ESCCAP

EUROPEAN SCIENTIFIC COUNSEL COMPANION ANIMAL PARASITES®

1 Worm Control in Dogs and Cats

ESCCAP Guideline 01 Sixth Edition – May 2021

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INTRODUCTION

There is a wide range of helminths including nematodes, cestodes and trematodes that can infect dogs and cats in Europe. Major groups by location in the host are:

Intestinal worms

- Ascarids (*Toxocara* spp.)
- Tapeworms
- Hookworms (*Ancylostoma* and *Uncinaria* spp.)
- Whipworm (*Trichuris vulpis*)

Non-intestinal worms

- Heartworm (*Dirofilaria immitis*)
- Subcutaneous worms (*Dirofilaria repens*)
- French heartworm (*Angiostrongylus vasorum*[†])
- Lungworms
- Eye worms (*Thelazia callipaeda*)

These groups are further summarised in Tables 2A, 2B and 2C. Factors affecting the importance of these worms include:

- Prevalence
- Pathogenicity for the host
- Zoonotic potential
- A combination of these factors

This guideline aims to give an overview of these worms and their significance and to suggest control measures for the most important species in order to prevent animal and/or human infection.

For simplicity, the nematodes, cestodes and trematodes mentioned in this guideline will be referred to as "worms" and therapeutic compounds as "anthelmintics".

[†] *A. vasorum* is sometimes referred to as a lungworm and sometimes named 'the French Heartworm', which is due to the fact that the adult worms are located in the circulatory system and not the lungs.

SCOPE

ESCCAP provides research-based, independent advice. It is the aim of ESCCAP to produce a guideline which delivers comprehensive information and support to assist both veterinarians and pet owners to successfully control worm infection in dogs and cats. This guideline concentrates on the most important groups of companion animal worms, both intestinal and non-intestinal. Other canine and feline parasites are addressed in other guidelines; these will be referred to, where appropriate, in the text. For more information on the control of ectoparasites, superficial mycoses, vector-borne diseases and intestinal protozoa see ESCCAP guidelines at www.esccap.org/guidelines/.

PRESENT SITUATION AND EMERGING THREATS

In Europe, an increase in pet travel plus climatic changes will probably influence the present epidemiological situation of certain endoparasites or may introduce them into different regions. Rare diseases may rise in frequency due to increased importation into presently non-endemic areas. Furthermore, within the European Union, removal of border controls under the Schengen Treaty and implementation of the PETS Travel Scheme in the United Kingdom have led to easy travel between the various countries within continental Europe and, except for the UK, there are no or limited customs controls of pet animals moving from one country to another. Whilst pets travelling with their owners account for the majority of pet movement, a large number of dogs and, to a lesser extent cats, are now being relocated by welfare organisations from, for example, Mediterranean countries to private households all over Europe. This is particularly significant as the Mediterranean is an area where parasites such as *Dirofilaria immitis* are highly prevalent.

Veterinary medicinal products go through a rigorous testing process prior to their approval by European or national authorities and each indication for use has to be scientifically justified. Veterinarians are trained in the appropriate use of these compounds according to current national legislation. Most modern endoparasiticidal compounds for companion animals can be used prophylactically or therapeutically to control endoparasites.

LIFELONG CONTROL OF COMMON WORMS

Parasite infections should be controlled through endoparasite and ectoparasite management and treatment. Few parasite infections are strictly age-related; the risk continues as the animal ages and so consideration should be given to provide each dog and cat with appropriate worm control throughout its lifetime. The routine treatment and prevention of all worms depends upon legislation in individual countries, veterinary professionals taking local epidemiological circumstances into account, owner perception and individual risk assessments i.e. hunting pets, previous lungworm exposure, raw meat diets etc. **Deworming practices should therefore always be on the advice of a veterinary professional**. See Figures 1 and 2: Schemes for individual deworming of dogs and cats.

Please be advised that:

- In countries or regions where routine treatments are not acceptable for legislative or other reasons, regular faecal examinations are recommended. See specific parasite sections within this guideline for more tailored treatment and control recommendations.
- Feeding commercial diets or cooked food (internal temperature of at least 65°C for 10 minutes) or deep frozen (at least for one week at -17 to -20°C) will prevent raw meat- transmitted parasite infections (see Tables 3 and 5).
- Dogs and cats should not be allowed access to rodents, carcasses, placentae or aborted foetuses of cattle or sheep.
- Dogs and cats should always be provided with fresh, potable water.

Where a specific worm infection is diagnosed, the infection should be appropriately treated and then preventive measures put in place. Symptomatic dogs or cats should have a physical examination, including relevant parasitic diagnostic procedures, and complete history considered as these are crucial for the diagnosis, treatment and control of parasitic infections.

For healthy dogs and cats, the prevention of worm infection is essential. To simplify preventive measures, ESCCAP has identified three "key" parasite groups that can cause severe disease, pose a zoonotic risk and have high prevalence in some or all areas of Europe:

- Ascarids (*Toxocara* spp., *Toxascaris leonina*) (prevalent in all areas)
- *Echinococcus* spp. (see Figures 9 and 10 for distribution)
- Heartworm (*Dirofilaria immitis* see Figure 18 for distribution; *Angiostrongylus vasorum* occurs Europe-wide in endemic spots).

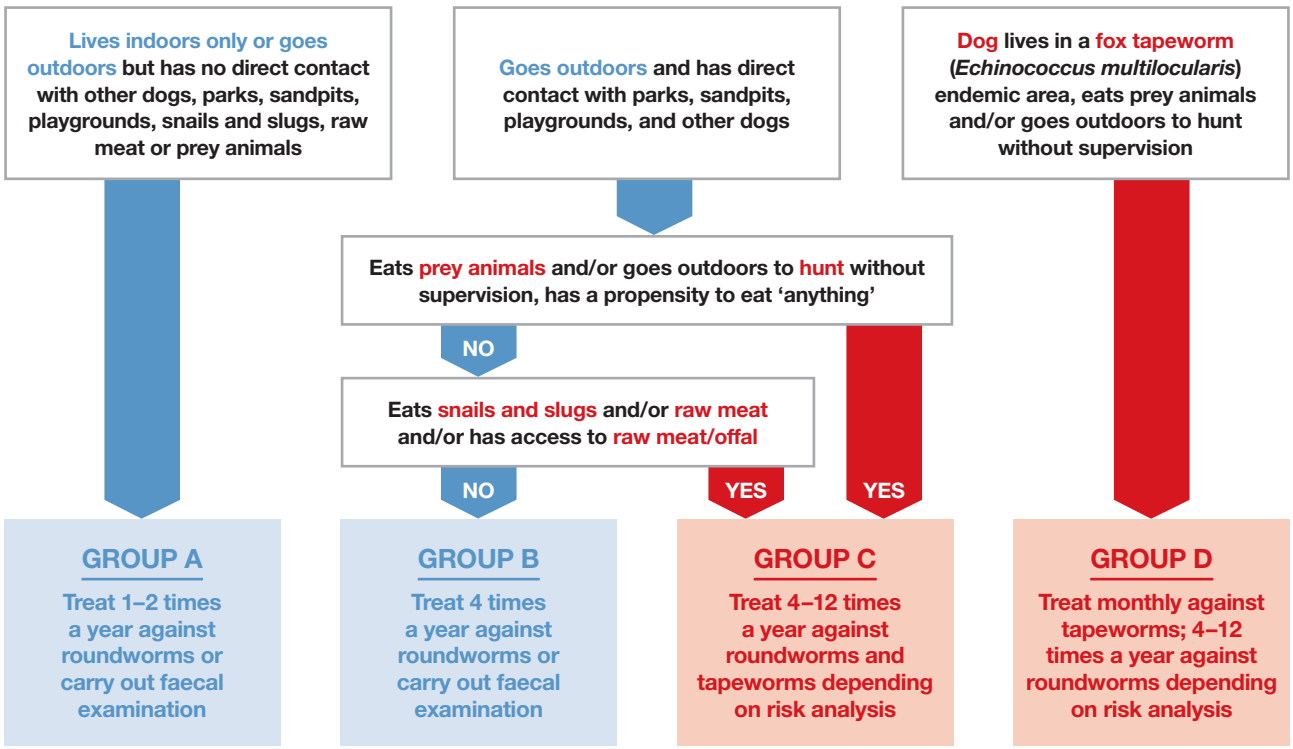
Ascarid infections occur across Europe, whilst the distribution of other infections is geographically related. By adding *Echinococcus* spp. and/or *D. immitis*/*A. vasorum* control to ascarid control measures, basic control plans can be produced for dogs and cats anywhere in Europe.

- In areas endemic for *Echinococcus multilocularis*, dogs that may hunt and eat small prey should be treated monthly with a product effective against this parasite.
- In areas endemic for *Echinococcus granulosus*, dogs with access to offal or livestock carcasses should be treated with a product effective against this parasite at least every 6 weeks.
- In areas endemic for *Dirofilaria* spp., administration of a monthly preventive or a long-acting injectable preventive during the vector season is recommended. In areas endemic for *Angiostrongylus vasorum*, regular diagnostic controls or monthly anthelmintic treatments against this parasite prevent the onset of important clinical signs.
- In areas where only *Toxocara* spp. is a concern, deworming at least four times a year is recommended if dogs and cats are housed outside or have access to the outdoors.

Control of other parasites, such as hookworms, whipworms and lungworms can be added as necessary. Appropriate anthelmintic treatment for all parasites can be identified and the animals treated at suitable intervals.

Responsible ownership of cats and dogs includes regular health controls with faecal diagnostics and deworming accompanied by regular testing for efficacy.

More detailed considerations for each of the companion animal parasites can be found in the individual parasite sections.

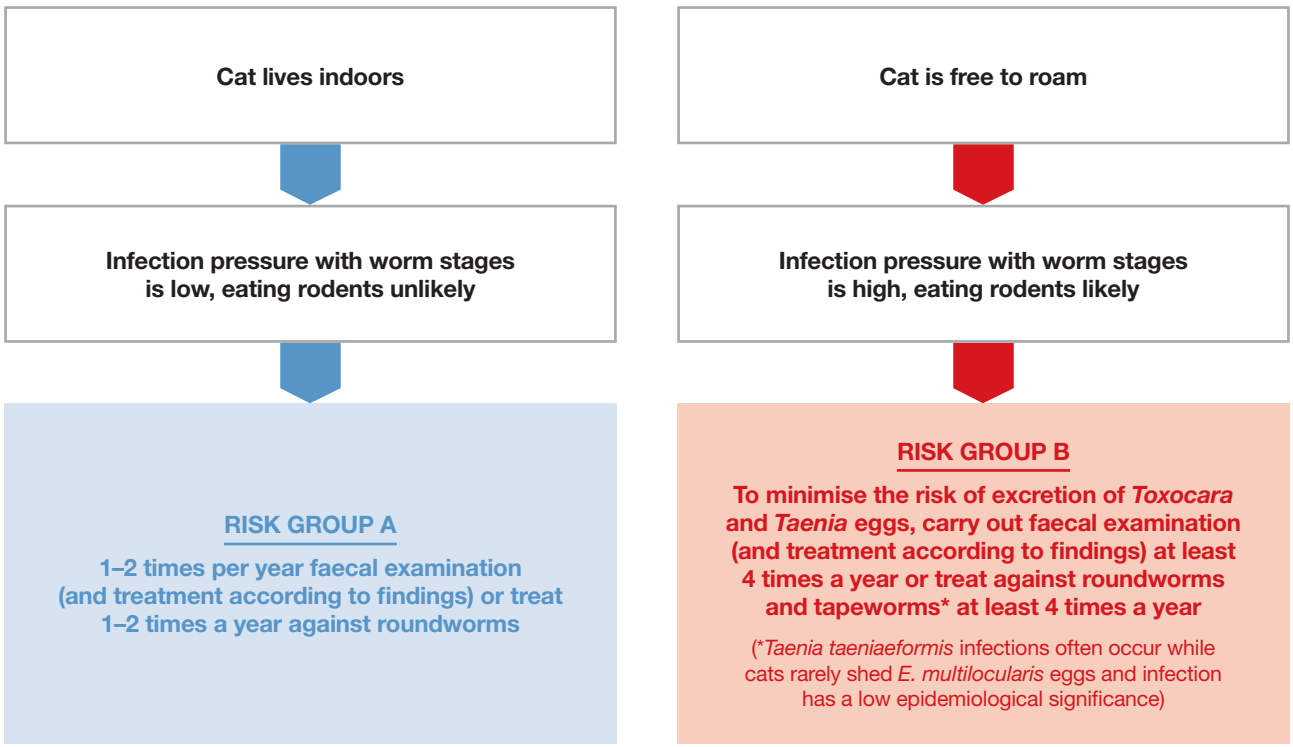


ADDITIONAL TREATMENTS FOR DOGS	
Roundworms	
Puppies	From the age of 2 weeks, then every 14 days up to 2 weeks after weaning and then monthly treatments up to six months of age.
Pregnant bitches	To reduce transmission to the puppies, pregnant females can be given macrocyclic lactones on the 40th and 55th day of pregnancy or fenbendazole daily from the 40th day of pregnancy continuing to 2 days postpartum.
Lactating bitches	Should be treated concurrently with the first treatment of puppies (see above).
Dogs with increased risk of infection i.e. those used in sport, competitions, shows or those kept in kennels etc.	Two treatments: a maximum of 4 weeks before and 2–4 weeks after the event. For kennels: use planned deworming once a month or examine faecal samples every four weeks and treat according to findings.
Professional dogs i.e. therapy, rescue or police dogs	Depending on the risk assessment, use planned deworming once a month or examine faecal samples once a month and treat according to findings.
Dogs sharing homes with children below 5 years or immunocompromised individuals	Depending on the risk assessment, use planned deworming once a month or examine faecal samples once a month and treat according to findings.
Tapeworms	
Travel or import into/from endemic areas for *Echinococcus* spp.	Dogs with a high risk of infection should be treated 4 weeks after starting the trip, then every 4 weeks until 4 weeks after return. After importation, immediate examination and treatment is recommended.
Eats raw meat and/or offal, eats prey or goes hunting	Dogs should be tested every 2–3 months by faecal examination and treated accordingly to findings or dewormed every 6 weeks.
Flea or chewing lice infestation (as a vector for *Dipylidium*)	Once when the infestation is established.
Heartworm (*Dirofilaria immitis*)*	
Dogs living in heartworm endemic areas (see Fig. 18)	Prophylactic larval treatment with macrocyclic lactones at monthly intervals during the mosquito season.
Travel or importation to/from endemic areas for heartworm	No later than 30 days after departure to 30 days after last possible travel date at monthly intervals.

