



TroCCAP

Tropical Council for Companion Animal Parasites

Guidelines for the diagnosis, treatment and control of feline endoparasites in the tropics.

Second Edition March 2019.

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Disclaimer

The guidelines presented in this booklet were independently developed by members of the Tropical Council for Companion Animal Parasites Ltd.

These best-practice guidelines are based on evidence-based, peer reviewed, published scientific literature. The authors of these guidelines have made considerable efforts to ensure the information upon which they are based is accurate and up-to-date.

Individual circumstances must be taken into account where appropriate when following the recommendations in these guidelines.

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The Tropical Council for Companion Animal Parasites Ltd. wish to acknowledge the kind donations of our sponsors for facilitating the publication of these freely available guidelines.



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General Considerations and Recommendations

Diagnosis

- Cats should be tested for endoparasites regularly (two times a year) to monitor the efficacy of control regimes and owner compliance.
- Standard or modified faecal flotation using a specific gravity (SG) of between 1.18-1.20 is recommended for the diagnosis of most, but not all internal parasites of cats. In some cases, more sensitive diagnostic methods may be appropriate for specific parasites and these are indicated in the guidelines.
- Diagnosis of endoparasite infections in cats may be complicated by the intermittent shedding of diagnostic parasitic stages in the faeces, even in symptomatic cases. Testing samples, taken over three consecutive days, may increase the probability of finding diagnostic parasitic stages in the faeces.
- Clinical signs of endoparasite infections in cats may occur prior to shedding of parasite stages in the faeces. Thus, history and clinical signs should guide treatment decisions.
- In some cases, ancillary tests (e.g. blood counts, urinalysis, x-ray, and echocardiography) should be conducted to better guide treatment and management of the feline patient.

Treatment

- The availability of drugs for treating endoparasite infections in cats may vary from country to country. TroCCAP recommends the use of approved drugs.
- Veterinary practitioners should apply a high level of caution when recommending off-label (=extra-label) use of drugs/protocols and closely monitor the cat for any unexpected adverse events. The responsibility for any adverse event related to the off-label use of drugs/protocols lies with the prescribing veterinary practitioner.
- All cats residing in the same household should be treated for intestinal parasites at the same time.
- Care should be taken to minimize the risk of endoparasite transmission and morbidity, especially in kittens, by improving nutrition, environmental hygiene, and by avoiding overcrowding and other stressors.
- Supportive care (e.g. fluid therapy, blood transfusion, iron supplementation and high protein diet) should be provided as indicated.

Prevention and control

- Considering trans-mammary transmission and the pre-patent period of *Toxocara cati*, kittens need to be treated for ascarids at 3 weeks of age and fortnightly thereafter until 10 weeks of age. However, in scenarios where queens and their kittens are kept outdoors in potentially contaminated environments, kittens should be treated against hookworms starting at 2 weeks of age and then every 2 weeks until they are at least 10 weeks old. Nursing queens should be treated simultaneously with their litters.

- Cats should be dewormed regularly (cats living in catteries, free roaming, outdoor cats are at a higher risk and should be dewormed monthly).
- Monthly heartworm prophylaxis is recommended in areas where canine infection is endemic.
- Cat faeces should be removed and disposed daily.
- The litter box should be cleaned daily and if bleach is used, it must be thoroughly rinsed to avoid exposing cats to the toxic effects of bleach.
- Disinfection of gravel, loam surfaces or lawns with sodium borate (5 kg/m²) will kill larvae but could also destroy vegetation.
- Do not feed raw meat or allow cats to hunt, as many animals (e.g., snails, slugs, birds, rodents and other micromammals) can act as intermediate or paratenic hosts for some endoparasites.
- If fleas are present, cats should be treated for *Dipylidium caninum*.
- Blood donor cats should be screened by PCR and serological tests to rule out the presence/exposure to pathogens that can potentially be transmitted via blood transfusion (e.g., *Bartonella henselae*, *Mycoplasma haemofelis*, Feline Immunodeficiency Virus, Feline Leukaemia Virus, FeLV, and where appropriate other infections including *Leishmania* spp. and *Babesia* spp.). Further information on blood transfusions in dogs and cats can be accessed at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4913655/pdf/JVIM-30-015.pdf>

Public health considerations

- Some endoparasites of cats are zoonotic (definition: within these guidelines, parasites for which at least one report of human infection has been published). These parasites and vector-borne agents may affect people, especially children and immunocompromised individuals. Thus, their control is also important from a public health perspective.
- Veterinary practitioners and public health authorities should educate cat owners regarding the potential risks of improper parasite control in cats.
- Veterinary practitioners should also advocate good hygienic practices (e.g. hand washing, wearing footwear while outdoors, and daily removal of cat faeces) for cat owners to avoid the risks of zoonotic parasite transmission.

Gastrointestinal Parasites

Ascarids (*Toxocara* spp., *Toxascaris leonina*)

Ascarids are nematodes that infect domestic and wild felids and can cause severe disease in kittens. *Toxocara cati* is zoonotic.

Parasite species: *Toxocara cati*, *Toxocara malaysiensis*, *Toxascaris leonina*

Common name: Ascarids

Hosts: Domestic and wild felids; *Toxascaris leonina* may also infect dogs

Pre-patent period: 3-10 weeks, depending on transmission route and species

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Ingestion of embryonated eggs, predation of paratenic hosts (usually rodents), and via transmammary route (*T. cati*)

Zoonotic: Yes (*T. cati*, *T. malaysiensis*?)

Distribution

Toxocara cati and *Toxascaris leonina* are found worldwide ^[1,2]. *Toxocara malaysiensis* infects cats in Malaysia, China and Vietnam ^[3].

Clinical signs

The clinical signs depend on the burden of infection and infecting roundworm species. *Toxascaris leonina* and low burden *T. cati* infections may be subclinical. Kittens infected with *T. cati*, especially by the trans-mammary route, may present with cachexia, pot-bellied appearance, respiratory disorders, diarrhoea, vomiting, among other signs as early as 3 weeks of age. Heavy infections may cause intestinal blockage or intussusceptions in kittens, which are potentially fatal.

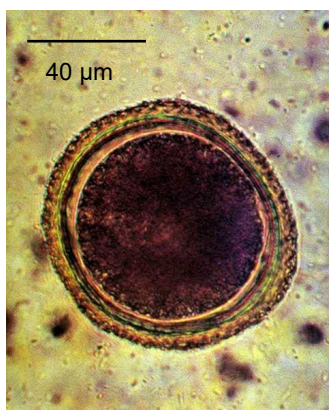


Figure 1. *Toxocara cati* egg showing pitted shell (Image credit: Dr. R. Traub)



Figure 2. Embryonated *Toxascaris leonina* eggs showing smooth shell (Image credit Dr. R. Traub)



Figure 3. *Toxocara cati* adult worm expelled in cat faeces (Image credit Dr. A. D. Mihalca)

Diagnosis

Ascarid infections in cats can be confirmed by standard faecal flotation (**SOP 1**). Eggs are unembryonated when passed, 65 µm x 77 µm and with a pitted shell in *T. cati* and *T. malaysiensis* and 70 µm x 80 µm and with a smooth shell in *T. leonina* ^[1] (**Fig. 1 and 2**). Creamy, spaghetti-looking worms may be observed in the vomitus or faeces of infected cats (**Fig. 3**).

Treatment

For anthelmintic treatment options, refer to **Table 1**.

Table 1. Routes of administration, dosage and efficacies of commonly utilised anthelmintics against the primary gastrointestinal parasites of cats ^[1,2].

Anthelmintics	Route	Dosage	Ascarids	Hookworms	Tapeworms
Pyrantel pamoate	PO	20 mg/kg	✓	✓	
Pyrantel embonate	PO	57.5 mg/kg	✓	✓	
Emodepside*	Topical	3 mg/kg	✓	✓	
Praziquantel	PO, SC, IM	5 -10 mg/kg			✓
Praziquantel	Topical	8 mg/kg			✓
Fenbendazole**	PO	50 mg/kg daily for 3-5 days	✓	✓	
Ivermectin	PO	0.024 mg/kg		✓	
Milbemycin oxime*	PO	2 mg/kg	✓	✓	
Selamectin	Topical	6 mg/kg	✓	✓	
Epsiprantel	PO	2.75 mg/kg			✓
Moxidectin**	Topical	1 mg/kg moxidectin	✓	✓	
Eprinomectin*	Topical	0.5 mg/kg eprinomectin	✓	✓	

*Effective whipworms.

**Effective against whipworms and stomach worms.

Abbreviations: PO, *per os*; SC, subcutaneous; IM, intramuscular.

Prevention and control

Considering trans-mammary transmission and pre-patent period of *T. cati*, kittens need to be treated for ascarids at 3 weeks of age and fortnightly thereafter until 10 weeks of age. However, in scenarios where queens and their kittens are kept outdoors in potentially contaminated environments, kittens should be treated against hookworms starting at 2 weeks of age and then every 2 weeks until they are at least 10 weeks old. Nursing queens should be treated simultaneously with their litters. Thereafter, all cats should be treated monthly. Preventing predation and scavenging activities as well as prompt removal of faeces are also recommended.

For further control options, refer to the **General Considerations and Recommendations** section of these guidelines.

Public health considerations

Ingestion of embryonated *T. cati* eggs in the environment (soil) may produce covert, visceral or ocular larva migrans in humans. Children are most at risk. Once ingested, the larvae undergo somatic migration to organs such as the liver, lungs, brain and eyes. Such migration may be asymptomatic or alternatively incite an eosinophilic inflammatory response which may lead to signs of fever, abdominal pain, hepatomegaly and cough. Symptoms are usually self-limiting, but in some cases may lead to serious complications if there is neurological or cardiac involvement. *T. cati* larvae may also enter the eye and its vasculature causing decreased vision or blindness associated with chorioretinitis, optic neuritis and endophthalmitis. The zoonotic potential of *T. malaysiensis* remains unknown but assumed potentially zoonotic. *Toxascaris leonina* is not considered zoonotic.

References

- [1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
- [2] Taton-Allen G, Cheney J. Gastrointestinal parasites. In: Lappin M (ed) Feline internal medicine secrets. Philadelphia, Hanley & Belfus, 2001; p. 85-95.
- [3] Le TH, Anh NT, Nguyen KT, Nguyen NT, Thuy do TT, Gasser RB. *Toxocara malaysiensis* infection in domestic cats in Vietnam - An emerging zoonotic issue? *Infect Genet Evol.* 2016;37:94-98.

Hookworms (*Ancylostoma* spp., *Uncinaria stenocephala*)

Hookworms are nematodes that infect domestic and wild felids and cause severe disease in kittens. They are zoonotic (except *U. stenocephala*).

Parasite species: *Ancylostoma tubaeforme*, *Ancylostoma braziliense*, *Ancylostoma ceylanicum*, *Uncinaria stenocephala*

Common name: Hookworms

Hosts: Wild and domestic felids; they can also infect dogs (except *A. tubaeforme*)

Pre-patent period: 2-4 weeks

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Ingestion of infective larvae, predation of paratenic hosts (usually rodents), and larval penetration of the skin

Zoonotic: Yes (except *U. stenocephala*)

Distribution

Ancylostoma tubaeforme has a worldwide distribution. *Ancylostoma ceylanicum* is found in the wet tropics and subtropics of the Asia Pacific, China, India and Africa. *Ancylostoma braziliense* is found in the wet tropics of Africa, Central and South America, Malaysia, Indonesia, and northern Australia. *Uncinaria stenocephala* is usually found in temperate, cooler climates in sub-tropical regions.

Clinical signs

Hookworm infection may be well tolerated in cats. In kittens, heavy infections may result in anaemia, diarrhoea, and weight loss. The cutaneous penetration of larvae may result in skin lesions (e.g. erythema, papules and pruritus). Respiratory signs and pneumonia may occur in kittens, in which infection may be fatal when large numbers of hookworms are present.

Diagnosis

Adult worms can be differentiated by morphology of the buccal capsule (**Fig. 1, 2**) and rays of the male bursa. Typical strongyle eggs can be recovered by standard faecal flotation (**SOP 1**). Eggs are oval, thin shelled, unembryonated when passed and approximately 52-79 µm by 28-58 µm in *Ancylostoma* spp. and 71-92 µm x 35-58 µm in *U. stenocephala*^[1] (**Fig. 2**).

Treatment

For anthelmintic treatment options, refer to **Table 1**.

Table 1. Routes of administration, dosage and efficacies of commonly utilised anthelmintics against the primary gastrointestinal parasites of cats ^[1,2].

Anthelmintics	Route	Dosage	Ascarids	Hookworms	Tapeworms
Pyrantel pamoate	PO	20 mg/kg	✓	✓	
Pyrantel embonate	PO	57.5 mg/kg	✓	✓	
Emodepside*	Topical	3 mg/kg	✓	✓	
Praziquantel	PO, SC, IM	5 -10 mg/kg			✓
Praziquantel	Topical	8 mg/kg			✓
Fenbendazole**	PO	50 mg/kg daily for 3-5 days	✓	✓	
Ivermectin	PO	0.024 mg/kg		✓	
Milbemycin oxime*	PO	2 mg/kg	✓	✓	
Selamectin	Topical	6 mg/kg	✓	✓	
Epsiprantel	PO	2.75 mg/kg			✓
Moxidectin**	Topical	1 mg/kg moxidectin	✓	✓	
Eprinomectin*	Topical	0.5 mg/kg eprinomectin	✓	✓	

*Effective whipworms.

**Effective against whipworms and stomach worms.

Abbreviations: PO, *per os*; SC, subcutaneous; IM, intramuscular.



Figure 1. Buccal capsule of *Ancylostoma tubaeforme* containing three pairs of teeth (Image credit: The University of Melbourne parasite image library)



Figure 2. Buccal capsule of *Ancylostoma ceylanicum* or *Ancylostoma braziliense* containing a single pair of teeth (Image credit: The University of Melbourne parasite image library)



Figure 3. Hookworm egg on faecal floatation (Image credit: Dr. R. Traub)

Prevention and control

Kittens should be treated against hookworms starting at 2 weeks of age and then every 2 weeks until they are at least 10 weeks old. Nursing queens should be treated simultaneously with their litters. Thereafter, cats should be treated monthly. Preventing predation and scavenging activities as well as prompt removal of faeces are also recommended.

For further control options, refer to the **General Considerations and Recommendations** section of these guidelines.

Public health considerations

Hookworms are zoonotic agents and the most common cause of cutaneous larva migrans in humans. *Ancylostoma braziliense* causes prolonged cutaneous larva migrans or 'creeping eruptions' in humans. *Ancylostoma ceylanicum* is capable of producing patent infections in humans in regions where this hookworm is endemic in dogs and cats. Most common clinical signs in humans include abdominal pain, watery diarrhoea, melena and peripheral eosinophilia^[3]. *Uncinaria stenocephala* is not considered zoonotic.

References

- [1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
- [2] Taton-Allen G, Cheney J. Gastrointestinal parasites. In: Lappin M (ed) Feline internal medicine secrets. Philadelphia, Hanley & Belfus, 2001; p. 85-95.
- [3] Traub RJ. *Ancylostoma ceylanicum* – a re-emerging but neglected parasitic zoonosis. *Int J Parasitol.* 2013;43:1009-1015.

Whipworms (*Trichuris* spp.)

Whipworms are nematodes of the caecum and colon of wild felids that can sporadically infect domestic cats.

Parasite species: *Trichuris campanula*, *Trichuris serrata*

Common name: Whipworms

Hosts: Wild and domestic felids

Pre-patent period: 62-91 days

Location in the host: Caecum and colon

Distribution: Worldwide

Transmission route: Ingestion of embryonated eggs

Zoonotic: No

Distribution

Worldwide.

Clinical signs

Whipworm infections are well tolerated by domestic cats, which typically remain asymptomatic.

