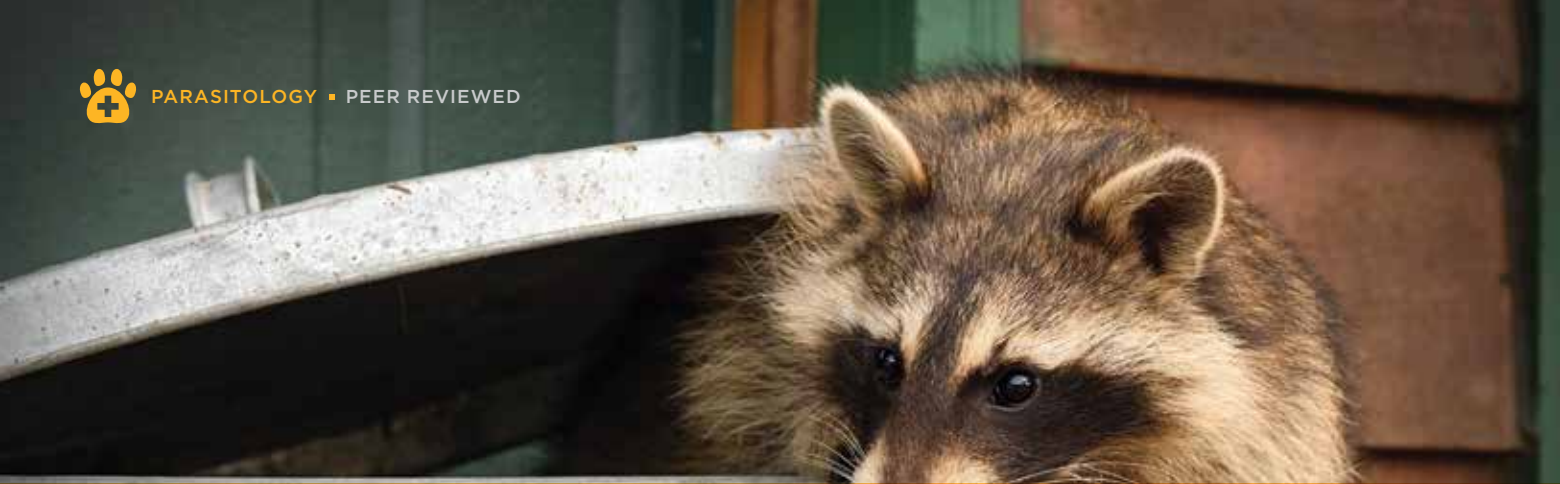

PARASITOLOGY

Echinococcus multilocularis and *Baylisascaris procyonis*: Emerging One Health Importance

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Gastrointestinal (GI) parasites, such as tapeworms and roundworms, are frequently detected in dogs and cats by veterinary teams in day-to-day small animal practice. However, the disease risk to dogs and cats and zoonotic risk to owners vary significantly depending on the species of tapeworm or roundworm identified. For tapeworms like *Echinococcus* species and for the raccoon roundworm, *Baylisascaris procyonis*, fecal detection in a dog or cat has significance beyond their typically subclinical effects on the pet's health status. Detection of these parasites carries significant public health (zoonotic) concern, and prompt, clear communication of disease risk, as well as counseling owners to communicate with human healthcare providers, is necessary.

Recent veterinary, human, and wildlife research has drawn attention to the emergence and range expansion of *Echinococcus multilocularis*.[1-13] These studies, as well as case reports on *E multilocularis* infections and new data on *B procyonis*, have One Health implications. Detection of *E multilocularis* through routine veterinary fecal surveillance has also raised antimicrobial use questions associated with multidrug parasite protection products, warranting consideration of antimicrobial (antiparasitic) and diagnostic stewardship.

ECHINOCOCCUS MULTILOCULARIS

Echinococcus species are tapeworms of human, veterinary, and environmental concern in the United States and Canada.[1-13] These tapeworms have complex

Abstract

Reports of the tapeworm *Echinococcus multilocularis* are increasing in the United States and Canada. Although parasite risk appeared to be confined to focal regions of Canada, infection is now being detected in dogs, humans, and wildlife in regions of the United States. Similarly, increased fecal detection of the raccoon roundworm *Baylisascaris procyonis* has enabled broader description of parasite geographic range. These parasites are emerging One Health concerns (animal, human, and environment), and fecal detection in dogs and cats requires immediate education of pet owners and, in some locations, reporting to public health authorities.

