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## Internal Parasitic Diseases of Dogs and Cats (30-Jul-2001)

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### Introduction

Reference to the Public Health Significance of parasites is only included if it is considered significant. Collection and Submission of Specimens for the diagnostic laboratory is discussed fully in Chapter 2. Control of worm infections is discussed in some detail at the end of the discussion of Internal Parasites. External parasitic disease are considered in Chapter 7.

Glossary of Terms Related to Parasitic Diseases

Nematodes

Acanthocephalans

Cestodes

Trematodes

General Measures for the Prevention of Worm Infections

Anthelmintics and Deworming Guidelines

### Glossary

Several terms are defined here for those who may have forgotten or are unsure of their meaning.

**Baerman technique** - In this sedimentation procedure, the fecal specimen in a tea strainer or in cheese cloth is placed in a funnel of water. The larvae come to the surface of the feces and descend in the water into a rubber tube at the end of the funnel. A pinch clamp holds the water back. A drop of water is drawn and examined for larvae.

**Bronchoscopy** - In this procedure endoscopic techniques are used to examine visually the tracheobronchial tree.

**Coprophagous** - Eating of excrement.

**Flotation methods** - When worm eggs are suspended in a liquid with a specific gravity greater than that of the eggs the latter will float to the surface. Nematode eggs and cestode eggs float in a liquid with a specific gravity of 1.1 to 1.2. Trematode eggs are heavier and a specific gravity of 1.3 to 1.35 is required for their flotation. Sodium chloride, magnesium sulfate or sugar are commonly used to prepare solutions of the required specific gravity. Direct and quantitative flotation procedures are used.

**Helminths** - These are nematodes (roundworms), trematodes (flat worms, flukes), cestodes (tapeworms) and acanthocephalans (thorny-headed worms).

**Knott's test** - In this procedure microfilariae are looked for in the centrifugate of a blood sample containing anticoagulant and a small amount of formalin.

**Lichenification** - The process by which the skin becomes hardened, lichenoid or leathery usually as a result of chronic inflammation.

**Patent period** - The period of time in which the parasite ova can be demonstrated in the feces.

**Prepatent period** - The time taken for development from initial infection until adult parasite is producing eggs or larvae.

**Paratenic host** - A host in which immature helminths may survive for indefinite periods but undergo no development. Their further development depends upon infecting the proper host. Infection is usually by carnivorousism of the paratenic host.

## Nematodes

These are roundworms of the phylum Nematoda. They have a smooth, narrow, non-segmented body, tapered at both ends. Most species are microscopic, with separate sexes, free-living and occurring worldwide. A relatively small number of species are parasitic in animals and are considerably larger. Included are heartworms, angiostrongylus, roundworms, hookworms, whipworms, lungworms, threadworms, eyeworms and others).

Heartworm Disease (*Dirofilaria*) in Dogs  
Heartworm Disease (*Dirofilaria immitis*) of Cats  
*Angiostrongylus* Infection  
Roundworms (Ascariasis)  
Hookworms of Cats  
Whipworms of Dogs  
Lungworms of Cats  
Lungworms of Dogs  
Thread Worms (Strongyloidosis)

Stomach Worms  
*Ollulanus* Infection  
Esophageal Worm of Dogs  
*Dioctophyma Renale* Infection  
*Dracunculus* Infection  
*Pelodera Strongyloides* Infection  
*Thelazia* (Eye Worm Infection)  
*Capillaria* Urinary Infection

### Heartworm Disease (*Dirofilaria*) in Dogs

Etiology - The nematode *Dirofilaria immitis* which infects mainly dogs but also the cat, ferret and some other animals. The adult male is ~17 cm; the adult female ~27 cm and microfilariae ~315 µm long by 6 - 7µm wide.

Occurrence - This nematode has a worldwide distribution and the disease is endemic where there is a reservoir of infection, usually involving dogs and mosquito vectors.

Life Cycle - The life cycle in the dog is completed in 6 - 7 months. Adult worms live in the chambers of the heart and the pulmonary arteries. Adults mate and large numbers of microfilariae are discharged into the blood stream. The latter circulate in the blood and can survive for 1 - 3 years. The microfilariae are ingested by the mosquito while feeding. They undergo development in the mosquito in 1 - 4 weeks and the larvae move to the mouthparts of the mosquito. During the mosquito's blood meal the larvae (third stage or L3), about a dozen or less, are deposited on the skin and enter the host via the bite wound. This L3 stage molts and migrates within several months to the chambers of the heart and the pulmonary arteries where they mature. These mature worms can remain alive and infective for as long as three years. A dog may harbor as many as 250 worms.

Clinical and Pathologic Features - The outcome of infection is largely dependent on the host response and degree of initial infection. Dogs with low numbers of adult worms may be asymptomatic and suffer no ill effects. Chronic disease may develop in dogs with appreciable infection that persist for years. Among the clinical signs seen are coughing, reluctance to exercise, weight loss, weakness and dyspnea. With heavy infections there may be circulatory distress due to reduction of blood flow or pulmonary hypertension. Chronic congestive heart failure, usually right-sided, may ensue with edema of the legs and ascites, listlessness and profound weakness. When a mass of worms lodge in the posterior vena cava the obstruction may lead to what is referred to as the vena caval syndrome. It is characterized by hemoglobinuria, anorexia, icterus, and collapse. Death usually ensues within several days. Among the pathologic changes seen in the various manifestations of heartworm disease are: pulmonary embolism, endocarditis of heart valves, glomerulonephritis due to immune complexes, pulmonary endoarteritis and eosinophilic to lymphoplasma cellular pneumonia.

Diagnosis - Heartworm disease should be suspected in dogs a year or more of age with some of the signs mentioned above in endemic regions. A highly specific ELISA is available for detection of adult *D. immitis* antigen both before and after microfilariae are found in blood. The test may be negative if the number of worms is small. The most direct approach to diagnosis is demonstration of microfilariae in the blood using Knott's test and filter procedures. These procedures are successful in more than 50 % of infected dogs. There can be microfilariae present when adults have been eliminated. If worms of only one sex are present there are no microfilariae. The microfilariae of the nonpathogenic nematodes *Dipetalonema reconditum* (parasite of the subcutis) and *D. repens* must be differentiated from the microfilariae of *D. immitis*. Thoracic radiography is used for screening dogs with clinical signs. Echocardiographs are useful for the recognition of adult worms in pulmonary arteries, postcaval syndrome and ascites.

Treatment -

- Before beginning treatment for adult worms the dog should be given a physical examination and an evaluation of liver and kidney function. If these are normal the drug thiactarsonide may be administered intravenously in two doses per day for three days; an alternative is two doses in two days. The dog's activity is restricted for 3 - 6 weeks depending upon the effect of treatment. Embolism resulting from dead or dying heartworms occurs occasionally.
- The adulticide drug melarsomine dihydrochloride is given intramuscularly and has the advantage of less hepatotoxicity.
- The serological test (ELISA) for antigen should be negative at 12 - 16 weeks after treatment for adult worms.

