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PARKS, PETS, & PARASITES: CONTROLLING CANINE INTESTINAL HELMINTHS

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Dogs have long been recognized as a source of emotional support and valued members of our communities, but the way we interact with dogs in society has changed dramatically in just a few decades.

Pet dogs are now welcome at many hotels, outdoor restaurants, and even some retail stores, and cities across the United States have built recreational parks wholly dedicated to the play of dogs and the owners that care for them. Many owners secure dog day care so their pets are not left at home alone while they are at work, and routine, standing grooming appointments are commonplace. Current estimates indicate that more than 80% of dog owners permit their dog in the bedroom, over 75% allow the dog to lick their face, and 21% to 56% sleep with the dog in the bed.[1,2] While dogs and owners usually benefit from the enriched social interactions these advances in the lifestyle of the modern dog have allowed, this close relationship creates some challenges.

Shared premises like dog parks, dog day cares, kennels, and pet-friendly public spaces bring dogs of many different backgrounds together, potentially facilitating transmission of parasites and other infections. Estimates from regional studies in Europe and the United States suggest that intestinal parasites, many of which are zoonotic, are present in 7.0% to 50.2% of fecal samples from dogs frequenting dog parks.[3-5] However, most dog parks do not require any documentation of care prior to using the area, preferring a "use at your own risk" approach. The high prevalence of parasitism seen in the few studies available suggests that dogs visiting dog parks could be at increased risk of infection from exposure to a contaminated environment.

Most common canine intestinal helminths can be readily controlled with use of monthly products. However, adherence rates and use practices appear to vary widely among dog owners. An estimated 40% to 52% of dogs that visit the veterinarian remain completely unprotected from internal parasites, including heartworm and intestinal parasites, and only a minority of dogs receive the recommended 12 months of protection each year.[6,7] Moreover, most common companion animal internal parasite preventives have been in use in veterinary medicine for decades, and some populations of parasites are now resistant.[8,9] The dual challenges of increased infection opportunities and waning efficacy of some control products makes understanding and effectively controlling canine intestinal parasites more important than ever. In this review, we describe strategies to manage the veterinary and public health risks posed by canine intestinal helminths given the evolving role of dogs in society.

Most nematode infections are readily identified by fecal testing although fecal flotation alone can miss 15% to more than 40% of infections in adult dogs.[10]

Important Intestinal Helminths of Dogs

Cestodes

Although common, infection with tapeworms is difficult to identify by fecal examination because eggs are only intermittently present, heavy, and not readily recovered for microscopic identification. Thus, if dogs are not shedding large numbers of proglottids, cestodes are often overlooked; antigen tests for tapeworms could address this diagnostic limitation but are not yet commercially available. *Dipylidium caninum,* the flea tapeworm (***Figure 1***), is usually transmitted by ingestion of an infected cat flea, *Ctenocephalides felis*. In areas of the United States where fleas are common, recent data indicates that almost 50% of dogs may be infected, and we now know dogs and cats are infected with distinct species of *D caninum.*[10,11] Gravid proglottids are passed in the feces of an infected

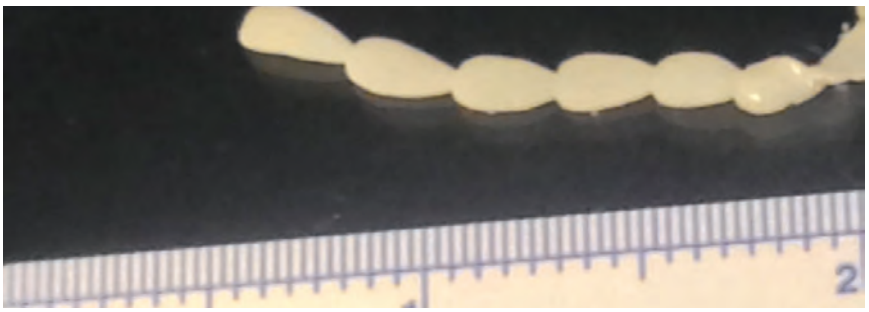

FIGURE 1 Adult *Dipylidium caninum*, the flea tapeworm, live in the small intestine of dogs. While not considered to be a significant cause of clinical disease, motile proglottids may be found in the feces or in areas where the dog has recently rested, negatively impacting the human–animal bond.
Figures 1 & 2 courtesy the National Center for Veterinary Parasitology (ncvetp.org)

