

INFORMATION FOR VETERINARIANS AND CLINICS

Hookworms in dogs and cats

Key facts

- Globally, one of the most common infectious concerns in dogs and cats
- Major concern in puppies and kittens – heavy parasite burden can be fatal
- Preventive care (AAHA), companion animal parasite council (CAPC), Canadian Parasitology Expert Panel (CPEP) evidence, and expert based fecal and deworming guidelines for puppies, kittens, adult dogs, and cats
- Zoonotic (human) health concern
- Hookworm resistance recent concern (2019) and rising (2022)
- KeyScreen™ GI Parasite PCR for hookworm diagnosis and identification of resistance, along with 20 other parasites, and *Giardia* zoonosis marker
- One Health, drug stewardship considerations

What is it and who gets it?¹

Hookworms (*Ancylostoma* and *Uncinaria spp.*) are nematodes with a 'hook-like' end.

- Dogs are typically infected with *Ancylostoma caninum*
- Cats are typically infected with *A. tubaeforme*
- Dogs and cats can be infected with *A. braziliense* and *U. stenocephala*

How common is it?

Prevalence in dogs and cats varies with deworming history, lifestyle (prey ingestion), season (time of year) and region (geography).

One US study reported hookworm prevalence of 2.5 to 10% and 0.5 to 7% in well-cared for dogs and cats, respectively.² A more recent publication reported a 47% increase in yearly prevalence of hookworms in dogs from 2012 to 2018.³

Hookworm infection is most common (and carries the largest risk of disease and negative outcomes) in young puppies and kittens. Risk factors for infection are age (more common in young animals), dogs and cats with outdoor lifestyles (stray, working dog, feral cat, etc.), and high-density housing (kennels, breeding facility, multi-cat household, etc.), especially if there is a lack of routine cleaning or dirt floors.

Where is it?

Hookworms are global pathogens, most prefer warmer (tropical, subtropical) climates (particularly *A. braziliense*), while some (*U. stenocephala*) are more common in the northern USA, Europe and Canada.

Regional variations, CAPC maps, as accessed September 2022

USA: capcvet.org/maps/#/2022/all-year/hookworm/dog/united-states

Canada: capcvet.org/maps/#/2022/all-year/hookworm/dog/canada

How is it transmitted (spread)?¹

Pathogenesis

Hookworm adults live in their host's (e.g., dog) small intestine for 4 to 24 months. Eggs from adult worms are shed within 2-3 weeks and pass from the host's feces to the environment. The eggs develop into 3rd stage larvae (after about 2-10 days) and become infective.

Dogs and cats become infected through direct ingestion of infected tissue (environmental contamination, prey) or infected cockroaches, cutaneous (skin) larval penetration or transmammary infection (nursing). Puppies infected while nursing may shed eggs from 10-12 days after birth.

After infection, larvae typically mature to adults in the small intestine. However, larvae that infect through the skin can move to the lungs and be coughed up and swallowed. Finally, some larvae move to other body tissues and can become dormant (arrested development).

Larval leak is the term given to what occurs once adult worms are removed (killed, e.g., deworming) and re-activation of larvae in the arrested development stage occurs, these larvae then 'leak' to the host intestine, which re-establishes infection.

What are the clinical signs in dogs and cats?

Clinical signs are related to level of infection (worm burden) and aggressiveness of worm feeding. Heavy gastro-intestinal parasite burden and voracious feeding can be fatal to the host animal, particularly in puppies and kittens, while older animals with few worms may display mild or no clinical signs.

Common clinical signs in dogs and cats are pallor related to anemia (blood loss), dark tarry feces, dehydration, thin body condition, and 'poor doers'. Less commonly, respiratory signs (tachypnea) or dermatitis (cutaneous migration) can occur.

How is it diagnosed?

Diagnosis is made through a combination of history, clinical signs and fecal testing (fecal centrifugal flotation, coproantigen ELISA, KeyScreen™ GI Parasite PCR). Laboratory testing (CBC, serum biochemistry) may indicate anemia, and assessment of iron levels may be indicated with chronic or persistent infections.

What is the treatment?