- Deworming practices should always be on the advice of a veterinary professional. Regular coprological examination of faeces, as suggested in Groups A and B, is a good alternative to standard deworming advice.
- If the individual risk of an animal cannot be judged clearly, the animal should be examined or dewormed at least 4 times a year. Studies have shown that deworming 1–3 times a year does not provide sufficient protection. Deworming every 3 months does not necessarily eliminate patent infections.

* Detailed information about heartworm infection in dogs and cats can be found in ESCCAP Guideline 5: Control of Vector-Borne Diseases in Dogs and Cats at www.esccap.org

Figure 1: Scheme for individual deworming of dogs



ADDITIONAL TREATMENTS FOR CATS	
Roundworms	
Kittens	From 3 weeks of age, then every 2 weeks until weaning and then monthly treatment until the age of 6 months.
Pregnant queens	A single treatment of emodepside spot-on approximately seven days before expected parturition prevents lactogenic transmission of *Toxocara cati* larvae to the kittens.
Lactating queens	Should be treated concurrently with the first treatment of kittens (see above).
Cats with increased risk of infection i.e. those used in competitions, shows or those kept in catteries etc.	Two treatments: a maximum of 4 weeks before and 2–4 weeks after the event. For catteries: use planned deworming once a month or examine faecal samples every four weeks and treat according to findings.
Cats sharing homes with children below 5 years or immunocompromised individuals	Depending on the risk assessment, use planned deworming once a month or examine faecal samples once a month and treat according to findings.
Tapeworms	
Eats raw meat and/or offal, eats prey or goes hunting	Cats should be tested at least 4 times a year by faecal examination and treated accordingly to findings or dewormed at least 4 times a year.
Flea infestation (as a vector for *Dipylidium*)	Once when the infestation is established.
Echinococcus multilocularis	Cats rarely shed *E. multilocularis* eggs and therefore infection is of little epidemiological significance.
Heartworm (*Dirofilaria immitis*)*	
Cats living in heartworm endemic areas (see Fig. 18)	Prophylactic larval treatment with macrocyclic lactones at monthly intervals during the mosquito season.
Travel or importation to/from endemic areas for heartworm	No later than 30 days after departure to 30 days after last possible travel date at monthly intervals.

- Deworming practices should always be on the advice of a veterinary professional. Regular coprological examination of faeces, as suggested in Groups A and B, is a good alternative to standard deworming advice.
- If the individual risk of an animal cannot be judged clearly, the animal should be examined or dewormed at least 4 times a year. Studies have shown that deworming 1–3 times a year does not provide sufficient protection. Deworming every 3 months does not necessarily prevent patent infections.

* Detailed information about heartworm infection in dogs and cats can be found in ESCCAP Guideline 5: Control of Vector-Borne Diseases in Dogs and Cats at www.esccap.org

Figure 2: Scheme for individual deworming of cats

BIOLOGY, DIAGNOSIS AND CONTROL OF WORMS

1. Roundworms (*Toxocara* spp.)

Toxocara canis is a large, intestinal nematode, with adults measuring as much as 15 cm in length that can cause disease in young dogs. Similarly, *Toxocara cati*, an intestinal nematode with adults measuring up to 10 cm in length, can cause disease in young cats.

Toxocara spp. infection can occur in puppies and kittens but also in older dogs and cats. Infection of humans can occur as a result of accidentally ingesting infective eggs or eating undercooked meat containing larvae.

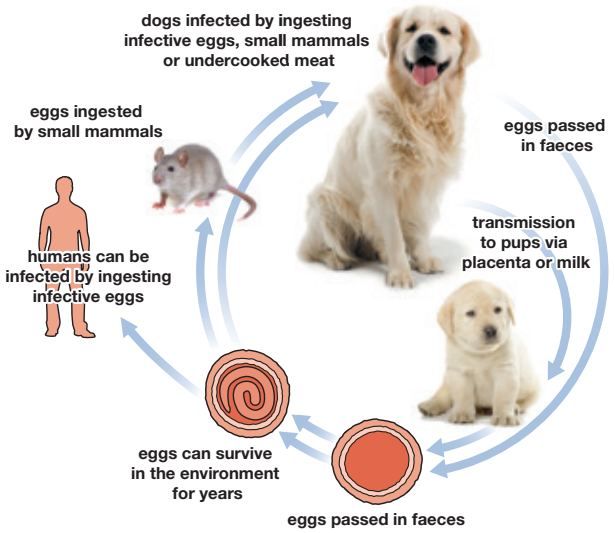


Figure 3: *Toxocara canis* life cycle

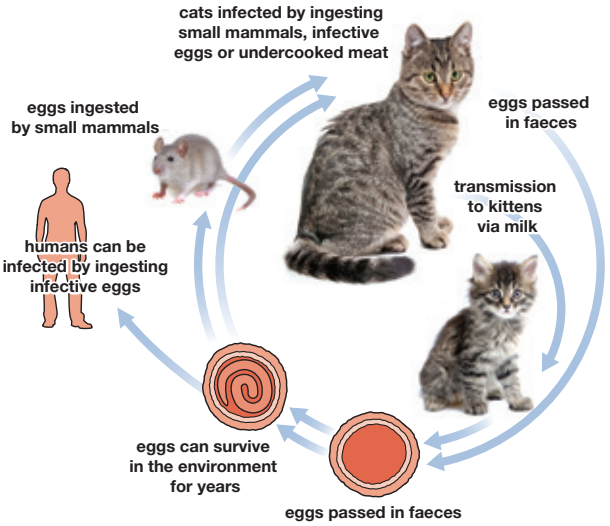


Figure 4: *Toxocara cati* life cycle

Adult worms inhabit the small intestine (Figure 5) where they lay eggs that are then passed in the faeces. The eggs can become infective after several weeks and these can survive in the environment for years. Dogs and cats become infected when they ingest infective eggs from the environment (Figure 6). Dogs and cats can also become infected when they eat undercooked meat or prey on an infected paratenic host (e.g. rodents).

The eggs hatch in the intestine releasing larvae that penetrate the intestinal wall and undergo a hepato- tracheal migration, with the life cycle completed when larvae are coughed up and swallowed, returning to the small intestine to complete their migration (Figure 3 and Figure 4). In puppies, infection can occur by the passage of larvae across the placenta from about the 42nd day of pregnancy and later through the milk (Figure 3). Kittens can be infected through the milk (Figure 4). Somatic migration can occur in older canines and felines and non-canid/felid hosts that can then act as paratenic hosts.

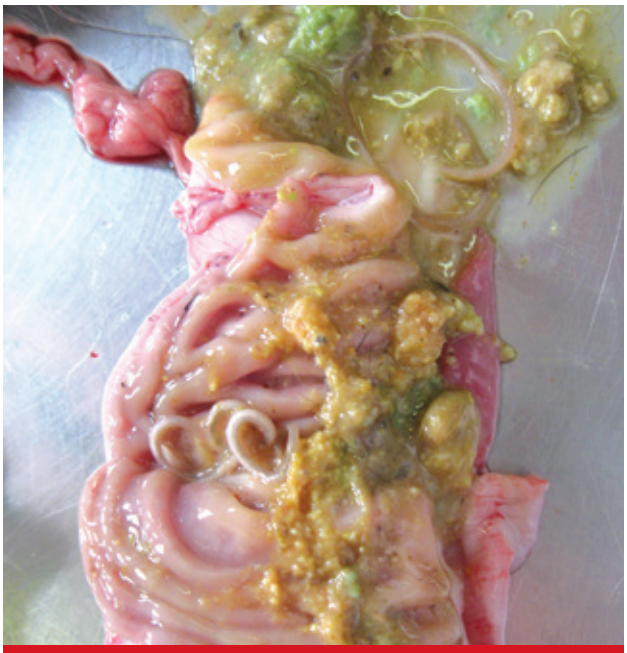


Figure 5: Adult worms live in the small intestine of infected dogs and cats

In adult animals, infections are extremely unlikely to be associated with clinical signs therefore it is difficult to determine whether a dog is infected unless regular faecal examinations are conducted. Puppies can be heavily infected by *T. canis* worms in utero or via nursing and these may cause serious illness before diagnosis is possible by faecal examination. In addition, these parasites are prolific egg-layers and just a few worms can produce large numbers of eggs which are able to survive for a long time in the environment.

Roundworms have an elevated zoonotic potential. After oral intake of infective roundworm eggs, the larvae may begin somatic migration (larva migrans complex). This can have serious consequences on human health (see chapter on **OWNER CONSIDERATIONS IN PREVENTING ZOONOTIC DISEASES**). For these reasons *Toxocara* spp. infections in dogs and cats of all ages merit consideration.

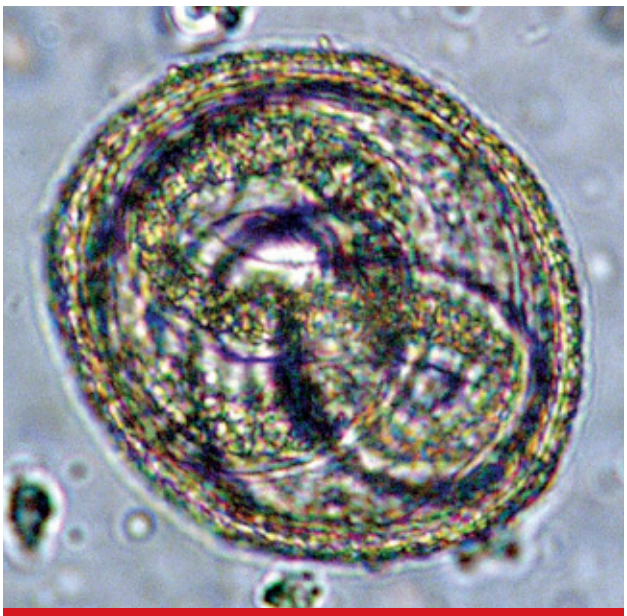


Figure 6: *Toxocara cati* infective egg

- **Puppies** should be treated with appropriate anthelmintics from 14 days old. The treatment should then be repeated fortnightly until two weeks after weaning and then monthly treatments carried out up to six months of age.
- Because prenatal infection does not occur in **kittens**, fortnightly treatment can begin at 3 weeks of age and be repeated fortnightly until two weeks after weaning, then monthly treatments carried out up to six months of age.
- To reduce transmission to the puppies, **pregnant bitches** can be given macrocyclic lactones on the 40th and 55th day of pregnancy, or fenbendazole daily from the 40th day of pregnancy continuing to 2 days postpartum.
- **Pregnant queens** should be treated with emodepside spot-on approximately seven days before expected parturition to prevent lactogenic transmission of *Toxocara cati* larvae to the kittens.
- **Nursing bitches and queens** should be treated concurrently with the first treatment of their offspring, as they often develop patent infections at this time.
- For **adult dogs and cats**, ESCCAP recommends an individual risk assessment for each animal to determine whether anthelmintic treatment is necessary, and how often. There is surprisingly little information about the impact of re-treatment intervals on parasite burdens and environmental contamination on which to base a maximum re-treatment interval under different epidemiological conditions. Current information suggests that annual or twice yearly treatments do not have a significant impact on preventing patent infection within a population. Therefore, a treatment frequency of at least 4 times per year is a general recommendation.
- As the pre-patent period for *Toxocara* spp. after ingestion of larvae via predation of paratenic hosts (rodents) or infective eggs from the environment is a little over four weeks, monthly treatment will minimise the risk of patent infections and is recommended in risk scenarios, for example when the pet shares a house with small children and has frequent risk of infection (free roaming, access to garden).
- As an alternative to repeated treatments, faecal examinations can be performed at suitable intervals followed by anthelmintic treatment where positive results are found (see chapter on **DIAGNOSIS OF HELMINTH INFECTIONS**). This approach should be adopted in countries where routine treatments are not acceptable for legislative reasons. Nevertheless, between faecal examinations the excretion of infective eggs is still possible and cannot be prevented. Caution must be taken in cases of negative results following faecal examination: it cannot be assumed with certitude that an animal is not infected with roundworms in case of prepatent infections or when the number of excreted eggs is under the detection limit of the analysis.

For further information on *Toxocara* spp. characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2A and 3–7.

2. Tapeworms

Echinococcus granulosus and *Echinococcus multilocularis*

Echinococcus granulosus (dog tapeworm) is a small cestode that inhabits the small intestine of dogs and some other canids, excluding foxes. *Echinococcus multilocularis* (fox tapeworm) is a small cestode that inhabits the small intestine of foxes, raccoon dogs, some other canids and rarely dogs and very seldom cats. See Figures 7 and 8 for life cycles.

Both the tapeworms, *E. granulosus* and *E. multilocularis* induce extra-intestinal metacestode stages in intermediate hosts and both are zoonoses of major public health concern. In humans, *E. granulosus* causes cystic echinococcosis and *E. multilocularis* causes alveolar echinococcosis, which if untreated can have potentially fatal consequences. Both infections result in the formation of cysts, most commonly in the liver (*E. multilocularis, E. granulosus*) or in the lung (*E. granulosus*). These occur following the oral ingestion of eggs or proglottids excreted in the faeces of the definitive hosts. They are immediately infective to intermediate hosts including humans.