- About six weeks after the treatment just referred to the dog is treated to eliminate circulating microfilariae. or milbemycin are highly effective. Then place on a heartworm preventive unless there are large numbers of microfilariae. Because of possible toxic reactions to treatment, animals should be carefully monitored after treatment and appropriate support and care provided. The efficacy of treatment can be determined by a test for the presence of microfilariae.

#### Control -

- Total mosquito control is ordinarily not practicable.
- Heartworm disease is effectively prevented by regular medication beginning at 2 - 3 months of age. In tropical regions medication is administered throughout the year; in temperate areas prophylaxis is begun about one month before the mosquito season and concluded about a month after. Diethylcarbamazine is given daily while , selamectin, moxidectin and milbemycin are given monthly during the mosquito season. It is advisable to determine the status of animals by adult antigen tests prior to beginning prophylactic medication. Animals that test positive should be treated before starting preventive medication.
- Some of the monthly products protect against heartworms, e.g., selamectin (Revolution) and milbemycin oxime with lufenuron (Sentinel).

Public Health Significance - Humans are only rarely infected with *D. immitis* (about 50 cases reported); infection results from mosquito bites. The worm(s) lodge in the pulmonary artery causing vascular occlusion, coagulation, necrosis and fibrosis. Symptoms include chest pain, coughing and in some cases hemoptysis. In some patients radiographs have disclosed an asymptomatic, fibrotic nodule 1 - 3 cm in diameter.

#### **Heartworm Disease (*Dirofilaria immitis*) of Cats**

Etiology and Occurrence - Heartworm disease caused by *Dirofilaria immitis* is also a significant disease of cats. It is found worldwide and in many states in the US where the canine disease occurs. Prevalence rates in cats are estimated to be about 10 percent of that of dogs in a particular region. The average worm burden is 1 - 5. The mean age of affected cats is 3 - 6 years and both indoor and outdoor cats are about equally affected.

Life Cycle - Cats like dogs, are infected by mosquitoes. The cat is a "dead-end" host in that there are not usually sufficient adult worms to breed and produce microfilariae. Larvae migrate to the heart and pulmonary arteries where they mature. Aberrant migration of larvae to the skin and lateral ventricles of the brain occurs occasionally. The lesions of endarteritis caused by adult heartworms are similar to those seen in the dog. The immune response which appears to be stronger in the cat than in the dog may be sufficient in some cats to destroy the invading microfilariae and thus prevent infection.

Clinical Features - Clinical signs may be absent to severe. A small worm burden can cause chronic vomiting, coughing, dyspnea, respiratory failure and weight loss. The infection is sometimes confused with bronchial asthma. Six to eight worms may cause right-side heart failure. When the disease is acute there may be convulsions, diarrhea, tachycardia and collapse.

Diagnosis - This is more difficult in the cat because of the absence of microfilariae. ELISA procedures are available for detection of antigen and antibodies. The test for antigen is considered more specific. As in the dog radiography and echocardiography are useful.

#### Treatment -

- The use of an adulticide such as thiacetarsamide intravenously may be accompanied by pulmonary thromboembolism and a mortality of 20 to 30 %.
- Various drugs are used for supportive therapy including prednisone or prednisolone to reduce inflammation, theophylline for bronchial dilation and inflammation reduction and supplemental oxygen.

Control - Cats are usually tested for antigenemia before beginning prophylactic medication which involves monthly administration of in tablet form to cats six weeks or older, or selamectin (Revolution) applied topically. These drugs kills the larvae of *D. immitis* as well as hookworms.

#### **Angiostrongylus Infection**

Etiology - The agent is the nematode *Angiostrongylus vasorum* which is the only species of the genus of veterinary significance. Adults are up to 2.5 cm long.

Occurrence - With the exception of North and South America it is found worldwide. Because of the infection's frequency in France it has been called the "French heartworm". Dogs are the definitive host and adults are found in pulmonary vessels. It

as been reported in dogs imported into the US.

Life Cycle - Eggs are laid in the pulmonary arteries and are caught in capillaries where they hatch. The larvae emerge into alveoli and move up the trachea to the pharynx where they are swallowed and passed in the feces. Larvae enter snails or slugs (molluscs) and undergo two molts. Dogs become infected by ingesting infected snails, slugs or paratenic hosts. The third stage larvae migrate from the intestine into lymph nodes and then to pulmonary arteries where they mature. The prepatent period is about seven weeks and adults may live in the host for longer than two years.

Clinical Features - Blockage of pulmonary arteries by adult worms and obstruction of arterioles and capillaries by larvae and eggs lead to perivascular fibrosis and endocarditis of the tricuspid valve. Sequelae can be congestive cardiac failure and/or cardiac insufficiency. Signs may include anorexia, coughing and dyspnea. Abnormalities relating to blood clotting have been reported.

Diagnosis - Demonstration of larvae in feces and saliva.

Treatment and Control -

- Levamisole, fenbendazole and mebendazole have been effective.
- Control measures are ordinarily not practicable.

### **Roundworms (Ascariasis)**

The ascarid worms are discussed below as a group.

Etiology - The following roundworms cause infections.

*Toxocara canis* (Infects the dog and fox).

*Toxocara cati* (Infects the cat and wild Felidae).

*Toxascaris leonina* (Infects the dog, fox, cat and wild Felidae).

Species of these genera range from 7 - 13 cm long.

Occurrence - All three species are widespread and occur worldwide. *T. cati* the more common species in cats, is often accompanied in the intestine by *T. leonina*.

Life Cycles - Reviewed individually, below.

*Toxocara canis* life cycle - There are four possible modes of infection:

1. The adult female lays large numbers of eggs (ova) in the intestine which are passed in the feces. The eggs are particularly resistant and can survive in the environment for years. They become infective in about four weeks depending upon various environmental factors. After ingestion the eggs hatch in the small intestine, larvae travel via the blood-stream to the liver then to the lungs and then via the trachea to the intestine where they mature. The hepatic and tracheal migration is less common in dogs more than three months of age.
2. In dogs more than three months of age the larvae go to the liver, lungs, brain, skeletal and heart muscle and walls of the intestinal tract and in the pregnant bitch to the lungs of the fetus (prenatal infection). After birth the third stage larva move from the lungs to the intestine via the trachea. The bitch has sufficient larvae to infect subsequent litters.
3. As a result of normal migration larvae are shed from the mammary gland in milk during the first three weeks of lactation. There is no migration from the intestine in the infected puppies.
4. This mode of infection is via paratenic hosts. Rodents and birds may ingest *T. canis* eggs and the developing larvae migrate into tissues and dogs become infected when they consume these tissues.

