4 ha; Twitchell and Dill 1949, Kennedy et al. 1986). When host population density is high, disease prevalence rate may also be elevated (Anderson and May 1982), but our data do not necessarily indicate this. Canine distemper virus has a 4-year epizootic cycle (Hoff et al. 1974, Roscoe 1993) and we may have studied raccoons on UCCA during a period when seroprevalence was low. Herein, we compare our findings to others in the wildlife literature and discuss potential impacts of *B. procyonis* and CDV on raccoons and other wildlife in southern Illinois.

Latrine Site Characteristics

Although we did not explicitly assess preference of latrine sites (via use vs. availability analysis), we provide information for comparison to other studies and elementary insight into raccoon behavior. Raccoon latrine sites have been documented on a variety of substrates (Page et al. 1998). Similar to other studies of raccoons at forested sites, we found latrine sites were most often associated with downed logs or tree bases (Kennedy et al. 1991, Page et al. 1998). We also noted that downed logs lacking bark were rarely used as latrine sites. This might result if bark provides a more stable contact surface for raccoons to travel along or if bark holds olfactory information necessary for raccoon communication (Ough 1982).

Relationships between latrine sites and characteristics of downed log and tree base substrates highlight the importance of forest structure to raccoons (Gehrt 2003). Tree bases were the most important latrine sites for raccoons on the UCCA, and were used almost twice as often as downed logs. Our results differ somewhat from Page et al. (1998), who reported that downed logs were used as latrine sites more than tree bases. Perhaps fewer downed logs existed on the UCCA relative to the west-central Indiana study site (Page et al. 1998). Large standing trees contained preferred raccoon den sites on the UCCA (Wilson and Nielsen 2007), thus raccoons were likely to be using these larger trees, and defecating at their bases before ascending. More latrine sites were found on larger and longer downed logs, which likely provide more surface area for raccoons to use.

B. procyonis

Prevalence of *B. procyonis* varies across the distributional range of raccoons, and comparison of prevalence rates must consider (1) the seasonality of parasite sampling, (2) latitude, and (3) method of determining prevalence rate (i.e., using feces from animals, latrine sites, or upon necropsy). Page et al. (2005) found that although latrine site sampling is a useful estimator of zoonotic potential for *B. procyonis*, this measure likely underestimates prevalence rate. We appropriately primarily limit our comparisons to those studies that have assessed *B. procyonis* prevalence at latrine sites, except where noted otherwise (i.e., Birch et al. 1994).

We report a prevalence rate (16%) very similar to that of Page et al. (1998) in west-central Indiana (14%), and slightly less than Page et al. (2005) at 23% in northern Illinois. However, prevalence rates from these studies are relatively low compared to other Mid-western and Northeastern sites (>60% prevalence; Ermer and Fodge 1986, Kazacos and Boyce 1989), and our results support previous findings that prevalence rates of *B. procyonis* are generally lower in more southerly latitudes. Birch et al. (1994) found that only 5% of raccoons sampled via necropsy in Pope County, southern Illinois, were infected with *B. procyonis*. The relatively high density of raccoons on the UCCA (Wilson 2005) may explain the increased prevalence rate relative to raccoons studied by Birch et al. (1994); such is especially true given that prevalence rates are often underestimated when based on latrine site sampling (Page et al. 2005).

Although *B. procyonis* has a relatively low prevalence on the UCCA, other wildlife may be impacted via ingestion of infected raccoon feces (Page et al. 1998, LoGiudice 2001, Page et al. 2001a). Specifically, latrine sites on or close to the ground may affect several ground-dwelling species. Small vertebrates such as the white-footed mouse (*Peromyscus leucopus*) and eastern chipmunk (*Tamias striatus*) are more susceptible to contracting *B. procyonis* at the base of trees because these animals are known to be ground foragers (Page et al. 1998, LoGiudice 2001). Birds species present on the UCCA such as the white-breasted nuthatch (*Sitta carolinensis*), northern flicker (*Colaptes auratus*), and northern cardinal (*Cardinalis cardinalis*) are also documented foragers of raccoon feces (Page et al. 2001a); these species are potentially susceptible to fatal or severe CNS disease as a result of *B. procyonis* (Kazacos 2001).

B. procyonis may have contributed to the decline in woodrat populations in eastern North America (Birch et al. 1994; LoGiudice 2001, 2003). LoGiudice (2001) explored food caching behavior of Allegheny woodrats and found that carrying entire feces to food caches resulted in a greater risk of contamination of the entire food cache as opposed to white-footed mice, which only carried *B. procyonis* eggs to food caches. At the current low prevalence rate, the ongoing eastern woodrat recovery effort in southern Illinois is probably not hindered by *B. procyonis* (G. Feldhamer, Southern Illinois University Carbondale, personal communication); again, this is due in part to latitudinal concerns. Furthermore, the high density of raccoons on our study area (Wilson 2005) is not likely to occur in xeric forested habitats preferred by woodrats in southern Illinois.

Raccoons are rarely affected by *B. procyonis*. As stated by Roussere et al. (2003), *B. procyonis* causes little or no clinical disease in raccoons, except in uncommonly heavy infections in juveniles. We recorded no known mortalities related to *B. procyonis* infection in a radiomarked sample of >60 raccoons on UCCA (Wilson 2005).

Canine Distemper Virus

Similar to *B. procyonis*, rates of CDV in raccoons reported in the wildlife literature vary considerably. Seroprevalence of CDV in our study was the same as Mitchell et al. (1999), who found a CDV seroprevalence of 23% in west-central Illinois raccoons. Other studies have reported higher rates of CDV in raccoon populations. For example, Davidson and Nettles (1997:147) indicated that 40-50% of all dead or sick Southeast raccoons studied had CDV, and CDV prevalence in Florida raccoons was 55% (Hoff et al. 1974). On the UCCA, we reported no known radiomarked raccoon mortalities due to CDV and no raccoons captured with obvious lesions associated with CDV (Wilson 2005).

Other wildlife species may be affected by high exposure risk to CDV. One carnivore species of concern in southern Illinois potentially affected by CDV is the gray fox. Others have shown that gray foxes can suffer significant mortality from epizootics of CDV; Nicholson and Hill (1984) reported that 7 of 25 study animals (28%) died from this disease. Gray fox populations appear to be declining in Illinois as evidenced by the Archery Deer Hunter Survey (ADHS) administered by the Illinois Department of Natural Resources. The ADHS has indicated a 68% decline in the statewide gray fox sighting index since the inception of the survey in 1992 (Bluett 2005). Although previous epizootics of CDV may have contributed to the gray fox decline, whether CDV is currently affecting gray foxes on the UCCA is unknown. Gray fox decline in southern Illinois may also be influenced by increasing competition from coyotes and bobcats (*Lynx rufus*), whose populations have increased in Illinois during the past 20 years (Woolf et al. 2000, Bluett 2005), or by habitat change to less preferred, older-aged forests.

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