Diagnosis

Whipworm infections in cats can be confirmed by standard faecal flotation (**SOP 1**) using a flotation solution with SG \geq 1.20. Eggs (approximately 54-85 x 34-40 μ m) have a thick, yellow-brown, symmetrical shell, with polar plugs at both ends ^[1] (**Fig. 1**). Eggs of *Trichuris* spp. should be differentiated from those of other parasites, including *Eucoleus aerophilus* and *Pearsonema feliscati* (which is found in the urine). Adults have a characteristic 'whip' shape with a long, thin anterior end (embedded in mucosa) and stout posterior end (**Fig. 2**).



Figure 1. *Trichuris* spp. egg on faecal flotation (Image credit: Dr. T. Inpankaew)



Figure 2. *Trichuris* spp. adult worms (Image credit: The University of Melbourne parasitology image library)

Treatment

Refer to **Table 1** for anthelmintics known to be efficacious for the treatment of *Trichuris* spp. in dogs and that are likely to be efficacious for the treatment of *Trichuris* spp. in cats when administered at labelled doses.

Table 1. Routes of administration, dosage and efficacies of commonly utilised anthelmintics against the primary gastrointestinal parasites of cats ^[1,2].

Anthelmintics	Route	Dosage	Ascarids	Hookworms	Tapeworms
Pyrantel pamoate	PO	20 mg/kg	✓	✓	
Pyrantel embonate	PO	57.5 mg/kg	✓	✓	
Emodepside*	Topical	3 mg/kg	✓	✓	
Praziquantel	PO, SC, IM	5 -10 mg/kg			✓
Praziquantel	Topical	8 mg/kg			✓
Fenbendazole**	PO	50 mg/kg daily for 3-5 days	✓	✓	
Ivermectin	PO	0.024 mg/kg		✓	
Milbemycin oxime*	PO	2 mg/kg	✓	✓	
Selamectin	Topical	6 mg/kg	✓	✓	
Epsiprantel	PO	2.75 mg/kg			✓
Moxidectin**	Topical	1 mg/kg moxidectin	✓	✓	
Eprinomectin*	Topical	0.5 mg/kg eprinomectin	✓	✓	

*Effective whipworms.

**Effective against whipworms and stomach worms.

Abbreviations: PO, *per os*; SC, subcutaneous; IM, intramuscular.

Prevention and control

The control of feline whipworms can be achieved through proper diagnoses, therapy and sanitation of the cattery. Overcrowding of cats should be avoided. Faeces should be removed daily from the litterbox.

For further control options refer to the **General Considerations and Recommendations** section of these guidelines.

Public health considerations

None.

Reference

[1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.

Threadworm (*Strongyloides* spp.)

Strongyloides spp. are nematodes that may infect wild and domestic carnivores, including cats. *Strongyloides stercoralis* is zoonotic.

Parasite species: *Strongyloides planiceps*, *Strongyloides tumefaciens*, *Strongyloides felis*, *Strongyloides stercoralis*

Common name: Threadworm

Hosts: Wild and domestic carnivores, including cats and dogs (only *S. stercoralis* and *S. planiceps*)

Pre-patent period: 5-21 days (10-11 days for *S. planiceps*)

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Larval penetration of the skin

Zoonotic: Yes (*S. stercoralis*)

Distribution

Strongyloides planiceps infections in cats have been reported mainly in Japan and Malaysia. *Strongyloides felis* has been reported in India and Australia. *Strongyloides tumefaciens* has been reported in North America and India. Cases of *Strongyloides* infections in cats have been reported in Africa, Europe, Southeast Asia, the Caribbean and South America ^[1,2,3]; in some cases, the species has been determined as *S. stercoralis* ^[2].

Clinical signs

Strongyloides infections in cats are usually asymptomatic and self-limiting. *Strongyloides tumefaciens* infections or aberrant location of *S. stercoralis* may produce tumour-like nodules in the large intestine as well as loose or diarrheic faeces.

Diagnosis

Strongyloides planiceps infections in cats can be confirmed by standard faecal flotation (**SOP 1**). Eggs of *S. planiceps* are 58-64 x 32-40 µm ^[4] and embryonated when passed (**Fig. 1**). For other species, the zinc sulphate centrifugal flotation (**SOP 2**) or the Baermann method (**SOP 3**) are recommended for detecting larvae (**Fig. 2**). While *Strongyloides* larvae can be found in fresh faecal smears, this method is not recommended due to its low sensitivity. In general, faecal examination for *Strongyloides* spp. can be challenging.

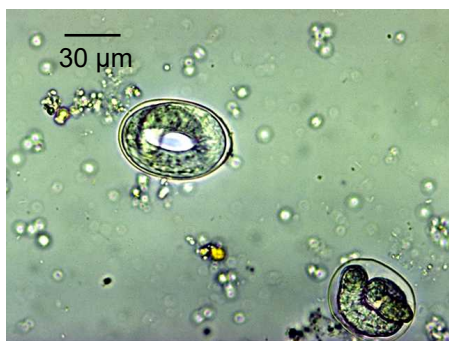


Figure 1. *Strongyloides* spp. eggs containing first stage larvae on faecal flotation (Image credit: The University of Melbourne parasitology image library)



Figure 2. *Strongyloides stercoralis* rhabditiform larva with prominent genital primordium (arrow) in stool, isolated using Baermann technique (Image credit: shutterstock)

Treatment

There are no approved treatments for *Strongyloides* spp. infections in cats. Ivermectin (200 µg/kg SC) is anecdotally effective [4]. Thiabendazole (25 mg/kg PO BID for 2 days) was effective against *S. felis* in three cats [4].

Prevention and control

Controlling and preventing *Strongyloides* infections in cats is difficult, considering that the principal route of transmission is through the direct penetration of the skin with larvae. For further control options refer to the **General Considerations and Recommendations** section of these guidelines.

Public health considerations

Strongyloides stercoralis is zoonotic. This species is primarily associated with dogs, humans, non-human primates and wild canids [1]. It has been shown experimentally that cats are susceptible to *S. stercoralis* and cases of alleged *S. stercoralis* infection in cats have been published [2]. The zoonotic potential of other cat-associated *Strongyloides* spp. is unknown.

References

- [1] Thamsborg SM, Ketzis J, Horii Y, Matthews JB. *Strongyloides* spp. infections of veterinary importance. *Parasitology*. 2017;144:274-284.
- [2] Nyambura Njuguna A, Kagira JM, Muturi Karanja S, Ngotho M, Mutharia L, Wangari Maina N. Prevalence of *Toxoplasma gondii* and other gastrointestinal parasites in domestic cats from households in Thika Region, Kenya. *Biomed Res Int*. 2017;7615810.
- [3] Rojekittikhun W et al., Gastrointestinal parasites of dogs and cats in a refuge in Nakhon Nayok, Thailand. *Southeast Asian J Trop Med Public Health*. 2014;45:31-39.
- [4] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. *Feline Clinical Parasitology*. Iowa State University Press, Ames, USA. 2002.

Stomach Worms (*Physaloptera* spp. and *Cylicospirura* spp.)

Physaloptera spp. and *Cylicospirura* spp. are spirurid nematodes that infect the stomach of wild and domestic cats. *Physaloptera* spp. are zoonotic, but of minor significance in humans.

Parasite species: *Physaloptera praeputialis*, *Physaloptera pseudopraeputialis*, *Physaloptera rara*, *Cylicospirura felineus*, *Cylicospirura subaequalis*, *Cylicospirura barusi*, *Cylicospirura heydoni*, *Cylicospirura advena*, *Cylicospirura dasyuridis*

Common name: Stomach worm

Hosts: Wild and domestic felids; *P. rara* may infect wild and domestic canids

Pre-patent period: 75-156 days

Location in the host: Stomach and anterior portion of the duodenum (*P. rara*)

Distribution: Worldwide

Transmission route: Predation of paratenic hosts (e.g. mice, frogs, snakes and lizards) or intermediate hosts (e.g. cockroaches, crickets and ground beetles)

Zoonotic: Yes

Distribution

Physaloptera praeputialis has a worldwide distribution. *Physaloptera rara* has been reported in the United States, whereas *P. pseudopraeputialis* has been found in the Philippines ^[1]. *Cylicospirura felineus* is found in India ^[1], Australia, North America and Africa ^[1,2,3,4]. *Cylicospirura subaequalis* and *C. barusi* are found in Asia, *C. heydoni* and *C. dasyuridis* in Australia ^[3], and *C. advena* in New Zealand ^[5].

Clinical signs

Cats infected by *Physaloptera* spp. may be asymptomatic. Most cases of overt disease are associated with *P. praeputialis* infections. Clinical signs may include anorexia, intermittent vomiting, weight loss, diarrhoea and dark faeces (melena), which may be associated with anaemia and eosinophilia. Adult worms may be expelled out with vomitus. *Cylicospirura* infections have been mainly associated with nodules in the stomach of cats (**Fig. 1**). In wild felids, chronic vomiting, weight loss and intestinal perforation have been attributed to *Cylicospirura* species infection ^[6].

Diagnosis

Physaloptera spp. infections in cats can be confirmed by faecal sedimentation (**SOP 4**). Flotation with high specific gravity solutions (e.g. 1.27) also is effective. Eggs of stomach worms are embryonated upon passage and are approximately 45-58 x 30-42 µm in *P. praeputialis*, 50 to 60 µm long in *P. pseudopraeputialis* and 42-53 x 29-35 µm in *P. rara* ^[1]. Eggs are quite clear (translucent) and may be difficult to see upon light microscopy. Eggs of *Cylicospirura* spp. (e.g., 29-38 x 13-22 µm in *C. felineus* and 34-36 x 22-24 µm in *C. advena*) are smaller than those of *Physaloptera* spp. Gastroscopy is the most efficient method for diagnosing *Physaloptera* spp. and *Cylicospirura* infections in cats. For

Cylicospirura spp., multiple red slender nematodes may extend through a fistula within nodules.



Figure 1. *Cylicospirura* spp. induced nodule in the stomach of a cat (Image credit: The University of Melbourne parasite image library)

Treatment

Off-label use of pyrantel pamoate (20 mg/kg PO, given 2-3 weeks apart) and ivermectin (0.2 mg/kg SC or PO, two doses given 2 weeks apart) are effective against *Physaloptera* spp. infections in cats. No treatment has been reported for *Cylicospirura* spp.

Prevention and control

The control of *Physaloptera* spp. can be achieved by preventing cats from hunting and eating paratenic hosts and intermediate hosts.

Public health considerations

Cases of *Physaloptera* spp. infection in humans have been reported on rare occasions but the species involved have not been determined. Infection in humans are probably a result of ingestion of arthropod intermediate hosts or uncooked paratenic hosts.

References

- [1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
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- [3] Gregory GG, Munday BL. Internal parasites of feral cats from the Tasmanian Midlands and King Island. *Aust Vet J.* 1976;52:317-320.
- [4] Crossland NA et al. First report of *Cylicospirura felineus* in a feral domestic shorthair cat in North America. *JFMS Open Rep.* 2015;1:2055116915593964.
- [5] Clark WC. *Cylicospirura advena* n. sp. (Nematoda: Spirocercidae) a stomach parasite from a cat in New Zealand, with observations on related species. *Syst Parasitol.* 1981;3:185-191.

[6] Ferguson JA, Woodberry K, Gillin CM, et al. *Cylicospirura* species (Nematoda: Spirocercidae) and stomach nodules in cougars (*Puma concolor*) and bobcats (*Lynx rufus*) in Oregon. *J Wildlife Disease* 2011;47:140-153.

Flea Tapeworm (*Dipylidium caninum*)

Dipylidium caninum is a common tapeworm of dogs, which can also frequently infect cats. It is zoonotic.

Parasite species: *Dipylidium caninum*

Common name: Flea tapeworm

Hosts: Wild and domestic canids, but also cats

Pre-patent period: 2-4 weeks

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Ingestion of infected fleas and lice ^[1]

Zoonotic: Yes

Distribution

Worldwide.

Clinical signs

Dipylidium caninum infections are well tolerated by cats. When present in large numbers, *D. caninum* can cause constipation or diarrhoea, and cats may present an unthrifty, pot-bellied appearance.

Diagnosis

Dipylidium caninum infection in cats can be confirmed by detecting characteristic, double pored segments or proglottids (creamy white, cucumber seed shape, approximately 10-12 mm in length) in the faeces or in the perianal area (**Fig. 1**). Large egg packets (containing eggs approximately 25-40 µm x 30-45 µm) (**Fig. 2**) may also be detected by standard faecal flotation (**SOP 1**), but this method presents very low sensitivity and it is therefore not recommended ^[2].



Figure 1. Adult *Dipylidium* tapeworms with typical 'barrel'- or 'cucumber seed'- like proglottids in the small intestines of a cat (Image credit: Dr. A. D. Mihalca)

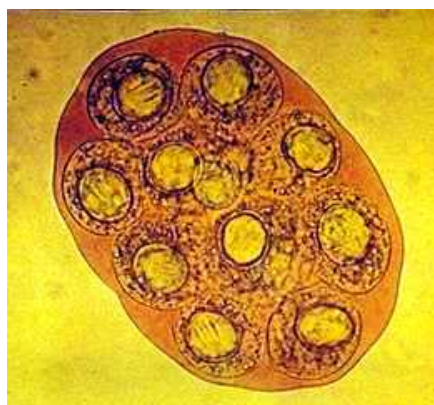


Figure 2. *Dipylidium* eggs within a capsule on faecal floatation (Image credit: The University of Melbourne parasite image library)

Treatment

For anthelmintic treatment options, refer to **Table 1**.

Prevention and control

The control of *D. caninum* can be achieved by treating infected cats at 2- 4-week intervals and using registered insecticides to keep them free of fleas and lice.

Public health considerations

Dipylidium caninum may infect humans, especially children. Most infected patients are asymptomatic, but nocturnal irritability, anorexia and weight loss may occur in infected people.

Table 1 Routes of administration, dosage and efficacies of commonly utilised anthelmintics against the primary gastrointestinal parasites of cats ^[2,3].

Anthelmintics	Route	Dosage	Ascarids	Hookworms	Tapeworms
Pyrantel pamoate	PO	20 mg/kg	✓	✓	
Pyrantel embonate	PO	57.5 mg/kg	✓	✓	
Emodepside*	Topical	3 mg/kg	✓	✓	
Praziquantel	PO, SC, IM	5 -10 mg/kg			✓
Praziquantel	Topical	8 mg/kg			✓
Fenbendazole**	PO	50 mg/kg daily for 3-5 days	✓	✓	
Ivermectin	PO	0.024 mg/kg		✓	
Milbemycin oxime*	PO	2 mg/kg	✓	✓	
Selamectin	Topical	6 mg/kg	✓	✓	
Epsiprantel	PO	2.75 mg/kg			✓
Moxidectin**	Topical	1 mg/kg moxidectin	✓	✓	
Eprinomectin*	Topical	0.5 mg/kg eprinomectin	✓	✓	

*Effective whipworms.

**Effective against whipworms and stomach worms.

Abbreviations: PO, *per os*; SC, subcutaneous; IM, intramuscular.

References

- [1] Low VL, Prakash BK, Tan TK, Sofian-Azirun M, Anwar FHK, Vinnie-Siow WY, AbuBakar S. Pathogens in ectoparasites from free-ranging animals: Infection with *Rickettsia asembonensis* in ticks, and a potentially new species of *Dipylidium* in fleas and lice. *Vet Parasitol.* 2017;245:102-105.
- [2] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
- [3] Taton-Allen G, Cheney J. Gastrointestinal parasites. In: Lappin M (ed) Feline internal medicine secrets. Philadelphia, Hanley & Belfus, 2001; p. 85-95.

Cat Tapeworm (*Taenia taeniaeformis*)

Taenia taeniaeformis is a common tapeworm of cats. It is zoonotic, but of minor significance.

Parasite species: *Taenia taeniaeformis*

Common name: Cat tapeworm

Hosts: Wild and domestic felids and canids

Pre-patent period: 34-80 days

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Predation of intermediate hosts (rodents)

Zoonotic: Yes

Distribution

Worldwide.

Clinical signs

Taenia taeniaeformis infections in cats are very rarely of clinical significance with only a few reports of intestinal obstruction due to extremely heavy infections.

