Baylisascaris procyonis Roundworm Seroprevalence among Wildlife Rehabilitators, United States and Canada, 2012–2015

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Baylisascaris procyonis roundworms can cause potentially fatal neural larva migrans in many species, including humans. However, the clinical spectrum of baylisascariasis is not completely understood. We tested 347 asymptomatic adult wildlife rehabilitators for B. procyonis antibodies; 24 were positive, suggesting that subclinical baylisascariasis is occurring among this population.

Baylisascaris procyonis, a roundworm of raccoons (Procyon lotor) and rarely dogs, can cause fatal neural larva migrans or ocular larval migrans in numerous bird and mammal species, including humans (1). At least 54 human cases have been reported; however, cases may not have been recognized or reported, especially ocular cases, for which parasite identification is rare (1–3). Most diagnosed cases have been in children and were severe or fatal. Treatment is difficult after onset of neurologic symptoms, and neural larva migrans survivors may have permanent neurologic sequelae (1).

The clinical spectrum of baylisascariasis is not fully understood. Limited evidence suggests that subclinical disease may occur (1,2,4,5). Baylisascaris larvae were an incidental finding in the brain of an Alzheimer disease patient (4), and B. procyonis antibodies were reported in the parents of a child with baylisascariasis and in 4 of 13 adults in Germany with raccoon contact; assay specificity was not reported (2,5). The occurrence of subclinical infections with related ascarids (e.g., Toxocara species) is well established; up to 14% of persons in the United States are seropositive, although it is unknown how many have clinical manifestations (6).

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Conclusions
Wildlife rehabilitators may represent a population at risk for subclinical baylisascariasis due to frequent contact with raccoons and their feces, which may contain infectious larvated B. procyonis eggs. We assessed the occurrence of antibodies to B. procyonis in a sample of wildlife rehabilitators from the United States and Canada and administered a questionnaire on rehabilitation experience and procedures.

The Study
During 2012–2015, we collected serum samples from and administered questionnaires to wildlife rehabilitators (details in online Technical Appendix, http://wwwnc.cdc.gov/EID/article/22/12/16-0467-Techapp1.pdf). We tested serum samples for B. procyonis IgG using a recombinant B. procyonis repeat antigen 1 protein Western blot as described (7).

Of 347 enrolled persons (Table 1), 315 (91%) reported current involvement in rehabilitation activities. Participants had an average of 10.5 (median 7.0) years of animal rehabilitation experience. Most respondents (92%) reported having contact with raccoons at some point; 64% reported actively rehabsilating raccoons in the past year (Table 2).

Twenty-four (7%; 95% CI 4.7%–10.1%) participants tested positive for B. procyonis antibodies; adjusted prevalence, considering assay performance characteristics, was 5.7% (95% CI 2.2%–9.2%) (Figure 1). Of those 24 participants, 22 (92%) were actively rehabilitating wildlife; the other 2 reported occasional wildlife contact, including contact with raccoons, through veterinary clinic activities. All but 2 seropositive persons reported raccoon contact, and 2 practiced rehabilitation in the same household. Nineteen (79%) of the 24 seropositive persons resided in a US state or Canadian province classified as having very high or high B. procyonis prevalence among raccoons (Table 2).

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seropositive persons in this study (S.G.H. Sapp, data not shown). *B. procyonis* is transmitted by ingestion of larvalated eggs; thus, proper use of personal protective equipment (PPE), adherence to cleaning and disinfection protocols, and proper hand hygiene should minimize the risk associated with exposure to feces.

Transmission risk can also occur when handling animals whose fur has been contaminated by infective raccoon eggs, as shown for *Toxocara canis* parasites and dog fur (13). More investigations are needed regarding the occurrence of *B. procyonis* eggs on raccoon fur and transmission implications. Lapses in PPE use and hand hygiene may indicate a lack of caution or risk awareness for other pathogens.