*T. cati* life cycle - Cats may be infected at the same time with this species and with *T. leonina*. This parasite undergoes a migratory cycle similar to *T. canis*. Cats are infected directly by ingesting eggs or by eating rodents that have ingested eggs and thus harbor infective larvae. The most common way that cats are infected is via the milk (transmammary) of lactating females. The larvae of ingested ova migrate into the adult's tissues where they remain dormant until reactivated during pregnancy at which time they migrate to the mammary glands. They are passed to kittens in the milk. Females shedding larvae in the milk will not necessarily be passing eggs in her feces. These infections in kittens are not migratory nor are infections derived from paratenic hosts. Prenatal infections do not occur with *T. cati*.

*T. leonina* life cycle - This species likewise produces eggs in the intestine and passes them in the feces but they do not become infective until larvae develop in several days. Cats are infected directly by ingesting infective larvae or like *T. cati* by eating rodents containing infective larvae. Transmission via milk does not take place with *T. leonina*.

Clinical Features - With small numbers of worms there is usually no clinical evidence of infection. Heavy infestations can cause intestinal obstruction. Adult roundworms are occasionally seen in feces and vomitus. Heavily infected cats and puppies may have digestive disturbances, intermittent diarrhea, a dull coat and a pot-belly appearance. Infections in adult dogs are usually asymptomatic. During migration there may be pulmonary injury resulting in coughing, a more rapid respiratory rate and sometimes a frothy nasal discharge. Fatalities in puppies shortly after birth may result from heavy transplacental infections.

Diagnosis - This is based on finding the characteristic eggs in fecal smears; floatation is not required. Species identification is

based on the distinctive characteristics of the eggs.

Treatment -

- Two oral treatments two weeks apart are recommended. Fenbendazole, febantel and pyrantel are among the drugs recommended. These drugs can be given to kittens 3 - 4 weeks old.
- Some treatments for heartworm reduce the number of viable larvae in tissues.

Control - The sources of infection are the eggs passed in the feces contaminating the feline environment and rodents harboring larvae. Prevention involves preventing exposure to these sources of infection.

Public Health Significance - When humans, most often children, swallow the eggs of *T. canis*, the developing larvae occasionally migrate in tissues. Such migrations are usually asymptomatic but occasionally a condition called visceral larva migrans develops. The signs observed depend on the extent and location of the infection. The liver is most frequently involved and there is fever, hepatomegaly and eosinophilia. Among the other tissues infected the eye is the most common with most often the development of endophthalmitis and granulomatous retinitis. It is only rarely that *T. cati* has been implicated in visceral larva migrans.

### **Hookworms of Cats**

Etiology - Three species of these small intestinal hookworms infect cats:

*Ancylostoma tubaeforme* (most common)

*A. brasiliense*

*Uncinaria stenocephala*

Hookworms are thin and less than one-half inch long. Infections are common and more frequent in subtropical and tropical regions. Kittens and young cats are most susceptible.

Life Cycle - Adult females in the intestine produce eggs which are passed in the feces. Cats are infected by ingesting eggs on fecally contaminated materials. The life cycle is completed in 2 - 3 weeks. Infections may also take place via the skin, e.g., the footpads, in such instances the larvae migrate to the intestine. Excepting cutaneous infection there is no migration external to the intestine. Transplacental and transmammary infections do not take place. Infections can also be acquired from ingesting infected rodents and cockroaches.

Clinical Features - Light infections are usually asymptomatic. *A. tubaeforme* is the major blood sucker; the other two species are minimal blood consumers. Signs seen in severe infections are diarrhea, vomiting, weight loss (particularly in kittens), lethargy, weakness and anemia.

Diagnosis - Detection of eggs in feces using the floatation technique for concentration.

Treatment - Effective drugs include , fenbendazole, dichlorvos, pyrantel pamoate and praziquantel. Liquid preparations are given orally , 2 doses 2 - 3 weeks apart.

Control -

- Hookworm eggs in the cat's environment may lead to reinfection. Keeping cats indoors greatly reduces infection. Keep litter box clean.
- Sodium borate may be applied to soil, lawns and fomites to kill hookworm larvae. Heart worm preventive is helpful in reducing infection.

Public Health Significance - Bare human skin , e.g., bare feet, may be infected by the larvae of cat hookworms in warm, moist soil. The condition is called cutaneous larva migrans and it is seen most commonly involving the feet, legs, buttocks, or back. The larvae burrow along a haphazard track leaving a winding, very narrow rash that becomes intensely itchy. Adults do not develop. It is effectively treated with topical thiabendazole.

### **Whipworms of Dogs**

Etiology - *Trichuris vulpis*, which is 40 - 70 mm long, with a slender anterior portion and a thicker posterior portion.

Occurrence - Whipworms are a common parasite of dogs worldwide. *Tricuris campula*, the whipworm of cats, rarely infects dogs. The following discussion applies to the canine whipworm.

Life Cycle - Adults are found in the cecum and colon. The life cycle is direct. The thick-shelled eggs are passed in the feces and in a warm, moist milieu become infective in 2 - 4 weeks. They may remain viable for up to five years. After ingestion the larvae penetrate and develop in the jejunal wall. They then move to the cecum and after maturation to adults they penetrate the mucosa and take in blood from capillaries. The prepatent period is 11 - 12 weeks and adults may live as long as 15 months.

Clinical Features - Light infections are asymptomatic. Clinical signs seen in heavy infections include mucoid diarrhea with blood, weight loss and anemia.

Diagnosis - Demonstration of eggs in feces.

Treatment - Effective drugs include fenbendazole, mebendazole, dichlorvos, butamisolol, milbemycin oxime and febantel. Milbemycin oxime and some other drugs individually or in combination as heartworm preventive are effective against the whipworm.

Control - Reduce exposure to eggs by strict sanitation.

### **Lungworms of Cats**

Several species of nematodes can infect the feline lung. The three most common are considered first.

Etiology - Disease can be caused by *Aelurostrongylus abstrusus* (principal lungworm of the cat) or *Capillaria aerophilia* (less frequent in cats). These are hair-like worms: *A. abstrusus* is 7 - 10 mm long; *C. aerophilia* is 25 - 35 mm long. Both inhabit the trachea, bronchi, bronchioles and aveoli. *Filaroides hirthei*, also a lungworm of cats, is discussed separately below.

Occurrence - Clinical disease is infrequent. Worldwide in distribution.

Life Cycles - Reviewed individually, below.

*A. abstrusus* life cycle - The adult females of *A. abstrusus* produce eggs in the lung which in the larval stage move up the trachea to the pharynx where they are swallowed. They do not remain in the intestine but are passed in the feces and when ingested by a snail or slug they develop into the infective stage. Small rodents, as well as birds, amphibians and reptiles eat infected snails or slugs and become infected. The larvae encyst in the tissues of these paratenic hosts and when a cat ingests these tissues the released larvae migrate from the stomach to the feline lungs via the thoracic and peritoneal cavities to develop into adults.