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Take-Home Points

- Detection of *Echinococcus multilocularis* is increasing in domestic dogs and cats, humans, and wildlife in the United States and Canada.
- Dogs and humans infected with *E multilocularis* can develop alveolar echinococcosis, which is often fatal.
- Most *E multilocularis* infections in dogs are detected through molecular fecal examination but not conventional fecal flotation tests. Dogs may or may not have clinical signs of disease.
- Increased fecal detection of *Baylisascaris procyonis* has provided a broader description of parasite geographic range and clinical features of infection.
- *B procyonis* infection is typically subclinical in dogs and cats; however, severe neurologic disease has been reported in humans and dogs.
- Both *E multilocularis* and *B procyonis* are One Health concerns.
- Dogs and cats serve as sentinels of disease risk for humans.
- Fecal detection of *E multilocularis* or *B procyonis* in dogs or cats requires immediate communication with pet owners.

lifecycles, with domestic dogs and wild canids (coyotes, foxes, wolves) serving as definitive hosts for *E multilocularis* and *Echinococcus granulosus* sensu lato. Cystic echinococcosis can occur in humans, cervids, and livestock after infection with *E granulosus* sensu lato. Humans, dogs, and rodents infected with *E multilocularis* are at risk of alveolar echinococcosis.

Infection and Disease

Wild and domestic dogs can become infected with *E multilocularis* by ingesting a rodent containing a metacestode (larval stage).[1-7] Dogs can also infect themselves through the oral route, typically through grooming. Development into the adult stage of the tapeworm occurs within the small intestine, and eggs are shed in the feces.[1-6] These eggs are immediately infective and environmentally resistant. Recent studies have reported GI signs (diarrhea) in dogs with enteric *E multilocularis*; however, infections are thought to be typically subclinical in dogs.[1,2,7] A recent report of PCR detection of enteric *E multilocularis* in a cat described GI signs (diarrhea) and resolution of *E multilocularis* detection with praziquantel treatment.[13]

Dogs—and humans—can also act as "dead-end" hosts for *E multilocularis* after consumption of eggs from contaminated water or food or the environment. In these cases, alveolar echinococcosis, characterized by tumor-like lesions (alveolar hydatid cysts), can develop. Alveolar echinococcosis is typically diagnosed when abdominal imaging shows these cysts within the liver, although they can form in other body locations as well.[1-9] Unfortunately, alveolar echinococcosis is often fatal in both dogs and humans if undiagnosed.[1-9]

While detection of *E multilocularis* in dogs and humans remains rare, reports are increasing, particularly in regions such as Alberta, Canada, where a relatively high prevalence has been detected in wild dogs.[1,2,5,11] One U.S. study in coyotes identified *E multilocularis* in new areas, including Illinois, Indiana, Kansas, and Missouri.[12] Additionally, this study reported detection as ranging between 16% and 47%, indicating the potential for regional "spillover" into pet dogs, cats, and humans.[12] Another recent publication reported fecal quantitative PCR (qPCR) results, management, preventive care status, and outcome in 26 pet dogs from Canada and the United States.[1] In this research, *E multilocularis* was detected in dogs from novel regions of the United States, including Colorado, Idaho, Illinois, Kansas, Montana, Nevada, Oregon, Washington, and Wyoming.[1]

Zoonotic Risk

Zoonotic infection with *E multilocularis* arises from human consumption of eggs shed in dog feces.[1-9]

Recent studies have reported GI signs (diarrhea) in dogs with enteric *E multilocularis*; however, infections are thought to be typically subclinical in dogs.[1,2,7]

Routine fecal screening in dogs, and potentially in cats, as advised by parasite guidelines from the CAPC and Canadian Parasitology Expert Panel (CPEP), can inform the risk of human *E multilocularis* infection in known endemic regions and alert to emerging risks.[14,15]

In veterinary medicine, fecal centrifugal flotation combined with microscopy is often used for fecal screening. However, this test, even when performed by reference laboratories, has low sensitivity for *Echinococcus* species. Further, eggs of *Taenia* species cannot be microscopically differentiated from those of *Echinococcus* species.[1-9] The CAPC and CPEP advise use of fecal qPCR testing for dogs living in (or traveling to) *E multilocularis* endemic regions, for dogs in regions considered high risk, and whenever taeniid eggs are found in dog feces to alert to both dog and human risk.[14,15]

