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Original article

Prevalence of *Baylisascaris* in domestic dog coprological examinations in the United States, 2013–2016

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ABSTRACT

Dogs are alternative definitive hosts for *Baylisascaris procyonis*, the raccoon roundworm, but broad-scale prevalence and distribution of canine cases is not known. Based on a large dataset from nationwide reference laboratories, *Baylisascaris* spp. eggs were detected in 504/9,487,672 (0.005%) canine fecal samples. While many of the positive dog samples originated in areas of known high *B. procyonis* prevalence in raccoons, positives were also detected in 9 new states. Young dogs, large breeds, and certain regions had higher prevalence. Although overall prevalence was low, and some infections may be spurious, these results demonstrate that dogs may shed *Baylisascaris* spp. into domestic environments. Routine parasitic testing, rigorous preventive use, and restrictions on coprophagy should be encouraged to reduce risk of human or animal exposure to infectious eggs.

1. Introduction

Baylisascaris procyonis, an ascarid roundworm of raccoons (*Procyon lotor*), can cause fatal neural larva migrans (NLM) or ocular larval migrans (OLM) in numerous bird and mammal species, including humans (Kazacos, 2016). At least 54 human cases have been reported; however, additional cases may not have been recognized or reported especially OLM cases for which parasite identification is rare (Cortez et al., 2010; Cunningham et al., 1994; Kazacos, 2016). The majority of fatal neurologic cases have occurred in children who likely ingested raccoon feces. The clinical presentation of NLM is severe and typically involves rapid degeneration to eosinophilic meningitis, paralysis, seizures, and coma. Furthermore, exposure to this parasite may be more common than previously anticipated and result in subclinical infections, as antibodies have been found in healthy adults (Sapp et al., 2016). Treatment is difficult after onset of neurologic symptoms and often results in permanent neurologic sequelae (Kazacos, 2016).

Alternative definitive hosts of *B. procyonis* have been reported including non-raccoon procyonids (e.g., olingo, coati) and domestic dogs (Kazacos, 2016; Overstreet, 1970). Domestic dog infections are a concern because of their close association with people and indiscriminate defecation habits. However, while some case reports and smaller studies exist, broader-scale systematic surveillance for canine baylisascariasis is lacking. Patent *B. procyonis* infections have been reported from ~47 dogs from Iowa, Indiana, Michigan, and Missouri (USA), 14 dogs from Quebec (Canada), and a low prevalence (0.36%) was detected on Prince Edward Island (PEI) (Canada), (Conboy et al., 2010; Kazacos, 2016). Experimental studies have confirmed that dogs are susceptible by exposure to eggs or larvae in non-definitive (paratenic) hosts (Bowman et al., 2005; Miyashita, 1993). Also, there have been several canine cases of NLM caused by *B. procyonis* so infection can result in disease, primarily in puppies (Kazacos, 2016; Rudmann et al., 1996; Thomas, 1988). To better understand the ecology of this zoonotic parasite, we determined the prevalence of *Baylisascaris* spp. ova in fecal samples from domestic dogs from the United States.

2. The study

Results of fecal centrifugal flotation results for dog fecal samples (~1 g) submitted to IDEXX Reference Laboratories from 2013 to 2016 were reviewed. For dogs that were positive for *Baylisascaris* spp. ova, the following information was extracted from the record: date of testing, zip code of customer, breed and age (in months) of dog, and other parasites diagnosed in that individual dog. Not all information was available for all positive dogs. In addition, a semi-quantification of egg numbers was determined rare = 1–2 eggs, few (3 − 10), moderate (11 − 30) and many (> 30) for *Baylisascaris* spp. and other ascarids (if present).

A total of 504/9,487,672 (0.005%) dog fecal samples were positive for *Baylisascaris* spp. ova. These positive fecal samples originated from

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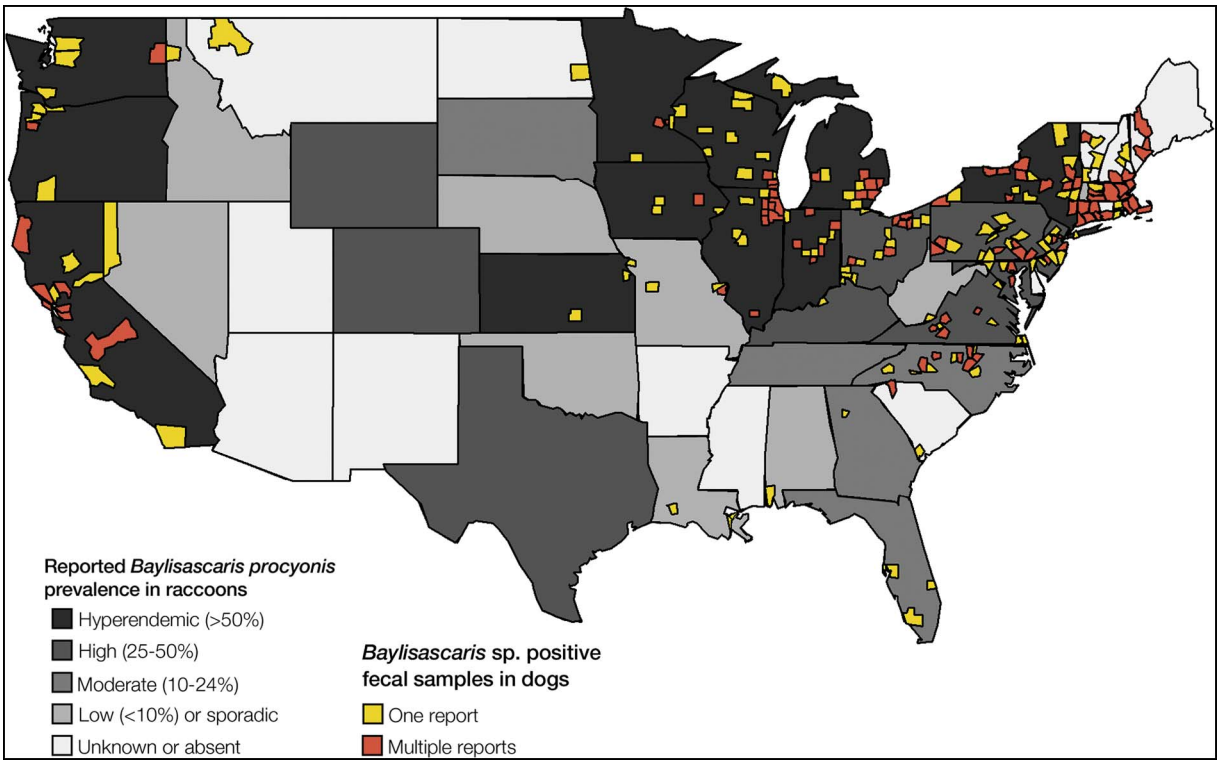