Wildlife rehabilitators in areas with a very high prevalence of *B. procyonis* infection among raccoons may be at

**Table 1.** Demographic characteristics of participants in a study of *Baylisascaris procyonis* roundworm seroprevalence among wildlife rehabilitators, United States and Canada, 2012–2015

| Variable                                      | No. (%) respondents, N = 347 | No. (%) seropositive |
|-----------------------------------------------|-------------------------------|----------------------|
| **Sex**                                       |                               |                      |
| Female                                        | 299 (86.2)                    | 21 (7.0)             |
| Male                                          | 48 (13.8)                     | 3 (6.3)              |
| **Race**                                      |                               |                      |
| Asian                                         | 6 (1.7)                       | 0                    |
| American Indian or Alaska Native              | 1 (0.3)                       | 0                    |
| Black or African American                     | 1 (0.3)                       | 0                    |
| White                                         | 327 (94.2)                    | 23 (7.0)             |
| Other                                         | 2 (0.6)                       | 0                    |
| Multiracial                                   | 10 (2.9)                      | 1 (10.0)             |
| **Ethnicity**                                 |                               |                      |
| Hispanic                                      | 5 (1.4)                       | 0                    |
| Not Hispanic                                  | 315 (90.8)                    | 19 (6.0)             |
| Declined to state                             | 27 (7.8)                      | 5 (18.5)             |
| **Geographic region of rehabilitation activities** |                               |                      |
| Northeastern                                  | 106 (30.5)                    | 4 (3.8)              |
| Midwestern                                    | 74 (21.3)                     | 8 (10.8)             |
| Central                                       | 23 (6.6)                      | 0                    |
| Southern                                      | 110 (31.7)                    | 5 (4.5)              |
| Western                                       | 34 (9.8)                      | 7 (20.6)             |

*Geographic regions are defined as follows: Northeastern: Delaware, Maryland, Massachusetts, Maine, New Jersey, New York, Pennsylvania, and Virginia, USA, and Quebec Province, Canada; Midwestern: Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin, USA, and Manitoba and Ontario Provinces, Canada; Central: Arizona, Colorado, Kansas, Oklahoma, and Texas, and Alberta, Province, Canada; Southern: Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee, USA; and Western: California, Oregon, and Washington, USA, and British Columbia Province, Canada.

**Table 2.** Rehabilitation work characteristics and experience of wildlife rehabilitators enrolled in a study of *Baylisascaris procyonis* roundworm seroprevalence among wildlife rehabilitators, United States and Canada, 2012–2015

| Variable                                      | No. (%) respondents | No. (%) seropositive |
|-----------------------------------------------|---------------------|----------------------|
| **Involvement in wildlife rehabilitation**    |                     |                      |
| Currently involved                            | 314 (90.5)          | 22 (7.0)             |
| Formerly involved                             | 19 (5.5)            | 0 (0)                |
| Other raccoon contact                         | 14 (4.0)            | 2 (14.3)             |
| **Rehabilitation experience**                 |                     |                      |
| <2.0                                          | 48 (14.9)           | 2 (4.2)              |
| 2.0–4.9                                       | 96 (28.9)           | 7 (7.3)              |
| 5.0–9.9                                       | 67 (20.8)           | 1 (1.5)              |
| 10.0–20.0                                     | 64 (19.9)           | 8 (12.5)             |
| >20.0                                         | 47 (14.8)           | 3 (6.4)              |
| **Raccoon rehabilitation**                    |                     |                      |
| Rehabilitated raccoons in past year           | 222 (64.0)          | 16 (7.2)             |
| Rehabilitated raccoons (prior to past year)   | 41 (11.8)           | 2 (4.9)              |
| Never rehabilitated raccoons                  | 84 (24.2)           | 6 (7.1)              |
| **General raccoon contact**                   |                     |                      |
| Had contact in past year                      | 266 (80.9)          | 19 (7.1)             |
| Had contact ever                              | 36 (10.9)           | 3 (8.3)              |
| Never had contact                             | 27 (8.2)            | 2 (7.4)              |
| **B. procyonis prevalence among raccoons in state or province of residence** |   |                      |
| Very high (>50%)                              | 79 (22.8)           | 14 (21.5)            |
| High (25%–49%)                                | 127 (36.6)          | 5 (4.6)              |
| Medium (10%–24%)                              | 92 (26.5)           | 4 (4.3)              |
| Low (<10%), sporadic, or unknown              | 49 (14.1)           | 1 (2.1)              |