Diagnosis

Taenia taeniaeformis infections in cats can be confirmed by the presence of distinctive whitish proglottids (segments) in the faeces bearing a single lateral genital pore (**Fig. 1**). As proglottids as opposed to eggs are shed in faeces, the absence of eggs on standard faecal flotation (**SOP 1**) does not rule out infection. Eggs are typical Taeniid eggs, spherical, 31-36 µm in diameter with a hexacanth embryophore (**Fig. 2**)^[1].



Figure 1. *Taenia taeniaeformis* adult tapeworms in the small intestine of a cat (Image credit: Dr. A. D. Mihalca)



Figure 2. *Taenia taeniaeformis* egg on faecal flotation bearing a hexacanth embryophore (Image credit: Dr. R. J. Traub)

Treatment

For anthelmintic treatment options, refer to **Table 1**.

Prevention and control

The control of *T. taeniaeformis* can be achieved by treating cats against tapeworms every 2-3 months, by preventing cats from hunting and eating rodents, and by controlling rodent populations.

Public health considerations

Adults of *T. taeniaeformis* have been recovered from the intestines of human patients and in a single case a strobilocercus (larval stage) was found in a serous cyst present in the liver of a human patient, who died from unrelated causes^[1]. Nevertheless, this parasite is considered of minor zoonotic significance.

Table 1 Routes of administration, dosage and efficacies of commonly utilised anthelmintics against the primary gastrointestinal parasites of cats^[2,3].

Anthelmintics	Route	Dosage	Ascarids	Hookworms	Tapeworms
Pyrantel pamoate	PO	20 mg/kg	✓	✓	
Pyrantel embonate	PO	57.5 mg/kg	✓	✓	
Emodepside*	Topical	3 mg/kg	✓	✓	
Praziquantel	PO, SC, IM	5 -10 mg/kg			✓
Praziquantel	Topical	8 mg/kg			✓
Fenbendazole**	PO	50 mg/kg daily for 3-5 days	✓	✓	
Ivermectin	PO	0.024 mg/kg		✓	
Milbemycin oxime*	PO	2 mg/kg	✓	✓	
Selamectin	Topical	6 mg/kg	✓	✓	
Epsiprantel	PO	2.75 mg/kg			✓
Moxidectin**	Topical	1 mg/kg moxidectin	✓	✓	
Eprinomectin*	Topical	0.5 mg/kg eprinomectin	✓	✓	

*Effective whipworms.

**Effective against whipworms and stomach worms.

Abbreviations: PO, *per os*; SC, subcutaneous; IM, intramuscular.

References

- [1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
- [2] Taton-Allen G, Cheney J. Gastrointestinal parasites. In: Lappin M (ed) Feline internal medicine secrets. Philadelphia, Hanley & Belfus, 2001; p. 85-95.

Intestinal Flukes

Intestinal flukes are food-borne digenean trematodes that can infect a wide range of definitive hosts, including cats. They are zoonotic.

Parasite species: *Echinochasmus perfoliatus*, *Echinochasmus japonicus*, *Echinostoma hortense*, *Echinostoma revolutum*, *Haplorchis yokogawai*, *Haplorchis taichui*, *Heterophyes heterophyes*, *Metagonimus yokogawai*, *Pharyngostomum cordatum*, *Stellantchasmus falcatus*, and many other species

Common name: Intestinal flukes

Hosts: Wild and domestic carnivores, including dogs and cats

Pre-patent period: 4-5 weeks

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Predation on intermediate hosts (e.g. brackish- and freshwater fish, toads, reptiles, shrews)

Zoonotic: Yes

Distribution

Echinochasmus perfoliatus is present in Europe, Middle and the Far East. *Pharyngostomum cordatum* is found in cats in Europe, Africa and China. *Echinochasmus japonicus*, *Echinostoma* spp. and *Haplorchis yokogawai* are present in Asia. *Haplorchis taichui* is found in the Middle East and Asia. *Stellantchasmus falcatus* has been reported from the Middle East, Asia, and Hawaii. *Heterophyes heterophyes* has been reported in the Middle East, Mediterranean, India and Japan. *Metagonimus yokogawai* has been reported in Asia, Spain and the Balkans.^[1,2,3]

Clinical signs

Most intestinal fluke infections in cats are asymptomatic. *Pharyngostomum cordatum* can cause chronic diarrhoea. Heavy infections by *M. yokogawai* are likely to cause small-bowel diarrhoea^[1].

Diagnosis

Intestinal fluke infections can be confirmed by faecal sedimentation (**SOP 4**). Eggs are large, oval, tan and operculate (**Fig. 1**) and approximately 90-135 x 55-95 µm for *E. perfoliatus*, 100 x 70 µm for *P. cordatum* and 83-120 x 58-90 µm for *Echinostoma* spp. Heterophyidae adults are minute (1-2 mm) and their eggs are small with a distinct shoulder below the operculum measuring 29-30 x 13-17 µm for *H. yokogawai*, 24-28 x 12-15 µm for *H. taichui*, 21-23 x 12-13 µm for *S. falcatus*, 27 x 16 µm for *H. heterophyes* and 26-28 x 15-17 µm for *M. yokogawai* and cannot be easily distinguished from those of feline liver fluke eggs^[1].



Figure 1. *Echinostoma* egg on faecal sedimentation (Image credit: Shutterstock)

Treatment

Off-label use of praziquantel at 30 mg/kg SC was effective in eliminating eggs from the faeces of infected cats and resolving signs of diarrhoea caused by *P. cordatum* ^[1].

Prevention and control

The control of intestinal fluke infections can be achieved by preventing cats from ingesting raw fish, and from hunting and ingesting other intermediate hosts.

Public health considerations

Many species of intestinal flukes that infect cats have been reported in humans ^[1]. Cats may act as a zoonotic reservoir for human infection in communities where fish-borne trematode zoonoses is endemic.

References

- [1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
- [2] El-Azazy OM, Abdou NE, Khalil AI, Al-Batel MK, Majeed QA, Henedi AA, Tahrani LM. Potential Zoonotic Trematodes Recovered in Stray Cats from Kuwait Municipality, Kuwait. *Korean J Parasitol.* 2015;53:279-287.
- [3] Khalil MI, El-Shahawy IS, Abdelkader HS. Studies on some fish parasites of public health importance in the southern area of Saudi Arabia. *Rev Bras Parasitol Vet.* 2014;23:435-442.

Toxoplasma (*Toxoplasma gondii*)

Toxoplasma gondii is an apicomplexan that infects domestic and wild felids (definitive hosts) and a wide range of intermediate hosts (e.g. small birds and mammals, including felids). It is zoonotic.

Parasite species: *Toxoplasma gondii*

Common name: Toxoplasma

Hosts: Cats and wild felids

Pre-patent period: 3-10 days (after ingestion of tissue cyst), but may be longer for oocyst induced infections

Location in the host: Small intestine (oocysts), different tissues (tachyzoites, bradyzoites)

Distribution: Worldwide

Transmission route: Ingestion of sporulated oocysts or tissue cysts (containing tachyzoites or bradyzoites), as well as passage of tachyzoites via placenta or milk

Zoonotic: Yes

Distribution

Worldwide.

Clinical signs

Toxoplasma gondii rarely causes clinical disease in cats. Initial infection may produce diarrhoea in young animals. As cats themselves act as intermediate hosts to the parasite, immunosuppressed cats may display clinical signs depending on the location of the tissue cysts. Common signs include fever, anorexia, uveitis, iritis, iridocyclitis, chorioretinitis, pneumonia, hepatitis, hyperaesthesia from polymyositis, and ataxia, circling, behavioural changes, seizures and tremors from nervous system infection^[1,2]. Clinical toxoplasmosis is most severe in neonates infected in utero or during lactation, leading to life-threatening, poly-systemic disease.

Diagnosis

Because cats only shed *T. gondii* oocysts (10 x 12 µm)^[1] for 1-3 weeks after their first exposure (**Fig. 1**), oocysts are rarely found in faeces by standard faecal flotation (**SOP 1**). Serological tests may be useful to determine if the cat is negative (thus, susceptible to infection) or positive (and whether it is a recent/active or past infection). Systemic, extra-intestinal symptomatic infection may be diagnosed by serology (high IgG titres) or via the detection of parasite DNA e.g. in cerebrospinal fluid or bronchoalveolar lavage. Concurrent immunosuppression with Feline Infectious Peritonitis, Feline Immunodeficiency Virus and Feline Leukaemia Virus commonly predispose to systemic toxoplasmosis as a result of recrudescence of latent infection.

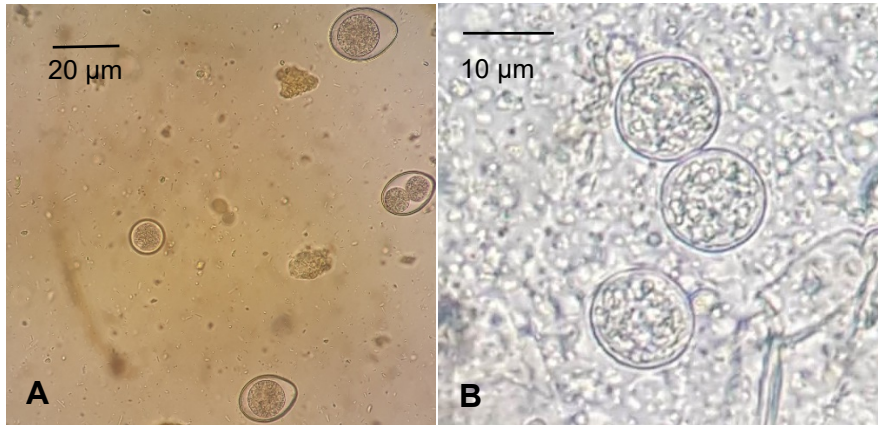


Figure 1. Oocysts of *Toxoplasma gondii* and *Cystoisospora rivolta* (A) and oocysts of *T. gondii* (B) from the faeces of a cat by faecal flotation (Image credit: Dr. B. K. Linh, Dr. M. Watanabe)

Treatment

Off-label use of clindamycin hydrochloride (10-12 mg/kg PO twice daily for 4 weeks) or clindamycin phosphate (12.5-25 mg/kg IM twice daily for 4 weeks) are reputed to be effective for treating clinical toxoplasmosis in cats. For ocular lesions, topical corticosteroids and atropine may be of additional benefit^[2].

Prevention and control

Cats should not be fed raw or undercooked meat, should be kept indoors and should not be allowed to hunt. The litter box should be changed daily; pregnant women and immunosuppressed individuals should not change litter to avoid the potential transmission of *Toxoplasma* through ingestion of sporulated oocysts.

Public health considerations

Toxoplasma gondii is zoonotic and can cause severe disease in humans. Congenital infection may occur in women that are infected for the first time during pregnancy or that are immunocompromised. Immunocompromised individuals (e.g. infected with HIV / AIDs or on immunosuppressive drugs) are also at increased risk of toxoplasmosis (either from previously latent or newly acquired infection).

Direct contact with cats is not a direct risk factor for *T. gondii* infection in humans, especially if faeces is removed from litter trays on a daily-basis as oocysts take at least 2-3 days to become infective^[2]. Ingestion of contaminated food (e.g., raw or undercooked meat, unwashed fruits and vegetables) or soil is the most common source of infection in humans. Prevention can be exercised by avoiding consumption of raw or undercooked meat, by washing hands and food preparation surfaces with warm soapy water, by wearing gloves while gardening or washing hands after gardening. Fruits and vegetables should also be washed thoroughly before eating.

References

- [1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
- [2] Davidson MG. Toxoplasmosis. *Vet Clin North Am Small Anim Pract.* 2000;30:1051-1062.
- [3] Dubey JP, Ferreira LR, Martin J and Jones J. Sporulation and survival of *Toxoplasma gondii* oocysts in different types of commercial cat litter. *J Parasitol.* 2011;97:751-754.

Intestinal Coccidia (*Cystoisospora* spp.)

Cystoisospora spp. (syn. *Isospora* spp.) are intestinal protozoans that infect a wide range of wild and domestic animals, including cats. Species that infect cats are highly host-specific and therefore not zoonotic.

Parasite species: *Cystoisospora felis*, *Cystoisospora rivolta*

Common name: Intestinal coccidia

Hosts: Wild and domestic felids

Pre-patent period: 7-11 days

Location in the host: Small intestine (asexual and sexual stages) and extra-intestinal tissues (asexual stages)

Distribution: Worldwide

Transmission route: Ingestion of sporulated oocysts and possibly predation of paratenic hosts

Zoonotic: No

Distribution

Worldwide.

Clinical signs

Cystoisospora-associated disease is mainly seen in kittens or naive adult cats entering in catteries where the infection is endemic. Clinical signs include vomiting, abdominal discomfort, inappetence, and watery diarrhoea (sometime with blood)^[1]. Severe dehydration and death can occur.

Diagnosis

Cystoisospora infections in cats can be confirmed by standard faecal flotation (**SOP 1**). Oocysts are approximately 38-51 x 27-39 µm in *C. felis* and 18-28 x 16-23 µm in *C. rivolta*^[1] (**Fig. 1**)

Treatment

Coccidiosis is generally self-limiting, and most healthy kittens will resolve clinically without therapy. However, administration of treatment can speed resolution of clinical disease and may lessen environmental contamination and the potential for infecting other in-contact animals^[1]. Options for labelled and off-label antiprotozoal treatment for coccidiosis in cats are detailed in **Table 2**.

Table 2. Routes of administration, dosage and efficacies of commonly utilised antiprotozoal agents against coccidiosis and cryptosporidiosis of cats ^[1,2].

Antiprotozoal agents	Route	Dosage	Coccidiosis	Cryptosporidiosis
Sulfadimethoxine*	Oral	50 mg/kg for 10 days or 55 mg/kg for 1 day and then 27.5 mg/kg until signs disappear	✓	
Sulfadimethoxine + ormetoprim*	Oral	55 mg/kg sulfadimethoxine + 11 mg/kg ormetoprim for up to 23 days	✓	
Sulfaguanidine*	Oral	150-200 mg/kg for 5 days	✓	
Sulfadiazine + trimethoprim*	Oral	25-50 mg/kg sulfadiazine + 5-10 mg/kg trimethoprim for 6 days for cats >4 kg; or 12.5-25 mg/kg sulfadiazine + 2.5-5 mg/kg trimethoprim for 6 days for cats under 4 kg	✓	
Furazolidone	Oral	8-20 mg/kg SID or BID for 5 days; this dose can be reduced to half if combined with sulfonamides	✓	
Paromomycin**	Oral	125-165 mg/kg SID or BID for at least 5 days		✓
Azithromycin	Oral	10 mg/kg SID until clinical signs are resolved		✓
Nitazoxanide	Oral	25 mg/kg BID for at least 7 days		✓
Tylosin[‡]	Oral	10-15 mg/kg every 8-12 hours for 21 days		✓
Ponazuril	Oral	20 mg/kg two doses given 7 days apart or 50 mg/kg, PO, once	✓	
Toltrazuril[€]	Oral	15-20 mg/kg, repeat in the following day in heavily infected cats	✓	

*Can produce profuse salivation and lethargy.

**Paromomycin should not be administered to cats with diarrhoea, considering the risk of absorption and possible nephrotoxicity ^[3].

[‡]Bitter taste so provide in capsule form.

[€] Ponazuril and toltrazuril may be superior to the other drugs because they are coccidiocidal.

Prevention and control

Good hygienic practices, regular washing of cages, and prompt removal of faeces before oocyst sporulation are advised.



Figure 1. Oocysts of *Cystoisospora rivolta* in cat faeces recovered by faecal floatation (Image credit: Dr. B. K. Linh)

Public health considerations

None.

References

- [1] Lappin M. Update on the diagnosis and management of *Isospora* spp. in dogs and cats. *Top Companion Anim Med.* 2010;25:133-135.
- [2] Scorza V, Tangtrongsup S. Update on the diagnosis and management of *Cryptosporidium* spp infections in dogs and cats. *Top Companion Anim Med.* 2010;25:163-169.

Cryptosporidium (*Cryptosporidium* spp.)

Cryptosporidium spp. are intestinal coccidia that may infect a wide range of hosts, including cats. *Cryptosporidium* spp. infecting cats are zoonotic.