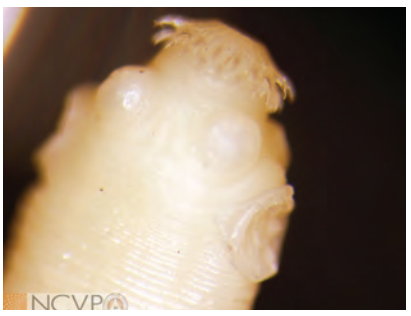

FIGURE 2 The scolex of *Taenia* spp has four suckers and a stout rostellum with prominent hooks to anchor the worms to the intestinal mucosa.

pet and the eggs are ingested by larval fleas, where the cestodes develop to the infective cysticercoid stage as the flea develops to an adult. *Taenia pisiformis* (***Figure 2***), *T hydatigena*, and a few other *Taenia* spp are transmitted to dogs when they ingest immature stages in herbivore intermediate hosts. Recent studies estimate that 5% to 10% of dogs in the central United States are infected with *Taenia* spp although prevalence has reportedly been greater—as much as 25%—in previous surveys.[10] When found on fecal examination, the brown, hexacanth eggs of *Taenia* spp are morphologically identical to those of *Echinococcus* spp, a less commonly reported cestode of pets. In recent years, *Echinococcus* spp have become increasingly recognized in some areas of Canada.[12] Although apparently rare in the United States, adult *Echinococcus* spp are very small (***Figure 3***) and may be overlooked. *Echinococcus* spp infections in pets can have severe implications for veterinary and public health *(see* **Health Risk Posed to Dogs & Humans**). Flea control and preventing predation are key to avoiding reinfection with cestodes.

Nematodes

Most nematode infections are readily identified by fecal testing although fecal flotation alone can miss 15% to more than 40% of infections in adult dogs.[10] *Ancylostoma caninum*, the canine hookworm (***Figure 4A***), is the most commonly reported gastrointestinal nematode of dogs and infects as many as 46.4% of dogs in animal shelters although prevalence in pet dogs, as estimated by detection of eggs in feces, is much lower.[10,13] *Uncinaria stenocephala* (***Figure 4B***) occurs much less commonly and is largely non-pathogenic. Hookworm eggs are passed in the feces of infected dogs and then mature over approximately the next week to infective third stage larvae. Infective hookworm larvae can persist in the environment for a month or more, creating an infection risk to dogs and people. Recent surveys suggest the canine whipworm, *Trichuris vulpis* (***Figure 5***), is present in as many as 39.2% of shelter dogs.[10] Detecting the heavier eggs of *T vulpis* in fecal samples can be challenging, and infections are often overlooked.[14] *Toxocara canis* (***Figure 6***) is most commonly identified in pups although as many as 10% to 15% of adult shelter dogs may be infected.[10,15] Larvated, infectious eggs of both whipworms and ascarids can remain viable for many years,[16] creating a source for reinfection of dogs that ingest soil or soil-contaminated objects like tennis balls or other toys.

Health Risk Posed to Dogs & Humans

Risks to Dogs

Dogs of all ages are at risk for intestinal helminths. Ascarids and associated clinical disease are most

FIGURE 3 Adult *Echinococcus* spp are only a few millimeters long. If careful sieving of the intestinal contents is not performed, this parasite can be readily overlooked.