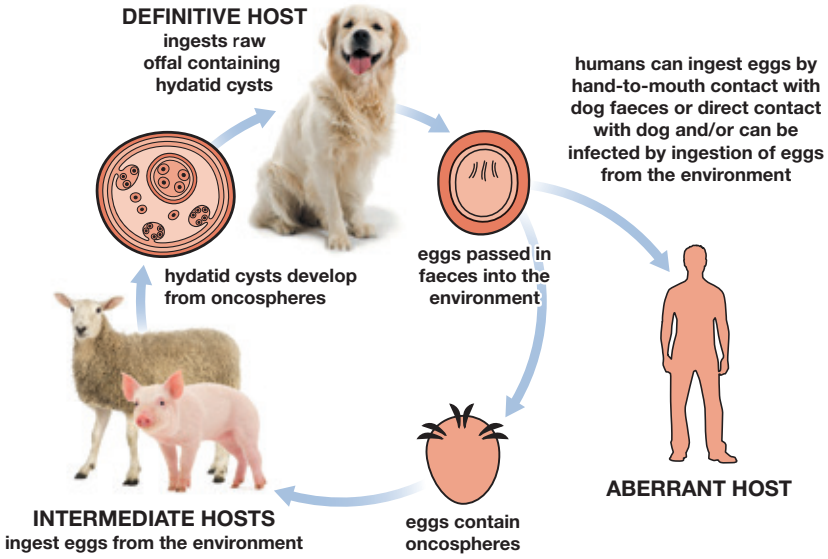


Figure 7: *Echinococcus granulosus* life cycle

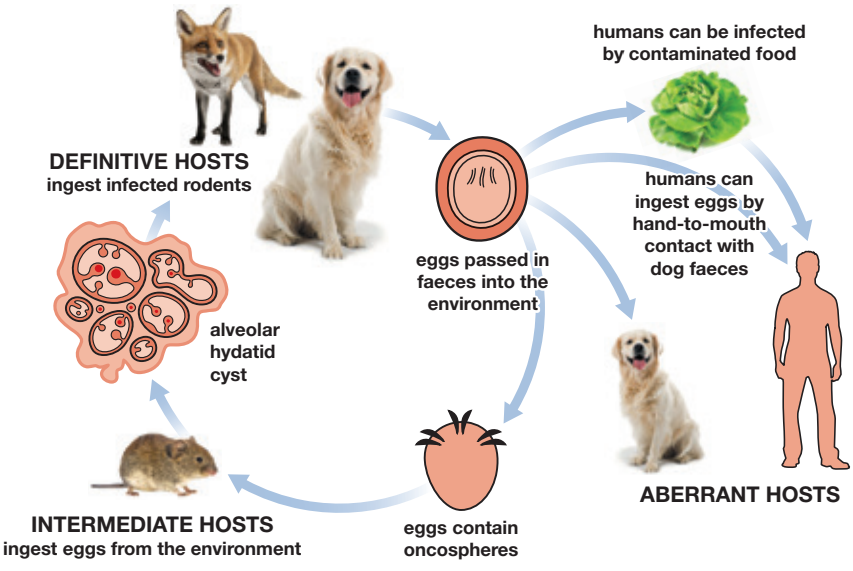


Figure 8: *Echinococcus multilocularis* life cycle

In areas where *E. granulosus* and related species are endemic (Figure 9), care should be taken to prevent dogs having access to raw offal and carcasses. Where dogs may have access to carcasses or raw viscera especially from sheep, pigs, cattle or horses (depending on the *Echinococcus* genotypes present locally) they should be treated at least every six weeks with an effective anthelmintic containing praziquantel or epsiprantel.

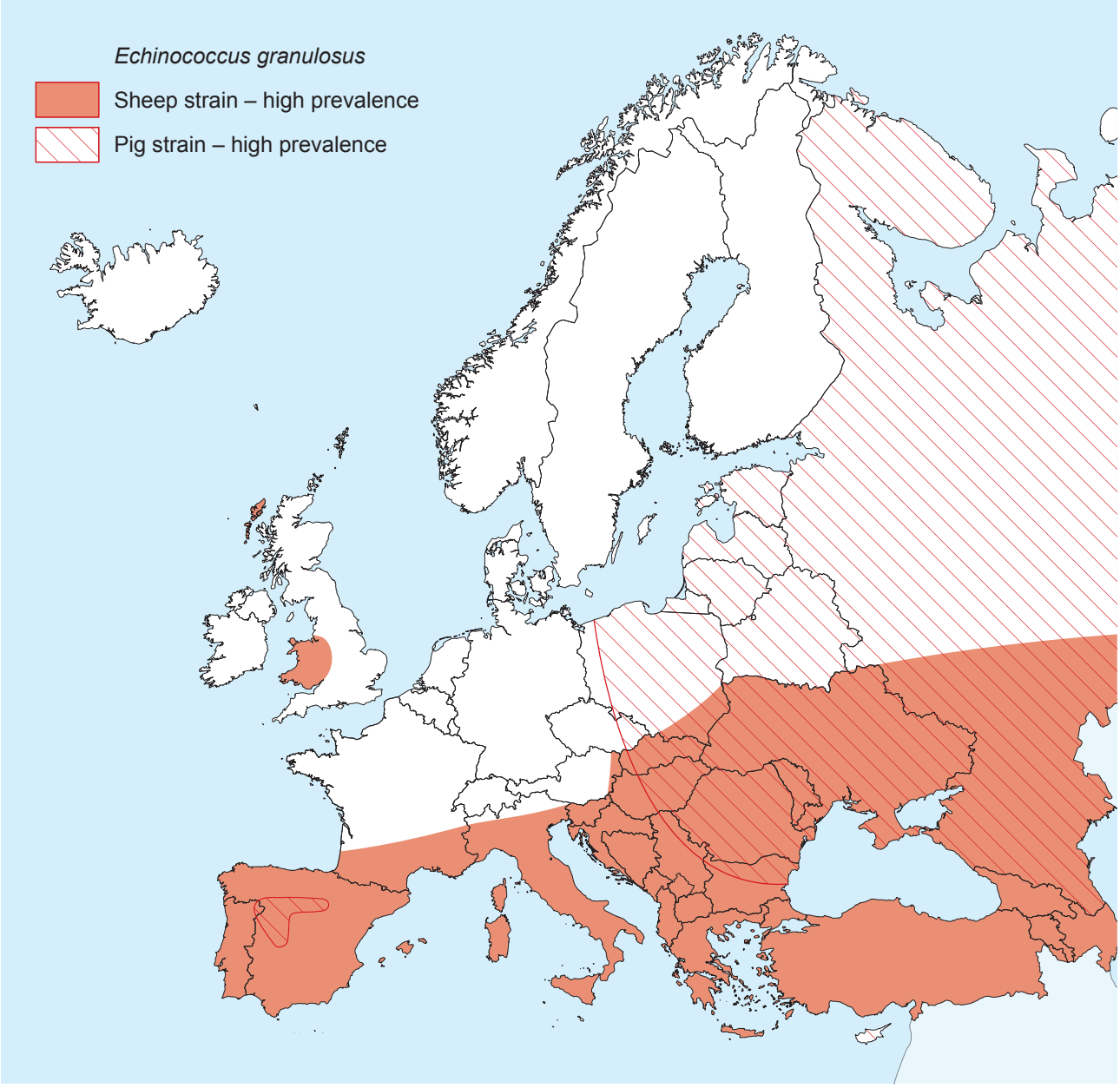


Figure 9: Approximate summary of distribution of *Echinococcus granulosus* and related species in Europe (© ESCCAP)

In the central and Eastern European endemic area of *E. multilocularis* (Figure 10) with red foxes as main definitive hosts and voles as intermediate hosts, dogs that have access to rodents should also be treated at four weekly intervals with an effective anthelmintic containing praziquantel or epsiprantel. Cats, in contrast to dogs, are epidemiologically insignificant as sources of egg output. Whilst in dogs, it is common to find eggs in the fur of infected animals, no eggs have been recovered to date from the coat of infected cats and their zoonotic potential is also probably limited because there is only a small risk of cats excreting large numbers of eggs. Specific diagnosis of *Echinococcus* infections in definitive hosts is difficult as taeniid eggs (including *Echinococcus* spp. and *Taenia* spp.) cannot be differentiated morphologically and are passed intermittently.

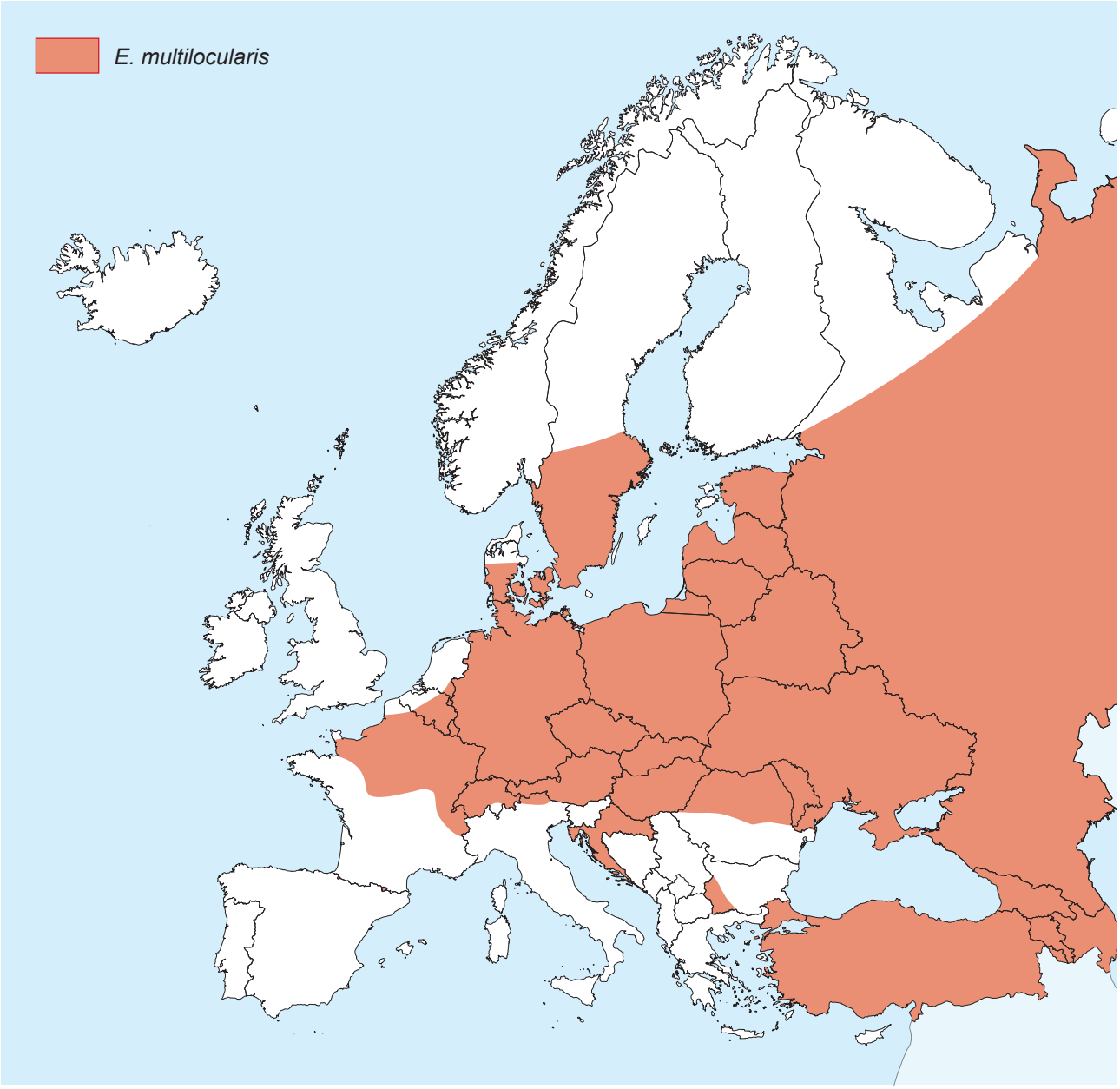


Figure 10: Approximate distribution of *Echinococcus multilocularis* in the fox in Europe (© ESCCAP)

DNA-based tests for species and/or genotype identification are only performed in specialised laboratories. Therefore in *Echinococcus* endemic areas, taeniid infections based on egg detection should be handled as potential *Echinococcus* infections since eggs are directly infective. Where animals are infected with an *Echinococcus* species, it is advisable that they are treated under the supervision of a veterinarian with praziquantel or epsiprantel on two consecutive days, and that the dogs are shampooed to remove any parasite eggs adhering to the coat. The faeces of treated dogs should be appropriately eliminated (in waste that will be burned) up to three days after anthelmintic treatment. The personnel involved should use suitable protective clothing such as gloves and a mask.

Prevention is achieved through the following recommendations:

- If possible, dogs should not have access to wild rodents.
- Dogs and cats should not be given slaughter waste or raw meat but only commercial food or meat that has been heated for 10 minutes (inner temperature: 65°C) or frozen for one week at -17 to -20°C.
- For dogs with a high risk of infection with *Echinococcus* spp., ESCCAP promotes monthly treatments with an appropriate anthelmintic containing praziquantel or epsiprantel.
- Dogs travelling into areas with a high risk of *Echinococcus* spp. infections should be treated four weeks after starting the trip and for four weeks after returning with an appropriate anthelmintic containing praziquantel or epsiprantel.
- Dogs imported from endemic areas should be promptly seen by a veterinarian and treated with an appropriate anthelmintic containing praziquantel or epsiprantel.
- Cats are comparatively unsuitable hosts for *E. multilocularis*. Even in infected cases, cats only excrete a low number of eggs which have not shown to be infective under experimental conditions, therefore representing a fractional risk. However, as a precaution, cats with excretion of taeniid eggs should be treated appropriately.

For further information on *Echinococcus* spp. characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2B and 3–7.

Dipylidium caninum

Dipylidium caninum is a tapeworm of dogs and cats. The parasite is common throughout Europe. The intermediate hosts are the flea or the chewing dog louse and dogs and cats become infected when they ingest the infected insects. The adult tapeworm develops within the dog or cat in the small intestine (Figure 11). *D. caninum* is zoonotic and if humans ingest infected fleas or lice they can become infected, although this is rare. The prepatent period is approximately three weeks.

