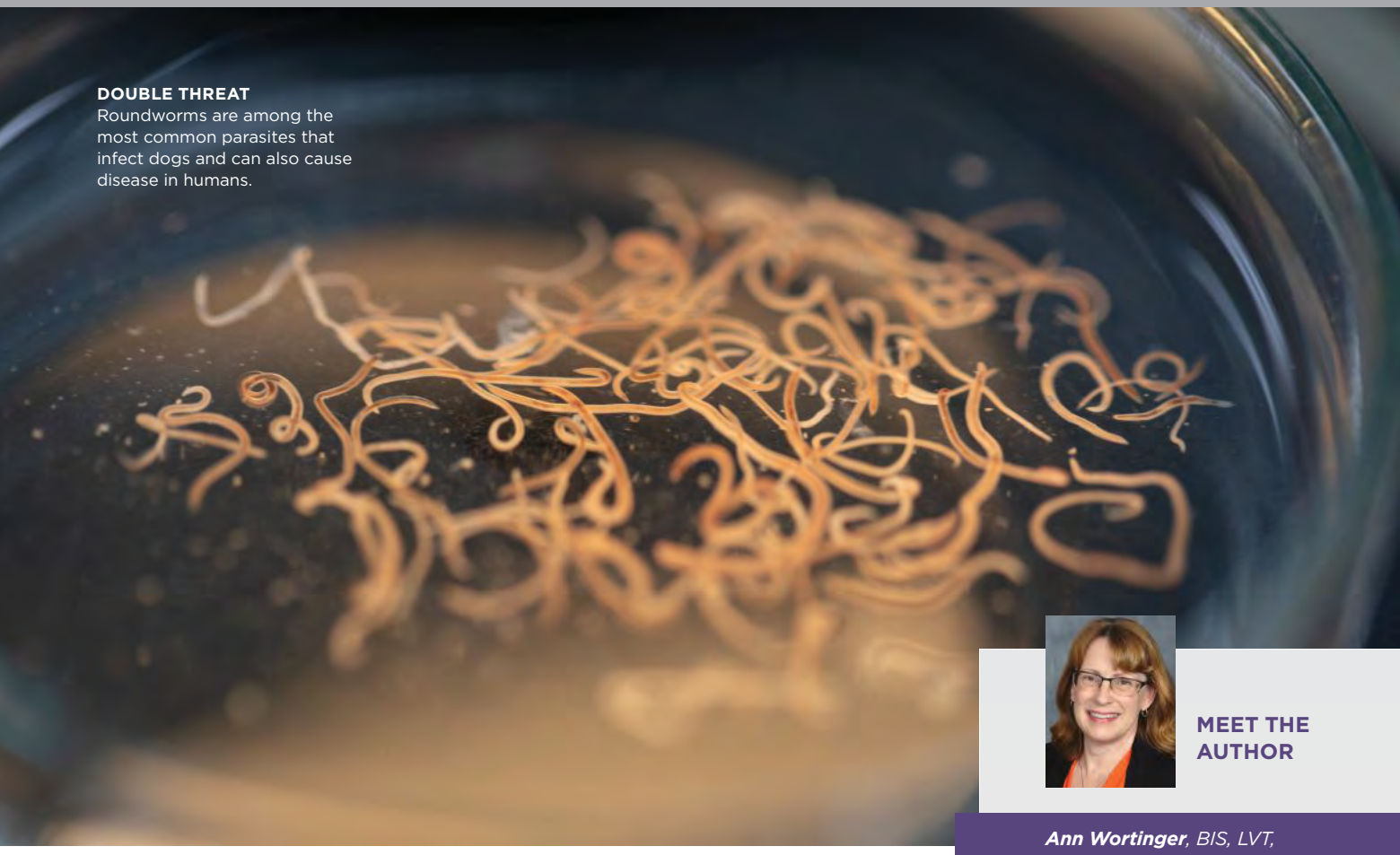

DOUBLE THREAT
Roundworms are among the most common parasites that infect dogs and can also cause disease in humans.

Rattiya Thongdumhyu/shutterstock.com. Opposite Source: cdc.gov/dpdx/toxocariasis/modules/Toxocara_LifeCycle_lg.jpg

MEET THE AUTHOR

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Roundworm Infections in Dogs

The nematode roundworms are so named because of their round or cylindrical shape on cross-section.[1] In dogs, the 2 most common roundworms are *Toxocara canis* and *Toxascaris leonina*. By far, *T canis* are the most common parasitic roundworms in dogs; an estimated 30% of dogs younger than 6 months actively shed these eggs, and virtually all puppies are born infected.[2,3] In the United States, an estimated 99% of puppies and 20% of adult dogs (>12 months of age) are infected with *T canis*.[4,5] Thus, most of this article focuses on *T canis*, the most common parasite of companion dogs in the United States.