Parasite species: *Cryptosporidium felis*, *Cryptosporidium parvum*

Common name: Cryptosporidium

Hosts: Cats are the primary definitive host for *C. felis*; *C. parvum* can infect a wide range of hosts and, eventually, cats

Pre-patent period: 5-7 days

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Ingestion of oocysts and possibly, tissue cysts in infected prey species

Zoonotic: Yes

Distribution

Worldwide.

Clinical signs

In most cases, *Cryptosporidium felis* infection in cats is asymptomatic. The majority of symptomatic cases of cryptosporidiosis manifest as watery diarrhoea and have been reported in cats with immune suppression or coinfection with other agents, for example feline leukaemia virus, feline immunodeficiency virus or *Tritrichomonas foetus*^[1].

Diagnosis

Cryptosporidium spp. infections in cats can be confirmed using the modified Ziehl-Neelsen staining technique (**SOP 6**). Oocysts are 3.5-5 µm in diameter in *C. felis* and 5 µm in diameter in *C. parvum* (**Fig. 1**). A direct immunofluorescent antibody assay (IFA) that simultaneously detects *Giardia* cysts and *Cryptosporidium* oocysts in dog and cat faeces is commercially available (Merifluor Cryptosporidium/Giardia; Meridian Bioscience, Inc., Cincinnati, OH) and is reputed to be more sensitive than traditional microscopic examination. PCR for the detection and quantification of *Cryptosporidium* DNA is also considered extremely sensitive and is offered by commercial labs in some countries.

Treatment

For antiprotozoal treatment options, refer to **Table 2**.

Prevention and control

Good hygienic practices, regular washing of cages, and the washing of bedding in a regular washer and drier will destroy oocysts, which are killed when exposed to high temperature (over 60°C). Contaminated surfaces can be soaked for 20 minutes in 3% hydrogen peroxide (99% kill rate) and then rinsed thoroughly. Commercial disinfectant options include soaking

surface in 10% Ox-Virin (hydrogen peroxide plus peracetic acid) for 1 hr, 3% Ox-Agua (hydrogen peroxide plus silver nitrate) for 30 min, an amine-based formula Keno-Cox 2-3% for 2 hours, cresol-based compounds including Neopredisan 135-1 and Aldecoc TGE (4% for 2 hours) [3]. Concentrated ammonia solutions (50%) can inactivate *Cryptosporidium* oocysts after 30 minutes, however care is required when handling this product as it is toxic.

Public health considerations

Cryptosporidium felis is a potential zoonoses but is responsible for less than 3% of total reported human cases [4,5]. *Cryptosporidium felis* has been isolated from HIV-positive adults and healthy children [4]. Therefore, immunocompromised individuals and children should be advised to minimise contact with cat faeces and practice high standards of personal hygiene.

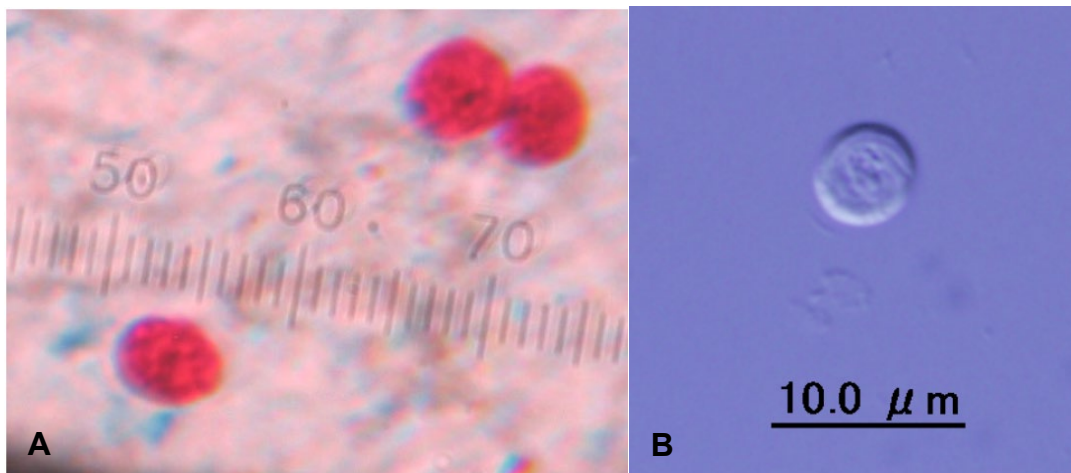


Figure 1. *Cryptosporidium* oocysts in cat faeces. A: Acid-fast staining of faecal smear. B: unstained faecal floatation (Image credit: Dr. B. K. Linh)

Table 2. Routes of administration, dosage and efficacies of commonly utilised antiprotozoal agents against coccidiosis and cryptosporidiosis of cats ^[1,2]

Antiprotozoal agents	Route	Dosage	Coccidiosis	Cryptosporidiosis
Sulfadimethoxine*	Oral	50 mg/kg for 10 days or 55 mg/kg for 1 day and then 27.5 mg/kg until signs disappear	✓	
Sulfadimethoxine + ormetoprim*	Oral	55 mg/kg sulfadimethoxine + 11 mg/kg ormetoprim for up to 23 days	✓	
Sulfaguanidine*	Oral	150-200 mg/kg for 5 days	✓	
Sulfadiazine + trimethoprim*	Oral	25-50 mg/kg sulfadiazine + 5-10 mg/kg trimethoprim for 6 days for cats >4 kg; or 12.5-25 mg/kg sulfadiazine + 2.5-5 mg/kg trimethoprim for 6 days for cats under 4 kg	✓	
Furazolidone	Oral	8-20 mg/kg SID or BID for 5 days; this dose can be reduced to half if combined with sulphonamides	✓	
Paromomycin**	Oral	125-165 mg/kg SID or BID for at least 5 days		✓
Azithromycin	Oral	10 mg/kg SID until clinical signs are resolved		✓
Nitazoxanide	Oral	25 mg/kg BID for at least 7 days		✓
Tylosin*	Oral	10-15 mg/kg every 8-12 hours for 21 days		✓
Ponazuril	Oral	20 mg/kg two doses given 7 days apart or 50 mg/kg, PO, once	✓	
Toltrazuril[€]	Oral	15-20 mg/kg, repeat in the following day in heavily infected cats	✓	

*Can produce profuse salivation and lethargy.

**Paromomycin should not be administered to cats with diarrhoea, considering the risk of absorption and possible nephrotoxicity ^[3].

‡Bitter taste so provide in capsule form.

€ Ponazuril and toltrazuril may be superior to the other drugs because they are coccidiocidal.

References

- [1] Scorza V, Tangtrongsup S. Update on the diagnosis and management of *Cryptosporidium* spp infections in dogs and cats. *Top Companion Anim Med.* 2010;25:163-169.
- [2] Lappin M. Update on the diagnosis and management of *Isospora* spp. in dogs and cats. *Top Companion Anim Med.* 2010;25:133-135.
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Giardia (*Giardia duodenalis*)

Giardia spp. are flagellated intestinal protozoa that can infect a wide range of wild and domestic animals, including cats. Some genetic assemblages (A and B) are zoonotic.

Parasite species: *Giardia duodenalis* (syn. *G. intestinalis*, *G. lamblia*)

Common name: Giardia

Hosts: Assemblage A and occasionally B is found in a range of wild and domestic animals (including cats), whereas assemblage F is restricted to cats

Pre-patent period: 5-16 days

Location in the host: Small intestine

Distribution: Worldwide

Transmission route: Ingestion of cysts from contaminated water and food

Zoonotic: Yes (assemblage A)

Distribution

Worldwide.

Clinical signs

The most common clinical sign of *G. duodenalis* infection in cats is diarrhoea. Some cats may present vomiting, weight loss, and kittens may fail to gain weight. Faeces tend to be soft and pale in colour ^[1]. Adults cats are usually asymptomatic.

Diagnosis

Giardia duodenalis infection in cats can be confirmed by centrifugal faecal flotation using zinc sulfate solution with a SG of 1.18 (**SOP 2**) for the detection of cysts (approximately 7.4 x 10.5 µm) (**Fig. 1**). A direct wet fresh faecal smear examination from cats with diarrhoea may reveal the presence of motile 'tumbling' or 'falling leaf' trophozoites (~10.5-17.5 x 5.25-8.75 µm) (**Fig. 2**), but these need to be differentiated from *Tritrichomonas foetus*. A direct immunofluorescence assay containing monoclonal antibodies that react with *Cryptosporidium* oocysts and *Giardia* cysts in faeces (Merifluor Cryptosporidium/Giardia direct immunofluorescence assay, Meridian Laboratories) is commercially available. Commercial enzyme-linked immunosorbent assays (ELISAs) are also widely available for the detection of *Giardia* coproantigens, including point-of-care tests (e.g. SNAP Giardia Test, IDEXX Laboratories). PCR for the detection and quantification of *Giardia* DNA is also considered extremely sensitive and is offered by commercial labs in some countries.

Treatment

For antiprotozoal treatment options, refer to **Table 3**.

Table 3. Routes of administration, dosage and efficacies of commonly utilised drugs against *G. duodenalis* infection in cats ^[2,3].

Drug	Route	Dosage
Metronidazole benzoate*	PO	25 mg/kg SID or BID for 7 days
Fenbendazole	PO	50 mg/kg SID for 5 days
Pyrantel + praziquantel + febantel	PO	56 mg/kg (based on the febantel component) SID for 3 days
Quinacrine	PO	11 mg/kg SID for 12 days
Furazolidone**	PO	4 mg/kg BID for 7-10 days

* Neurological toxicity may develop following either chronic therapy or acute high doses

** Furazolidone causes inappetence and vomiting



Figure 1. *Giardia duodenalis* cysts on centrifugal faecal flotation (Image credit: Dr. T. Inpankaew)

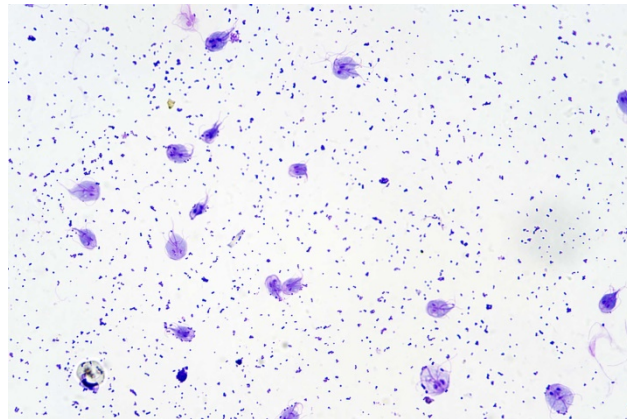


Figure 2. Stained faecal smear displaying *Giardia duodenalis* binucleate trophozoites in cat faeces (Image credit: Shutterstock)

Prevention and control

The most effective way to control *Giardia* infection is by treating all cats in the household or cattery at the same time and practicing high standards of environmental hygiene. For cats that appear unresponsive to treatment, the potential for re-infection should be considered.

Public health considerations

Although assemblage A and B of *G. duodenalis* is zoonotic, cats are primarily infected with assemblage F and, therefore, not considered to play a role in the transmission of *Giardia* to humans.

References

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Tritrichomonas (*Tritrichomonas foetus*)

Tritrichomonas foetus causes chronic diarrhoea and is recognised as an emerging disease of cats worldwide.

Parasite species: *Tritrichomonas foetus* (syn. *Tritrichomonas blagburni*)

Common name: Tritrichomonas

Hosts: *Tritrichomonas foetus* is specific to the cat. The bovine and feline isolates of *T. foetus* are phenotypically distinct

Pre-patent period: Several days to years

Location in the host: Large intestine

Distribution: Worldwide

Transmission route: Faecal-oral route. Cats become infected by ingestion of trophozoites from contaminated sources or through grooming an infected cat

Zoonotic: No

Distribution

Worldwide.

Clinical signs

The most common clinical sign of *Tritrichomonas* infection in cats is subacute or most often chronic, intermittent large-bowel diarrhoea which is often 'cow pat'-like, pale in colour and malodorous. Associated signs of colitis including fresh blood, mucous, faecal incontinence, tenesmus and flatulence may be observed ^[1,2]. Clinical signs are reported to persist for 5 to 24 months. Cats may also act as asymptomatic carriers.

Diagnosis

Tritrichomonas foetus infections in cats can be detected by direct microscopic examination of wet faecal smears, however this method is insensitive, and motile trophozoites (**Fig. 1**) must be differentiated from *Pentatrichomonas hominis* and *Giardia* trophozoites, which appear similar. *Tritrichomonas foetus* has a forward swimming rapid movement compared with the "falling leaf" movement of *Giardia* trophozoites. *Tritrichomonas foetus* (and *P. hominis*) can be cultured from faeces in special media (InPouch TF; BioMed Diagnostics, Inc, White City, OR USA). Both the aforementioned diagnostic techniques require faeces be freshly collected and not refrigerated. PCR for the detection and quantification of *T. foetus* DNA is offered by commercial labs in some countries.

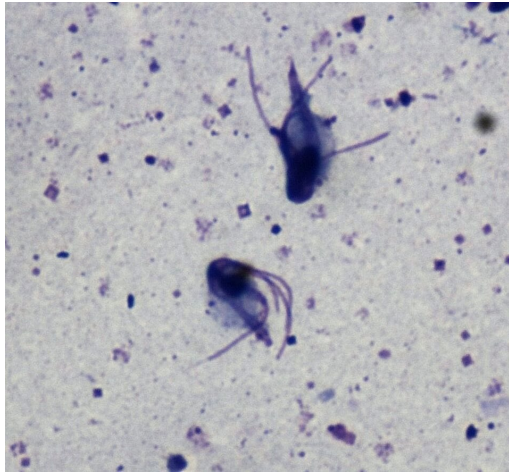


Figure 1. Stained trophozoites of *Tritrichomonas foetus* in a faecal smear of a cat (Image credit: Dr. M. Watanabe)

Treatment

There are no products registered for the treatment of trichomoniasis in cats. Off-label ronidazole (30 mg/kg PO SID for 14 days) has been recommended in cats ^[1]. Ronidazole should not be used in cats that are systemically unwell, in pregnant or lactating female cats, or in kittens less than 12 weeks of age. Signs of ronidazole neurotoxicity include lethargy, inappetence, ataxia and seizures. Cats must be closely monitored and treatment discontinued if these side effects are observed ^[1].

Prevention and control

Trichomoniasis is a particular problem in catteries and where large numbers of cats are kept together. Proper attention to hygiene, cleaning litter trays, and disinfection are important to minimise the spread of infection.

Public health considerations

None.

References

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Parasites of Other Systems

Lungworms

Feline lungworms include a range of metastrongyloid worms whose adults live in the lungs of their vertebrate hosts, including cats. Some trichurids and flukes also live in the respiratory system of cats and are zoonotic.

Parasite species: *Aelurostrongylus abstrusus*, *Angiostrongylus chabaudi*, *Oslerus rostratus*, *Troglostrongylus brevior*, *Troglostrongylus subcrenatus*, *Eucoleus aerophilus* (syn. *Capillaria aerophila*)

Common name: Lungworms

Hosts: Wild and domestic felids

Pre-patent period: Variable, depending on species

Location in the host: Lungs

Distribution: Worldwide

Transmission route: *Aelurostrongylus abstrusus*, *A. chabaudi*, *O. rostratus*, *Troglostrongylus* spp.: predation of intermediate hosts (snail and slugs) or paratenic hosts (rats, mice, lizards, frogs, birds); *E. aerophilus*: ingestion of embryonated eggs or predation of facultative paratenic hosts (earthworms)

Zoonotic: Yes (*E. aerophilus*)

Distribution

Aelurostrongylus abstrusus and *E. aerophilus* have a worldwide distribution. *Troglostrongylus* spp. have been reported in Europe. *Angiostrongylus chabaudi* has been detected in cats in Italy, Romania, Greece and Bulgaria^[1,2,3]. *Oslerus rostratus* has been reported in the United States, Pacific Islands, Southern Europe, and the Middle East.