*Capillaria aerophilia* life cycle - *C. aerophilia* has a direct life cycle. Eggs are laid in the lungs, coughed up, swallowed then passed in feces. Cats acquire infection by ingesting feed or water contaminated with embryonated ova. After development in the intestine the larvae reach the lungs via the circulatory system. They mature about 40 days postinfection.

*Filaroides hirthei* life cycle - Sporadic infections in cats with this small nematode have been reported worldwide. Clinical disease is infrequent. Direct. Infective larvae are passed in the feces. After ingestion they penetrate the intestinal wall and pass to the lungs via the portal system. Auto-infection may take place resulting in heavy infections.

Clinical Features - Infections in normal healthy individuals is generally subclinical. Focal granulomatous lesions may be produced in the parenchyma of the lung. Among the signs seen in cats with impaired immunity are cough, rapid breathing and dyspnea.

Diagnosis - Larvae and eggs containing larvae may be demonstrated in feces, saliva and tracheal mucus. A special flotation procedure (specific gravity 1.8) is preferred to the Baerman technique for the demonstration of eggs and larvae.

Treatment and Control -

- Fenbendazole and albendazole have been effective. Probable causes of immunosuppression should be investigated.
- Sanitary measures to prevent infection and reinfection.

Additional Feline Lungworms - There are other lungworms in cats, especially, *Mammomonogamus* spp. Several species of this genus of small nematodes have been reported to occur in the respiratory tract of some mammals. *Mammomonogamus ierei* has been found in the nasal passages of cats in the Caribbean; *M. mcgaughei* has been recovered from the nasal passages and throat of cats in southeast Asia. The life cycles of species of *Mammomonogamus* are not known and their pathogenic significance would appear to be minor. Some other nematodes of the genera *Troglostrongylus*, *Filaroides* and *Osleroideis* have been found in the lungs of cats in particular geographic regions. To date, for the most part, they are considered to be of marginal clinical significance.

### **Lungworms of Dogs**

Three species of lungworms are recognized in dogs: *Oslerus (Filaroides) osleri*, *Filaroides milksi* Infection, and *Crenosoma vulpis* Infection. They are discussed separately below.

*Oslerus (Filaroides) osleri* Infection. - The females of this small nematode are 10 - 15mm long, the males ~ 5 mm long.

*Filaroides milksi* - A questionable pathogen, is referred to below.

Occurrence - *O. Osleri* causes tracheitis and bronchitis in dogs worldwide. Infections are most frequent in breeding kennels.

Life Cycle - Adults are found in thin-walled nodules in the region of the bronchial bifurcation. Eggs are moved up the tracheobronchial tree; they are swallowed and larvae are passed in the feces. Infective larvae are also present in the saliva. After ingestion larvae enter blood and are carried to the lungs and bronchi where they mature producing small granulomatous nodules.

Diagnosis - There is a persistent dry cough which may be followed by breathing difficulties. Demonstration of eggs

containing larvae in feces. Lesions can be seen with the bronchoscope.

Treatment and Control -

- Fenbendazole, levamisole and thiabendazole are effective. Surgical removal of nodules may be impractical.
- Infection of puppies is difficult to prevent. Thorough treatment of infected animals is the best approach. Infection can be prevented by rearing caesarian-obtained puppies in isolation.

Filaroides milksi - This nematode has a direct life cycle similar to *F. hirthei* and also resembles it morphologically. It is of questionable pathogenicity in normal dogs but can cause pneumonia and lung granulomas in dogs with impaired immunity.

Crenosoma Vulpis Infection -

*Crenosoma vulpis*, a small nematode, up to 1.5 cm long, is a parasite of the tracheobronchiolar tree of dogs. It occurs in Europe and North America and is recognized as a cause of tracheobronchitis.

Life Cycle - Larvae are moved up the respiratory tract to the pharynx, swallowed then passed in the feces. Larvae penetrate snails or slugs and further develop. Infection is acquired by ingesting infected snails or slugs. Development to adults takes place in the tracheobronchiolar tree.

Clinical Features - Catarrhal bronchitis and bronchiolitis result in a dry, hacking cough.

Diagnosis - Adult nematodes can be seen by bronchoscopy. The Baerman technique is used to demonstrate larvae.

Treatment - Fenbendazole has been effective.

### **Strongyloidosis (Thread Worms)**

*Strongyloides* spp., the cause of strongyloidosis (strongyloidiasis), are nematodes that occur worldwide and are most prevalent in tropical and subtropical countries including the southern US. They are slender and about 2 mm long. Humidity, a moist environment and unsanitary conditions contribute to infection and dissemination.

Etiology - Four species.

*Strongyloides stercoralis* (Most common in dogs and humans; rarely in cats)

*S. planiceps*, *S. fuelliborni* (Less common in dogs)

*S. cati* (In cats mainly in Southeast Asia)

*S. tumefaciens* (Occurs rarely in cats, )

Life Cycle - Adult females lay eggs in their habitat, the small intestine; males are not present. Most eggs embryonate before being passed in the feces. Development takes place rapidly; the third stage larvae can become parasitic infecting the host via the skin or oral mucosa. Alternatively the larvae from embryonated eggs may develop through four stages to become free-living adult male and female worms. These may produce larvae similar to those produced by females in the small intestine. Infective larvae penetrate the skin or the mucosa of the mouth and pass via the blood stream to the lungs. They are coughed up, swallowed and grow to adults in the small intestine. Transmammary transmission is suspected but not proved.

Clinical Features - Migration through the lungs may give rise to coughing. *Strongyloides* infect the small intestine of young animals and ordinarily are of no pathogenic significance. Occasionally they give rise to an enteritis of varying severity. The cardinal sign is a watery diarrhea that may contain blood and mucus. A pododermatitis, with cracking and bleeding, may be seen in dogs due to penetration of footpads by larvae. *S. tumefaciens* causes diarrhea and nodular lesions in the wall of the large intestine of cats.

Diagnosis - Demonstration of larvated eggs by direct examination of fresh feces or by the Baerman technique. Adult females may be found in mucus scraped from intestinal mucosa.

Treatment and Control -

- Animals with clinical strongyloidosis should be isolated and infected areas thoroughly washed and rinsed with hot water. When one dog or cat in a household is infected it is likely that others are also infected. All should be treated.
- Single doses of albendazole and multiple doses of thiabendazole have been effective. The latter is given daily for five days and then monthly until feces are negative.
- Supportive care and fluid therapy for dehydration as indicated.

Public Health Significance - Human strongyloidosis caused by *S. stercoralis* is endemic in some regions of tropical and subtropical countries and human cases are a major source of infection for dogs and cats. Because humans can be infected with *S. stercoralis* great care should be exercised in handling dogs and cats passing larvated eggs. Clinical signs seen in human infections resemble those observed in dogs.

## **Stomach Worms**

Etiology - Several nematode species of the genus *Physaloptera* parasitize the stomach of the dog and cat worldwide. They resemble small ascarids and are ~ 40 mm long.