Roundworm distribution is worldwide; incidence is higher in urban areas. The definitive hosts for *T canis* parasites are canids (e.g., dogs, wolves, foxes, coyotes). Adult worms can be found in the small intestine of canids, robbing the host of nutrients.[1] However, other animals can ingest the parasite and become a paratenic host or a dead-end host. A paratenic host is one that ingests the eggs and can transport them, but the parasites do not develop in the host. All small mammals can be paratenic hosts.[4] A dead-end host is an inappropriate host in which the larvae can migrate through various body organs but do not develop or become infective.[3] Humans are dead-end hosts for roundworms; the parasite cannot complete its life cycle in humans but can cause clinical illness.[1]

LIFE CYCLE: A COMPLEX STORY

Dogs can become infected with roundworms in multiple ways (**FIGURE 1**). This description of life cycle begins with adult worms in the small intestines of a dog.

After worm copulation, unembryonated eggs pass into the external environment in the dog's feces. A single female adult can produce >85 000 eggs per day.[2] The period between eggs being passed out of the dog and becoming infective is termed the prepatent period. For *T canis* parasites, this period is 2 to 4 weeks, depending on how the larvae are acquired. For *T leonina,* it is 8 to 10 weeks.[2]

Many animals, including a variety of mammals as well as earthworms, can serve as paratenic, or transport, hosts. When a paratenic host ingests roundworm eggs,