Clinical signs

Infection by lungworms in cats may be subclinical. Some cats may present mild to severe respiratory signs due to allergic bronchopneumonia, occasionally complicated by pleural effusion or pneumothorax. Common clinical signs in sick cats include productive cough, mucopurulent nasal discharge, tachypnoea, dyspnoea with laboured, abdominal breathing and end-inspiratory crackles upon auscultation^[4].

Diagnosis

First-stage larvae of feline lungworms can be detected using the Baermann method and differentiated to the species level by morphology (approximately 360-415 µm in *A. abstrusus* (**Fig. 1**), 335-412 µm in *O. rostratus*, 300-357 µm in *T. brevior* (**Fig. 2**), 269-317 µm in *T. subcrenatus*, and 307-420 µm in *A. chabaudi*, based on larvae from wildcats). As their length may overlap^[3,5], species identity is usually preferentially confirmed by genetic characterization in epidemiological studies. *Eucoleus aerophilus* infections (**Fig. 3**) can be diagnosed using standard faecal flotation, by detecting eggs (approximately 60-65 x 25-40

µm) with a typical barrel shape, asymmetric polar plugs, with no thickening at the base of the plug (Fig. 4).

Treatment

For preventative treatment options, refer to **Table 6**.

Table 6. Routes of administration, dosage and efficacies of commonly utilised anthelmintics against the main lungworms of cats ^[4].

Anthelmintics	Route	Dosage	<i>A. abstrusus</i>	<i>E. aerophilus</i>	<i>T. brevior</i>
Fenbendazole	PO	50 mg/kg SID for 3 days (5 - 7 days for <i>E. aerophilus</i>)	✓	✓	
Moxidectin	Topical	1 mg/kg	✓	✓	
Emodepside	Topical	3 mg/kg repeated in 15 days	✓	✓	✓
Eprinomectin	Topical	0.5 mg/kg	✓		✓
Milbemycin oxime	PO	2 mg/kg administered 3 times, at 15 days intervals	✓		
Selamectin	Topical	6 mg/kg monthly, administered 2-3 times	✓		

Prevention and control

Cats should be kept indoors and should not be allowed to hunt. The litter box should be changed daily.

Public health considerations

Human infections with *E. aerophilus* have been reported in several countries around the world. The most common signs described were acute bronchitis and bronchiolitis, usually with asthma and a productive cough.



Figure 1. *Aelurostrongylus abstrusus* larva with a 'kinked' tail in cat faeces isolated by the Baermann technique (Image credit: Dr. A. D. Mihalca)



Figure 2. *Trogostrongylus brevior* larva with a 'kinked' tail in cat faeces isolated by the Baermann technique (Image credit: Dr. H. Salant)



Figure 3. *Eucoleus aerophilus* adult worms under the epithelium of the trachea (Image credit: Dr. A. D. Mihalca)

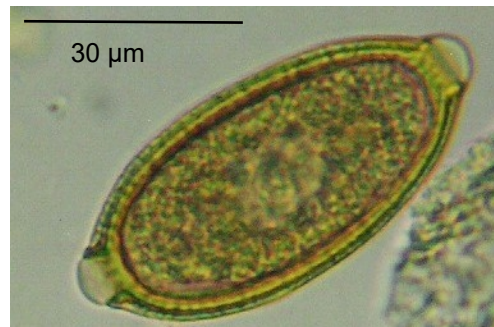


Figure 4. *Eucoleus aerophilus* egg (Image credit: Dr. G. Perez-Tort)

References

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Lung Flukes (*Paragonimus* spp.)

Lung flukes are trematodes that can infect a wide range of definitive hosts, including cats. They are zoonotic.

Parasite species: *Paragonimus westermani*, *Paragonimus pulmonalis*, *Paragonimus skrjabini*, *Paragonimus heterotremus*, *Paragonimus kellicotti*, *Paragonimus mexicanus*, and many other species ^[1]

Common name: Lung fluke

Hosts: Wild and domestic carnivores, including dogs and cats

Pre-patent period: 5-7 weeks (reported for *P. kellicotti*)

Location in the host: Lungs

Distribution: Worldwide

Transmission route: Predation on intermediate hosts (e.g. freshwater crabs, crayfish)

Zoonotic: Yes

Distribution

Paragonimus westermani is found in far East Asia and the Philippines. *Paragonimus pulmonalis* is found in Japan, Korea and Taiwan. *Paragonimus heterotremus* is found in China, India, Thailand, Vietnam and Laos. *Paragonimus skrjabini* is found in China, Japan, India and Vietnam ^[1]. *Paragonimus kellicotti* is found in North America. *Paragonimus mexicanus* is found in Mexico, Central America, and South America ^[2].

Clinical signs

Heavy *P. westermani* infection in cats may cause pneumothorax with pleural effusion as early as 3-4 weeks post infection due to the migration of juvenile worms through the diaphragm, pleura and lung parenchyma prior to becoming encapsulated as adults ^[3]. A fatal case of *P. heterotremus* infection has been reported in a cat in Thailand ^[2]. Occasional coughing, as well as bouts of paroxysmal coughing and dyspnoea due to pneumothorax from rupture of lung cysts has been described in cats infected by *P. kellicotti* ^[4].

Diagnosis

Lung fluke infections can be confirmed by faecal sedimentation. Eggs, which are operculated and contain a fully developed miracidium (**Fig. 1**), are approximately 70-100 x 39-55 µm in *P. westermani*, 85-100 x 40-58 µm in *P. pulmonalis*, 86 x 48 µm in *P. heterotremus*, 80-100 x 55-65 µm in *P. kellicotti* and 79 x 48 µm in *P. mexicanus* ^[1].

Treatment

Off-label use of praziquantel at 100 mg/kg PO twice daily for 2 days was effective against *P. westermani* in a heavily infected cat. Off-label use of praziquantel 23 mg/kg PO three-times daily for 3 days was effective in treating cats experimentally infected by *P. kellicotti*.



Figure 1. *Paragonimus* sp. egg with a distinct operculum (Image credit: Shutterstock)

Prevention and control

The control of lung fluke infections can be achieved by preventing cats from hunting and eating intermediate hosts and not allowing them to ingest raw crab and crayfish.

Public health considerations

Many species of lung flukes that infect cats have been reported in humans. Cats do not pose a direct zoonotic risk as humans acquire paragonimosis through the ingestion of undercooked crab and crayfish.

References

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Liver Flukes

Liver flukes are digenean trematodes that can infect a wide range of definitive hosts, including cats. They are indirect (food-borne) zoonoses.

Parasite species: *Platynosomum concinnum* (syn. *P. fastosum*, *P. illiciens*), *Amphimerus pseudofelineus*, *Clonorchis sinensis*, *Opisthorchis felineus*, *Opisthorchis viverrini*, *Metorchis conjunctus*, and many other species

Common name: Liver fluke

Hosts: Wild and domestic carnivores, including dogs and cats

Pre-patent period: 2-4 weeks

Location in the host: Gallbladder and/or bile ducts; some species can occasionally be found in the pancreatic duct or the small intestine

Distribution: Worldwide

Transmission route: Predation of intermediate and paratenic hosts (e.g. freshwater fish, lizards, frogs, toads and potentially mice and birds)

Zoonotic: Yes

Distribution

Platynosomum concinnum is found in Malaysia, Hawaii, West Africa, South America, the Caribbean, and areas surrounding the Gulf of Mexico ^[1,2]. *Amphimerus pseudofelineus* is found in the Americas. *Clonorchis sinensis* is found in northern Vietnam, China ^[3]. *Opisthorchis felineus* has been reported from Europe and Russia. *Opisthorchis viverrini* is found in southern Vietnam, Thailand, Laos, Malaysia, and India ^[3]. *Metorchis conjunctus* is found in North America.

Clinical signs

Cats infected by *P. concinnum* may present diarrhoea, depression, anorexia, weight loss, jaundice, liver enlargement and vomiting. *Amphimerus pseudofelineus*-infected cats may present anorexia, weight loss, diarrhoea, vomiting, icterus, and liver enlargement; some cats may develop severe cirrhosis of the liver and ultimately die ^[2]. *Clonorchis sinensis* may also cause cirrhosis. *Metorchis conjunctus* can cause icterus, haematuria, diarrhoea, chronic cholangiohepatitis, cirrhosis, emaciation, ascites and jaundice.

Diagnosis

Liver fluke infections can be confirmed by faecal sedimentation. Eggs are operculated and measure approximately 34-50 x 20-35 µm in *P. concinnum*, 27 x 15 µm in *A. pseudofelineus*, 28-35 x 12-19 µm in *C. sinensis*, 30 x 11 µm in *O. felineus*, 27 x 15 µm in *O. viverrini* and 22-32 x 11-18 µm in *M. conjunctus* ^[1].



Figure 1. Liver fluke eggs with distinct 'shoulder' below the operculum 'cap' (Image credit: Shutterstock)

Treatment

The following treatments represent off-label use of praziquantel. Praziquantel at 20 mg/kg PO or IM once daily for 3-5 days, repeated 12 weeks later is considered to be the most effective drug against *P. concinnum* infections in cats [4]. For feline opisthorchiasis, a single dose of 40 mg/kg praziquantel was effective and safe for the treatment of cats [5].

Prevention and control

The control of liver fluke infections can be achieved by preventing cats from hunting and eating intermediate or paratenic hosts. Infection in humans is due to consumption of intermediate or paratenic hosts.

Public health considerations

Many species of liver flukes that infect cats have been reported in humans [1]. Cats may act as a zoonotic reservoir for human infection in communities where fish-borne trematode zoonoses is endemic.

References

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Giant Kidney Worm (*Diioctophyme renale*)

Diioctophyme renale is a large enoplid nematode that infects the kidneys of dogs and occasionally cats. It is zoonotic.

Parasite species: *Diioctophyme renale*

Common name: Giant kidney worm

Hosts: Wild carnivores, dogs, and cats

Pre-patent period: 3.5-6 months

Location in the host: Kidneys

Distribution: Worldwide

Transmission route: Ingestion of intermediate (aquatic worms) or paratenic hosts (fish, crustaceans, frogs or other amphibians)

Zoonotic: Yes

Distribution

Diioctophyme renale is found worldwide but is less common in Africa and Oceania.

Clinical signs

Diioctophyme renale infection in cats may cause a range of clinical manifestations, varying from subclinical to severe life-threatening disease. Clinical signs may include weakness, jaundice, dehydration, ascites and prostration. Parasite invasion into the peritoneal cavity can lead to adhesions, peritonitis and, eventually, death ^[1].

Diagnosis

Diioctophyme renale infections in cats can be confirmed by finding eggs in urine samples. Eggs (approximately 62-75 x 36-53 µm) (**Fig. 1**) have elliptical shape, generally with symmetrical and clear bipolar plugs, covered by a thick, rough shell ^[2]. Imaging techniques (e.g. radiography and ultrasonography) may help in revealing the presence of adult worms in the kidneys. Nonetheless, the diagnosis is often done during surgery for other reasons or eventually during necropsy (**Fig. 2**).



Figure 1. Egg of *Diioctophyme renale* in a urine sample (Image credit: Dr. G. Perez-Tort)

Treatment

The surgical removal of worms from the kidney is the most effective and commonly recommended treatment against *D. renale*.

Prevention and control

The control of *D. renale* may be achieved by preventing cats from hunting and eating aquatic worms, fish, crustaceans, frogs or other amphibians.



Figure 2. Adult *Diotophyme renale* worms excised from kidney of a dog (Image credit: Dr. G. Perez-Tort)

Public health considerations

Cases of human infection by *D. renale* have been reported. The eggs shed by infected dogs and cats are not directly infective for humans. Humans become infected after eating raw or insufficiently cooked fish or frogs (paratenic hosts).

References

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Paralysis Worm (*Gurltia paralyans*)

Gurltia paralyans is a unique metastrongyloid nematode that causes paralysis in cats in South America.

Parasite species: *Gurltia paralyans*

Common name: Paralysis worm

Hosts: Wild and domestic felids

Pre-patent period: Unknown

Location in the host: Veins of the spinal cord subarachnoid space and parenchyma

Distribution: South America

Transmission route: Predation of paratenic hosts (possibly lizards, rodents, and birds) or intermediate hosts (possibly terrestrial slugs or snails)

Zoonotic: Unknown

Distribution

South America.

Clinical signs

Clinical signs reported in *G. paralyans*-infected cats include chronic and progressive ambulatory paraparesis or paraplegia, pelvic limb ataxia, pelvic limb proprioceptive deficit, hyperactive patellar reflexes, pelvic limb muscle atrophy, tail trembling, tail atony, diarrhoea, weight loss, urinary and faecal incontinence ^[1]. Some cats may die from this infection.

Diagnosis

Gurltia paralyans eggs and larvae are not typically found in faecal samples of domestic cats. The infection is usually diagnosed based on neurological signs and the exclusion of other possible causes of feline myelopathies. Imaging tools (radiography, computed tomography) may be useful in this way. Nonetheless, many cases are only confirmed by finding adult worms during post-mortem examination. A semi-nested PCR assay has been developed to detect *G. paralyans* DNA, but this assay has not yet been validated using blood or faecal samples.

Treatment

To date, no therapy has been proven effective against *G. paralyans* infection in cats.

Prevention and control

Owners should be advised to prevent cats from hunting and eating potential paratenic and intermediate hosts.

Public health considerations

Zoonotic potential of *G. paralyans* is unknown.

Reference

- [1] Muñoz P, Hirzmann J, Rodriguez E, Moroni M, Taubert A, Gibbons L, Hermosilla C, Gómez M. Redescription and first molecular characterization of the little known feline neurotropic nematode *Gurltia paralyisans* (Nematoda: Metastrongyloidea). *Vet Parasitol Reg Stud Rep*. 2017;10:119-125.

Gapeworms (*Mammomonogamus* spp.)

Gapeworms are stronglylid nematodes of the respiratory system that can infect a wide range of hosts, although *M. ierei* and *M. auris* appear to be host specific. Neither *M. ierei* nor *M. auris* are considered zoonotic, although other *Mammomonogamus* spp. can be.

Parasite species: *Mammomonogamus ierei*, *Mammomonogamus auris*

Common name: Gapeworms

Hosts: Wild felids, cats

Pre-patent period: Unknown

Location in the host: *M. ierei* nares and naso-pharynx; *M. auris* middle ear

Distribution: Worldwide

Transmission route: Unknown but likely via intermediate hosts

Zoonotic: No

Distribution

Mammomonogamus has a disparate distribution in cats with *M. ierei* reported in the Caribbean and *M. auris* reported in China, Japan and Sri Lanka. Non-specified species also have been reported in wild felids in Africa, Thailand, South, Central and North America ^[1].

Clinical signs

Cats can be asymptomatic. When clinical signs are present they can include inflammation of the nasopharynx resulting in a mucoid nasal discharge, coughing, sneezing episodes and weight loss (*M. ierei*) and head shaking with *M. auris* ^[1].

Diagnosis

Eggs shed via the faeces or sputum and may be observed by simple floatation (**SOP1**). *Mammomonogamus ierei* eggs are ovoid and approximately 49.5 × 92.0 µm (**Fig. 1**). Although the eggs of *Mammomonogamus* superficially resemble those of hookworms, they can be easily distinguished from the latter based on their larger size and the thicker striated shell. Otoscopic examination also can be used for *M. auris* diagnosis with the adult worms visible and presenting as a “Y” shape (**Fig. 2**). Occasionally, the adult worms are expelled by the host ^[1].

Treatment

Fenbendazole (50 mg/kg PO daily for 5 days) was shown to be effective in treating *M. ierei*. Selamectin and a combination of thiabendazole, dexamethasone and neomycin have been used to treat *M. auris*. Since mebendazole and ivermectin have been used to treat *Mammomonogamus* in other hosts, this suggests that both benzimidazoles and macrocyclic lactones could be effective in cats.