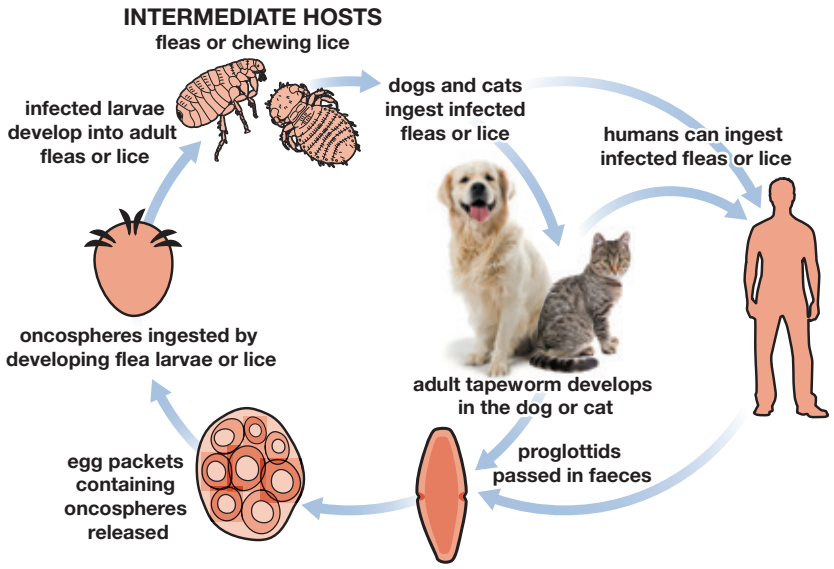


Figure 11: *Dipylidium caninum* life cycle

Infection with *D. caninum* is rarely associated with clinical signs in dogs and cats. The mature segments leaving the anus may result in anal irritation (pruritus) causing an animal to rub its bottom along the ground.

The white proglottids may be seen in fresh faeces or in the coat around the anus. When dry, these are shaped like rice grains and may be evident around the perianal area and in samples from the animal's bedding.

Treatment is performed with praziquantel or epsiprantel and control management is achieved by additional control of fleas and lice.

For further information on *D. caninum* characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2B and 3–7.

Taenia spp.

Taenia spp. are tapeworms that can infect dogs, cats and foxes by the ingestion of intermediate hosts. They are common throughout Europe.

Dogs and cats become infected when they eat the tissue or viscera of infected intermediate hosts. Infection of the intermediate host occurs by ingestion of tapeworm eggs in proglottids passed in the faeces of the definitive host (Figure 12). The effects on the intermediate host may be more profound than on the definitive host. The intermediate hosts are varied and, depending on the *Taenia* spp., range from sheep and cattle (*Taenia multiceps*) to rabbits (*Taenia serialis, Taenia pisiformis*), rodents (*Taenia taeniaeformis*), ruminants and pigs (*Taenia hydatigena*) and sheep and goats (*Taenia ovis*) (Table 1).

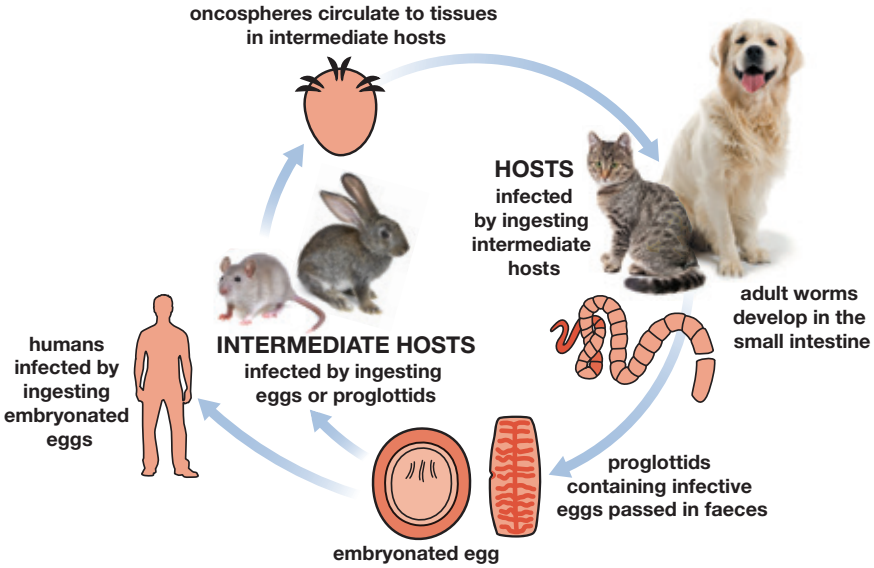


Figure 12: *Taenia* spp. life cycle

The prepatent period for *Taenia* spp. ranges from about four to ten weeks in dogs (depending on the species) and is approximately five to ten weeks for *T. taeniaeformis* in cats, which uses rodents as intermediate hosts. Patency can last for several months up to several years, for example *T. ovis*, a *Taenia* species infecting dogs, can be patent for up to five years.

Taenia spp. infections are rarely associated with clinical signs in dogs or cats. The mature segments leaving the anus may result in anal pruritus causing an animal to rub its bottom along the ground. Owners may also notice motile segments crawling on the animal's coat after leaving the anus.

Taeniid eggs (Figure 13) may be detected upon faecal examination. *Taenia* spp. eggs cannot be differentiated microscopically from *Echinococcus* eggs. Therefore in *Echinococcus* endemic areas, taeniid infections based on egg detection should be considered as a potential *Echinococcus* infection. Macroscopic examination of the faeces may demonstrate the presence of white proglottids; microscopically, unlike *D. caninum* each has only one genital pore.

Treatment is by the administration of an effective anthelmintic at suitable intervals which will most likely depend upon evidence of an existing infection. Eggs can remain viable for lengthy periods in the environment. Owners should try and prevent dogs and cats having access to the various intermediate hosts. The feeding of raw meat and viscera should be discouraged.

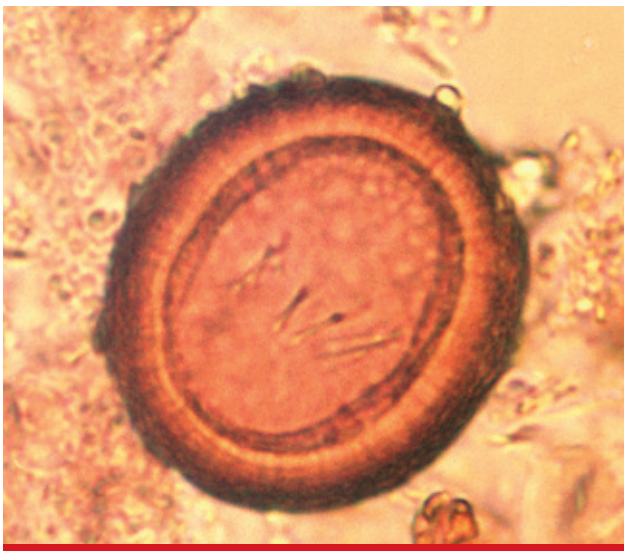


Figure 13: Taeniid egg

Table 1: Summary of *Taenia* spp. found in dogs and cats

Definitive hosts	**DOGS**						**CATS**
Species	***Taenia multiceps***	***Taenia serialis***	***Taenia crassiceps****	***Taenia pisiformis***	***Taenia hydatigena***	***Taenia ovis***	***Taenia taeniaeformis***
Prepatent period (approx. in weeks)	6		4–6	6–8	7–10	6–8	5–10
Intermediate host	Sheep, goats and cattle	Rabbits (and rodents)	Rodents	Rabbits/hares (and rodents)	Sheep, goats, cattle and pigs	Sheep and goats	Rodents
Intermediate stage and site	Coenurus larvae in brain and spinal cord	Coenurus larvae in connective tissue	Cysticercus larvae in body cavities or subcutaneous tissue	Cysticercus larvae in abdomen or liver	Cysticercus larvae in abdomen or liver	Cysticercus larvae in muscles	Strobilocercus larvae in liver and abdomen

* much more frequently found in red foxes

For further information on *Taenia* spp. characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2B and 3–7.

3. Heartworm and Subcutaneous Worms

Dirofilaria immitis

Dirofilaria immitis is a filarial worm that resides in pulmonary arteries of dogs and cats (Figure 14). Also known as heartworm, it is transmitted by intermediate mosquito hosts (Figure 15). Heartworm infection (*D. immitis*) is endemic in many southern and south-eastern European countries (Figure 18). Climatic changes favourable to parasite development and the increasing number of travelling pets have increased the risk of infection for dogs, cats and pet ferrets.

Although cats are potential hosts for heartworm, their relevance as definitive hosts is clearly reduced compared to dogs.

Infection with *D. immitis* may cause severe and potentially fatal disease in dogs and cats. Low worm burdens can be asymptomatic. Increasing worm burdens can cause clinical signs such as loss of condition, weakness, dyspnoea and chronic cough. If untreated, the disease can progress to right side heart failure and death. In cats, the disease is mostly asymptomatic but in rare cases may cause sudden death.

In most parts of Europe where infection is endemic, the transmission season of heartworm lasts from April to October (depending on the climate). Yearlong transmission of *D. immitis* is only actually reported for the Canary Islands (Spain).

In dogs and cats, control depends upon the use of heartworm preventive treatments (macrocyclic lactones) that kill the juvenile heartworm stages prior to their migration towards the pulmonary artery and right side of the heart. Infection cannot be hindered, but the use of appropriate products can effectively prevent development into adult heartworm and the onset of clinical signs of infection.

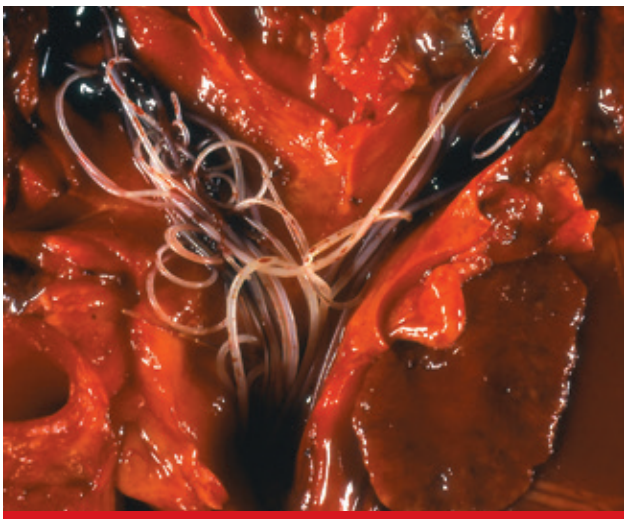


Figure 14: Adult worms live in the pulmonary arteries

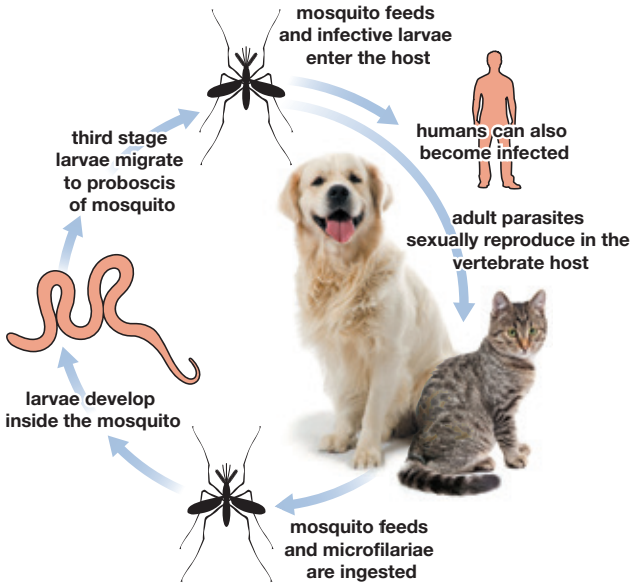


Figure 15: *Dirofilaria immitis* life cycle

The combination of heartworm preventatives with repellents/insecticides designed to prevent mosquito blood-feeding activity during the heartworm transmission season could be useful in protecting dogs from infection. Recently, topical administration of permethrin with dinotefuran has shown repellent efficacy against mosquitoes on dogs for at least 4 weeks.

In endemic areas, puppies and kittens need to be placed on preventive heartworm treatment as soon as possible after birth (consistent with label recommendations). Most preventive anthelmintics effective against heartworm also control a range of other worms, therefore a product should be chosen to control all relevant worms. In addition, treatment can be extended throughout the year to ensure the continued control of non-seasonal parasites such as *Echinococcus* spp. and *Toxocara* spp., where necessary. The use of such products should commence within the first four weeks after the start of a potential transmission and maintained monthly until 30 days after the last potential date of an infection. As a principle, all dogs previously exposed to the risk of *D. immitis* infection should receive a complete clinical check-up, including blood tests to detect microfilariae and/or serology to detect circulating antigens or antibodies for the diagnosis of heartworm infections.

Detailed information about heartworm infection in dogs and cats can be found in ESCCAP Guideline 5: Control of Vector-Borne Diseases in Dogs and Cats at www.esccap.org

Dirofilaria repens

Dirofilaria repens can infect both dogs and cats and is also transmitted by mosquitoes (Figure 17). *D. repens* is the species most frequently associated with subcutaneous filariosis of dogs and cats. Most infections are subclinical, though cold, painless nodules (unique or multiple) containing the adult parasites and microfilariae can be found under the skin of infected animals (Figure 16). In cases of heavy infection or in sensitised animals, a mild to severe dermatitis can sometimes be observed.

Areas where *D. repens* is endemic overlap with endemic *D. immitis* areas in many regions of Europe. *D. repens* is the main species occurring in areas such as northern France and Hungary and is the most important *Dirofilaria* species responsible for zoonotic infections in Europe. There have been recent reports of autochthonous infection in Germany, the Netherlands, Poland, Austria and Portugal. Autochthonous infections are contracted in the country where they are reported. The distribution of *D. repens* is shown in Figure 18.

Despite infections of *D. repens* being mostly asymptomatic, therapy is recommended because of the zoonotic potential of the parasite. The nodules can be eliminated by surgery but it is preferable to extract the adult worms by aspiration with a catheter.

Before and after travelling, dogs and cats should be examined for infection by *D. repens* microfilariae. In dogs, blood tests can demonstrate the presence of microfilariae. In cats, detection of microfilariae in the blood is unlikely to be successful as the density of the microfilariae in the circulation is very low.

When microfilariae are present in a blood sample, dogs and cats should not travel to non-endemic areas without prior microfilaricidal treatment. Treatment using an appropriate prophylactic will give protection before entry into an endemic area.

