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Cerebral Larva Migrans Caused by *Baylisascaris* spp. in a Free-ranging North American Porcupine (*Erethizon dorsatum*)

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ABSTRACT: A free-ranging North American porcupine (*Erethizon dorsatum*) from Utah, US, exhibited neurologic symptoms and was submitted for necropsy. Histologic examination of the brain revealed severe encephalitis with an intralesional nematode larva consistent with *Baylisascaris* spp. Neurologic larva migrans had not been reported in free-ranging porcupines, or from wildlife in Utah.

Baylisascaris spp. in raccoons (*Procyon lotor*; *Baylisascaris procyonis*), skunks (*Mephitis mephitis*; *Baylisascaris columnaris*), and badgers (*Taxidea taxus*; *Baylisascaris melis*) can cause visceral larva migrans in a wide range of aberrant or intermediate hosts (Kazacos 2001). Neurologic larva migrans due to *B. procyonis* has been reported in >100 species of mammals and birds, including humans (Kazacos et al. 2013; Page 2013).

We describe severe neurologic disease caused by cerebral larva migrans of *Baylisascaris* spp. in a juvenile, female, free-ranging North American porcupine (*Erethizon dorsatum*) from northern Utah, US. Porcupines are large, solitary rodents found from southern Canada to northern Mexico (Linzey et al. 2008). The animals commonly inhabit trees and feed on leaves, bark, twigs, and grass (Linzey et al. 2008). Due to their elusive nature, there is little information on diseases affecting free-ranging porcupines. Neurologic larva migrans has been reported in captive North American porcupines in Michigan, Pennsylvania, and Manitoba (e.g., Thompson et al. 2008), but not in free-ranging porcupines, and clinical neurologic larva migrans due to *Baylisascaris* spp. has, to our knowledge, not been reported in Utah wildlife.

In August 2015, the Utah Division of Wildlife Resources (UDWR) was notified of an abnormally behaving porcupine at a home near Morgan, Utah. The porcupine was ataxic and exhibited compulsory circling in one direction (see Supplementary Material for video). The homeowner reported seeing this behavior for 2 d. Due to the severity and duration of clinical signs, the porcupine was humanely euthanized by UDWR personnel and submitted to the Utah Veterinary Diagnostic Laboratory in Logan, Utah, for necropsy. Tissue samples were fixed in 10% buffered formalin, processed, and stained with H&E using standard procedures. Intestinal parasites and eggs were examined morphologically, and nematodes identified by sequencing the 18s rRNA gene amplicon (Ryss et al. 2013). *Baylisascaris* spp. identification by PCR was attempted following Dangoudoubiyam et al. (2009).

The porcupine was in good body condition with adequate fat stores and musculature. Subdural hemorrhage was observed around the ventral portion of the brainstem and surrounding the cerebellum and cranial 3 cm of the spinal cord. The stomach and intestines contained digesta and formed, brown fecal pellets. The ceca contained a moderate number of 1–3-cm-long, 1–2-mm-diameter slender, white, nematodes and few 5–10-mm cestodes with proglottids 3 mm by 1–2 mm thick. Nematode eggs were morphologically consistent with pinworms (*Oxyuridae*), and the 18s rRNA gene amplicon sequence was >99% homologous to *Wellcomia* spp. The cestode species was not identified.

Histology revealed a severe, multifocal to coalescing, eosinophilic, neutrophilic, and histiocytic encephalitis in all sections of the

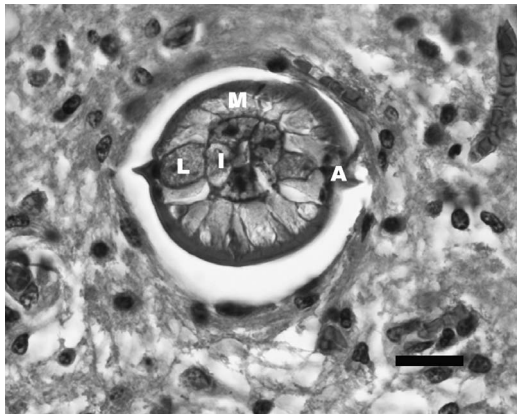

FIGURE 1. Cross-section of a *Baylisascaris* spp. larva in the cerebrum of a free-ranging, female, juvenile, American porcupine (*Erethizon dorsatum*) from Utah, USA, August 2015. A=lateral alae; I=intestine; L=lateral cords; M=coelomyarian/polymyarian musculature. 600×. Bar=20 μm.