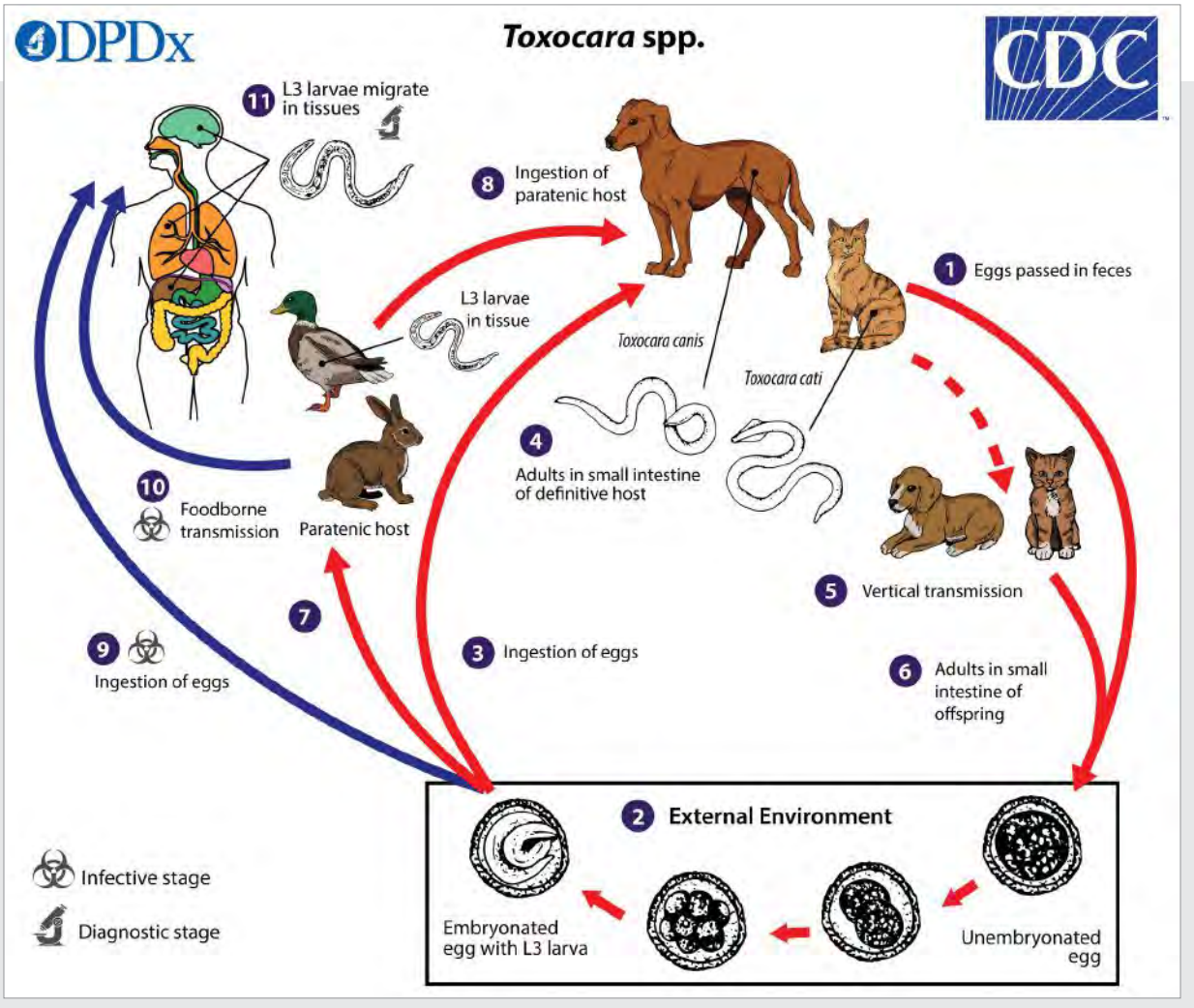

FIGURE 1. Life cycle of *Toxocara* species roundworms.

If a puppy younger than 3 months ingests infective eggs, the larvae migrate through the trachea.

the host does not become infected with the roundworms, but the second-stage larvae hatch from the eggs (**FIGURE 2**) and migrate within the host and either encyst or rest in the tissue.[3] When a dog eats an infected paratenic host, roundworm larvae are released and enter the dog's intestines directly, with no somatic migration.[1,3] Thus, the dog can shed parasite eggs into the environment as early as 2 weeks after infection.[2]

Roundworm eggs will embryonate in the environment, developing into first-stage larvae. The larvae will molt and become second-stage larvae within the embryonated egg. The egg can remain infective in the environment for up to 3 years.[4] If second-stage larvae are ingested, the cycle begins again. If a puppy younger than 3 months ingests infective eggs, the larvae migrate through the trachea. If the host dog is older than 3 months, migration will be somatic.[1,3]

Tracheal Migration

For tracheal migration, the infective egg enters the gastrointestinal (GI) tract, hatches, and releases third-stage larvae into the intestines. The larvae penetrate the GI wall, enter the bloodstream, and travel to the lungs where they enter the alveoli. The larvae move from the lungs into the trachea and are coughed up and swallowed; when they reach the small intestine, they mature into adults. Alveolar penetration of large numbers of worms can cause verminous pneumonia.[1,3]

Somatic Migration

After entering the host and traveling through the blood to the liver and lungs, larvae reenter the host's alveolar blood vessels and travel to the muscles and organs where they become encysted and their development is arrested.

Transmission to Puppies

Puppies can be infected while in utero or while nursing.

Transplacental

In pregnant dogs, encysted larvae become reactivated and migrate through the umbilical vein to infect the developing puppies' liver and lungs. After the puppies are born, the larvae are coughed up, then swallowed, and move to the small intestine to complete their development. In transplacentally infected puppies, egg shedding can begin as early as 2.5 to 3 weeks of age.

Transmammary

During lactation, encysted larvae in the dam become active and pass into the milk to directly infect the puppies with no tracheal migration.[1,3] In transmammarily infected puppies, egg shedding can begin as early as 4 weeks of age.

CLINICAL SIGNS

Puppies infected with *T canis* may exhibit a variety of clinical signs, including diarrhea, vomiting (with or without adult worms in vomitus), enlarged abdomen, occasional constipation, flatulence, dull hair coat, and poor growth. Severe infections in puppies can cause verminous pneumonia, ascites, fatty liver disease, and mucoid enteritis, and can also lead to acute death at a few days of age. Death can result from pneumonitis caused by migrating worms, enteritis, and GI blockage.[4,6] Infected adult dogs exhibit diarrhea as the most common clinical sign. Signs of disease are not confined solely to the presence of adult worms in the small intestine. Immature worms migrating through the viscera or located in the small intestines can cause clinical signs with no detectable eggs.[6] Some clinical signs are related directly to larval migration and to the immature and mature adults in the GI tract.[7]

FIGURE 2. Second-stage *Toxocara canis* larva emerging from egg.

olgaru79/shutterstock.com. Opposite from left: MRAORAOR/shutterstock.com; Dew_gdragon/shutterstock.com; olgaru79/shutterstock.com

DIAGNOSTIC TESTS

Diagnosis can be made by direct visualization of adult worms in the vomitus or feces of an infected dog, by visualization of eggs during microscopic examination of feces, or by enzyme-linked immunosorbent assay (ELISA) testing.