Established deworming protocols for puppies, kittens and adult dogs and cats consist of benzimidazoles (febantel and fenbendazole), macrocyclic lactones (moxidectin and milbemycin oxime), and tetrahydropyrimidine (pyrantel). Nursing puppies should be dewormed and deworming of the bitch (from day 40 of gestation to day 14 of lactation) will aid reduction of larvae. Note, take care to use medication safe for reproductive stages is advised.

It is critical to be aware (and convey to dog-owners) that larvae in the arrested development phase will not be killed with a single deworming. As such, re-assessment fecal testing is needed to determine need for further therapy. Fecal testing to ensure clearance of larvae in the arrested development phase can be done by performing a pre and post treatment fecal egg count reduction test and through the KeyScreen™ GI Parasite PCR (protocol in monitoring section).

Drug resistance concerns emerging?

In 2019, reports of *A. caninum* (anthelmintic) resistance to benzimidazole and macrocyclic lactones emerged in Greyhound populations.⁴ Unfortunately, these reports were shortly followed by confirmation of *A. caninum* multi-drug (MDR) resistance to further drug classes, i.e., avermectin/milbemycin and tetrahydropyrimidine.⁵⁻⁷

Clinical evidence suggests that the MDR status of these *A. caninum* isolates evolved from greyhound breeding farms and kennels.⁶ Given the closure of Greyhound racing tracks across the US and the rehoming of MDR hookworm infected dogs, the

potential spread of these isolates poses a serious threat to the general dog population in the US and has major public health ramifications due to the parasite's zoonotic potential. While retired racing greyhounds have been over-represented in cases of MDR hookworms, positive cases have also been diagnosed in non-greyhound breeds.⁸

Regional distribution of positive dog samples appears to be widening, as while over 80% of positives were submitted from FL, positive results were reported from CA, ID, NV, and other US states.⁸ Further, emerging hookworm MDR is so important that the American Association of Veterinary Parasitologists (AAVP) has formed a task force 'to address multi-anthelmintic drug resistant (MADR) *Ancylostoma caninum*.'⁹

When to suspect drug resistance? How determine resistance?

Drug resistance should be suspected when re-assessment fecal testing reveals that worms have not been killed by routine deworming and persistent infection is unrelated to larval leak (re-activation of arrested development hookworm larval stage) or environmental re-infection.

Fecal testing for anthelmintic resistance can be done by: performing a pre and post treatment fecal egg count reduction test, submitting fecal samples to a laboratory that can perform *in vitro* drug bioassays, or molecular (PCR) testing for resistance.⁵ The KeyScreen™ GI Parasite PCR identifies multiple (20) GI parasites, including hookworms, and detects the presence of the F167Y single-nucleotide polymorphism associated with hookworm (*A. caninum*) benzimidazole (fenbendazole and febantel) resistance.⁸

Monitoring?

Re-testing fecal samples

Fecal re-testing (either through fecal egg count reduction or KeyScreen™ GI Parasite PCR) is critical for hookworm positive cases to monitor these dogs for environmental re-infection, larval leak or resistance related therapy failure.

What to do in cases of resistance (MDR)?

There is no simple or easy answer.

Initially long-term treatment protocols, composed of triple drug combinations, together with strict environmental hygiene (to avoid re-infection), demonstrated success in resistant case and this is still advised in many cases.^{6,10} However, more recently, triple drug combinations have failed to successfully treat some infections and one drug (emodepside/praziquantel) for dogs (not currently labelled for use in the US) is currently undergoing evaluation for its potential against MDR strains.^{6,10}

Step-wise approach to potential hookworm resistant cases:

1. Begin with a thorough history and evaluation of clinical signs, and query environment, housing, lifestyle, treatment (specific drugs, doses, and compliance, recheck intervals, recheck methodology and results, etc.) to assess for explanations other than MDR. These include environmental re-infection, larval leak, under treatment (incorrect drug or dose), poor compliance, etc.
2. Assess drugs used, i.e., it is helpful to know what the dog has already been treated with, as they may have already "failed" therapies in addition to typical fenbendazole or pyrantel.
3. Assuming the hookworms express the KeyScreen™ GI Parasite PCR resistance marker (and with the information from steps 1 and 2) triple therapy (moxidectin + febantel/pyrantel/praziquantel) may be elected.^{6,10} While MDR hookworms tend to be ivermectin-resistant, it seems some may be moxidectin sensitive.
4. If the animal proves resistant to this treatment (step 3), a discussion regarding off-label use of emodepside may be appropriate. Note that emodepside is not approved for use in dogs in North America, nor is an oral product commercially available.⁶

What is the prognosis?