cerebrum consistent with parasite migration tracts. One nematode of 50–60 μm diameter with morphology consistent with *Baylisascaris* spp. was detected in the cerebrum (Fig. 1) (Bowman 1987). The nematode had a thick cuticle, lateral chords, lateral alae, coelomyarian-polymyarian musculature, a pseudocoelom, and an intestine with large uninucleate cells. The meninges were multifocally expanded by hemorrhage. Although the parasite morphology was characteristic of *Baylisascaris* spp., confirmation of the nematode species by PCR was unsuccessful, likely due to the low amount of DNA present in paraffin-embedded formalin-fixed tissue sections of a single parasite larva.

Other observations included a mild, chronic, lymphoplasmacytic esophagitis; acute pancreatic hemorrhage; and diffuse follicular atresia of the ovaries. No significant lesions were detected in the lung, liver, kidney, spleen, lymph node, adrenal gland, salivary gland, thyroid gland, thymus, stomach, small intestine, skin, trachea, skeletal muscle, cardiac muscle, uterus, or eyes.

Clinical and neurologic signs, encephalitis, and detection of a nematode larva in the cerebrum were consistent with neurologic larva migrans in mammals due to *Baylisascaris* spp. infection (Bowman 1987; Kazacos 2001). The meningeal hemorrhages were most likely caused by secondary trauma, possibly from a fall. Since the porcupine was in good body condition with ingesta in the intestines, the clinical symptoms were likely acute. The progression of disease due to *Baylisascaris* spp. infection in aberrant hosts depends on the number of eggs ingested and tissue migration paths of the larvae. In mild infections without migration into the nervous system, symptoms can be subclinical, but in heavy infections with neurologic involvement, animals can develop fatal disease in 3 d (Kazacos 2001). Rodents, rabbits, primates, and birds are especially susceptible to neural larva migrans (Kazacos 2001). Clinical differential diagnoses considered included toxoplasmosis, head trauma, inner ear pathology, and neoplasia, all of which can cause neurologic disease and circling. The other detected lesions were considered incidental and not associated with the clinical behavior. Pinworms (*Oxyruridae*) and cestodes have been reported in North American porcupines (Jellison 1933). *Wellcomia evaginata* and *Wellcomia evoluta* are common pinworms of rodents and are to our knowledge the only *Wellcomia* species described in porcupines (Jellison 1933; Olsen and Tolman 1951).

Closely related nematodes of skunks and badgers, *B. columnaris* and *B. melis*, respectively, are rare causes of clinical larva migrans in animals (Kazacos 2001), and *B. procyonis* is the most likely cause of neurologic larva migrans in this porcupine. Unfortunately an adequate amount of DNA for molecular analysis to differentiate *B. procyonis* from *B. columnaris* and *B. melis* could not be obtained. *Baylisascaris procyonis* is most common in raccoons from the Midwest and the Pacific coast, with varying prevalences in raccoon feces (Kazacos 2001), including 45% in Wyoming (Pipas et al. 2014), 30–60% in Ohio (Ingle et al. 2014), 58.5% in eastern Colorado (Chavez et al. 2012), and 65% in rural and 41% in urban raccoon populations in Indiana, Kansas, Michigan, Minnesota, Missouri, and Wisconsin (Pipas et al. 2014). The prevalence may reach 90% in young

raccoons (Kazacos and Boyce 1989). Raccoons are widespread in Utah, and *B. procyonis* occurs around Salt Lake City (B. Zscheile pers. comm.), but there are no published reports on prevalences in raccoon latrines in Utah and raccoon population sizes are unknown. Due to public health concerns associated with *B. procyonis*, a better understanding of its prevalence and distribution in Utah raccoons is needed.

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SUPPLEMENTARY MATERIAL

Supplementary material for this article is online at http://dx.doi.org/10.7589/2015-11-316.

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