Figure 1. Egg of *Mammomonogamus* on a faecal float (Image credit: Dr. J. Ketzis)

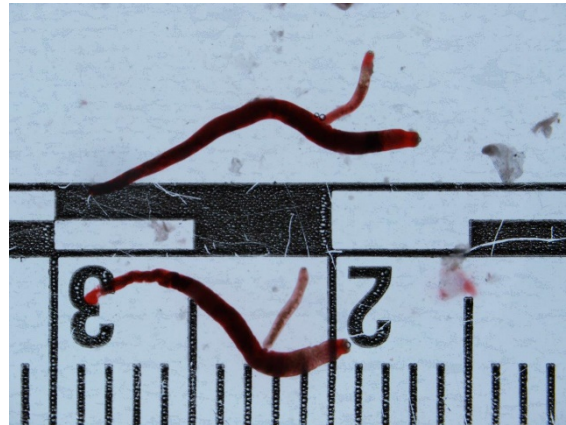


Figure 2. *Mammomonogamus* paired male and female adult worms (Image credit: Dr. J. Ketzis)

Prevention and control

The route of infection is unknown and hence prevention and control measures are unclear. It is believed that infection is likely through intermediate or paratenic hosts; therefore, preventing cats from hunting and eating insects should decrease the risk of infection.

Public health considerations

Mammomonogamus spp. infecting cats have not been identified as zoonotic.

Reference

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Lagochilascaris (*Lagochilascaris* spp.)

Lagochilascaris spp. are nematodes found in Neotropical regions of Latin America. There are two species which affect domestic cats: *L. minor* and *L. major*. The adults are localized in abscesses in the neck region or in the oral cavity that tend to fistulise outward.

Parasite species: *Lagochilascaris major*, *Lagochilascaris minor*

Common name: Lagochilascaris

Hosts: Cats, dogs, wild felids, rodents and opossums

Pre-patent period: Between 17-26 days or more

Location in the host: The adults are inside nodules in the neck region or in the oral cavity. Less frequently, in the ears, tongue, eyes or pharynx

Distribution: Tropical areas in Central and South America

Transmission route: Indirect cycle, mice are the intermediate host

Zoonotic: Yes

Distribution

Lagochilascaris minor is the most important species infecting cats and it is found in several countries, including Mexico, Costa Rica, Venezuela, Suriname, Trinidad and Tobago, Colombia, Bolivia, Paraguay, Ecuador, Argentina and Brazil.

Clinical signs

The most important clinical sign in cats is nodules, fistulized or not, in the neck or inside the mouth. Others signs are anorexia, dysphagia, mimic of touching the affected area, presence of an exudate in the neck, profuse salivation, cough, otitis, vestibular syndrome, neurological signs.

Diagnosis

The faecal floatation constitutes diagnostic method of choice in a patient where no nodule or fistula is found. Eggs are around 60 µm in diameter. Eggs have a thickened brown shell and approximately 15 to 25 pits around the circumference in *L. minor* and 33 to 45 in *L. major*. It is important to note that these eggs can be observed microscopically when studying the fistula fluid. The extraction of the worms under anaesthesia or sedation as required will allow their taxonomic identification.

Treatment

The treatment is with fenbendazole (50 mg/kg/day PO for 7 days) or ivermectin (0.4 mg/kg SC). Some authors recommend repeating at 15 days.

Prevention and control

There is limited knowledge about the prevention and control of *Lagochilascaris* spp. infections in cats. As a general recommendation, preventing predation and scavenging activities as well as prompt removal of faeces is advised.

Public health considerations

Lagochilascaris minor is implicated in the human form of the disease. It is remarkable that the majority of cases of human lagochilascariasis in the Americas have been reported in Brazil ^[1].

References

[1] Campos DMB, Barbosa AP, Oliveira JA, Tavares GG, Cravo PVL, Ostermayer AL. Human lagochilascariasis-A rare helminthic disease. *PLoS Negl Trop Dis*. 2017;11(6):e0005510.

Pentastomids (*Armillifer* spp., *Porocephalus* spp.)

Armillifer spp. are parasitic crustaceans belonging to the group Pentastomida, whose immature forms are incidentally discovered within the abdominal cavity and viscera of dogs and cats. They are mostly non-pathogenic.

Parasite species: *Armillifer armillatus*, *Armillifer moniliformis*, *Armillifer grandis*, *Armillifer agkistrodontis*, *Porocephalus crotali*

Common name: Visceral pentastomids

Hosts: Snakes and other reptiles are definitive hosts, small mammals (rodents) are intermediate hosts. Dogs, cats and humans are accidental hosts for larval and nymphal stages

Pre-patent period: N/A

Location in the host: Usually abdominal cavity within viscera

Distribution: Tropics and subtropics

Transmission route: Ingestion of parasite eggs shed by reptiles, ingestion of undercooked reptile meat/rodents

Zoonotic: Yes (snakes are primary reservoirs)

Distribution

Visceral pentastomiasis has been reported in humans throughout the tropics and subtropics and is considered an emerging zoonosis in West Africa. *Armillifer armillatus* is present in West and Central Africa, *A. moniliformis* in Southeast Asia, *A. grandis* in Africa, *A. agkistrodontis* in China, and *Porocephalus crotali* is worldwide distributed.

Clinical signs

Visceral pentastomiasis is usually asymptomatic. Rarely, large parasite loads may result in abdominal or thoracic involvement due to organ dysfunction.

Diagnosis

Nymphs may be incidentally discovered within the liver, mesenteries, spleen, and lungs during surgery (**Fig. 1**) or coiled opacities of calcified dead parasites may be observed on abdominal or chest radiographs.



Figure 1 Nymph of *A. moniliformis* (anterior end damaged) incidentally found within the omentum of a cat during surgery (*Image credit: Dr. S. Teoh*)

Treatment

Visceral pentastomiasis is usually asymptomatic and surgical removal of the nymphs should be considered only for symptomatic animals with high parasite loads.

Prevention and control

Owners should be advised to prevent their animals from hunting and roaming freely.

Public health considerations

Dog (and cats) do not pose a direct risk to humans.

Heartworm (*Dirofilaria immitis*)

Dirofilaria immitis is a filarial nematode of domestic and wild canids that can also infect other hosts, including cats. It rarely causes zoonotic infections.

Parasite species: *Dirofilaria immitis*

Common name: Heartworms

Hosts: Domestic and wild canids, cats

Pre-patent period: 7-8 months

Location in the host: Right ventricle and pulmonary artery

Distribution: Worldwide

Transmission route: Via infected mosquito bites

Zoonotic: Yes

Distribution

Tropics and subtropics, where heartworm is known to occur in dogs. The prevalence of feline adult heartworm infection is estimated to be 5-20% the rate of dogs ^[1].

Clinical signs

In cats, clinical signs develop either due to arrival of heartworms in the pulmonary arteries (3-4 months post-infection) or due to death of adult worms. The predominant clinical signs in cats are wheezing, coughing, dyspnoea and respiratory distress. Other clinical signs include vomiting and neurological deficits. As the clinical signs of involvement of the lower respiratory tract is more common than that of the heart, heartworm associated respiratory disease (HARD) is often used to describe the disease in cats. In some cats, disease can be peracute and present as sudden death, often associated with the death of adult worms.

Diagnosis

Dirofilaria immitis infections in cats can be difficult to confirm. Cats typically present with low worm burdens (often a single worm) and without circulating microfilariae. In the same way, many infected cats will not present circulating heartworm antigens or anti-heartworm antibodies. A lateral flow immunoassay for the detection of IgG antibodies to *D. immitis* is commercially available (HESKA Solo Step FH, Heska Corporation, Loveland, USA). A positive heartworm antibody test would increase 'suspicion' of *D. immitis*, but is not in itself diagnostic. Radiography and echocardiography are reputed to be useful for diagnosing feline heartworm disease ^[2,3]. Heat treatment of blood prior to antigen testing also can be helpful in diagnosing heartworm in cats suspected of infection ^[4]. Bronchioalveolar wash may reveal eosinophil infiltrates which can be confused with allergic bronchitis e.g. feline asthma or *Aelurostrongylus abstrusus* infection.

Treatment

In contrast to treatment of canine heartworm disease, adulticides (e.g. melarsomine) are not recommended in cats. There is no approved drug for the treatment of heartworm infection in

cats. There is no recommendation to treat asymptomatic cats with confirmed heartworm infection; however, owners should be advised that clinical signs may develop and sudden death is a possible outcome. Sick cats should receive supportive care, according to the clinical signs present. Cats in acute respiratory distress should receive corticosteroids (prednisolone at 1 mg/kg BID or dexamethasone at 0.01-0.16 mg/kg IV or SC daily for 3 days), bronchodilators (e.g. terbutaline at 0.1-0.2 mg/kg PO BID), aminophylline at 6.6 mg/kg PO BID or theophylline at 4 mg/kg PO BID) and oxygen supplementation ^[1]. Prednisolone (1 mg/kg BID, tapering dose) is recommended for symptomatic infected cats with radiographic evidence of lung disease. All heartworm positive cats should be given chemoprophylaxis using a macrocyclic lactone. Surgical removal of heartworms from right atrium of cats has been successfully performed, but the owners should be advised that this is a very risky procedure.

Control

Monthly chemoprophylaxis is recommended for cats living in areas where canine heartworm is endemic. For preventative treatment options, refer to **Table 4**.

Table 4. Routes of administration and dosage of commonly utilised preventatives against heartworm infection in cats ^[1,2].

Anthelmintics	Route	Dosage (monthly)
Milbemycin oxime	PO	2 mg/kg
Ivermectin	PO	0.024 mg/kg
Eprinomectin	Topical	0.5 mg/kg
Moxidectin	Topical	1 mg/kg
Selamectin	Topical	6 mg/kg

Public health considerations

Although *D. immitis* infection is rare in humans, it can cause respiratory manifestations such as coughing, chest pain and haemoptysis. Granulomas in the lungs resembling ‘coin-like’ lesions have also been detected on radiographs of infected humans. Ocular infections have also been reported. As cats are not the natural definitive host for *D. immitis*, they are unlikely reservoirs for zoonotic infection.

References

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Babesia (*Babesia* spp.)

Babesia spp. are protozoans that infect wild and domestic cats worldwide. *Babesia* species that infect cats are not known to be zoonotic.

Parasite species: *Babesia felis*, *B. cati*, *B. leo*, *B. lengau*, *B. hongkongensis*, *B. presentii*, and others

Common name: Babesia

Hosts: Domestic cats and wild felids

Pre-patent period: Unknown

Location in the host: Erythrocytes (trophozoites) and bloodstream (merozoites)

Distribution: Worldwide

Transmission route: Not experimentally proven in cats, but supposedly tick-borne

Zoonotic: No

Distribution

Babesia infections in cats have mainly been reported from southern Africa but various species have a worldwide distribution^[1].

Clinical signs

The main clinical sign is pallor (pale mucous membranes) caused by anaemia which is generally haemolytic and regenerative. Cats tolerate anaemic states better than dogs as they are less active; however, severe anaemia will result in weakness and lethargy. Icterus (jaundice), vomiting, diarrhoea and an unkempt coat are also reported. Cerebral babesiosis has been described in cats with *B. lengau* infection^[2].

Diagnosis

Diagnosis of feline babesiosis is based on cytological examination of a stained-blood smear (Romanowsky-type stain) to identify characteristic red blood cell inclusions (**Fig. 1**). *Babesia felis* is a small piroplasm, very similar in appearance to *B. gibsoni*, but other species and larger forms of *Babesia* may be observed in some geographical localities. It is not possible to determine the species visually (although local knowledge is helpful). Reliable speciation of piroplasms requires molecular tools. The differential diagnoses for such inclusions are *Cytauxzoon* spp. and *Theileria* spp. (both piroplasms), and haemotropic *Mycoplasma* species. Serological and molecular diagnostic testing (PCR) are not widely available.

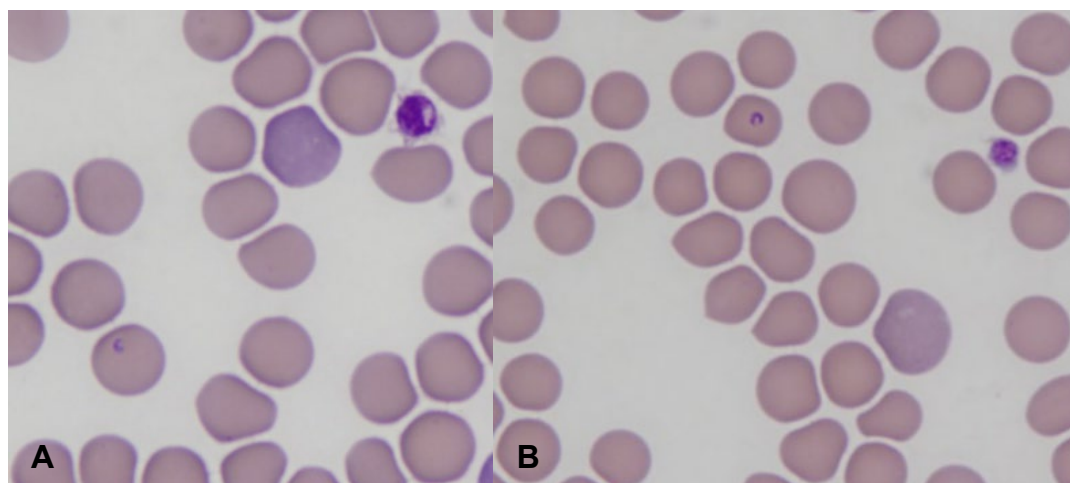


Figure 1. *Babesia felis* trophozoites (A, B) in a blood smear (Photo credit: Dr. P. Irwin)

Treatment

Most anti-babesial drugs that are commonly used in dogs have not been thoroughly tested for safety and efficacy in cats. Primaquine phosphate is used to treat *B. felis* infection, but the availability of primaquine is restricted to only a few countries. Given that the signs of feline *Babesia* infection are often relatively mild (and the efficacy and safety of most anti-babesial drugs unknown in cats) it may not be necessary to use an anti-babesial drug in some cases. If the cat is very anaemic, a blood transfusion may be required to permit clinical recovery and the development of stable (chronic) infection (be aware about the danger of incompatible transfusions in cats and always cross match or type the blood prior to transfusion). There are limited data for other anti-babesial therapy in cats and they should be used with caution.

Table 5. Routes of administration and dosage of commonly utilised anti-babesial drugs a in cats.

Drug	Route	Dosage
Primaquine phosphate	PO, IV, IM	0.5-1 mg/kg once or daily for 3 days
Imidocarb dipropionate	IM	2.5-3.5 mg/kg repeated 7 days later. Atropine 0.05 mg/kg SC should be given 15 minutes before imidocarb injection
Atovaquone + azithromycin	PO	Atovaquone 15 mg/kg q8h + Azithromycin 10 mg/kg q24h in combination for 10 days
Diminazen acetate*	IM	3.5 mg/kg

*Effective doses of diminazen approach doses that are toxic, so it should be used with caution.

Adverse effects include tachycardia and CNS signs such as ataxia, nystagmus, and opisthotonos

Prevention and control

Prevention or reduction of exposure to tick vectors by utilisation of long-acting registered acaricidal products (topical solutions, collars) with repel and kill activity and keeping cats indoors to avoid fighting. Blood donors should be tested (by PCR) to rule out *Babesia* spp. infection.

Public health considerations

None.

Reference

- [1] Hartmann K, Addie D, Belák S, Boucraut-Baralon C, Egberink H, Frymus T, Gruffydd-Jones T, Hosie MJ, Lloret A, Lutz H, Marsilio F, Möstl K, Pennisi MG, Radford AD, Thiry E, Truyen U, Horzinek MC. Babesiosis in cats: ABCD guidelines on prevention and management. *J Feline Med Surg*. 2013;15:643-646.
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Cytauxzoon (*Cytauxzoon felis*)

Cytauxzoon felis is tick-borne apicomplexan parasite that infects wild and domestic felids. It can cause severe, often fatal disease in domestic cats.

Parasite species: *Cytauxzoon felis*

Common name: Cytauxzoon

Host: Wild and domestic felids

Pre-patent period: 6-8 days

Location in the host: Erythrocytes (trophozoites), bloodstream (merozoites), walls of the circulatory blood system and bone marrow (schizonts)

Distribution: North and South America, Europe

Transmission route: Tick-borne

Zoonotic: No

Distribution

Cytauxzoon felis is mainly reported from North and South America. However, infections by an apparently different (yet unnamed) species of *Cytauxzoon* have been reported in domestic cats from several European countries^[1]. This species is phylogenetically close to *Cytauxzoon manul*, which infects the Pallas cat (*Otocolobus manul*) in Mongolia.