In some regions, human health guidelines advise a risk assessment be performed for humans in contact with a dog shedding *E multilocularis* eggs.[16]

Few reports of *E multilocularis* detection in cats are available, aside from morphologic descriptions of worms observed in necropsy findings in Saskatchewan and North Dakota from the 1970s.[17] *E multilocularis* prevalence in cats in the United States and Canada is currently unknown. In endemic regions in Europe, where prevalence rates in foxes are 35% (France), 48.2% (Poland), and 53% (Switzerland), detection of *E multilocularis* in cats has been between 7% and 9.3%, 6%, and < 1%, respectively.[18-20] A recently published report of *E multilocularis* detection in a cat through fecal qPCR testing provides much-needed outcome information on resolution of detection after praziquantel treatment and serves to highlight the infection risk for cats with outdoor access or hunting behaviors as well as a reminder of the zoonotic risk potential in felines.[13]

Public Health, Antimicrobial Use, and Stewardship Considerations

If a dog or cat tests positive for *E multilocularis,* the veterinary team should immediately inform the owners of zoonotic risk potential and advise them to promptly connect with their healthcare provider to decide on next diagnostic or medical decisions. In some U.S. states and Canadian provinces, detection is also reportable to public health authorities. Other dogs, and potentially cats, in the household of an infected animal should also be tested and treated, along with the affected pet, with praziquantel.[1,14-16]

The commercial availability of multidrug parasite preventives has raised questions surrounding antimicrobial (antiparasitic) and diagnostic stewardship. While tapeworm resistance is an evolving concern for *Dipylidium caninum*, it is not known if this will be a concern for *Echinococcus* species. As such, recommendations surrounding screening and prevention (i.e., test and then treat, treat every 3 months, or treat monthly) are not yet clear, and further research is indicated.

BAYLISASCARIS PROCYONIS

B procyonis is highly prevalent in raccoons, and humans and dogs may become infected after ingestion of eggs. In the United States and Canada, the parasite is typically found in dogs incidentally during fecal screening and may reflect either transient egg shedding (due to coprophagy) or true enteric infection.[20,21] GI infection with *B procyonis* is not thought to cause

clinical disease in dogs or cats. However, rare case reports of neural larva migrans have been described in infected dogs, and neurologic disease, in some cases fatal, has been reported in humans.[22,23]

Veterinary clinics that use fecal flotation and microscopy as the sole method of screening in dogs and cats are at risk of misidentifying *B procyonis* as *Toxocara canis* or *Toxocara cati*. These two roundworms can be differentiated through fecal qPCR testing or by very careful microscopic review (e.g., slight size and color difference in eggs and outer shell).[15,20,21,24]

Zoonotic Risk

High human *B procyonis* seroprevalence was described in a study from California, indicating exposure risk for people and dogs from common environmental sources (e.g., raccoon latrines).[23] Recent fecal qPCR surveillance in dogs and cats has detected *B procyonis* in multiple regions of the United States and Canada.[21]

B procyonis eggs observed on microscopy in dogs or cats living in or travelling from endemic regions must be promptly differentiated from *T canis* and *T cati* eggs. Additionally, animals infected with *B procyonis* should be immediately treated with routine dewormers due to zoonotic risk, and testing other household pets should be considered.[15,20,23,24]

As with *E multilocularis*, fecal detection of raccoon roundworm in a dog or cat should be immediately communicated to the owners so they may promptly contact their healthcare provider. Owners should be made aware of the risk for zoonotic infectious disease and counseled to contact their healthcare provider for potential consideration of prophylactic therapy.[15,20-25] They should also be educated about how to reduce exposure to raccoons (e.g., removal of raccoon latrines) and to promptly dispose of dog and cat feces.

SUMMARY

Routine veterinary fecal screening in dogs and cats will be a critical component of ongoing One Health surveillance for emergence of *E multilocularis,* as well as for raising awareness of dog and human disease risk associated with both *B procyonis* and *Echinococcus* species. Further interdisciplinary efforts and collaboration between wildlife, human, and veterinary researchers is indicated to assist in provision of information that benefits pet and human health. TVP

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