See ESCCAP Guideline 5: Control of Vector-Borne Diseases in Dogs and Cats for a range of diagnostic options that may be appropriate.

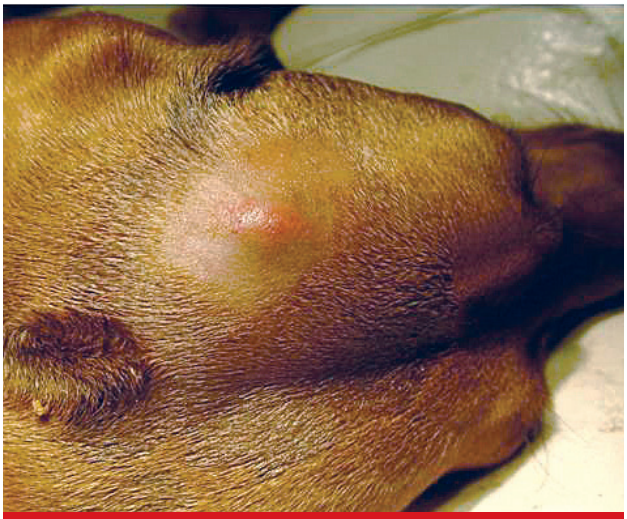


Figure 16: The worm may cause skin nodules and swelling

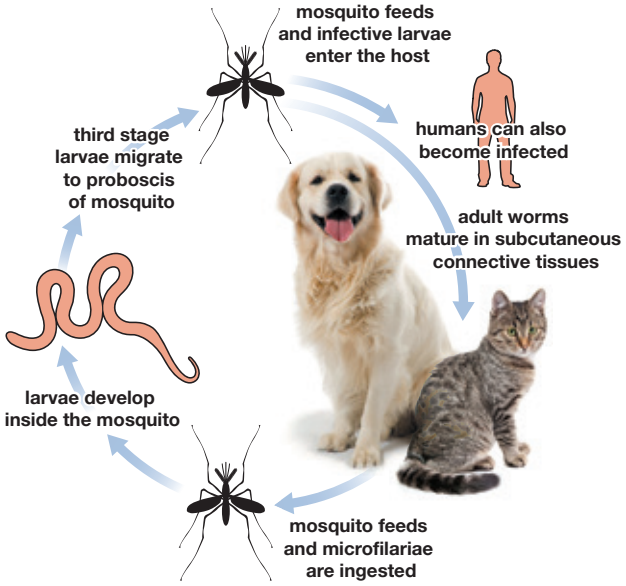


Figure 17: *Dirofilaria repens* life cycle

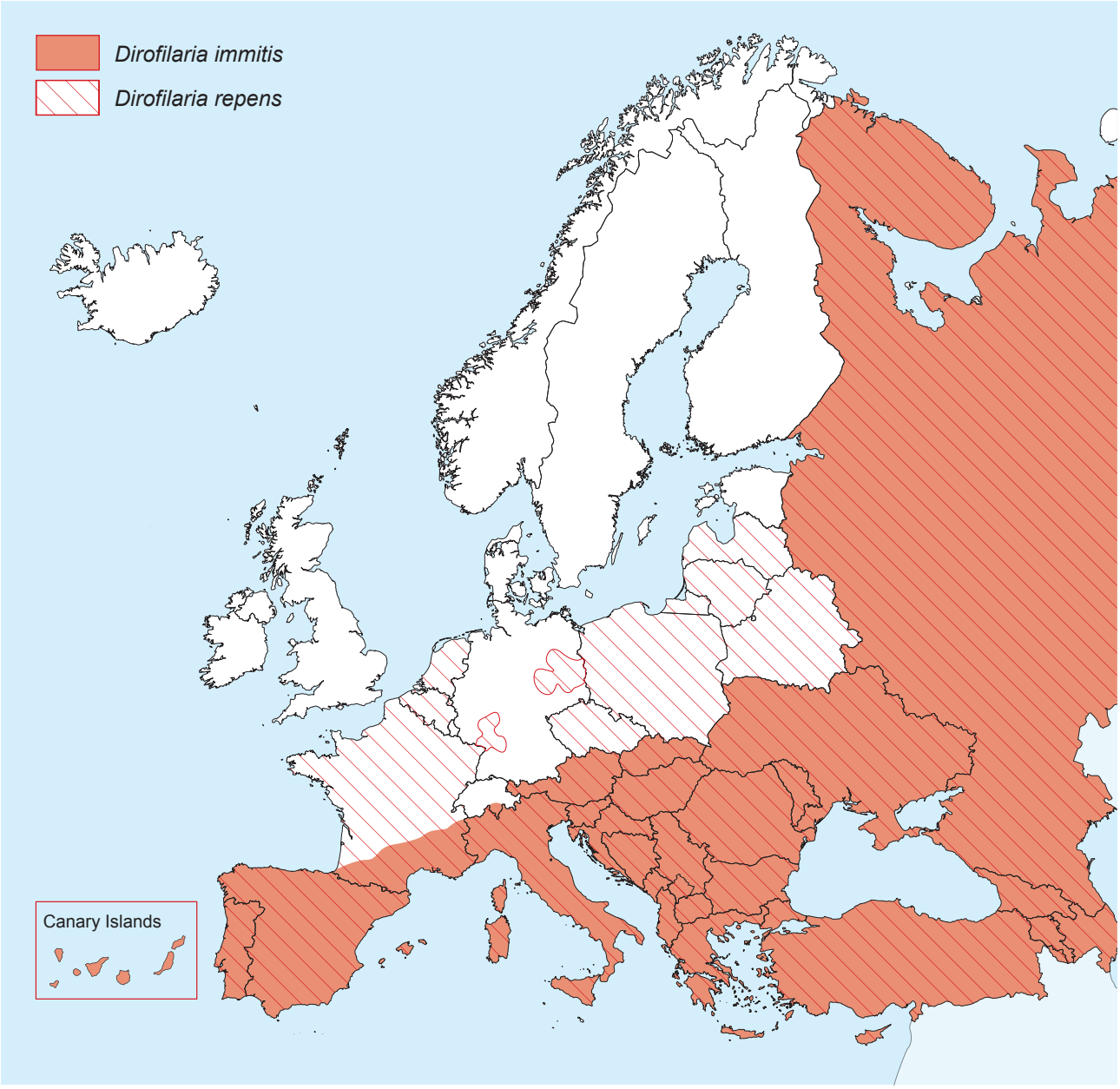


Figure 18: Approximate distribution of *Dirofilaria immitis* and *Dirofilaria repens* in Europe (© ESCCAP)

Zoonotic potential of *D. immitis* and *D. repens*

Most cases of zoonotic *Dirofilaria* infections in Europe are caused by *D. repens*. After being bitten by a mosquito infected with *D. repens* the most common findings have been subcutaneous nodules and under the conjunctiva of the eye. *D. immitis* can develop into granulomas in different organs (mainly the lungs), which nevertheless remain mostly without clinical relevance. Since *Dirofilaria* spp. infections are asymptomatic they usually do not require therapy. Often the infection is diagnosed after surgical removal of a nodule containing worms. Together with the classical solitary lung nodules, worms can also be found in the eye and in deep body cavities, occasionally simulating tumours.

For further information on *Dirofilaria* spp. characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2C and 3–7 and ESCCAP Guideline 5: Control of Vector-Borne Diseases in Dogs and Cats at www.esccap.org

4. French Heartworm (*Angiostrongylus vasorum*)

Angiostrongylus vasorum is a nematode that resides as the adult stage in the pulmonary arteries and the right side of the heart in dogs and other carnivores (excluding cats).

The distribution of *A. vasorum* includes endemic areas in several European countries. However, former reports of isolated endemic foci are being increasingly replaced by the description of larger endemic areas, involving dogs and wildlife. Foxes in particular are considered an important reservoir, with wolves, coyotes and jackals being further potential sources of infection.

Figure 19: *A. vasorum* larvae measure approximately 345 µm and are characterised by a wavy tail with a dorsal notch

Like other metastrongylids, the life cycle of *A. vasorum* includes some species of slugs and snails as intermediate hosts. Dogs acquire infection through the ingestion of intermediate hosts or frogs or possibly birds acting as paratenic hosts (Figure 20).

Following the ingestion of infective L3 by a dog, larvae (Figure 19) develop and migrate to the right side of the heart and pulmonary artery. Female worms begin to produce eggs from 38–60 days after infection (prepatency). Eggs hatch rapidly and larvae penetrate the alveoli. They are then coughed up and excreted in faeces as first stage larvae (L1). Without treatment, lifelong infections can persist.

Clinical manifestations of *A. vasorum* infection in dogs are variable. Naturally infected subclinical dogs are reported but respiratory signs such as coughing and dyspnoea induced by verminous pneumonia are frequently observed, complemented by bleeding disorders, neurological, gastrointestinal or non-specific signs. In chronic infections, anorexia, anaemia, weight loss, depression, pulmonary hypertension and signs of coagulopathy (e.g. melaena, haemoptysis, prolonged bleeding from minor injuries and subcutaneous haematomas) can be seen. In rare cases sudden death may occur.

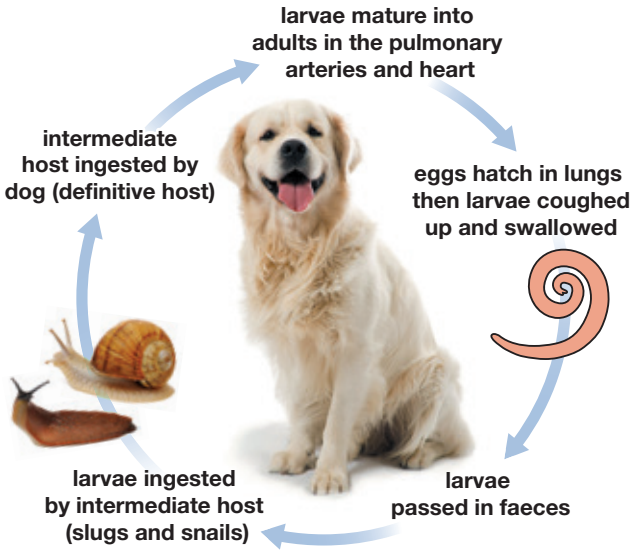


Figure 20: *Angiostrongylus vasorum* life cycle

Occasionally, larvae and rarely adult stages of *A. vasorum* are located in ectopic locations such as the brain, bladder, kidney or anterior chamber of the eye. This may result in clinical signs relating to the invasion of these organs.

Diagnosis can be performed by detecting first stage larvae from (at least) 4 g of fresh faeces using the Baermann method. Faeces are preferentially sampled on three consecutive days due to large daily variation in larval excretion. Alternatively, microscopic detection of first stage larvae in bronchial lavage material can be used. Furthermore, serology, in particular a commercial serological test for detection of circulating antigen is available.

Anthelmintic therapy includes the use of a macrocyclic lactone-based anthelmintic with varying treatment protocols or repeated daily administration of a benzimidazole-based anthelmintic (for three weeks). Supportive treatment, with antibiotic and glucocorticoid-based products as well as blood substitute fluids, may be needed in severe clinical cases, and the animal should be rested during the treatment period (at least two to three days).

In local areas of high endemicity and/or if the dog is exposed, e.g. used for hunting or eats grass, slugs or snails ("hoovers"), prevention can be achieved with the monthly administration of macrocyclic lactones.

For further information on *A. vasorum* characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2C, 3 and 6.

5. Hookworms (*Ancylostoma* spp. and *Uncinaria* spp.)

Hookworms are small nematodes characterised by large mouthparts that are at an angle to the rest of the worm, hence the common name. There are three significant species in Europe: *Ancylostoma caninum* (dogs), *Ancylostoma tubaeforme* (cats) and *Uncinaria stenocephala* (dogs and rarely cats).

U. stenocephala, known as the northern hookworm, tolerates colder climates than *A. caninum* and is found throughout Europe. *A. caninum* is found predominantly in central and southern Europe and *A. tubaeforme* is found throughout continental Europe.

The adult worms (Figure 21) inhabit the small intestine and have a direct life cycle with eggs passed in the faeces developing to third stage larvae (L3) in the environment. When these are ingested, they develop within two to three weeks to adult worms (Figure 22).

Hookworms, most notably *Ancylostoma* spp. larvae, can be transmitted through milk from the lactating mother to the puppies and are also capable of penetrating skin and thus making their way to the intestine. It is unlikely that this latter route of infection contributes greatly to the *U. stenocephala* life cycle.

All species feed by grasping the intestinal mucosa with their mouthparts and damaging the surface to obtain nutrients: largely blood in the case of *Ancylostoma* spp., as they require oxygen from the blood, whilst *U. stenocephala* obtain nourishment from tissue components on the surface of the intestine.

Diarrhoea, weight loss and anaemia are the common clinical signs and in the case of *A. caninum* and *A. tubaeforme* the diarrhoea may contain blood. Skin lesions can appear on the foot pads of dogs and cats caused by larvae burrowing into and along the skin. *Ancylostoma* species can cause significant anaemia when present in high numbers or over a period of time. Lactogenic transmission of larvae by *A. caninum* can result in acute anaemia and even the death of young pups. *U. stenocephala* is less pathogenic.

Figure 21: Hookworms are small nematodes that live in the intestine of infected dogs and cats

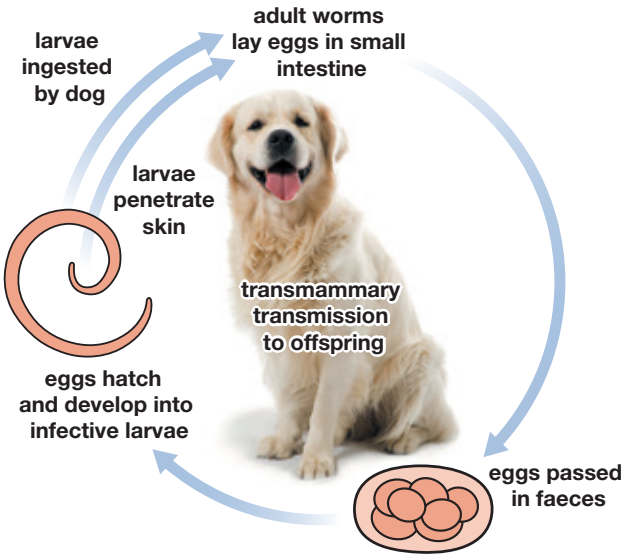


Figure 22: Hookworm life cycle

Immunity develops after exposure, but is unlikely to be absolute. Infection thrives best where animals have access to outdoor environments such as kennel runs. Diagnosis is based on identifying hookworm eggs in fresh or fixed faecal samples using a flotation method, although the eggs of the two genera are indistinguishable (Figure 23). When they are detected, anthelmintic treatment should be administered. Diagnosis in young puppies can be complicated by signs of disease occurring before infection is patent i.e. before eggs are passed in faeces. Animals in heavily infected environments may require regular anthelmintic therapy to control hookworm infections. Where young animals are clinically affected by the infection, supportive therapy may be necessary in addition to anthelmintic treatment.