Clinical signs

Cytauxzoon felis infections produce an acute or peracute febrile disease in cats or may be asymptomatic. The most frequent clinical manifestations are lethargy, anorexia, high fever, icterus, dyspnoea, tachycardia, generalised pain and vocalisation. Pale mucous membranes, pigmenturia, splenomegaly and hepatomegaly are also frequent. Neurological signs such as ataxia, seizures, and nystagmus may be seen in the late stage of the disease. Cats may be hypothermic, moribund and enter into coma. Death may occur 1 week after onset of clinical signs. Most *Cytauxzoon*-infected cats in Europe are asymptomatic, suggesting that the parasite species circulating among European felids is less virulent than *C. felis*^[1].

Diagnosis

Cytauxzoon spp. infections can be confirmed by cytological examination of blood smears and/or fine-needle aspirates from the liver, spleen and lymph nodes using rapid Romanowsky-type stains (**Fig. 1**). It is not possible to determine the species visually (although local knowledge is helpful). Reliable speciation of piroplasms requires molecular tools. The differential diagnoses for such inclusions are *Babesia felis* and *Theileria* spp. (both piroplasms), and haemotropic *Mycoplasma* species. PCR assays (conventional and quantitative) are also available and may be useful to detect low-level parasitaemia.

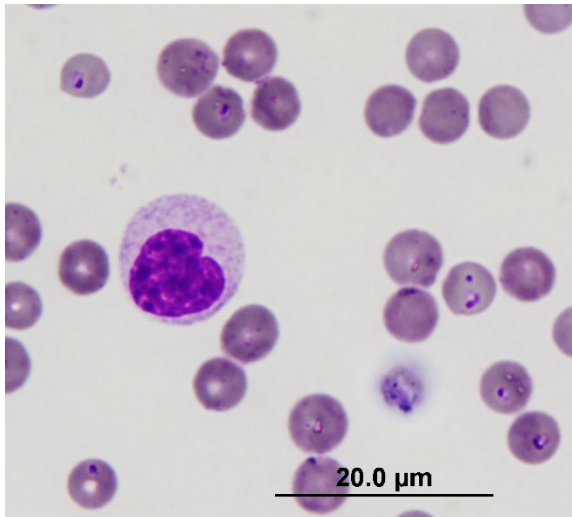


Figure 1. *Cytauxzoon felis* trophozoites in a blood smear of a cat (Photo credit: Dr. P. Irwin)

Treatment

Different antiprotozoal drugs have been used in case reports or experimental studies, but their efficacy is limited. The combination of atovaquone (15 mg/kg PO q8h) and azithromycin (10 mg/kg PO SID) was more effective as compared with imidocarb (3.5 mg/kg IM once) in 80 cats with acute disease [2]. Supportive therapy and care are of paramount importance to keep treated cats alive. The prognosis is usually more favourable in cats with lower parasitaemia.

Prevention and control

Prevention or reduction of exposure to tick vectors by utilisation of long-acting registered acaricidal products (topical solutions, collars) with repel and kill activity and keeping cats indoors to avoid fighting. Blood donors should be tested (by PCR) to rule out *Cytauxzoon* spp. infection.

Public health considerations

None.

References

- [1] Lloret A, Addie DD, Boucraut-Baralon C, Egberink H, Frymus T, Gruffydd-Jones T, Hartmann K, Horzinek MC, Hosie MJ, Lutz H, Marsilio F, Pennisi MG, Radford AD, Thiry E, Truyen U, Möstl K. European Advisory Board on Cat Diseases. Cytauxzoonosis in cats: ABCD guidelines on prevention and management. *J Feline Med Surg.* 2015;17:637-641.
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Hepatozoon (*Hepatozoon* spp.)

Hepatozoon spp. infecting cats are blood apicomplexans that are transmitted through ingestion of an infected tick.

Parasite species: *Hepatozoon felis*, *Hepatozoon canis*, *Hepatozoon silvestris*

Common name: Hepatozoon

Hosts: Domestic cat (*H. felis*, *H. canis*, *H. silvestris*), wildcat (*Felis silvestris*) (*H. felis*, *H. silvestris*), other wildlife felids and carnivores (*H. felis*)

Pre-patent period: In dogs 26 days from infection to gamont parasitaemia (*H. canis*)

Location in the host: Meront stages infect cardiac and skeletal muscles, parenchymal tissues including spleen, gamont stage in leukocytes

Distribution: *Hepatozoon felis* in Europe, Asia, Africa, and the Americas. *Hepatozoon silvestris* has only been described in Europe

Transmission route: Ingestion of vector infected with mature *Hepatozoon* oocysts. *Hepatozoon canis* by tick hosts *Rhipicephalus sanguineus* sensu lato, *Amblyomma ovale* and *Rhipicephalus turanicus*. The arthropod hosts of *H. felis* and *H. silvestris* are currently unknown. Transplacental (*H. canis* and *H. felis*)

Zoonotic: No

Distribution

Hepatozoon felis has been described and detected from all continents except for Australia^[1,2]. There are several genetically-distinct variants of *H. felis* infecting domestic cats as well as wild felids, wild carnivores and rodents^[1,2,3]. *Hepatozoon canis* infection is more prevalent in domestic dogs and also in foxes than in felids and has been described in cats from Israel, Italy and Spain^[2,4,5]. *Hepatozoon silvestris* has been described in domestic cats from southern Italy and Switzerland, wildcats (*F. silvestris silvestris*) from Bosnia-Herzegovina, and an *Ixodes ricinus* tick removed from a domestic cat in the United Kingdom^[4,6,7,8].

Clinical signs

Hepatozoon felis causes mostly sub-clinical infection usually with a low parasitaemia in domestic cats and minimal inflammatory responses in the striated muscle tissues where its meronts are found^[2]. Some elevation of muscle enzyme activities has been described in cats infected with *Hepatozoon* spp.^[9]. *Hepatozoon silvestris* has been associated with a fatal myocardial infection in a domestic cat from Switzerland^[6]. There are currently no clinical descriptions of *H. canis* infection in domestic cats.

Diagnosis

Hepatozoonosis can be diagnosed by the detection of *Hepatozoon* spp. gamonts in leukocytes (**Fig. 1**) and by the detection of meront stages of *Hepatozoon* spp. in histopathological specimens of striated skeletal muscles, the myocardium, and occasionally the spleen, lungs, lymph nodes, bone marrow (and other tissue). PCR of the blood and tissues is a sensitive technique for the detection and species determination of *Hepatozoon* spp. infection^[1,2].

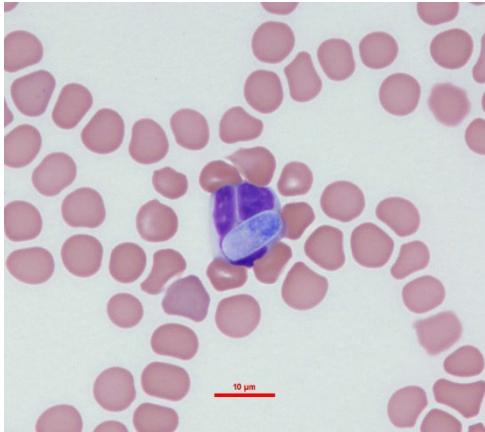


Figure 1. *Hepatozoon* sp. gamont within a neutrophil in a cat's blood smear (Image credit: Dr. G Baneth)

Treatment

Hepatozoon canis infection in dogs is treated with imidocarb dipropionate and anti-coccidial drugs ^[1]. There is no description of controlled trials for the treatment of feline hepatozoonosis to date. Treatment of sub-clinical infection is currently not recommended.

Prevention and control

Although the vectors of *H. felis* and *H. silvestris* are currently unknown, it is likely that they are transmitted by ectoparasites. Therefore, prevention of infection may include treatment against ectoparasites including fleas and ticks, and not allowing the cat to hunt, particularly rodents.

Public health considerations

Hepatozoon spp. infecting cats are not known to be zoonotic.

References

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Leishmania (*Leishmania* spp.)

Leishmania spp. are protozoa transmitted by the bites of infected female phlebotomine sand flies, which may infect several wild and domestic animals, including cats. They are zoonotic.

Parasite species: *Leishmania infantum*, *Leishmania braziliensis*, *Leishmania amazonensis*, *Leishmania mexicana*, and *Leishmania venezuelensis*

Common name: Leishmania

Hosts: Wild and domestic animals, including cats

Pre-patent period: A minimum of 1-16 weeks for *L. infantum* and 6 weeks for *L. braziliensis*, but infection may only be detectable months to years after exposure

Location in the host: Cells of the mononuclear phagocyte system

Distribution: Worldwide

Transmission route: Through the bites of infected female sand flies

Zoonotic: Yes

Distribution

Clinical disease caused by *Leishmania infantum* has been described in cats in many countries including Italy, Switzerland, France, Spain, Portugal, Greece, Brazil and Iran. *Leishmania amazonensis* infection has been reported in Brazilian cats, whereas *L. braziliensis* has been reported in cats from Brazil and French Guiana. *Leishmania mexicana* and *L. venezuelensis* have been found in cats from the United States and Venezuela, respectively.

Clinical signs

Most cats infected by *Leishmania* spp. present subclinical infections. The most frequent clinical signs of *Leishmania* spp. infection in cats are skin lesions, including ulcerative, crusty, nodular or scaly dermatitis, and alopecia or a poor haircoat condition ^[1,2]. The most frequent non-cutaneous clinical signs reported include: lymph node enlargement, weight loss, nodular blepharitis, uveitis, panophthalmitis, decreased appetite, chronic gingivostomatitis and lethargy ^[1,2].

Diagnosis

The diagnosis of *Leishmania* spp. infection in cats can be confirmed by cytology with the detection of amastigotes forms within the cytoplasm of polymorphic nuclear cells or extracellularly in stained smears of skin lesions, bone marrow, spleen (**Fig. 1**) or lymph node aspirates. Serology (e.g. indirect immunofluorescence assay and ELISA) and PCR are also used. ^[1,2].

Treatment

Allopurinol (10 mg/kg q12h) is usually effective in alleviating clinical signs of *L. infantum* infection in cats. Relapses may occur as in dogs. Meglumine antimoniate (5-50 mg/kg or 375

mg/cat q24h SC or IM under different protocols) has produced a good clinical response in some cases and it is recommended to use it combined with allopurinol ^[1].

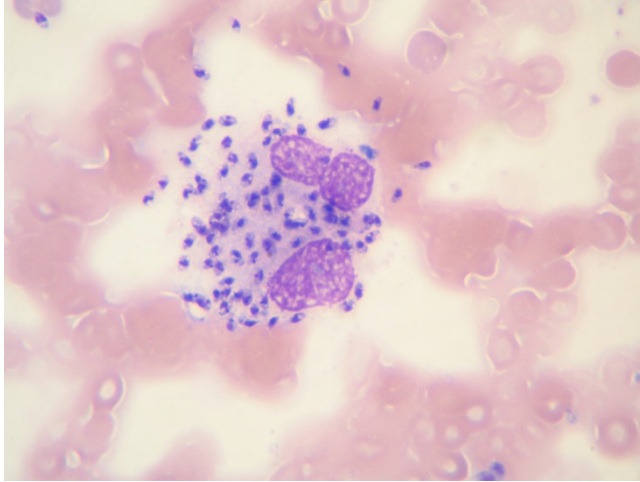


Figure 1. Intracellular and extracellular amastigotes of *Leishmania infantum* in a splenic smear (Image credit: Dr. G. Baneth)

Prevention and control

The risk of *L. infantum* infection in cats can be reduced by applying a 10% imidacloprid plus 4.5% flumethrin collar ^[3]. Importantly, while flumethrin is safe for cats, other pyrethroid-based products should not be applied to cats, due to their natural sensitivity to this class of insecticide.

Public health considerations

All *Leishmania* spp. reported in cats are zoonotic, but the cat's role as a potential reservoir host of these parasites is unclear.

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Trypanosome (*Trypanosoma* spp.)

Trypanosoma spp. are vector-borne parasites that infect a wide range of wild and domestic mammal species, including cats. *Trypanosoma cruzi* is zoonotic.

Parasite species: *Trypanosoma brucei*, *T. evansi*, *T. congolense*, *T. cruzi*, *T. rangeli*

Common name: Trypanosomes

Hosts: Several wild and domestic mammal species, including cats

Pre-patent period: 5 days for *T. brucei* (25-44 days when cats were fed with infected goat meat, mouse or guinea pig), 11-25 days for *T. congolense*, 14-15 days for *T. evansi*

Location in the host: Blood and eventually tissue fluids

Distribution: Worldwide

Transmission route: By tsetse flies (*T. brucei*, *T. congolense*), triatomine bugs (*T. cruzi*, *T. rangeli*), biting flies (*T. evansi*), and possibly predation of infected rodents (*T. cruzi*, *T. evansi*)

Zoonotic: Yes (*T. cruzi*)

Distribution

Trypanosoma brucei is found in western Africa and *T. congolense* is found in tropical Africa south of the Sahara. *Trypanosoma evansi* is found in Africa north of the Sahara, Asia, and Central and South America. *Trypanosoma cruzi* is found in the southern United States, and throughout Mexico, Central America, and South America down into Argentina. *Trypanosoma rangeli* is found in Central America and South America down into Chile.

Clinical signs

Trypanosoma brucei can cause severe disease in cats. Clinical signs may include fever, pale mucous membranes, ocular disorders (even blindness) and weakness. In experimental infections, post-mortem examination revealed pronounced wasting with generalized lymphadenomegaly, splenomegaly, hepatomegaly and pleural and pericardial haemorrhages. Experimental infection by *T. congolense* produced a fatal outcome in six cats, all of which presented hepatomegaly upon post-mortem examination. *Trypanosoma evansi* can cause lethargy and inappetence, sunken eyes, and incoordination in cats. *Trypanosoma cruzi* infections in cats are usually subclinical; a cat from Montevideo, Uruguay, showed convulsions and transient posterior paralysis.

Diagnosis

Trypanosoma infections can be confirmed by cytological examination of Giemsa stained blood smears (**Fig. 1**). The trypomastigote stages are 20 µm long in *T. cruzi* (1-2 undulations of the undulating membrane), 26-34 µm long in *T. rangeli* (with 4-5 undulations of the undulating membrane), 9-18 µm in long in *T. congolense* (with 3-4 undulations of the undulating membrane). *Trypanosoma brucei* has a short and stumpy form (12-26 µm long) with no free flagellum and a long and slender form (23-42 µm long) with a free flagellum. *Trypanosoma evansi* is morphologically indistinguishable from *T. brucei*^[1].

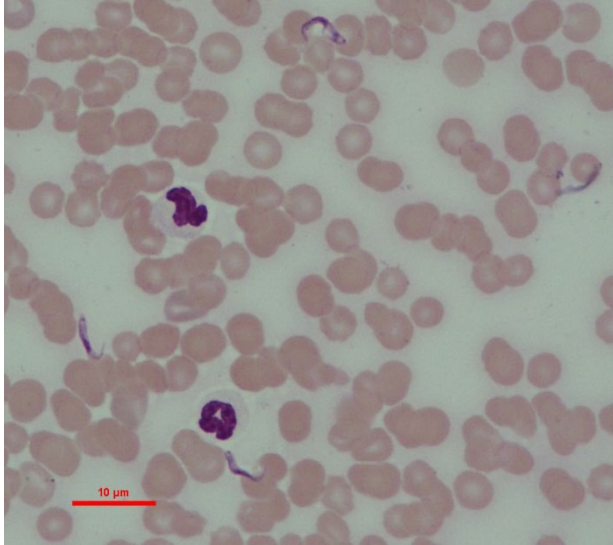


Figure 1. *Trypanosoma congolense* from a blood smear of a dog (Image credit: Dr. G. Baneth)

Treatment

No effective treatment has been described in cats.