*Prevalence levels in the various US states and Canadian Provinces are shown in the Figure.*
elevated risk for subclinical infections. Only 1 B. procyonis–seropositive wildlife rehabilitator resided in a state with low or sporadic prevalence (Alabama); however, that person lived in an area adjacent to a Florida county where the prevalence of B. procyonis infection in raccoons was 9% (M.J. Yabsley, unpub. data) (Figure). Data on B. procyonis prevalence in raccoons are outdated or missing for many US states and Canadian provinces. Furthermore, raccoon infections with B. procyonis are now being reported in areas where the parasite has historically been absent (e.g., the southeastern United States); thus, awareness of this parasite may be limited in those areas (8). More surveillance is needed on the distribution and prevalence of B. procyonis infection among raccoons to assess the association with exposure risks among humans.

Rehabilitation facilities housing raccoons can easily be contaminated with B. procyonis because high numbers of environmentally hardy eggs are passed by infected raccoons (1). Our finding of 2 seropositive raccoon rehabilitators operating out of the same household highlights the importance of infection-control practices. Facility contamination can be prevented by treating raccoons for parasites at intake and at regular intervals thereafter and by sterilizing enclosures using heat-based methods (14). Several anthelmintic drugs can kill adult B. procyonis, but raccoons with high worm burdens may require retreatment (15). Raccoon enclosures and housing should be constructed with materials that are easy to clean and disinfect using heat-based methods.

We tested persons with wildlife (mostly raccoon) contact, so our results describe an exposure risk that likely does not apply to the general public. However, persons in other occupations or activities (e.g., zoo keepers, wildlife biologists) may have similar exposure risks. Domestic dogs, other wildlife species (e.g., skunks, bears), and some exotic pets (e.g., kinkajous) are hosts for Baylisascaris spp. parasites and may present exposure risks (1). Although the assay we used has a sensitivity of 88% and specificity of 98%, it is time-consuming and not ideal for large-scale epidemiologic studies (7). Development of a high-quality ELISA would facilitate larger epidemiologic studies on the risk for baylisascariasis among different demographic groups and help further elucidate specific risk factors.

Our study had several limitations. We used a convenience sampling, so not all regions were well represented, and sample size was relatively small. Our prevalence estimate may be inflated because positive predictive value is reduced in populations in which prevalence is low. The assay we used is the reference standard for clinical diagnosis but has not been used to test asymptomatic persons. Although an association between human B. procyonis exposure and seroconversion has not been established, asymptomatic seropositive infections would be expected because clinical disease probably occurs only when larvae cause damage to neural tissue or eyes (1). An estimated 95% of migrating larvae enter muscle or visceral organs, where they may stimulate an immune response but not cause clinical disease (1). In support of this presumption, the assay we used indicated that experimental infections of Peromyscus rodents with low numbers of B. procyonis parasites resulted in no
clinical disease with seroconversion (S.G.H. Sapp, unpub. data). Last, participants were primarily licensed rehabilitators who belonged to professional organizations, and many practiced rehabilitation in large, dedicated facilities. Such facilities generally have safety protocols that may encourage more consistent PPE use and awareness of zoonotic diseases, so the risk for infection may be greater in smaller or informal rehabilitation settings.

To prevent infection with *B. procyonis* parasites, proper PPE and hand hygiene practices should be used consistently when handling animals and when contact with animal feces might occur. Education materials and outreach efforts discussing PPE use, infection control, and zoonotic pathogens should be directed to wildlife rehabilitators to increase awareness of potential occupational risks.

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Ms. Sapp is a doctoral student in the Department of Infectious Diseases at the University of Georgia. Her research interests include the epidemiology of parasitic zoonoses and other emerging zoonotic diseases.

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