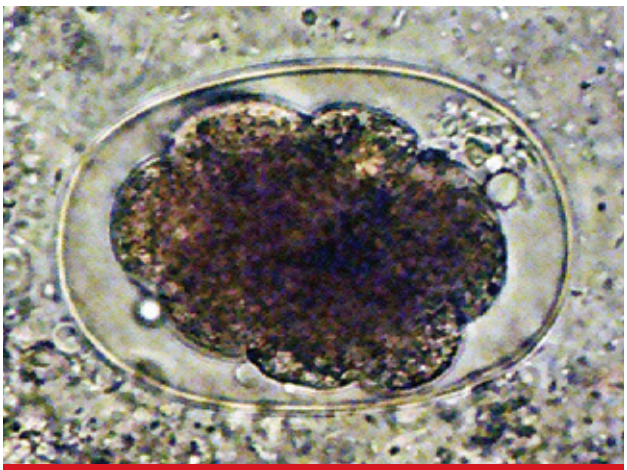


Figure 23: Infection can be diagnosed by faecal examination and identification of eggs

For further information on hookworm characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2A and 3–7.

6. Whipworm (*Trichuris vulpis*)

Trichuris vulpis is a nematode of the large intestine in dogs (Figure 24). *T. vulpis* is most likely to occur in central and southern parts of Europe where temperatures are suitable for the environmental development of eggs and in specific premises, such as kennels and animal shelters. Considerable and persistent contamination of the environment with infective eggs can occur. Control can therefore be difficult, as dogs may become re-infected if they remain in the same environment.

Eggs are passed in the faeces of infected dogs and the infective L1 develops within the egg in one to two months at temperatures above 4°C. The larvae are protected by the eggshell and can survive in the environment for years. Dogs become infected when they ingest infective eggs (Figure 25). The prepatent period is two to three months, after which infected dogs may continue to shed eggs for up to a year.

Figure 24: *Trichuris vulpis* worm

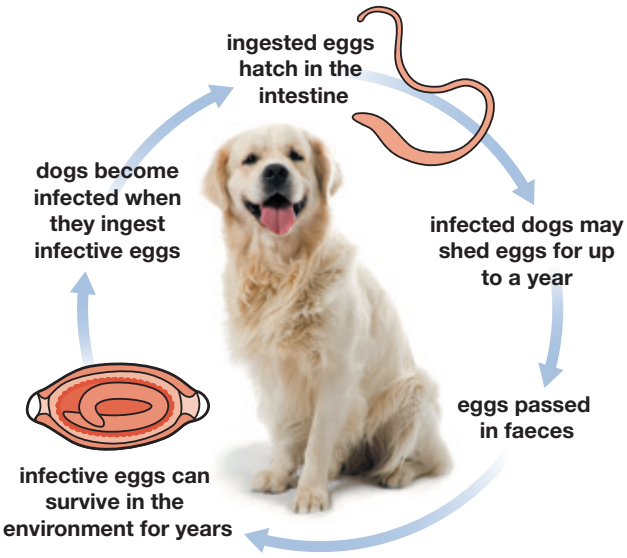


Figure 25: *Trichuris vulpis* life cycle

A heavy infection (Figure 26) will result in diarrhoeic, bloody, mucus-filled faeces accompanied by weight loss and ultimately, the animal will no longer be able to compensate and will develop metabolic disturbance including hyponatraemia.

Infection can be diagnosed by finding characteristic "lemon-shaped" eggs (Figure 27) on examination of 3–5 g of faecal samples using a suitable flotation technique. Most modern anthelmintics are effective against *T. vulpis*. To be effective, repeated deworming is often required.

Where possible, dogs should be removed from contaminated areas and put on repeated anthelmintic treatment. Since the eggs are difficult to eliminate from the environment, it may be necessary to consider resurfacing kennel flooring (e.g. by paving or laying concrete) to facilitate thorough cleaning. Rotavating and reseeding may also help to eliminate contamination.

For further information on *T. vulpis* characteristics, risk factors, clinical signs, diagnosis and treatments see Tables 2A, 3 and 6.

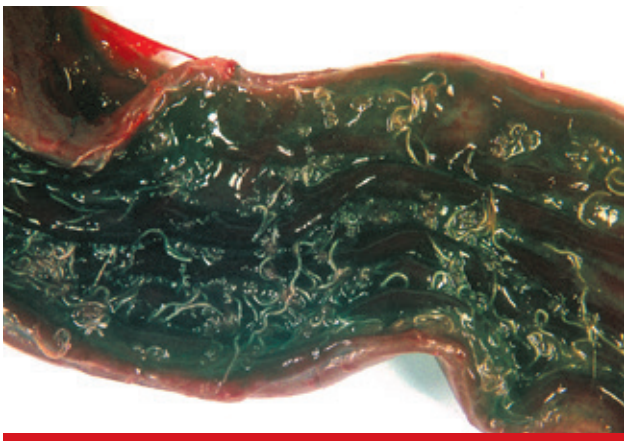


Figure 26: A heavy infection of *Trichuris vulpis* in the large intestine of a dog

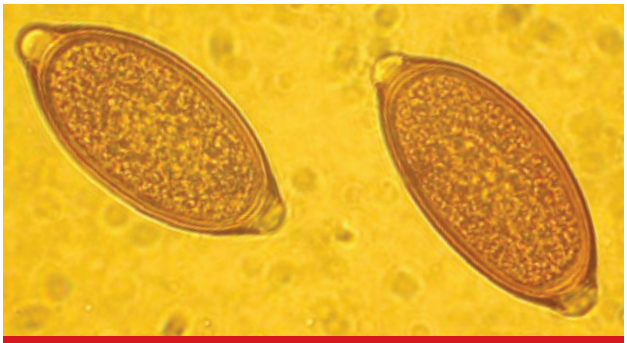


Figure 27: *Trichuris vulpis* eggs

DIAGNOSIS OF HELMINTH INFECTIONS

Patent infections of all of the worms mentioned can be identified by faecal examination, except for *D. immitis* and *D. repens* where a blood sample is examined for microfilariae or for antigens (dogs). Faecal examination for worm eggs should be carried out with at least 5–10 g fresh faeces and can be conducted using flotation techniques with solutions of appropriate density (Tables 6 and 7). The analysis of faecal samples collected over different days increases the sensitivity of the employed methods.

Eggs of ascarids, hookworms, whipworm and most taeniids are easily recognisable. In some cases, worm burden can be crudely estimated from the number of eggs present in the sample. However, it should be noted that for ascarids such as *Toxocara*, a negative correlation between fecundity per worm and number of adult worms has been reported. Furthermore, there is poor correlation between taeniid infection and the detection of eggs in faeces. Since dogs and potentially also cats may ingest or eat faeces, care should be taken to identify and eliminate false positive results caused by coprophagia.

Where larvae (L1) are produced (lungworms and *A. vasorum*), faecal samples should be examined using the Baermann technique (Tables 6 and 7). If possible, faeces should be sampled on three consecutive days due to daily variation in larval excretion. Faeces should be collected from a fresh sample and not from the ground in a kennel or run. Differentiation of the metastrongylid L1 is based on size measurements and morphology of the tail. Re-testing is recommended approximately three weeks after starting the anthelmintic treatment(s) to check that treatment has resulted in the removal of adult worms. Dogs clinically affected by angiostrongylosis should be further investigated to evaluate pulmonary and circulatory status and clotting parameters. Alternatively, a commercially available test for serological detection of circulating antigens of *A. vasorum* can be used for clinical suspect cases.

IMPACT OF PET HEALTH AND LIFESTYLE FACTORS

The type and frequency of diagnostic, preventive and therapeutic measures need to be tailored to suit individual needs based upon where the animal is kept. When recommending a parasite management programme, veterinarians should consider the following (see Tables 3 and 5 for more details).

The animal

Age: puppies, kittens and geriatric animals are at greater risk than healthy adults.
Reproductive status: pregnant bitches may pass *T. canis* larvae to the foetus in utero.
Lactation: lactating bitches may pass *T. canis* to their sucking pups via milk (lactating bitches often have patent *T. canis* infections as they become infected by their offspring). Lactating queens can pass *T. cati* to their sucking kittens via milk. *A. caninum* infections can also be transmitted to pups via milk.
Health status: e.g. ectoparasite infestation.

Environment/use of the animal

Shared accommodation: animals kept in kennels, shelters or breeding stations or those living with other dogs or cats are at greater risk of acquiring parasites and may require special consideration.
Roaming: dogs and cats who live outdoors or those with unrestricted access to the outdoors are at greater risk of acquiring parasites.
Working dogs: hunting and working dogs may also be at a greater risk.

Nutrition

Dogs and cats with access to the following may be at risk of acquiring specific parasites:
Rodents
Slugs and snails
Raw fish
Raw meat including viscera without appropriate heating or freezing
Carcasses, placenta or aborted foetuses

Location and travel

Dogs and cats living in or travelling to specific geographic areas (e.g. holidays, relocation, boarding facilities, shows and field trials) may be at increased risk of acquiring infections that occur in those areas. Non-endemic diseases can be a diagnostic challenge for veterinarians who are unfamiliar with them. Dogs imported from areas endemic for particular parasites (e.g. *E. multilocularis*) should be promptly visited by a veterinarian and treated with an appropriate anthelmintic.

In each case, diagnostic methods can be used to verify the success of the prevention measures taken and medication chosen.

RESISTANCE TO ANTHELMINTICS

To date there have been no proven cases of anthelmintic resistance to intestinal and extraintestinal worms in dogs and cats in Europe. However, in the USA, anthelmintic resistance of *D. immitis* larvae is commonly recognised and there are a number of studies suggesting that drug resistance is present in hookworm populations in Australia and the USA. Recent studies also report on single resistant *Toxocara canis* and *Dipylidium caninum* worm populations in the USA. At present there is no way of detecting anthelmintic resistance in vivo in dogs or cats other than the faecal egg count reduction test.

Traditional anthelmintic treatment of dogs and cats has always left many parasite stages outside the definitive host that are unselected for resistance by treatment. If the frequency of anthelmintic treatment increases, this could increase the selection pressure for resistance and is most likely to occur in the case of the kennel situation, where there may be simultaneous treatment of a group of dogs or cats with the same product. It is therefore recommended that careful consideration should be given to worm control programmes for dogs in a kennel situation and faecal monitoring should be conducted regularly to identify worm species present and the effectiveness of any control programme.

ENVIRONMENTAL CONTROL OF PARASITE TRANSMISSION

For parasites whose eggs or larvae are passed in the faeces, the control of parasite stages in the environment is essential to minimise the infection risk to other animals or humans (zoonosis).

Parasitic contamination of the environment can occur in a number of ways, including the excretion of parasitic eggs or larvae in the faeces and the release of cestode proglottids.

Environmental infection pressure of dog-transmitted parasites can be maintained by wild foxes and stray dogs in both rural and urban areas. Similarly, feral and wild cats can form a reservoir of feline infection.

The infection of intermediate or paratenic hosts (i.e. birds, rodents, slugs and snails) can contribute to a longer survival time of parasitic stages in the environment.

Most environmental parasite stages are highly resistant to environmental degradation (from months to years). Freshly excreted stages of many parasites can be directly infective (e.g. *Taenia* spp. and *Echinococcus* spp. eggs). Other parasites, such as nematode eggs, require anything from a few days to a few weeks at appropriate temperatures, usually above 16°C, to reach the infective stage. It is therefore important to prevent initial parasite environmental contamination by implementing comprehensive parasite control programmes based on local epidemiological knowledge.

- The safe disposal of animal faeces is essential. This should be on a daily basis and faeces should not be flushed down the toilet or disposed of in compost intended for edible crops. In countries or regions where legislation permits, faeces can be disposed of in household waste collections or dedicated “poo bins”.
- Measures to facilitate faecal removal, such as the provision of disposal bins and bags should be encouraged. As it is difficult to control where outdoor cats defecate, particular attention should be given to worm control in cats.
- Leash-control and faecal clean-up laws should be enforced by the local authorities, especially in urban areas.
- Legislation to control stray dogs and feral cat populations should also be enforced by the appropriate authorities.
- Parasitised animals should be treated to minimise environmental contamination. In justified cases, animals should be monitored by faecal examination (e.g. animals with persistent clinical signs or suspected resistance).
- Because eggs may persist in the soil for months or years for very contaminated areas, such as highly populated kennels, extreme measures are needed for decontamination, including the removal of sand/soil or covering the soil with concrete or asphalt.
- In kennels or multi-animal households, the strict treatment and quarantine of new entrants is essential to avoid the introduction of infected animals.
- Children’s playgrounds should be well fenced to prevent entry of animals, especially cats. Sandboxes should be covered when not in use. Sand, particularly if it is uncovered and is likely to have been contaminated with faeces, should be replaced regularly e.g. at least once or twice a year.
- Desiccation and ultraviolet light are highly detrimental to worm eggs, so allowing exposure to sunlight and drying of contaminated areas can assist in reducing the level of contamination.

OWNER CONSIDERATIONS IN PREVENTING ZOONOTIC DISEASES

Since some dog and cat parasites can also potentially cause infection in humans, veterinarians have an additional responsibility for human health. A particular zoonotic risk comes from the widely present *Toxocara* spp. roundworms: after oral ingestion of infective eggs, the larvae can perform a somatic migration (larva migrans complex). If larvae become blocked in the human eye, nerve tract and/or brain during migration, serious health problems can occur.