Life Cycle - The adult female in the stomach lays larvated eggs that are passed in the feces. After the dog or cat ingest a paratenic host (mice, frogs and possibly birds and rodents) or beetles, cockroaches and crickets containing encysted larvae. The latter develop directly to adults which embed their head in the stomach mucosa.

Clinical Features - A sufficient number of worms may give rise to gastritis and duodenitis. Among the signs are anorexia, vomiting, dark feces and loss of condition. Anemia may occur with heavy infestations.

Diagnosis - Worms may be present in vomitus and seen in the stomach by gastroscopy. Eggs are difficult to demonstrate by direct examination of feces.

Treatment and Control -

- Pyrantel pamoate is effective.
- Control, other than keeping dogs and cats indoors, is largely impracticable.

## ***Ollulanus* Infection**

*Ollulanus tricuspis*, a small nematode, about 1 mm long, occasionally causes a mild catarrhal gastritis in cats. Adult females in the stomach produce living third stage larvae (viviparous) resulting in endogenous infection.

Transmission is by ingestion of vomitus.

The principal sign is vomiting following eating.

Diagnosis involves demonstration of worms by microscopic examination of vomitus. The Baermann procedure is helpful in separating worms from vomitus.

Fenbendazole has been an effective treatment.

## **Esophageal Worm of Dogs**

Etiology - *Spirocerca lupi*, a bright red nematode worm; males ~40 mm and females ~70 mm long.

Occurrence - Southern US and in tropical and subtropical countries worldwide. Clinical disease is infrequent.

Life Cycle - Worms are found in the nodules they produce in the esophageal, gastric and aorta walls. Larvated eggs are passed into the alimentary tract via fistulous tracts in nodules and then passed in the feces. Eggs are ingested by the intermediate host, coprophagous beetles and the paratenic hosts, mice, chickens, lizards and rabbits which have been infected by eating beetles. Dogs are infected by ingesting an intermediate host most often a dung beetle or the paratenic or transport host, referred to above. Larvae penetrate the dog's stomach wall and migrate in the walls of the gastric and gastropiloic arteries. Migration may continue to the coeliac artery and the thoracic aorta. From the aorta they migrate into the esophagus. In 5 - 6 months after infection eggs are passed in feces.

Clinical Features - Infections are usually asymptomatic. When the esophageal lesion is large it often becomes neoplastic.

Dogs salivate profusely, have difficulty swallowing, vomit repeatedly and lose condition. Signs may indicate metastasis of the neoplasm, and death sometimes results from hemorrhage following rupture of the aorta. Among the lesions seen are: aortic aneurysm, granulomas (nodules) and sarcoma involving the esophagus and metastases to the thoracic vertebrae.

Diagnosis - A clinical diagnosis is difficult and the disease is most often recognized at necropsy. A presumptive diagnosis is sometimes made radiographically based on observing the nodules and in advanced cases metastases to lungs, heart, kidneys, liver and lymph nodes. Endoscopy may be helpful. The characteristic lesions confirm a diagnosis at necropsy. Attempts should be made to demonstrate larvated eggs in feces both directly and by floatation (high specific gravity); however, eggs are shed intermittently.

Treatment and Control -

- Although usually impracticable in endemic areas dogs should be prevented from eating beetles and transport hosts. Affected dogs should be isolated and their vomitus and feces should be considered infectious and adequately disposed of.
- Treatment is not usually feasible. Some success has been attributed to avermectins, levamisole and albendazole.
- Surgery is not usually feasible given the extent of the lesions in clinical cases.

Public Health Significance - Rare human infections as a result of ingesting the paratenic hosts have been reported.

## ***Dictyophyma Renale* Infection (Giant Kidney Worm Infection)**

Etiology - *Dictyophyma renale*, a large, red nematode. Adult males are ~ 35 cm by 3 - 4 mm; adult females are 75 - 100 cm by

5 - 12 mm.

Occurrence - Europe and North America. The definitive hosts of this large nematode are mink, weasels, otters, skunks, martens, seals and infrequently dogs and some other animals.

Life Cycle - Adults, one to a few, are present in the kidney. Eggs are passed in the urine and the first larval stage in the egg develops in water. Earthworms ingest the eggs that hatch and the larvae develop to the fourth stage. The definitive host, often mink, infrequently dogs, ingest the annelid worm or a paratenic host that harbors the annelid. The larvae penetrate the intestinal wall and migrate through tissues to the right kidney where they grow to adults. The prepatent period is 3.5 - 6 months. Eggs are passed several months after infection.

Clinical Features - A few adult worms severely damage the parenchyma of the kidney. Most infections are subclinical as the other kidney compensates. The compensating kidney may undergo hypertrophy. The ureter may be blocked resulting in hydronephrosis and rarely adult worms are found in the bladder and ureter. Hematuria, frequent urination and loss of condition may be seen.

Diagnosis - Adult worms can be seen radiographically. Demonstration of the characteristic eggs in urine.

Treatment and Control -

- Removal of worms surgically.
- If feasible, prevent dogs from ingesting frogs and raw fish in endemic areas.

### ***Dracunculus Infection***

Etiology - *Dracunculus insignis* is a long (females up to 120 cm, males up to 40 mm) white nematode found in the subcutaneous connective tissue of wild carnivores, raccoons, mink and rarely in dogs.

Occurrence - The infection occurs in North America and is rare in dogs. This worm produce ulcers of the skin mainly of the abdomen and extremities. It is of interest that the "guinea worm" (*D. medinensis*) of regions of Asia, Africa and the Middle East occasionally infects dogs.

Life Cycle - When in water the anterior of the worm protrudes from the ulcer and releases long, thin-tailed larvae. These penetrate water fleas (*Cyclops*) the intermediate host in which they develop. The definitive host including dogs becomes infected by ingesting *Cyclops* while drinking water. Infection can also take place by ingestion of frogs the paratenic host. The larvae migrate to subcutaneous tissue where they produce nodules with ulcers as referred to above. The latter become crater-like, slow to heal and may have inflammatory tracts.

Diagnosis - Finding *D. insignis* in lesions and larvae in smears of exudate from ulcers.

Treatment and Control -

- Careful, manual removal of worms.
- In view of the rarity of canine infections, control measures are not considered practicable.

### ***Pelodera Strongyloides Infection***

*Pelodera strongyloides* is a very small (1 - 2 mm long), free-living nematode of worldwide distribution that may infect, superficially, the skin of dogs, rodents and other animals. This nematode lives in damp straw and organic material associated with soil where eggs hatch producing larvae. The third stage larvae invade damaged skin but do not penetrate below it. They die in the skin and the reaction to their presence, which may be allergenic, results in erythema, pruritis and dermatitis with pustules and nodules.

Diagnosis - Demonstration of larvae and adult worms in skin scrapings.

Treatment and Control -

- Topical application of parasiticides is effective.
- Control involves keeping kennels and the dog's environs clean and dry.