FIGURE 4 Hookworms take their name from the bent anterior end. The stoma of *Ancylostoma caninum* (**A**) bears 3 pairs of teeth used to lacerate the intestinal mucosa while that of *Uncinaria stenocephala* (**B**) has cutting plates.
Figure 4 courtesy the National Center for Veterinary Parasitology (ncvetp.org)

common in young pups while hookworms and whipworms are more common in older pups and young adult dogs, particularly those with frequent access to parasite-laden environments.[13] However, tapeworms may be present in dogs of any age. Clinical disease due to adult *Taenia* spp, *Echinococcus* spp, or *D caninum* in the small intestine is considered uncommon, but some tapeworm-infected dogs may present with anal pruritus, and a few reports describe intestinal impaction due to massive *Taenia* spp infections.[17] When dogs serve as the definitive host of *E multilocularis*, eggs are passed in the feces. If eggs are ingested during self-grooming, dogs can become an aberrant intermediate host and may develop aggressively metastasizing hemorrhagic masses of immature cestodes in the liver, lungs, or other organs.[18] Although canine *E multilocularis* infection is increasingly reported in Canada, recognized cases are rare in the United States.[12]

Occasionally, *A caninum* larvae migrate and mature to adults in the small intestine of people causing eosinophilic enteritis.[25]

Nematodes also cause disease in dogs. Feeding by immature and adult *A caninum* results in blood loss usually accompanied by diarrhea; when infection intensity is high, massive hemorrhagic anemia can result, especially in young dogs.[19] In contrast, *U stenocephala* is thought to cause only 1% to 2% of the blood loss caused by *A caninum*; thus, infections caused by the "northern hookworm" are rarely associated with disease.[20] Whipworms also cause diarrhea, with feces often containing fresh blood. Heavy infection with *T vulpis* can lead to electrolyte imbalance that presents as pseudohypoadrenocorticism and resolves following treatment for *T vulpis*.[21] Disease due to *T canis* is most often seen in pups infected early in life and results in ill-thrift and a classic "pot-bellied" appearance; severe infections in very young pups may be fatal.[22] Adult dogs are less likely to show clinical signs associated with *T canis* infection, but left untreated, these silent infections can result in massive environmental

FIGURE 5 *Trichuris vulpis* burrows its thin anterior end into the cecal mucosa leaving the thick posterior end in the lumen. Damage to the mucosa results in diarrhea, fluid loss, and, when trauma is severe, the presence of fresh, bright red blood in the feces.
Figure 5 courtesy the National Center for Veterinary Parasitology (ncvetp.org)

contamination with ascarid eggs. Risk for infection and subsequent disease from nematodes is greatest when dogs come in contact with environments where other dogs frequently defecate, such as dog parks, which are likely to contain infective third-stage larvae of hookworms or larvated eggs of whipworms or ascarids.

Risks to Humans

Most canine intestinal helminths pose some zoonotic risk although severity of resultant human disease varies. People, usually children, become infected with *D caninum* when they ingest an infected flea and develop adult tapeworms in the small intestine. Ingestion of taeniid eggs can result in development of cysticerci or, if *Echinococcus* spp are involved, severe disease due to formation of hydatid cysts.[23] Larvae of *A caninum* directly penetrate the skin of people leading to cutaneous larva migrans; lesions are intensely pruritic and most commonly develop on the hands, feet, and back of the legs. In one outbreak, 22 individuals at a children's summer camp in Florida developed lesions after contact with a contaminated sandbox.[24] Occasionally, *A caninum* larvae migrate and mature to adults in the small intestine of people causing eosinophilic enteritis.[25] Ingestion of larvated eggs of *T canis* can lead to ocular and visceral larva migrans which can manifest as retinitis or hepatomegaly and pulmonary disease, respectively. Additionally, covert toxocariasis can lead to development of chronic abdominal pain. Within the United States, 13.9% of people are seropositive for *T canis*.[26] Ingestion of larvated eggs of *Baylisascaris procyonis*, a raccoon ascarid occasionally found in dogs, can result in severe, progressive neurologic disease.[27] Although limited reports describe human infection with *T vulpis*, the identity of the nematodes were not confirmed molecularly and canine whipworms are not regarded as zoonotic.[28,29]