After infection with *E. multilocularis* or *E. granulosus*, humans develop alveolar or cystic echinococcosis, respectively, with formation of cysts in the liver and/or other organs. Alveolar echinococcosis is a carcinoma-like disease, which without treatment can have fatal consequences. Human infection occurs as a result of oral ingestion of worm eggs. The main source of contamination of the environment is the fox. Infection can also occur by the ingestion of eggs found on a dog's fur or of eggs that have been excreted in dog faeces.

Important preventive measures for pet owners include:

- Practicing good personal hygiene, particularly washing hands after handling pets and before eating food.
- Minimising the exposure of children in particular to potentially contaminated environments and teaching them good personal hygiene. Keeping nails short. Teaching children the importance of such practices.
- Wearing gloves when gardening.
- Washing raw fruit, vegetables and mushrooms before eating.
- Controlling pet parasite infections through repeated treatments and/or regular diagnostic testing.
- Preventing infection by reducing, where possible, the risk of the pet acquiring infection.
- Cleaning up pet faeces regularly to reduce environmental contamination with infective parasite stages. Not disposing of faeces or cat litter in recyclable waste or compost.
- Grooming dogs regularly to minimise the risk of coat contamination with worm eggs.
- Changing shoes to prevent contamination of domestic areas.

People who are in regular contact with animals that may potentially transmit zoonotic parasites should be made aware of the risks and advised that these health risks are greater for pregnant women and those suffering from underlying illnesses or immunosuppression. This information should be made available through physicians and veterinarians, without the need for a medical history of the client and his/her family.

With this in mind, special care should be taken in the case of:

- Immunocompromised individuals such as the elderly, diabetics, people with HIV-infection and those undergoing immunosuppressive chemotherapy, organ transplantation or treatment for autoimmune diseases.
- Other susceptible groups such as pregnant women, babies, toddlers and those with learning disabilities.
- People with occupational risks such as farmers, kennel workers and hunters.

STAFF, PET OWNER AND COMMUNITY EDUCATION

Protocols and recommendations for the control of parasitic infection should be communicated clearly to veterinary and para-veterinary staff and consistently applied.

Cooperation between the medical and veterinary professions should be encouraged wherever possible and its benefits underlined in the case of zoonoses. Pet owners should be made aware of the potential health risks of parasitic infection, not only to their pets but also to themselves and their family and friends. Professional brochures and posters placed in veterinary practices and pet shops are useful tools to facilitate this, as are websites.

The importance of regular anthelmintic treatment or joining a “pet health-check programme” should be made clear to the general public by veterinary surgeons, veterinary nurses and other animal health professionals and promoted consistently. Responsible dog and cat ownership can ease public health concerns and encourage the acceptance of dogs and cats as human companions.

Additional information and resource materials can be obtained from www.esccap.org

Table 2A: Characteristics of worms of dogs in Europe: intestinal nematodes

Worm species	Pre-patent period	Patent period	Infective stages and route of infection	Distribution in Europe	Definitive hosts
Roundworms or ascarids					
Toxocara canis	Variable, typically 16–21 days after prenatal infection; 27–35 days after lactogenic infection; 32–39 days after ingestion of eggs	4–6 months	Ingestion of embryonated eggs from soil or on fur, larvae in milk or paratenic hosts In utero from dam	Everywhere	Dogs and foxes
Toxascaris leonina	About 8 weeks	4–6 months	Ingestion of embryonated eggs from soil or larvae from paratenic hosts	Everywhere	Dogs, cats and foxes
Hookworms					
Ancylostoma caninum	2–3 weeks	Can be prolonged depending on immune status (7 months to 2 years)	Ingestion of L3 from environment, larvae in bitches' milk or paratenic hosts Percutaneous infection of larvae	Predominantly southern Europe, sporadic in other parts of Europe	Dogs and foxes
Uncinaria stenocephala	3–4 weeks	Can be prolonged depending on immune status	L3 orally from environment	Predominantly central and northern Europe	Dogs and foxes (and cats)
Threadworms (*Strongyloides*)					
Strongyloides stercoralis	Variable, from 9 days	Several months (3–15 months)	L3 orally from environment or through milk Percutaneously Auto-infections	Rarely everywhere but more predominant in southern Europe	Dogs (and humans and cats)
Whipworm					
Trichuris vulpis	At least 8 weeks	Up to 18 months	Ingestion of embryonated eggs from the environment	Everywhere	Dogs and foxes

Table 2B: Characteristics of worms of dogs in Europe: tapeworms (cestodes)

Worm species	Pre-patent period	Patent period	Infective stages and route of infection	Distribution in Europe	Definitive hosts
Tapeworms					
***Taenia* spp.**	4–10 weeks	Months up to several years	Ingestion of larval stages (cysticercus or coenurus type) in intermediate hosts	Everywhere, with differences depending on the species	Dogs and foxes (and cats)
***Mesocestoides* spp.**	4–10 weeks	Several years	Ingestion of larval stages in meat or tissues of prey	Everywhere (rare)	Dogs, cats and foxes
Dipylidium caninum	3 weeks	Several months	Ingestion of larval stages in fleas or lice	Everywhere	Dogs, cats and foxes
Echinococcus granulosus* complex	45 days	Several months	Ingestion of larval stages in intermediate hosts (herbivores and omnivores)	See map (Figure 9)	Dogs (foxes)
Echinococcus multilocularis	28 days	Several months	Ingestion of larval stages in intermediate hosts (rodents)	See map (Figure 10)	Foxes, dogs, racoon dogs (and cats)

* There are different species and strains: *E. ortleppi* (cattle), *E. equinus* (horse), sheep-, pig-, cervid- and other strains, see Figure 9 for distribution.

Table 2C: Characteristics of worms of dogs in Europe: non-intestinal nematodes

Worm species	Pre-patent period	Patent period	Infective stages and route of infection	Distribution in Europe	Definitive hosts
Heartworm					
Dirofilaria immitis	6–7 months	Several years	L3 transmitted by mosquito vector (intermediate host)	Southern Europe and parts of Central Europe, see map (Figure 18)	Dogs (and cats) and ferrets
French heartworm					
Angiostrongylus vasorum	40–49 days	Up to 5 years	L3 within mollusc or paratenic host, infection orally	Everywhere in endemic foci	Foxes and dogs
Lungworms					
Oslerus osleri	10 weeks	Unknown	Direct oral transmission from bitch to pups mostly by coprophagia	Everywhere sporadically	Foxes and dogs
***Filaroides* spp. (*F. hirthi, F. milksi*)**	10–18 weeks	Unknown	Direct oral transmission from bitch to pups mostly by coprophagia	Everywhere sporadically	Dogs
***Eucoleus aerophilus* (syn. *Capillaria aerophila*)**	4 weeks	10–11 months	Ingestion of larvae or infective eggs from environment or via earthworms	Everywhere	Foxes, dogs and cats
Crenosoma vulpis	3 weeks	Up to 10 months	L3 within mollusc or paratenic hosts, infection orally	Everywhere	Dogs and foxes
Subcutaneous worms					
Dirofilaria repens	27–34 weeks	Several years	L3 transmitted by mosquito vectors (intermediate hosts)	Southern Europe and parts of Central Europe, see map (Figure 18)	Dogs (and cats)
Eye worms					
Thelazia callipaeda	About 3 weeks	Months to years	Arthropod dipteran vectors (intermediate hosts) while feeding lachrymal fluids	Italy, France (Dordogne), southern Switzerland, Spain, Portugal, Balkan area and Hungary	Dogs, cats and foxes
***Spirocerca lupi* (oesophagus worm)**	6 months		Ingestion of infective larvae in intermediate hosts (coprophagus insects) and paratenic hosts (rodents, lizards)	Everywhere (rare)	Dogs

Table 3: Risk factors for worms of dogs in Europe. Shaded boxes indicate increased risk.

Some dogs are more likely to have parasite infections than others, although the difference is rarely absolute. This table highlights those factors that are likely to increase the probability of dogs carrying specific parasites. It has been drawn up on the basis of available understanding, but is not the result of a formal risk assessment. Shaded boxes indicate increased risk.

Worm species	Dog type			Health	Environment		Nutrition			Location and travel
	Pup	Lactating	Stray	Fleas or lice	In kennels	Outdoors	Rodents/ amphibians/ reptiles	Molluscs	Raw meat/ viscera	
INTESTINAL WORMS										
Ascarids										
Toxocara canis	■	■	■		■	■	■		■	
Toxascaris leonina			■		■	■	■			
Hookworms										
Ancylostoma caninum	■	■	■		■	■				More in southern Europe
Uncinaria stenocephala			■		■	■				In colder climate (northern Europe)
Threadworms (*Strongyloides*)										
Strongyloides stercoralis	■	■			■	■				
Whipworm										
Trichuris vulpis			■		■	■				
Tapeworms										
***Taenia* spp.**			■			■	■		■	
***Mesocestoides* spp.**			■			■	■			
Dipylidium caninum			■	■	■					
Echinococcus granulosus*			■						■	Central, southern and eastern Europe, see map (Figure 9)
Echinococcus multilocularis			■			■	■			Central, eastern and northern Europe, see map (Figure 10)
NON-INTESTINAL WORMS										
Heartworm										
Dirofilaria immitis			■			■				See map (Figure 18)
French heartworm										
Angiostrongylus vasorum							■	■		
Lungworms										
Oslerus osleri	■	■			■					
***Filaroides* spp.**	■				■					
***Eucoleus aerophilus* (syn. *Capillaria aerophila*)**			■			■				
Crenosoma vulpis			■			■		■		
Subcutaneous worms										
Dirofilaria repens			■			■				See map (Figure 18)

* There are different species and strains: *E. ortleppi* (cattle), *E. equinus* (horse), sheep-, pig-, cervid- and other strains, see Figure 9 for distribution.

Table 4: Characteristics of worms of cats in Europe: nematodes and tapeworms (cestodes)

Worm species	Pre-patent period	Patent period	Infective stages and route of infection	Distribution in Europe	Definitive hosts
INTESTINAL WORMS					
Roundworms or ascarids					
Toxocara cati	Variable, usually around six weeks after ingestion of eggs	4–6 months	Ingestion of embryonated eggs from soil, larvae in milk or paratenic hosts	Everywhere	Cats
Toxascaris leonina	8–10 weeks	4–6 months	Ingestion of embryonated eggs from soil, larvae from paratenic hosts	Everywhere	Dogs, cats and foxes
Hookworms					
Ancylostoma tubaeforme	2–3 weeks	Can be prolonged depending on immune status	Primarily ingestion of larvae from soil Some percutaneous infection	Continental Europe	Cats
Uncinaria stenocephala	3–4 weeks	Can be prolonged depending on immune status	Ingestion of larvae from soil	Predominantly northern and central Europe	Dogs, foxes (and cats)
Other worms					
Ollulanus tricuspis **(stomach worm)**	5 weeks	33–37 days	Ingestion of larvae or adults in vomitus	Everywhere (rare)	Cats
Tapeworms					
Taenia taeniaeformis	5–10 weeks	Several years	Ingestion of larvae in rodents	Everywhere	Cats
Mesocestoides **spp.**	4–10 weeks	Several years	Ingestion of larval stages in meat or tissues	Everywhere (rare)	Cats, dogs and foxes
Dipylidium caninum	3 weeks	Several months	Ingestion of larval stages in fleas or lice	Everywhere	Dogs, cats and foxes
Echinococcus multilocularis	28 days	Several months	Ingestion of larval stages in intermediate hosts (rodents)	See map (Figure 10)	Foxes, dogs, racoon dogs (and cats)
Liver trematodes					
Opisthorchis felineus	3–4 weeks	Several months	Larval stages (metacercariae) in fresh water fish	North-eastern Germany, locally in central Europe	Cats, foxes, dogs, (humans rarely)

Table 4: Characteristics of worms of cats in Europe: nematodes and tapeworms (cestodes) (continued)

Worm species	Pre-patent period	Patent period	Infective stages and route of infection	Distribution in Europe	Definitive hosts
NON-INTESTINAL WORMS					
Heartworm					
Dirofilaria immitis	about 6 months	Rarely occurs with cats, and usually short	L3 transmitted by mosquito vectors (intermediate host)	See map (Figure 18)	Dogs (and cats)
Lungworms					
Aelurostrongylus abstrusus	7–9 weeks	Several years	L3 in mollusc or paratenic host	Everywhere	Cats
***Troglostrongylus* spp.**			L3 in mollusc or paratenic host (and transplacentally)	Italy, Spain, Greece, Portugal	Cats
***Eucoleus aerophilus* (syn. *Capillaria aerophila*)**	4 weeks	10–11 months	Ingestion of larvae or infective eggs from environment or via earthworms	Everywhere	Foxes, dogs and cats
Subcutaneous worms					
Dirofilaria repens	27–34 weeks	Several years	L3 transmitted by mosquito vectors (intermediate host)	See map (Figure 18)	Dogs (and cats)
Eye worms					
Thelazia callipaeda	About 3 weeks	Several months	Dipteran vectors (intermediate hosts) while feeding lachrymal fluids	Italy, France (Dordogne), southern Switzerland, Spain, Portugal, Balkan area	Dogs and cats

Table 5: Risk factors for worms of cats in Europe

Some cats are more likely to have parasite infections than others, although the difference is rarely absolute. This table highlights those factors that increase the likelihood of cats carrying specific parasites. It has been drawn up on the basis of available understanding, but is not the result of a formal risk assessment. Shaded boxes indicate increased risk.