### ***Thelazia (Eye Worm) Infection***

Etiology - *Thelazia* spp., are small (up to 19 mm long), white nematodes found associated with the eye of dogs, cats and other animals. They are found in the conjunctival sac, under eyelids and the nictitating membrane. As many as 100 may be present and they can be seen moving rapidly across the eye.

Occurrence - *Thelazia californiensis* infects dogs and cats in North America; *T. callipaeda* infects dogs in Asia.

Life Cycle - Eggs containing larvae are laid by females. The intermediate hosts are the so-called filth flies including *Musca* spp. They ingest first stage larvae while feeding on lachrymal secretions. Larvae develop to third stage and move to the mouthparts of the fly from which they infect the eye while feeding on ocular secretions.

Clinical Features - Signs include conjunctivitis, excessive lachrymation, photophobia, keratitis and in the absence of treatment corneal opacity and ulceration.

Diagnosis - Worms can be seen in the eye with the naked eye. Finding eggs and larvae in ocular secretions.

Treatment and Control -

- Removal of worms under local anesthesia. Application of ocular preparations containing levamisole or morantel or administration of the former orally or parenterally.
- Fly control with insecticides if feasible.

### **Capillaria Urinary Infection**

*Capillaria* spp., are thread-like nematodes, the females of which are up to 60 mm long. Two species of these bladder worms occur in dogs and cats. *Capillaria plica* infects dogs, cats, wolves and foxes; *C. feliscati* infects cats.

Occurrence - The former species has been reported from North America, Europe and Russia; the latter occurs worldwide.

Life Cycle - Adults are present in the bladder and eggs are passed in urine. Earthworms, the intermediate host, ingest eggs.

The definitive host ingests the earthworm in which eggs hatch producing first stage larvae. Larvae presumably migrate to the bladder where they mature to adults. Although infections in dogs with *C. plica* are infrequent, infections in cats with *C. feliscati* are common in some regions.

Clinical Features - The adults of both species are found in the bladder and occasionally in the pelvis of the kidney. Infections are usually subclinical and harmless. Rarely there is cystitis, hematuria, frequent or difficulty in urination.

Diagnosis - Demonstration of eggs in urinary sediment.

Treatment and Control -

- Fenbendazole, levamisole and are effective.
- Control is not practicable.

### **Acanthocephalans (Thorny-headed Worms: *Oncicola* and *Macracanthorhynchus*)**

These parasites, referred to as thorny-headed worms, are in the small phylum Acanthocephala. They are closely related to nematodes. Two thorny-headed worms infect the dog, *Oncicola* sp. and *Macracanthorhynchus* sp.; the former species can also infect cats. *Oncicola* sp. is discussed first, followed by *Macracanthorhynchus* sp.

#### ***Oncicola* Infection**

Etiology - *Oncicola canis*, a small, white worm 6 - 14 mm long. It has a thorny-head which it imbeds in the mucosa of the small intestine.

Occurrence - It occurs in North and South America and is rarely of clinical significance. Most infections are asymptomatic. The definitive hosts are dogs, cats, bobcats and coyotes.

Life Cycle - The adult female in the small intestine produces and passes in the feces, thick-shelled, wide, oval eggs about 45 by 65  $\mu\text{m}$  in size. The life cycle is not fully known but it is thought to involve an arthropod as intermediate host; the latter ingests eggs. The paratenic hosts, viz., the turkey and nine banded armadillo are thought to be infected when they ingest the infected arthropod. The dog or cat becomes infected by ingesting the arthropod or the paratenic hosts.

Diagnosis - Diagnosis is based on finding the characteristic eggs in feces; also by finding adult worms at necropsy.

Treatment and Control -

- Treatment is not necessary.
- Prevent dogs from eating turkeys and armadillos.

#### ***Macracanthorhynchus* Infection**

Etiology - The thorny-headed worm *Macracanthorhynchus ingens*. It is large (8 - 12 cm long), white, wrinkled and found in the small intestine.

Occurrence - Infections are uncommon, asymptomatic and probably worldwide in distribution. The definitive hosts are racoons and occasionally dogs.

Life Cycle - Eggs are passed in the feces. The intermediate host is a millipede and other animals may serve as paratenic hosts.

Diagnosis - The eggs are similar in appearance to *Oncicola canis* but somewhat larger. Eggs probably can't be demonstrated in canine feces as infections are not patent.

Treatment - Not necessary.

## **Cestodes (Tapeworms)**

These are ribbon-like parasites of the intestine of vertebrates. They consist of a head (scolex), a series of segments (proglottids) containing female and male reproductive systems. They attach to the intestinal wall and may attain a length of two feet or more.

Life Cycle - Eggs are not generally passed in the feces but segments are. These are motile and in the case of the common tapeworm of the dog and cat (*Dipylidium caninum*) are about the size of a cucumber seed. They move around their environment and lay large numbers of eggs, that develop into infective larvae. The life cycle requires two hosts, a primary, usually considered a predator and a secondary or intermediate host. The intermediate host ingests eggs or infective larvae which encyst in various tissues (larval stage) depending upon the tapeworm species. The dog or cat becomes infected by consuming infected tissues containing the larval stage (metacestode) from which adult tapeworms develop. Hunting and rural dogs with access to various small mammals, the offal and tissues of domestic and wild ungulates may become infected with more than a dozen species of tapeworms.

### **The More Important Tapeworm Species of Dogs and Cats**

*Dipylidium caninum* - This is the common tapeworm of the dog and cat. The eggs of this tapeworm are ingested by flea larvae in which they develop and the dog and cat become infected by eating the infected adult flea (intermediate host).

*Taenia taeniaformis* - This is probably the second most frequent tapeworm of the dog and cat. The intermediate hosts are rats, mice and other rodents.

*Echinococcus granulosus* - This hydatid tapeworm is found occasionally, mainly in rural dogs (see Public Health Significance below). The intermediate hosts are sheep, cattle, swine, horse, wild ungulates and some rodents.

*E. multilocularis* - This the alveolar hydatid tapeworm of dogs and cats (see Public Health Significance below). The intermediate hosts are field mice, lemmings, voles and sometimes humans and domestic animals.

*Spirometra mansonioides* - This tapeworm is an infrequent tapeworm of cats along the Gulf Coast regions of North America. The intermediate hosts are frogs, rodents, snakes and copepods (small crustaceans).

Clinical Features - Tapeworms rarely cause significant disease in dogs and cats. Some signs observed with heavy infestations are malaise, mild diarrhea and loss of condition.

Diagnosis - The owner frequently observes motile proglottids in feces and dried ones adherent to hair in the perineal region. Diagnosis is based on finding eggs and proglottids in feces by microscopic examination and with the aid of fecal floatation. Definitive identification of species is based on morphological features of the proglottids.