Routine Deworming to Limit Infections

Veterinary and public health organizations like the Companion Animal Parasite Council (capcvet.org) and Centers for Disease Control and Prevention (cdc.gov) advise that all dogs should be routinely dewormed year-round for intestinal helminths because of the high risk for infection and disease that parasites pose.[30,31] Monthly heartworm preventives marketed in the United States are also dewormers, with label-approved efficacy as treatments for hookworms, ascarids, and, in the case of oral milbemycin oxime or transdermal moxidectin, whipworms. Heartworm preventives that contain praziquantel are approved treatments for common tapeworms including *D caninum, Taenia* spp, and *Echinococcus* spp (***Table***). For example, in northern Europe, a milbemycin oxime–praziquantel

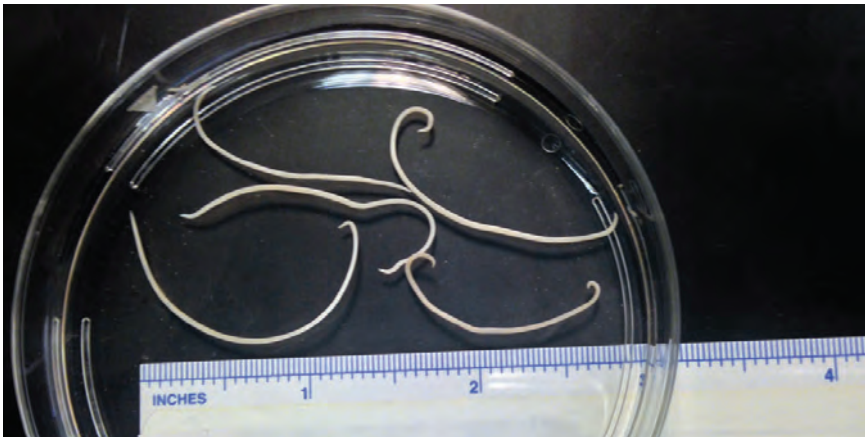

FIGURE 6 Adult *Toxocara canis* are the largest of the common canine gastrointestinal parasites. Heavy burdens in pups can result in ill thrift and stunting, but infections in adult dogs are often subclinical. When untreated, these silent infections can allow long-term environmental contamination with eggs. *Figure 6 courtesy the National Center for Veterinary Parasitology (ncvetp.org)*

formulation is used in dogs as a dewormer even in areas where heartworm is not endemic; in the United States, the same formulation is widely used as a heartworm preventive that also treats intestinal nematodes and cestodes.

Compounds and formulations that in the United States are commonly referred to as "heartworm preventives" often protect dogs from more than just heartworm disease, but specific efficacy of the different products varies (***Table***). Injectable moxidectin prevents heartworm infection for 6 or 12 months, and treats hookworms when administered, but does not prevent hookworm infection for the full 6- to 12-month treatment period, and is not effective for ascarids or whipworms.[32,33] Similarly, monthly ivermectin–pyrantel parasite control products treat hookworms and ascarids when administered but do not have efficacy against whipworms. Pyrantel-resistant populations of *A caninum* have long been recognized in greyhounds, and recent data suggest additional resistance issues may limit the utility of several dewormers, including pyrantel, ivermectin, and thiabendazole, against certain populations of *A caninum*.[8,9,34]

Dog management to limit parasite infection risk is also helpful in protecting canine and human health.

Other Strategies to Prevent Infections

Dog management to limit parasite infection risk is also helpful in protecting canine and human health. Canine feces should be promptly disposed of with municipal waste whether it is deposited on a sidewalk, at the dog park, or in the owners' backyard. Larvae of *A caninum* are most likely to develop and transmit to other dogs (and to people) in a warm, humid environment, so spring and summer pose the greatest risk. In contrast, infective eggs of *T canis* and *T vulpis* are able to survive through the winter months, presenting year-round opportunities for infection. Effective flea control all but eliminates the risk for *D caninum* infection, and restricting roaming to prevent dogs from scavenging or preying on wildlife reduces