Direct Visualization of Worms

By far, the easiest way to detect roundworm infection is direct visualization of worms. Adult worms are 3 to 8 cm long, white, and very stout (**FIGURE 3**). When passed, they tend to be very tightly coiled. They are most commonly seen in the vomitus or feces of puppies. It is advisable to ask clients to bring in any suspect worms for correct identification.[5,8]

Microscopic Visualization of Eggs

Before running a microscopic examination, first visually evaluate the sample for consistency; color; odor; and presence or absence of blood, mucus, or adult parasites. Microscopically examining feces for roundworm egg identification is best done with the freshest sample possible because larvated eggs are more challenging to identify (**FIGURE 4**). Differentiating nematodes that typically reside in soil from hatched *T canis* larvae is impossible. If a sample cannot be examined soon after receipt, refrigeration can help slow down larval development, and mixing equal parts feces with 10% formalin can arrest the larval development.[5]

Direct Smear

The easiest microscopic examination is a direct fecal smear; however, the small amount of sample used may not be sufficient for detecting low parasite burdens or intermittent egg shedding. For this procedure, a small amount of feces is placed on a glass slide and mixed with a small amount (2 to 3 drops) of 0.9% saline. To enable egg identification, the resulting emulsion should be thin enough to read newsprint through; if the emulsion is too thick, it is hard to find the eggs through all the fecal debris. A coverslip is then applied and the slide is examined at 10× and 40× magnification, looking for *T canis* or *T leonina* eggs.[5]

- *T canis* eggs are spherical with a deeply pigmented center and a rough outer shell. Measured by the micrometer on your microscope, they are usually 75 to 90 µm in diameter.
- *T leonina* eggs are spherical to oval with a smooth outer shell and a ground-glass center; they are 75 to 85 µm in diameter.

Fecal Flotation

The standard test for the presence of parasite eggs is fecal flotation. This test is based on the principle of the

FIGURE 3. Adult *Toxocara canis* worms.

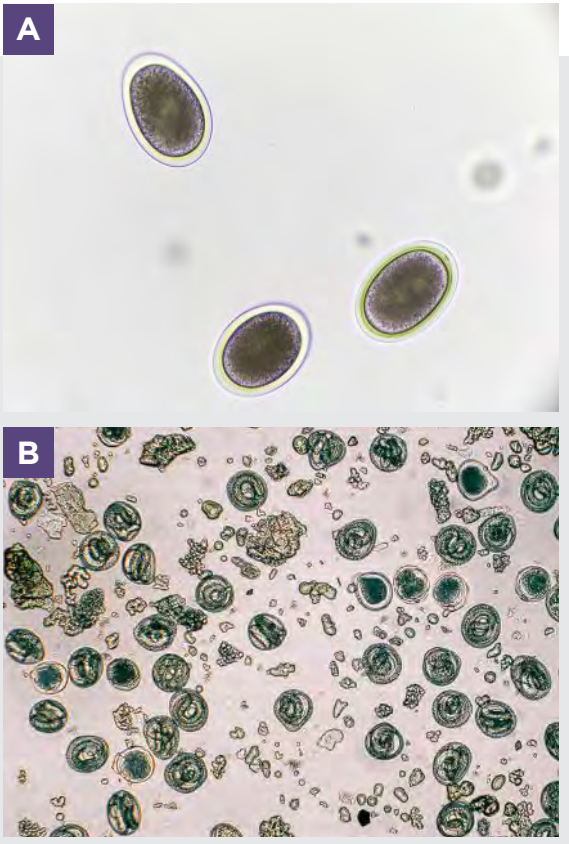

FIGURE 4. *Toxocara canis* eggs: **A)** unembryonated and **B)** embryonated with larvae.

A major disadvantage to fecal flotation is that it cannot detect roundworm infection during the prepatent period, when adults are not yet producing eggs.

weight of the float solution versus the weight of the eggs. If the solution is heavier (specific gravity) than the eggs, the eggs will float to the top of the sample. The recommended fecal flotation solutions have a specific gravity of 1.1 to 1.2 as read by using a hydrometer. The range for zinc sulfate, sodium nitrate, and saturated salt is 1.18 to 1.2, and for Sheather's solution the specific gravity is 1.27.[5]

Fecal flotation can be performed by using either gravity or centrifugation. The same solution can be used for both methods.[1,5] Compared with passive gravity flotation, centrifugation is more sensitive and recovers more eggs from a given sample. However, centrifugation requires a dedicated tabletop swing-arm centrifuge. A major disadvantage to fecal flotation is that it cannot detect roundworm infection during the prepatent period, when adults are not yet producing eggs.