Fig. 1. County-level locations of dogs with *Baylisascaris* spp. ova-positive fecal examinations. Shading of states indicates the prevalence of *B. procyonis* in raccoons based on published reports. Prevalence estimates derived from Kazacos, 2016.

Table 1
Prevalence of *Baylisascaris* spp. ova in dogs from regions of the United States, 2013–2016.

Region[#]	No. negative	No. positive	Prevalence (%)	OR	95% CI	p value[b]
Northeast	3,444,053	244	0.00708	Ref.	–	–
South	1,124,464	36	0.00320	0.452	(0.318–0.641)	< 0.0001[a]
Midwest	2,239,605	176	0.00786	1.109	(0.913–1.346)	0.2950
Central	1,018,609	4	0.00039	0.055	(0.021–0.149)	< 0.0001[a]
West	1,596,950	43	0.00269	0.380	(0.275–0.525)	< 0.0001[a]
Total	9,423,681	503**	0.00531			

Regional categories are as follows: Northeast: Maine, New Hampshire, Massachusetts, Vermont, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Delaware, West Virginia, Virginia, Washington DC; South: Florida, Georgia, South Carolina, North Carolina, Tennessee, Alabama, Mississippi, Louisiana, Arkansas; Midwest: Ohio, Kentucky, Indiana, Michigan, Illinois, Wisconsin, Minnesota, Iowa, Missouri; Central: Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Montana, Wyoming, Colorado, New Mexico, Arizona, Utah; West: Washington, Oregon, Idaho, California, Nevada. Note: Alaska and Hawaii were excluded from regional analysis.

[a] significant *p*-value at alpha = 0.05.

[b] Fisher's Exact Test.

** Alaska and Hawaii excluded from regional analysis.

dogs in 35 states and Washington D.C (Fig. 1). Prevalence was significantly lower in the southern, central, and western regions compared to the northeastern and Midwestern regions (Table 1, Appendix Table). Of positive dogs with a predominant breed indicated, 70% were large (> 50 lbs) breeds with most being sporting group breeds (41%), followed by working (20%) and herding (15%) breeds (Table 2). Age of positive dogs ranged from 1 month to 15 years (mean 39 months; median 12 months); 35% were ≤ 6 months of age (Table 2). Interestingly, 48 positive dogs (10% of positive dogs) were ≤ 2 months old (Table 2). Each semi-quantitative category was similarly represented (Table 2).

For the 498 dogs positive for *Baylisascaris* that had full fecal exam results available, numerous co-infecting parasites were noted including *Toxocara* spp. (61 dogs, 12%), another zoonotic ascarid, and other common dog parasites (e.g., *Giardia* spp., *Cystoisospora* spp., *Dipylidium*, *Strongyloides* spp., *Trichuris* spp., *Uncinaria* spp., *Ancylostoma* spp., capillarids). Importantly, spurious parasites of dogs were also detected, suggesting coprophagy: *Eimeria* spp. (75 dogs; 15%), common parasites of numerous hosts including raccoons and ruminants; *Moniezia* spp. (6 dogs; 1.2%), ruminant cestodes; and *Anoplocephala* spp. (1 dog; < 0.01%), equine cestodes. It is also possible that some other parasites detected (e.g., hookworms, capillarids) were spurious parasites; however, morphologically they were similar to canine-infecting species.

3. Discussion

We detected *Baylisascaris* ova in the feces of domestic dogs across a wide geographic range within the US. The prevalence was low, but confirms that dogs are shedding *Baylisascaris* ova into the domestic environment, which may put people or other animals at risk of exposure. These results highlight the importance of testing, treatment, and preventive use. The Companion Animal Parasite Council (CAPC) recommends testing dogs for intestinal parasites at least four times during their first year and then at least two times per year afterwards (www.capcvet.org). Puppies should be given anthelmintics, many of which are efficacious for treating intestinal *Baylisascaris* infections, and