Prognosis is excellent in most cases, although severely infected animals may require more intensive therapy (e.g., blood transfusion, monitoring for iron related anemia, etc.) and may die if severely affected or owners cannot afford intensive therapy. Similarly, persistently infected animals and animals with MDR resistance can require repeated therapy and additional monitoring for parasite clearance.

What is the prevention?**What can I do to stop this happening to dogs?**

Following existing evidence- and expert-based guidelines (CAPC/CPEP) or prevention testing, monitoring and therapy is indicated for puppies, kittens, and adult animals. Puppies and kittens should have 3-4 fecals in their first year of life, and adult dogs twice annually (as determined based on risk assessment), and routine deworming schedules followed as per CAPC and CPEP. Environmental cleaning (pick up poop) and decontamination (infection control) can reduce re-infection risk and limit the development and geographic spread of MDR *A. caninum*.

“An ounce of prevention is worth a pound of cure” – Ben Franklin

Is this a One Health concern (zoonotic (human), animal, drug stewardship and environment)?

Yes – this is a zoonotic (human) and animal (dog and cat) concern. Humans can develop dermatologic signs (cutaneous larval migrans), as related to infection.

Yes – this is a drug (pharmacologic) stewardship concern due to evolving MDR resistance that impacts animals and humans.

Yes – this is environmental concern as we work to reduce the parasite burden by ensuring parasite clearance (re-testing and effective deworming) and ‘pick up the poop’ messaging.

Your preventive care contribution in the clinic is at the level of:

- The individual pet (puppy, kitten, adult dog or cat)
- Pet-owner
- One Health
- Education of self, staff, and pet-owner to follow appropriate fecal and deworm plan supported by CAPC, CPEP and AAHA evidence- and expert-based guidelines

How does Antech provide veterinary and clinic support?**Provision of diagnostic options that:**

Follow existing evidence- and expert-based guidelines (CAPC, CPEP, AAHA-AAFP, Infectious disease in dogs in group setting.

KeyScreen™ GI Parasite PCR is a stable, single sample test with a fast turnaround time (TAT), provides reliable and accurate results, and is backed by scientific support (publications, internal data).

- Quickly identifies hookworm resistance (benzimidazole resistance marker)
- Aids drug selection for therapy (if needed)
- Reduce zoonotic risk to humans
- Limits environmental contamination and subsequent worsening of MDR concern
- Allows for infectious disease surveillance, identification of ‘hot spots’ and risk mapping for MDR
- Antimicrobial (Drug) stewardship (MDR)
- Environmental stewardship-reduce burden due to parasite clearance re-assessment, supports pick up poop messaging

Provision of medical support

Internal Medicine Consultant team access, clinical pathologist, radiologist, others.

Vet team and pet-owner resources (visual aids graphs of labs, lifestage, breed, parasite and protocol, tidbits that are fun and individualized), technician training (Preventive care modules).

Webinar (RACE approved), case studies, FAQ on disease, pathogen, etc. (IM consultants), visual aids for prevention (trends of labs, parasite checks, body weight based on species-breed and lifestage).

Resources

Companion Animal Parasite Council (CAPC), As accessed September 2022.

Canadian Parasitology Expert Panel (CPEP), As accessed September 2022.

Canine (2019) and Feline (2021) Life stage Guidelines, AAHA, AAHA/AAFP, As accessed September 2022.

American Animal Hospital Association (AAHA) Infectious disease in dogs in group setting (Stull, 2016, As accessed September 2022.

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9. American Association of Veterinary Parasitologists (AAVP) Hookworm Task Force. 2021, As accessed September 2022: <https://www.aavp.org/aavp-forms-hookworm-task-force/>
10. Castro J, et al, 2020. Efficacy evaluation of anthelmintic products against an infection with the canine hookworm (*Ancylostoma caninum*) isolate Worthy 4.1F3P in dogs. *Int J Parasitol: Drugs and Drug Resist.* 2020;13:22-27.