Worm species	Cat type			Health	Environment		Nutrition			Location and travel
	Kitten	Lactating	Stray	Fleas or lice	In cattery	Outdoors	Rodents/ amphibians/ reptiles	Molluscs	Raw meat/ viscera	
INTESTINAL WORMS										
Roundworms or ascarids										
Toxocara cati	■	■	■		■	■	■		■	
Toxascaris leonina			■		■	■				
Hookworms										
Ancylostoma tubaeforme	■	■	■		■					Continental Europe
Uncinaria stenocephala					■					
Stomach worm										
Ollulanus tricuspis			■		■	■				■
Tapeworms										
Taenia taeniaeformis			■			■	■			
***Mesocestoides* spp.**			■			■	■			
Dipylidium caninum			■	■	■					
Joyeuxiella pasqualei			■	■	■		■			
Echinococcus multilocularis						■	■			Central Europe
Liver trematodes										
Opisthorchis felineus									■	North-eastern Germany
NON-INTESTINAL WORMS										
Heartworm										
Dirofilaria immitis						■				See map (Figure 18)
Lungworms										
Aelurostronylus abstrusus			■			■	■	■		
***Troglostrongylus* spp.**			■			■	■	■		Italy, Spain, Greece, Portugal
***Eucoleus aerophilus* (syn. *Capillaria aerophila*)**			■			■	■	■		■
Subcutaneous worms										
Dirofilaria repens			■			■				See map (Figure 18)

Table 6: Worm infection of dogs: main clinical signs and diagnosis

Worm species	Clinical signs	Material	Diagnosis
INTESTINAL WORMS			
Roundworm or ascarids			
Toxocara canis	Low burden asymptomatic, higher burden may appear as cachexia and pot-bellied appearance in pups Large numbers of worms may cause intestinal blockage or intussusception	At least 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Toxascaris leonina	Mostly asymptomatic	At least 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Hookworms			
Ancylostoma caninum	Diarrhoea, bloody diarrhoea, weight loss and anaemia	May be acute or chronic signs At least 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Uncinaria stenocephala	Clinical signs rarely occur. In rare cases: diarrhoea, weight loss and anaemia.	At least 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Threadworms (*Strongyloides*)			
Strongyloides stercoralis	Heavy infections: watery diarrhoea and occasionally bronchopneumonia	At least 10 g faeces (fresh or fixed)	Eggs (larvated) detection by centrifugation-flotation
Whipworm			
Trichuris vulpis	Asymptomatic but heavy infections associated with anaemia, diarrhoea and weight loss	At least 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Tapeworms			
***Taenia* spp.**	Asymptomatic, sometimes anal pruritus	At least 10 g fresh faeces or separate proglottids in faeces, sampling on 3 consecutive days	Proglottids grossly visible with only one genital pore. Taeniid eggs in faeces (see *Echinococcus* below for methods of distinguishing taeniid eggs)
Dipylidium caninum	Mostly asymptomatic, anal pruritus	At least 10 g fresh faeces or separate proglottids in faeces, sampling on 3 consecutive days	Proglottids similar in size to *Taenia* spp. proglottids but morphologically distinct as they have two genital pores. Eggs within proglottids are grouped in egg packets. These can be seen microscopically in faecal samples.
Echinococcus granulosus	Asymptomatic	At least 10 g faeces, sampling on 3 consecutive days Freezing faeces at -80°C for 7 days kills eggs	Morphology and size of proglottids. Egg detection with flotation, sedimentation or combined techniques (not very sensitive and taeniid eggs cannot be differentiated morphologically). Coproantigen detection enables detection of prepatent infections 10 days p.i. Sensitivity more than 90% if more than 50 worms are present, less if under 50 worms*. PCR/sequencing allows species identification (from isolated eggs or proglottids)*.
Echinococcus multilocularis	Asymptomatic	At least 10 g faeces, sampling on 3 consecutive days Freezing faeces at -80°C for 7 days kills eggs	Morphology and size of proglottids. Egg detection with flotation, sedimentation or combined techniques (not very sensitive and taeniid eggs cannot be differentiated morphologically). Coproantigen detection enables detection of prepatent infections 10 days p.i. Sensitivity more than 90% if more than 50 worms are present, less if under 50 worms*. PCR/sequencing allows species identification (from isolated eggs or proglottids)*.

* In specialised laboratories only
p.i. post infection

Table 6: Worm infection of dogs: main clinical signs and diagnosis (continued)

Worm species	Clinical signs	Material	Diagnosis
NON-INTESTINAL WORMS			
Heartworm			
Dirofilaria immitis	Low worm burdens asymptomatic. First clinical manifestation 5–7 months p.i.: loss of condition, dyspnoea, cough Chronic disease: cough, tachycardia, "Caval syndrome", tachypnoea, exercise intolerance, asthenia	2–4 ml EDTA** blood 1 ml serum or plasma	Circulating antigens* (from 5 months p.i.) (sensitivity around 90% if 1 female worm or approximately 100% if more are present). Detection of microfilariae from 6–7 months p.i. Detection improved by concentration of microfilariae with Difil-Test or Knott's Test. Microfilariae can be identified to species level using morphological, biochemical or molecular species identification. Thoracic radiography and echocardiography are complementary diagnostic measures.
French heartworm			
Angiostrongylus vasorum	Highly variable: from asymptomatic to respiratory and cardiovascular signs: cough, dyspnoea; coagulopathy (e.g. subcutaneous haematomas); neurological signs	At least 10 g fresh faeces, sampling on 3 consecutive days, bronchial lavage fluid 1 ml serum or plasma	Detection of live larvae from fresh faeces using the Baermann method, or microscopic detection of larvae in bronchial lavage material (less sensitive), detection of circulating antigens in serum or plasma with a commercially available kit.
Lungworms			
Crenosoma vulpis	Respiratory signs such as coughing, dyspnoea and possibly exercise intolerance	Fresh faeces (at least 10 g) or bronchial lavage fluid	Detection of live larvae from fresh faeces using the Baermann method, or microscopic detection of larvae in bronchial lavage material (less sensitive).
Oslerus osleri	Respiratory signs such as coughing, dyspnoea and possibly exercise intolerance	Fresh faeces (at least 10 g) or bronchial lavage fluid	Detection of live larvae from fresh faeces using the Baermann method, or microscopic detection of larvae in bronchial lavage material (less sensitive).
***Filaroides* spp.**	Respiratory signs such as coughing, dyspnoea and possibly exercise intolerance	Fresh faeces (at least 10 g) or bronchial lavage fluid	Detection of live larvae from fresh faeces using the Baermann method, or microscopic detection of larvae in bronchial lavage material (less sensitive).
***Capillaria* spp.**	Respiratory signs such as coughing, dyspnoea and possibly exercise intolerance	Fresh faeces (at least 10 g) or bronchial lavage fluid	Egg detection by flotation.
Subcutaneous worms			
Dirofilaria repens	Mostly asymptomatic, subcutaneous lesions. Sometimes skin irritation.	2–4 ml EDTA** blood	Detection of microfilariae from 6 months p.i. Detection improved by concentration of microfilariae with Difil- Test or Knott's Test. Microfilariae can be identified to species level using morphological, biochemical or molecular species identification*.
Eye worms			
Thelazia callipaeda	Blepharospasm and epiphora	Material from the surface of the eye or under the nictitating membrane	Detection of adult or larval stages from samples of the tear film from the surface of the conjunctiva or from the conjunctival sac.

* In specialised laboratories only
** acid
p.i. post infection

Table 7: Worm infection of cats: main clinical signs and diagnosis

Worm species	Clinical signs	Material	Diagnosis
INTESTINAL WORMS			
Roundworms or ascarids			
Toxocara cati	Low burden asymptomatic, higher burden may appear as cachexia and pot-bellied appearance in kittens. Large number of worms may cause intestinal blockage or intussusceptions. Occasional pneumonia in kittens.	If possible 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Toxascaris leonina	Mostly asymptomatic	If possible 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Hookworms			
Ancylostoma tubaeforme	Diarrhoea, bloody diarrhoea, weight loss and anaemia. May be acute or chronic signs.	If possible 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Uncinaria stenocephala	Clinical signs rarely occur. In rare cases: diarrhoea, weight loss and anaemia.	If possible 10 g faeces (fresh or fixed)	Egg detection by centrifugation-flotation or antigen test
Tapeworms			
Taenia taeniaeformis	Asymptomatic	If possible 10 g faeces (fresh or fixed), sampling on 3 consecutive days, proglottids in faeces	Proglottids grossly visible: morphology of proglottids, particularly that each proglottid has a single genital pore. Taeniid eggs in faecal sample (see *Echinococcus* section for methods to differentiate taeniid eggs).
Dipylidium caninum	Mostly asymptomatic	If possible 10 g faeces (fresh or fixed), sampling on 3 consecutive days, proglottids or eggs in faeces	Proglottids similar in size but morphologically distinct to proglottids of *Taenia* spp., as each proglottid has two genital pores. Eggs within proglottids are grouped within egg packets which can be seen microscopically within faecal samples.
Echinococcus multilocularis	Asymptomatic	If possible10 g faeces, sampling on 3 consecutive days Freezing faeces at -80°C for 7 days kills eggs	Morphology and size of proglottids. Egg detection with flotation, sedimentation or combined techniques (not very sensitive and taeniid eggs cannot be differentiated morphologically). PCR/ sequencing allows species identification (from isolated eggs or proglottids)*.
Stomach worm			
Ollulanus tricuspis	Gastritis, vomitus	Vomitus	Detection of larvae or adult worms
Liver trematodes			
Opisthorchis felineus	Vomitus, anorexia, digestive problems	If possible 10 g faeces (fresh or fixed)	Egg detection through sedimentation or other special procedures

Table 7: Worm infection of cats: main clinical signs and diagnosis (continued)

Worm species	Clinical signs	Material	Diagnosis
NON-INTESTINAL WORMS			
Heartworm			
Dirofilaria immitis	Often asymptomatic. Initial signs as the worms reach the heart. Later disease: acute signs associated with worm death including cough, tachycardia, tachypnoea, sudden death.	2–4 ml EDTA** blood, 1 ml serum or plasma	Microfilariae and/or antibody detection. Detection of microfilariae from 8 months p.i. (low sensitivity). Detection may be improved by concentration of microfilariae with Difil-Test or Knott's Test. Microfilariae can be identified to species level using morphological, biochemical or molecular species identification*. Often a definite diagnosis of heartworm infection can only be obtained by haematological tests in conjunction with thoracic radiography and echocardiography.
Lungworms			
Aelurostrongylus abstrusus	Respiratory signs, coughing and possibly exercise intolerance	Fresh faeces (at least 4 g) or bronchial lavage material	Detection of live larvae from fresh faeces using the Baermann method or microscopic detection of larvae in bronchial lavage material (less sensitive)
***Troglostrongylus* spp.**	Respiratory signs, coughing and possibly exercise intolerance	Fresh faeces (at least 4 g) or bronchial lavage material	Detection of live larvae from fresh faeces using the Baermann method or microscopic detection of larvae in bronchial lavage material (less sensitive)
Subcutaneous worms			
Dirofilaria repens	Mostly asymptomatic, subcutaneous lesions	2–4 ml EDTA** blood	Detection of microfilariae from 6 months p.i. Detection improved by concentration of microfilariae with Difil- Test or Knott's Test. Microfilariae can be identified to species level using morphological, biochemical or molecular species identification*
Eye worms			
Thelazia callipaeda	Blepharospasm and epiphora	Material from the surface of the eye or under the nictitating membrane	Detection of adult or larval stages from samples of the tear film from the surface of the conjunctiva or subconjunctival sac

* In specialised laboratories only
** acid
p.i. post infection

APPENDIX 1 – GLOSSARY

Application	Like treatment, but describing the various forms of veterinary medicinal products which can be given (applied) to animals, such as spot-ons, pour-ons, oral products, injectables etc.
Control	General term comprising ‘therapy’ (treatment) and ‘prevention’ (prophylaxis).
Endoparasiticide	Compound developed for the animal. Use as a therapeutic agent to eliminate any existing endoparasite infection and prevent reinfection.
Integrated control	The use of several measures to control different parasites or parasite stages present in the animal and stages present in the environment.
Pesticide	Compound developed for the elimination of different stages of parasites in the environment.
Prevention	Measures taken prior to any infection of the pet animal with endoparasites, to prevent the establishment of an infection. Prevention for an extended period may be achieved by the use of a product with persistent activity for certain periods of time following treatment.
Therapy	Any medical intervention to cure a disease; this includes the use of veterinary medicinal products (treatment), to eliminate an existing parasite infection.
Treatment	Administration of veterinary medicinal products (medication) as deemed necessary based on any given diagnosis.

APPENDIX 2 – BACKGROUND

ESCCAP (European Scientific Counsel Companion Animal Parasites) is an independent, not-for-profit organisation that creates guidelines based on up-to-date scientific information and promotes good practice for the control and treatment of parasites in companion animals. With application of the proper advice, the risk of diseases and parasitic transmission between animals and humans can be minimised. ESCCAP aspires to see a Europe where companion animal parasites no longer threaten the health and well-being of animals and humans.

There is a great diversity in the range of parasites and their relative importance across Europe and the ESCCAP guidelines summarise and highlight important differences which exist in different parts of Europe and, where necessary, specific control measures are recommended.

ESCCAP believes that:

- Veterinarians and pet owners must take measures to protect their pets from parasitic infections.
- Veterinarians and pet owners must take measures to protect the pet population from risks associated with travel and its consequent potential to change local parasite epidemiological situations through the export or import of non-endemic parasite species.
- Veterinarians, pet owners and physicians should work together to reduce the risks associated with zoonotic transmission of parasitic diseases.
- Veterinarians should be able to give guidance to pet owners regarding risks of parasite infection and diseases and measures which can be taken to minimise these risks.
- Veterinarians should attempt to educate pet owners about parasites to enable them to act responsibly not only for their own pet's health but for the health of other pet animals and people in their communities.
- Veterinarians should wherever appropriate utilise diagnostic tests to establish parasite infection status in order to provide the best possible advice.

To achieve these objectives, ESCCAP produces guidelines in different formats:

- A detailed guideline for veterinary surgeons and veterinary parasitologists.
- Translations, extracts, adaptations and summarised versions of guidelines which address the varied requirements of European countries and regions.

Versions of ESCCAP guidelines can be found at www.esccap.org

Disclaimer:

Every effort has been taken to ensure that the information in the guideline, which is based on the authors' experience, is accurate. However, the authors and publishers take no responsibility for any consequence arising from the misinterpretation of the information herein nor is any condition or warranty implied. ESCCAP emphasises that national, regional and local regulations must be borne in mind at all times before following ESCCAP advice. All dosages and indications are provided for guidance. However, vets should consult individual data sheets for details of locally approved treatment regimens.

ESCCAP
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1 Worm Control in Dogs and Cats

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