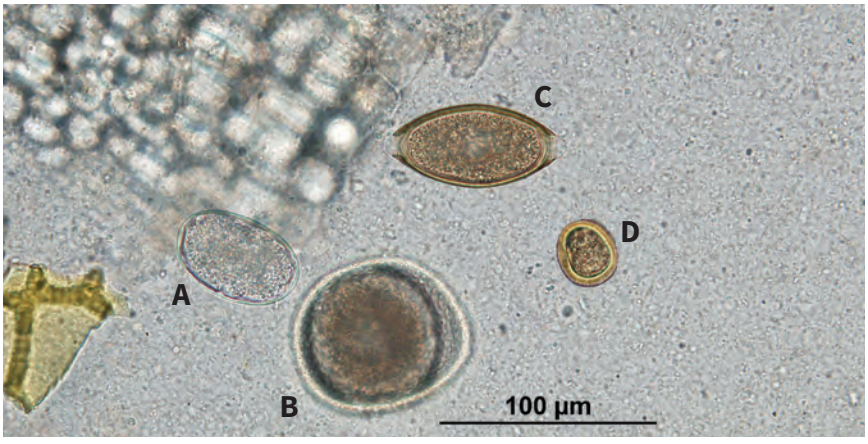

FIGURE 7 *Ancylostoma caninum* (**A**), *Toxocara canis* (**B**), *Trichuris vulpis* (**C**), and taeniids (**D**) eggs in a canine fecal sample. Eggs of *Taenia* spp and *Echinococcus* spp are morphologically indistinguishable and thus usually referred to as taeniid.

Taenia spp and *Echinococcus* spp infection. Dogs that frequent shared facilities like dog parks, dog day care, groomers, or boarding kennels will benefit from additional vigilance regarding parasite control.

Responsible kennels and groomers often require evidence of parasite prevention and testing—in addition to vaccination—prior to accepting dogs. Groups like CAPC recommend that any dogs using shared facilities be current on parasite control and have a recent heartworm test and fecal examination for parasites,[30] an approach that protects both canine and human health since some common canine infections are potentially zoonotic. Because compliance may be less than ideal, resistance can develop, and all products are not effective against all parasites of importance, fecal testing for intestinal parasites is recommended every 6 to 12 months, even for dogs that routinely receive parasite control products (***Figure 7***).[30] Dog owners should be encouraged to inquire about parasite control practices and consider avoiding areas with open-access policies that may be frequented by unvaccinated dogs or those not on parasite control products. Dogs that frequent dog parks or other areas where pets from varied backgrounds mingle may benefit from more frequent (eg, quarterly) testing.

Conclusion

Effective parasite control efforts, including strategies that limit canine intestinal parasites with zoonotic potential, remain critically important for protecting the human–animal bond and ensuring that dogs and people continue to enjoy a close, healthy relationship. The success of parasite control in companion animal medicine in the United States has resulted in a relatively low prevalence of parasite infection and subsequent clinical disease in well-cared-for adult pet dogs, with national data indicating that parasites are detected in fecal samples from 29.6% of dogs less than 6 months of age but only 6.1% of dogs over 1 year of age.[13] However, that success, which is the result of decades of focused effort, can create a false sense of security that intestinal parasites are no longer a major concern for pet dogs. As those who work with shelter or rescue dogs can attest, the risk of intestinal parasites has not been eliminated. Parasites remain in contaminated soil, water untreated domestic dogs, and wildlife hosts across the United States, making consistent parasite preventive use critical.

FDA label-approved spectrum of efficacy of active ingredient combinations present in parasite control products used to prevent heartworm infection and treat and control intestinal helminths in dogs. All products listed are approved heartworm preventives in the United States.

Parasite control product	Route	Frequency of administration	Intestinal parasite control
Ivermectin–pyrantel	Oral	Monthly	Hookworms, ascarids
Ivermectin–pyrantel–praziquantel	Oral	Monthly	Hookworms, ascarids, cestodes
Milbemycin oxime	Oral	Monthly	Hookworms, ascarids, whipworms
Milbemycin oxime–praziquantel	Oral	Monthly	Hookworms, ascarids, whipworms, cestodes
Moxidectin	Transdermal	Monthly	Hookworms, ascarids, whipworms
Moxidectin	Subcutaneous injection	Every 6 months or every 12 months depending on formulation	Hookworms present when injection administered
Selamectin	Transdermal	Monthly	None

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