Prevention and control

The only effective way to control *Trypanosoma* infections in cats is by reducing their exposure to the vectors, which may be unrealistic in free-roaming cats living in rural areas where these agents are endemic.

Public health considerations

Trypanosoma cruzi is the causative agent of Chagas disease (American trypanosomiasis), a major neglected tropical disease. Cats are considered reservoirs of this parasite, potentially an amplifying host, but the actual role of cats in the maintenance of the zoonotic cycle of this parasite is probably minor.

References

- [1] Bowman DD, Hendrix CM, Lindsay DS, Barr SC. Feline Clinical Parasitology. Iowa State University Press, Ames, USA. 2002.
- [2] Gürtler RE, Cardinal MV. Reservoir host competence and the role of domestic and commensal hosts in the transmission of *Trypanosoma cruzi*. *Acta Tropica*. 2015;151:32-50.

Eyeworms (*Thelazia* spp.)

Eyeworms are spirurid nematodes that infest the eyes of several mammals, including dogs and cats. They are zoonotic.

Parasite species: *Thelazia californiensis*, *Thelazia callipaeda*

Common name: Eyeworms

Hosts: Wild and domestic mammals, including dogs and cats

Pre-patent period: 2 weeks

Location in the host: Conjunctiva and under the lids and nictitating membrane

Distribution: North America, Europe and Asia

Transmission route: By fruit flies (*P. variegata*) or by muscoid flies (*Fannia* spp.)

Zoonotic: Yes

Distribution

Thelazia callipaeda is present in Asia and Europe, whereas *T. californiensis* is restricted to western North America.

Clinical signs

Thelazia infections in cats are usually asymptomatic. Clinical signs in cats may include blepharospasm and epiphora of the eye.



Figure 1. *Thelazia callipaeda* adult worms in the eye of a dog (Image credit: Dr. G. D'Amico)

Considering the external location of the eyeworms, the diagnosis can be confirmed by finding the worms during ocular examination (**Fig. 1**).

Treatment

Thelazia infections are usually treated by mechanically removing the worms from the eye. An oral formulation containing milbemycin oxime (2 mg/kg) and praziquantel (5 mg/kg) showed therapeutic efficacies of 53.3% and 73.3% after one or two treatments, respectively ^[1]. The application of the spot-on formulation moxidectin 2.5% and imidacloprid 10% was 100% effective in the treatment of thelaziosis in dogs and may have similar efficacy in cats ^[2]

Prevention and control

Control may be achieved by preventing flies from feeding around the eyes of cats. In dogs, the monthly application of a spot-on formulation containing 10% imidacloprid and 2.5% moxidectin was shown to be highly effective in preventing *T. callipaeda* infection^[3], although similar field-studies have not been carried out in cats.

Public health considerations

Both *T. californiensis* and *T. callipaeda* are zoonotic.

References

- [1] Motta B, Schnyder M, Basano FS, Nägeli F, Nägeli C, Schiessl B, Mallia E, Lia RP, Dantas-Torres F, Otranto D. Therapeutic efficacy of milbemycin oxime/praziquantel oral formulation (Milbemax®) against *Thelazia callipaeda* in naturally infested dogs and cats. *Parasit Vectors*. 2012;5:85.
- [2] Otranto D, Colella V, Crescenzo G, Solari Basano F, Nazzari R, Capelli G, Petry G, Schaper R, Pollmeier M, Mallia E, Dantas-Torres F, Lia RP. Efficacy of moxidectin 2.5% and imidacloprid 10% in the treatment of ocular thelaziosis by *Thelazia callipaeda* in naturally infected dogs. *Vet Parasitol*. 2016;227:118-121.
- [3] Lechat C, Siméon N, Pennant O, Desquilbet L, Chahory S, Le Sueur C, Guillot J. Comparative evaluation of the prophylactic activity of a slow-release insecticide collar and a moxidectin spot-on formulation against *Thelazia callipaeda* infection in naturally exposed dogs in France. *Parasit Vectors*. 2015;8:93.

Lymphatic Filarial Worms (*Brugia* spp.)

Brugia spp. are nematodes that cause lymphatic filariasis in humans. Dogs, and especially cats, are considered to be reservoirs of human infection yet rarely show clinical signs themselves when infected.

Parasite species: *Brugia malayi*, *Brugia pahangi*, *Brugia patei*, among others

Common name: Lymphatic filarial worms

Hosts: Humans, dogs, cats

Pre-patent period: 54-69 days, up to >10 weeks for *B. malayi* and *B. pahangi*

Location in the host: Bloodstream and lymphatics

Distribution: Indonesia, Malaysia, Philippines, Thailand and India (*B. malayi*, *B. pahangi*) and Kenya (*B. patei*)

Transmission route: Mosquitoes

Zoonotic: Yes (*B. malayi*, *B. pahangi*)

Distribution

Brugia malayi and *B. pahangi* are limited to Southeast Asia and India, whereas *B. patei* is reported in Kenya.

Clinical signs

Cats infected with *B. malayi* and *B. pahangi* are mostly asymptomatic and tolerate infection well. There have been limited reports of infected cats developing lymphadenopathy and lymphedema.

Diagnosis

The diagnosis of *Brugia* spp. infections in cats can be made upon detection of the sheathed microfilariae using a modified Knott's technique (**Fig. 1**). Serological assays such as ELISA can also be used to confirm a diagnosis through the detection of antibodies or antigen. PCR with sequencing is useful for detection of low parasitaemia and for species determination.

Treatment

Brugia spp. infections in cats can be treated with a combination of doxycycline and ivermectin^[1] or moxidectin or selamectin.

Prevention and control

Monthly administration of heartworm preventatives (e.g. moxidectin spot-on, selamectin spot-on) is likely to also protect against feline lymphatic filariasis.

Public health considerations

Brugia malayi and *B. pahangi* are both zoonotic and there have been several reports in humans in endemic areas.



Figure 1 *Brugia* sp. sheathed microfilaria in the blood smear of a cat (Photo credit: Dr. R. Traub, Dr. Sangaran)

Reference

[1] Khowawisetsut L, Sarasombath PT, Thammapalo S, Loymek S, Korbarsa T, Nochote H, Phuakrod A, Choochote W, Wongkamchai S. Therapeutic trial of doxycycline plus ivermectin for the treatment of *Brugia malayi* naturally infected cats. *Vet Parasitol.* 2017;245:42-47.

Standard Operating Procedures (SOP)

SOP 1: Simple Faecal Floatation

The simple faecal floatation procedure is suitable for the isolation and identification of a majority of nematode eggs and protozoan (oo)cysts in feline faeces. The method is quick, inexpensive and does not require use of a centrifuge.

Reagent

- Flotation solution (e.g. saturate salt or sodium nitrate)

Preparation of flotation solutions of specific gravity (S.G.) 1.20:

Sodium nitrate solution

Dissolve 315 g sodium nitrate in approximately 700 ml warmed distilled water (dH₂O). Add more dH₂O until the entire solution weighs 1200 g (this equates to a S.G. of 1.2). Mix solution and then check S.G. with hydrometer.

Saturated salt

Dissolve salt (~300-400 g depending on purity) in 1000 ml warmed dH₂O while stirring continuously. Keep adding more salt until no more dissolves (i.e. salt remains precipitated out of solution once cooled). Check S.G. with hydrometer.

Procedure

1. Place ~2 g faeces into a wide-mouthed plastic disposable cup
2. Add ~4 ml flotation solution to the jar and mix with faeces thoroughly
3. Pour/filter this faecal suspension through a tea strainer into a new jar
4. Empty the contents of the jar into a 10-15 ml test-tube supported in a rack or stand
5. Keep adding contents or top up with flotation solution until a positive meniscus forms over the lip of the test tube
6. Carefully place a 22 x 22 mm coverslip on top of the test tube
7. Stand for 10-15 min
8. Carefully lift off the coverslip from the tube, with the drop of fluid adhered to the bottom of it and place it on a microscope slide
9. Examine under a light microscope at low power (10x) for helminth stages and at high power (40x) for protozoal stages

For an alternative step-by-step guide with useful images of this procedure, refer to: http://www.rvc.ac.uk/review/parasitology/Flotation/Simple_flotation/Purpose.htm

Safety precautions

- Wear lab coat and disposable gloves
- Wash hands thoroughly when finished

Clean up procedures

- Pour sodium nitrate into appropriate chemical waste container
- Dispose of all slides and cover slips in a sharps container
- Clean all equipment (tea strainer, glass test tubes) thoroughly with a 10% bleach solution
- Wipe down work area with 70% ethanol

SOP 2: Centrifugal Faecal Floatation

The zinc sulfate [specific gravity (S.G.) 1.18] centrifugal floatation procedure is suitable for the isolation and identification of a protozoan cysts and oocysts in canine and feline faeces, in particular cysts of *Giardia duodenalis*. Centrifugal floatation is also more sensitive for the isolation of heavier nematode eggs such as those of *Trichuris vulpis* and *Spirocerca lupi*, in which a heavier floatation solution with a SG of 1.25 is utilised (e.g. Sheather's sugar solution). These methods are inexpensive; however, they do require the use of a centrifuge.

Reagents

- Flotation solution (e.g., Zinc sulfate solution or Sheather's solution)
- Lugol's iodine

Preparation of flotation solutions

Zinc sulfate solution (S.G. 1.18)

Dissolve 331 g zinc sulfate in 900 ml warmed distilled water (dH₂O). Add more dH₂O until the entire solution weighs 1180 g (this equates to a S.G. of 1.18). Mix solution and then check SG with hydrometer. Note: if zinc sulfate heptahydrate is used, then additional quantities will be needed (e.g., approx. 750 g).

Sheather's solution (SG 1.25)

To 355 ml hot water, add (while stirring) 454 g sugar. Add 6 ml formalin per 454 g sugar. Adjust to ensure SG is 1.25 using a hydrometer.

Procedures

1. Place ~2 g faeces into a wide-mouthed plastic disposable cup
2. Add ~4 ml flotation solution to the jar and mix with faeces thoroughly
3. Add a further 4 ml flotation solution to the jar and mix again
4. Pour/filter this faecal suspension through a tea strainer into a new jar
5. Empty the contents of the jar into a 10-15 ml test-tube supported in a rack or stand
6. Centrifuge at 500 g for 10 min
7. Carefully add more flotation solution until a positive meniscus forms at the top of the test tube and place a coverslip on top
8. Stand for a further 5-10 minutes
9. Carefully lift off the coverslip with the drop of fluid adhered to the bottom of it and place it on a microscope slide. Adding a drop of Lugol's iodine to the slide before placing the coverslip on it can make the *Giardia* cysts easier to see
10. Examine under a light microscope at low power (10x) for helminth stages and at high power (40x) for protozoal stages

Safety precautions

- Wear lab coat and disposable gloves
- Wash hands thoroughly when finished

Clean up procedures

Pour sodium nitrate into appropriate chemical waste container

Dispose of all slides and cover slips in a sharps container

Clean all equipment (tea strainer, glass test tubes) thoroughly with a 10% bleach solution

Wipe down work area with 70% ethanol

SOP 3: Baermann Technique

The Baermann technique is suitable for the isolation and identification of larvae in fresh faeces (e.g. *Strongyloides* spp., lungworms)

Reagents

- Distilled water (dH₂O)

Equipment set up

Secure a glass or plastic funnel to a stand and connect a rubber tube with a clamp to the stem of the funnel.

Procedure

1. Place 3-5 g of faeces in the centre of a large cheese cloth and tie with a rubber band or string to form a pouch
2. Place this within a tea strainer and suspend this in the funnel or within the mouth of a 50 ml centrifuge tube using toothpicks to keep the faecal pouch in place
3. Add warmed dH₂O to the funnel until the water covers the top of the faecal pouch
4. Leave standing for 24 h
5. If utilising a funnel, open the stopper on the rubber tubing and collect 2 ml of the filtered sediment into a test tube. If using a 50 ml centrifuge tube, go to step 7
6. Leave the test-tube standing for 30 min, or alternatively centrifuge at 500-1000 g for 2 min
7. Carefully remove the supernatant with a pipette, leaving ~0.5 ml of the sediment undisturbed
8. Take 1-2 drops of the sediment and place on a microscope slide with a cover slip
9. Examine under a light microscope at low power (10x) for larvae

For an alternative step-by-step guide with useful images of this procedure, refer to: <http://www.rvc.ac.uk/review/parasitology/Baermann/Purpose.htm>

Safety precautions

- Wear lab coat and disposable gloves
- Wash hands thoroughly when finished

Clean up procedures

- Dispose of all slides and cover slips in a sharps container
- Clean all equipment (tea strainer, glass test tubes) thoroughly with a 10% bleach solution
- Wipe down work area with 70% ethanol

SOP 4: Sedimentation Technique

The faecal sedimentation technique is suitable for the isolation and identification of heavier eggs, especially those of flukes (e.g. *Paragonimus* spp.). The method is quick, inexpensive and does not require the use of a centrifuge.

Reagents

- Distilled water (dH₂O)
- 5% aqueous methylene blue solution

Procedure

1. Soak 5 g faeces in 50 ml dH₂O and mix thoroughly
2. Pass through tea strainer into a plastic jar to filter
3. Pour all contents into a conical test tube (50 ml)
4. Allow to sediment for 5 min
5. Pour off supernatant
6. Pour sediment into a 10-15 ml conical test tube
7. Allow to sediment 5 min
8. Pour off supernatant carefully
9. Can add 1 or 2 drops of 5% aqueous methylene blue solution in test tube to aid in identification (yellow or colourless fluke eggs against a blue background)
10. Transfer 1-2 drop of the sediment to a microscope slide, place a cover slip and examine using a light microscope at low power (4x and 10x)

Safety precautions

- Wear lab coat and disposable gloves
- Wash hands thoroughly when finished

Clean up procedures

- Dispose of all slides and cover slips in a sharps container
- Clean all equipment (tea strainer, glass test tubes) thoroughly with a 10% bleach solution
- Wipe down work area with 70% ethanol

SOP 5: Modified Knott's Test

The method is used for the detection of microfilariae in the blood. The method is more sensitive than a direct smear with fresh blood as it concentrates the microfilariae.

Reagents

- 2% formalin
- 1% methylene blue

Procedure

1. Mix 1 ml blood with 9 ml of 2% formalin in a conical centrifuge tube
2. Invert the tube gently 4 times to mix the solution
3. Centrifuge at 500 g for 5 min
4. Discard supernatant
5. Stain sediment for 1-2 min with 1-2 drops of 0.1% methylene blue
6. Add a drop of the sample on a glass slide and cover with a coverslip
7. Examine under a light microscope at low power (10x) for microfilariae

Safety precautions

Wear lab coat and disposable gloves

Clean up procedures

Dispose of all slides and cover slips in a sharps container

SOP 6: Acid Fast Stain for *Cryptosporidium* oocysts

As the oocysts of *Cryptosporidium* spp. are very small and difficult to detect by inexperienced examiners, this method provides specific staining and allows an easier detection.

Reagents

- Absolute methanol
- Kinyoun's carbol fuchsin
- 10% sulfuric acid solution (H₂SO₄)
- 3% Malachite green

Procedure

1. Make a thin faecal smear and allow to air dry
2. Fix with absolute methanol for 10 min and allow smear to dry
3. Stain with cold Kinyoun's carbol fuchsin strong stain (filtered) for 5 min
4. Wash thoroughly in tap water until no further stain comes out (very important step that can take 3-5 min)
5. Decolourise in 10% H₂SO₄ (for very thin smears a rapid dip in Coplin jar of acid followed by an immediate rinse in tap water is sufficient)
6. Counterstain with 3% Malachite green for 2-5 min
7. Wash in tap water and blot dry
8. Examine under a light microscope at high power (40x) for oocysts

Results

Oocysts are seen as acid fast (bright pink) oval to round bodies (4 to 6 µm in diameter), surrounded by a colourless halo. Bacteria and yeasts stain green.

Safety precautions

- Wear lab coat and disposable gloves
- Wash hands thoroughly when finished

Clean up procedures

- Dispose of all disposable equipment in clinical waste bin or sharps as appropriate