Treatment -

- Dogs and cats are treated similarly.
- Treatment is mainly important because of the public health significance of some tapeworms (see below). Effective drugs for all tapeworm species are: praziquantel and epsiprantel. Although single doses are usually sufficient an additional dose may be required for some species.
- There are a number of alternative anthelmintics less frequently used including bunamidine and nitroscanate; the latter is not recommended for cats. The benzimidazole drugs are only effective against taenid tapeworms.

Control -

- Flea control is essential to control *D. caninum*. Unless exposure to infected fleas can be prevented, dogs and cats will become reinfected with *D. caninum*.
- Infection by other species can only be prevented by also controlling predatory and scavenging behavior involving the metacestodes (larval stage) in carrion and prey animals.

Public Health Significance - Species specific.

*D. caninum* - Children may inadvertently swallow infected fleas while playing with dogs or cats. The tapeworm becomes established in the intestine and eggs and proglottids are shed in stools.

*E. granulosus* - Dogs are infected by the parasitic scolex of hydatid cysts in tissues of the intermediate host which is often sheep. The infected dog passes eggs and segments and if humans swallow these hydatid cysts they may develop in tissues including lungs, liver, kidney and spleen. When these, often quite large cysts, rupture, the result can be anaphylaxis and formation of multiple secondary cysts.

*E. multilocularis* - The dog and cat are primary hosts. Sheep and cattle are intermediate hosts. When humans swallow eggs or segments passed by dogs or cats alveolar hydatid cysts may develop in the liver with occasional spread to other tissues. This infection in humans occurs most often in the Northern Hemisphere. Clinical diagnosis of echinococcosis in humans is frequently difficult.

## **Trematodes (Platyhelminthes, Flatworms, Flukes)**

Trematodes are flatworms of the class Trematoda and Phylum Platyhelminthes. There are both parasitic and free-living species. They are hermaphroditic but self-fertilization is uncommon. There is a mouth with a simple branched gut with no anus. They attach to the host with hooks and suckers. There is great variation in size and most have a complex life cycle which involves larval development in a snail. Individual entries below provide details about intestinal flukes, blood flukes, liver flukes and lung flukes.

Intestinal Flukes I. *Nanophytus Salmonicola* Infection

Intestinal Flukes II. *Alaria* Spp Infections

Intestinal Flukes III. Usually Nonpathogenic Intestinal Flukes

*Heterobilharzia* Infection (Blood fluke)

Hepatic Flukes

Lung Flukes (Paragonimosis)

### **Intestinal Flukes I. *Nanophytus Salmonicola* Infection**

Etiology - *Nanophytus salmonicola*, the salmon poisoning fluke is small, oval shaped and about 0.5 x 0.3 mm in size.

Occurrence - Northwest USA, southwest Canada and Siberia. The definitive hosts are dogs, cats and wild carnivores.

Life Cycle - Adult flukes are present in the small intestine. Light brown eggs, 45 x 55 µm are passed in the feces. Snails, the first intermediate host, ingest eggs from which cercariae develop and infect young salmonid fishes in which encystment (metacercariae) takes place mainly in muscles, kidneys and fins. Metacercariae can remain viable in tissues for years. Dogs and other hosts become infected by eating raw or inadequately cooked infected fish. The metacercariae develop to adult flukes in the intestine.

Clinical Features - A large infestation of these intestinal flukes may cause enteritis. Because this fluke harbors and transmits the rickettsia, *Neorickettsia helminthoeca*, these infestations frequently give rise to the disease salmon poisoning complex which is discussed separately. Another rickettsia, the Elkomin fluke fever agent, which is discussed separately is also transmitted by *N. salmonicola* and may act alone or complicate *N. helminthoeca* infections.

Diagnosis - Clinical signs of salmon poisoning. Demonstration of the characteristic eggs in feces.

Treatment and Control - Praziquantel is effective. Raw or uncooked fish should not be fed.

### **Intestinal Flukes II. *Alaria* Spp Infections**

Etiology - *Alaria canis*, *A. alata* and other *Alaria* spp. are small (~ 5 mm long) flukes that occur in the small intestine of dogs, cats, fox, mink and other wild carnivores.

Occurrence - They probably occur worldwide.

Life Cycle - Eggs are passed in feces. In water miracidia emerge and penetrate a freshwater snail. Cercariae emerge from sporocysts in the snail and penetrate frogs. Dogs are infected by ingesting infected frogs. The definitive hosts can also be infected by ingesting paratenic host, e.g., birds, snakes and rodents. Larvae migrate through various tissues to the small intestine in which they develop to adults.

Clinical Features - Infections are ordinarily subclinical. In rare instances heavy infestations lead to enteritis.

Diagnosis - Demonstration of eggs in feces.

Treatment and Control -

- Fenbendazole and praziquantel are effective
- Preventing predation when feasible.

### **Intestinal Flukes III. Usually Nonpathogenic Intestinal Flukes**

Some other flukes, usually nonpathogenic, occur infrequently in the intestine of dogs, cats and other carnivores. They include the following:

*Metagonimus yokogawai*: Asia

*Heterophytes heterophytes*: Asia, North Africa

*Cryptocotyle lingua*: Probably worldwide

*Apophallus donicum*: North America, Europe.

Their first intermediate host is a snail and the second intermediate host is fish in which metacercariae produce cysts. Hosts become infected from ingesting fish containing cysts.

### ***Heterobilharzia* Infection (Blood fluke)**

Etiology - The small, so-called blood fluke, *Heterobilharzia americana*.

Occurrence - The definitive hosts are dogs and some wild animals in the southern USA. The site of infection is the mesenteric veins.

Life Cycle - Adults are found in the mesenteric veins. Eggs move through intestinal tissue to the lumen and are passed in the feces. Miracidia enter the snail and after development cercariae penetrate the skin of the host. The immature fluke migrates to the liver where they mature and then move to the mesenteric veins. Granulomas develop around eggs found in the liver, the wall of the intestine and sometimes other tissues.

Clinical Features - Heavy infections may result in enteritis and eventual loss of condition. When sufficient cercariae penetrate the skin a condition called "water dermatitis" may develop.

Diagnosis - Dogs pass eggs intermittently thus more than one fecal examination may be required. Flotation, using 0.85 saline solution, helps separate eggs from feces.

Treatment and Control - Fenbendazol and praziquantel have been effective.

### **Hepatic Flukes**

Many species of flukes occur in the gallbladder and bile ducts of dogs, cats and other carnivores throughout the world. Light infections are usually subclinical. Some of the more common hepatic flukes are as follows:

*Platynosomum fastosum* - *Platynosomum fastosum* is a small fluke (16 x 2 mm) which occurs in the bile duct of cats in the southern USA, Caribbean Islands, South America and Africa. A snail is the intermediate host and some lizard spp., are paratenic hosts. Cats become infected by eating infected lizards.

Light infections are usually asymptomatic. Heavy infections may cause so-called "lizard poisoning" syndrome. This is characterized by diarrhea, vomiting, anorexia and icterus. In the absence of treatment death may ensue.

Nitroscarnate and praziquantel are reported to be effective.