ELISA

The newer ELISA testing, made available to veterinary teams in 2017, is currently available only at reference laboratories. ELISA testing is more sensitive than fecal egg evaluation. An IDEXX study of 750 000 fecal samples found that centrifugal fecal flotation detected roundworms in 2.2% of the specimens and ELISA testing found them in an additional 1.3%.[9] The IDEXX Fecal Dx antigen test (**idexx.com**) detects coproantigens (antigens in feces) produced by immature adults in the small intestinal lumen. It detects male and female worms and is not linked to egg production.[2,10]

TREATMENT

A variety of anthelmintics have been approved for treatment of roundworm infections in dogs. The more common ones include fenbendazole, piperazine, and pyrantel pamoate, which are given either daily for a specified duration or every 2 to 4 weeks.[2] In addition, topical and oral monthly heartworm preventives are also effective against roundworms. The Companion Animal Parasite Council (CAPC) recommends year-round, monthly preventives effective against roundworms for all dogs.[2] Clients who are unable to consistently administer monthly preventives should deworm the dog with a broad-spectrum anthelmintic effective against internal nematode parasites at least 4 times a year.[2]

Because of the risk for transplacental and transmammary infections, female dogs should be dewormed before breeding and during pregnancy. The Merck Manual recommends the following treatment schedules for pregnant dogs and their puppies.[7]

Dam: Give fenbendazole daily from gestation days 40 to 65 through postpartum day 2, or give ivermectin on gestation days 0, 30, and 60 and postpartum day 10.

Puppies: Begin treatment at 2 weeks of age and continue every 2 weeks until the puppies are old enough to begin monthly nematode preventives.

MONITORING FOR REINFECTION

Monitoring for reinfection is done primarily through fecal evaluations. The CAPC recommends fecal flotation testing using a centrifuge.[2] Detection of occult roundworm infections can be increased by combining commercial ELISA antigen testing with fecal flotation. The CAPC recommends combining ELISA testing with fecal centrifugation for detection of roundworms during the prepatent period and for single-sex roundworm infections in which eggs would not be produced.[2]

PREVENTION

Prevention of primary infection and reinfection requires a multipronged approach. It begins with trying to prevent transplacental and transmammary infection of puppies through routine deworming of the dam during gestation and lactation.

The primary reservoirs for infection are somatic larvae encysted in dams and larvated eggs in the environment.[7] To help prevent environmental contamination, all dogs should receive monthly preventive treatment year-round. Feces should be picked up daily from the yard and immediately from public spaces. Strict adherence to leash laws will help

limit environmental contamination.[1,2] Preventing access to hunting or dead animals will limit exposure to infection from paratenic hosts.[2]

Unfortunately, egg removal from the environment is challenging because eggs are resistant to weather and common disinfectants are not effective. Because of these challenges, prevention of environmental contamination is the most effective environmental control measure.[2,4]

ZOONOTIC POTENTIAL

Roundworms can cause disease in humans. People can become infected by ingesting eggs or eating undercooked paratenic hosts. Because roundworm infection of humans is not a reportable disease, the exact number of persons affected each year is difficult to determine; the estimate, however, is 10 000 human cases per year.[1,3] Children are infected more commonly than adults.[11] Because humans are dead-end hosts, the larvae do not become infective and do not encyst but continue to migrate through the body tissues. Somatic migration of roundworm larvae in humans can cause visceral larval migrans (migration through internal organs) or ocular larval migrans (migration to the eye), which usually renders that eye blind.[1,11]

As with dogs, preventing exposure is key to preventing infection. Preventing roundworm infection depends on routine handwashing after playing with puppies or being exposed to dog feces, regularly removing dog feces from the yard and public areas, and routinely treating companion dogs to prevent egg shedding in the environment.[2,11]

CLIENT COMMUNICATION TIPS

- Roundworms are among the most common parasites that infect dogs.
- Roundworms steal nutrients from growing animals.
- Female dogs can become reinfected during pregnancy, which can lead to infection of puppies before birth or during nursing. Thus, females should receive treatment before breeding, and dam and puppies should receive treatment after delivery.
- Treatment medications are very effective but only when given consistently and on schedule.
- People can become infected by handling infected puppies and adult dogs or their feces or from the environment. Risk is highest for families with young children or immunocompromised adults. **TVN**

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