*Opisthorchis tenuicollis* - *Opisthorchis tenuicollis* is a small fluke (9 x 2 mm) which occurs in the pancreatic and bile ducts and small intestine of dogs and cats and other carnivores in Asia and eastern Europe.

*O. viverrini* - *O. viverrini* is also a hepatic fluke which occurs in southeast Asia.

The life cycle of both the above species involves various snails and fresh-water fish as intermediate hosts.

*Clonorchis sinensis* - This is the Oriental fluke of humans, which is somewhat larger than *Opisthorchis* spp. and is occasionally found in the pancreatic and bile ducts of dogs and cats. The presence of hepatic flukes for long periods can lead to fibrosis and thickening of bile duct walls. Their chronic presence has been associated with pancreatic and hepatic cancer. Diagnosis involves demonstration of the operculated eggs in feces.

*Metorchis albidus* and *M. conjunctus* - These are very small flukes (1.5 x 5 mm) which are found in the bile ducts and gall bladder of dogs, cats and other carnivores in North America, Europe and Asia. Infections are generally subclinical. The life cycle involves as intermediate host, some fresh-water snails and fish.

### **Lung Flukes (Paragonimosis)**

Etiology - *Paragonimus kellicotti* and *P. westermani*, small flukes, 10 - 12 mm long by 5 - 7 mm wide which infect dogs, cats and other mammals. Some other *Paragonimus* spp., have been recovered from dogs, cats and other carnivores in Asia, Africa and South America.

Occurrence - *Paragonimus kellicotti* occurs in central and eastern US and some parts of Canada; *P. westermani*, is found in some regions of Asia. Mink and other wild carnivores serve as a reservoir of *Paragonimus* spp.

Life Cycle - Eggs are produced by mature flukes in the lung. They are moved up the tracheobronchial tree then swallowed and then passed in the feces. They hatch and the miracidia enter amphibious and aquatic snails. Cercariae emerge from the snail and enter a crayfish where they encyst. Dogs, cats and other animals become infected as a result of ingesting infected freshwater crayfish or crabs. After ingestion the developing young flukes penetrate the intestinal wall, migrate via the peritoneal cavity, pass through the diaphragm to the lungs. Flukes mature, usually in pairs, in cysts in the parenchyma of the lung. Cysts occur infrequently in other organs and the brain. The complete cycle takes about six weeks.

Clinical Features - Infections are sporadic and seen most often in hunting dogs and free-ranging cats. Light infections are generally asymptomatic but heavy infections lead to deep coughing, hemoptysis, lethargy, weakness and loss of weight.

Diagnosis - Cysts can be seen in radiographs. The characteristic eggs can be demonstrated in fecal smears and by flotation using a solution with a specific gravity of 1.3 to 1.35.

Treatment and Control -

- Fenbendazole and praziquantel are effective.
- Prevent ingestion of crayfish which may be impractical for hunting dogs.

Public Health Significance - There have been rare human infections with *P. kellicotti* as a result of eating undercooked crayfish. Infections are not transmitted directly to humans from dogs and cats. Human infections in Asia with *P. westermani*, attributed to eating undercooked crayfish, are not uncommon.

### **General Measures for Prevention of Worm Infections**

- The primary strategy is to destroy parasitic eggs and larvae before they infect.
- Good general sanitation; maintaining clean, dry quarters.
- Avoid dirt kennel runs; cement, gravel or sand is preferred; the latter two provide good drainage. Cement runs should be hosed down daily and a disinfectant (e.g., 1 % bleach) applied frequently.
- Lime, rock salt or borax added to cement, gravel and sand runs kill larvae.
- Remove stools as often as possible.
- Lawns where pets range should be kept short and watered sparingly. Exposure is greatest in damp, shady areas.
- Remember that fleas, mice and other rodents are intermediate hosts for tapeworms.
- Keep the litter box clean. Wet spots and feces should be removed daily. Empty and disinfect the box weekly.
- Keep pets indoors as much as is feasible.
- The more pets are allowed to roam and hunt outdoors the greater is the exposure to parasitic infection. Carrion, dead and live rodents, earthworms, frogs and other animals are potential intermediate and paratenic hosts.
- In the interest of preventing zoonotic infections, clients (and through them their children), should be made aware of the need for good hygienic practices when handling pets. Collect and dispose of cat and dog feces where children play.

### **Anthelmintics and Deworming Guidelines**

These guidelines are adapted in part from recommendations of the American Association of Veterinary Parasitologists and the Centers for Disease Control. These guidelines can serve to assist practitioners in preparing deworming programs for clients. In view of the introduction of some new anthelmintics it may not always be necessary or feasible to adhere strictly to these recommendations. The potential for exposure to infection for each particular situation, must be taken into account. A list of frequently used anthelmintics and their range of efficacy is presented in Table 1.

#### Puppies and Kittens -

- Puppies: treat at 2, 4, 6 and 8 weeks.
- Kittens: treat at 6, 8 and 10 weeks.
- Puppies and kittens: treat once a month from 3 - 6 months of age.
- After six months follow adult recommendations.

Adult Dogs and Cats - Treat regularly depending on the potential exposure to parasites, ordinarily not more than 4 times a year.

#### Bitches and Queens -

- Once prior to mating
- Once following parturition
- Lactating bitches and queens should be treated concurrently with puppies and kittens.

Newly Acquired Animals - Immediately treat; then repeat after two weeks and then follow the guidelines above.

Screening - Annual or biannual fecal screening is recommended for adult cats and dogs.

**Table 1. Anthelmintics and their range of efficacy expressed as worm infections groups that can be treated.\* (Products should be used according to manufacturer's recommendations)**

Anthelmintic	Asc**	Hook	Range of Efficacy				Species
			Whip.	Taen.	Dipyl.	Echino.	
Febental/praziquantel/pyrantel pamoate	+	+	+	+	+	+	Dogs
Febental/praziquantel	+	+	+	+	+		Dogs, cats
Febendazole	+	+	+	+			Dogs
Mebendazole	+	+	+	+			Dogs
Dichlorophene/toluene	+	+		+	+		Dogs
Pyrantel pamoate/praziquantel	+	+		+	+		Cats
Dichlorvos	+	+	+				Dogs, cats
Milbemycin oxime	+	+	+				Dogs
Oxibendazole/diethyl/carbamazine	+	+	+				Dogs
Febentel	+	+	+				Dogs
ivermectin/pyrantel pamoate	+	+					Dogs
N-butyl chloride	+	+					Dogs, cats
Pyrantel pamoate	+	+					Dogs
Piperazine salts	+						Dogs
Diethylcarbamazine citrate	+						Dogs, cats

\*Information in this table adapted from recommendations of the Centers for Disease Control.

\*\*Asc.= ascarids; Hook.= hookworms; Whip.= whipworms; Taen.= taeniid tapeworms; Dipyl.= flea tapeworm (*Dipylidium caninum*); Echin.= *Echinococcus granulosus*.

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