Internal Parasites of Dogs and Cats

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THE LIFE HISTORIES of the more important internal parasites of dogs and cats are here described, together with an account of the injuries they produce and the symptoms of infestation. The article closes with a rather detailed discussion of methods of prevention and medicinal treatment.

During the course of their evolution, dogs and cats have acquired an imposing number of different kinds of parasites—a total of more than 500. They include the Protozoa, helminths (worms), and arthropods. The arthropods, including fleas, lice, ticks, and mites, usually live on the exterior of the body; they are discussed in other articles. The Protozoa and helminths are all internal parasites, that is, they occur within the body of their hosts. Many of the internal parasites are of little importance, occurring so rarely as to be little more than zoological curiosities. A few, however, cause marked injury and even death to their hosts. Only the more important of the injurious species are discussed here. Measures for their control are given at the end of the article.

The damage inflicted by parasites on their hosts and the losses they occasion cannot be stated accurately, as no reliable statistics on these subjects are available. In the case of dogs, however, some idea of the losses that may result from parasitism can be obtained from recent estimates given by Judy (16). According to these estimates about 900,000 puppies are whelped annually in the United States. About 30 percent of this number fail to reach maturity. It may be assumed

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2 Italic numbers in parentheses refer to Literature Cited, p. 1172.
that about one-third of this loss—a conservative estimate—is due to parasites.

Parasites infecting adult animals do not cause spectacular losses as a rule, and often parasitism is not suspected until after the death of the animal. This is especially true of parasites occurring in the lungs and the circulatory and urinary systems. In fact, it is only during recent years that veterinarians have come to realize the injuries that can be caused by parasites other than the most common of those occurring in the intestinal tract.

The most widely distributed of the parasites of pet animals are those that have a direct life history, such as hookworms, large intestinal roundworms, and whipworms. Those that require intermediate hosts for their perpetuation, and hence have an indirect life history, are usually restricted to certain areas. The restriction is not absolute, however, since the heart worm, which until recent years was unknown except in the Southern States or in dogs that had at some time been in the South, has now become established in a number of sections of the country where suitable intermediate hosts are present. Other parasites, such as the dog eye worm, esophageal worm (infecting the esophagus, or gullet), and salmon-poisoning fluke, are definitely restricted in their distribution, even though the increasing traffic in dogs has offered many opportunities for them to become established elsewhere.

**PROTOZOA**

Only a few diseases of dogs and cats are caused by the minute primitive animals classed as Protozoa. Two such diseases are of importance in this country. One of these, canine piroplasmosis, has been known to exist in the United States during recent years only; it occurs in Florida and possibly in other Southern States. The other protozoan disease is coccidiosis. Coccidial infection is widespread, especially in dogs, but acute infections are either rare or are not generally recognized.

**Canine Piroplasmosis**

The organism causing this disease is known as *Piroplasma canis*. It lives in the red blood cells and is somewhat similar in appearance to the organism causing tick fever (also a piroplasmosis) of cattle. As in the case of cattle, this parasite is transmitted from one dog to another by ticks. Several ticks have been shown to be capable of transmitting piroplasmosis, but in this country the most probable vector, or carrier, appears to be the brown dog tick, *Rhipicephalus sanguineus*, which is widely distributed throughout the South.

Canine piroplasmosis may assume either the acute or the chronic form. In the acute form of the disease the affected dog may show a rise in temperature, increased pulse and respiration rates, reddening of the visible mucous membranes, loss of appetite, and increased thirst. Jaundice is present in about half the animals affected. Acute cases are frequently fatal.
In the chronic form, fever may be noted during the first days of the infection, and in rare instances there may be an intermittent fever. The affected dog becomes listless, the mucous membranes are pale, the appetite diminishes, and the animal loses weight. Jaundice is usually absent, although it sometimes appears in the later stages of the disease.

In some respects the symptoms of canine piroplasmosis resemble those of distemper, and a positive diagnosis is therefore extremely important. Diagnosis is based on microscopic examination of the blood and the finding in the red blood cells of the causative organism of the disease. In chronic cases the organism may not be demonstrable, and it may be necessary to inoculate susceptible puppies with the blood from the sick animal in order to be certain that the disease in question is actually piroplasmosis. In inoculated puppies the piroplasms can be easily demonstrated in the blood in about 4 to 7 days.

**Coccidiosis**

Coccidiosis in dogs and cats is an intestinal disease caused by protozoan parasites of the genus *Isospora*. Several species occurring in dogs and cats have been described. Some infect the cells lining the small intestine, while others live in the tissue beneath this lining. The parasites multiply in these locations and ultimately give rise to resistant egglike forms, known as oöcysts, which pass out in the animal's feces. These oöcysts become infective in the course of a few days and serve to infect other dogs and cats. Dogs appear to be more susceptible to coccidiosis than cats, although coccidia are frequently detected in the feces of cats.

In light infections, no symptoms may be detected in either dogs or cats, but in heavy infections a diarrhea, which may be severe and accompanied by the passage of blood and gas, appears at the time the oöcysts are passing in the feces. Sometimes a slight rise in temperature may be noted. Under unfavorable conditions, as in heavy infections in very weak or young animals, death may result. Since coccidiosis may be confused with other intestinal disorders, a diagnosis must be based on the demonstration in the feces, by microscopic examination, of the oöcyst stage of the parasite.

**Flukes**

Most trematodes, or flukes, of carnivores require two intermediate hosts in order to complete their life cycle. The first of these is invariably a snail, and the second is usually a fish, although in a few instances other animals may serve as second intermediate hosts. The most important trematode parasite of the dog is the so-called salmon-poisoning fluke, which is associated with a serious disease of dogs in the Pacific Northwest.

**The Salmon-Poisoning Fluke**

The fluke known scientifically as *Troglofrema salmonicola* occurs in California, Oregon, Washington, and southwestern Canada, where
it is associated with a disease of dogs, foxes, and coyotes known as salmon poisoning. The parasites are very small, hardly visible to the unaided eye, and live deeply imbedded in the mucous membrane of the small intestine.

The life cycle of this fluke is complex. The eggs produced by the mature fluke pass out in the feces of the host animal and on getting into water develop embryos within 2½ to 3 months. The eggs then hatch and liberate ciliated, free-swimming larvae known as miracidia, which swim about and penetrate into a fresh-water snail (determined by investigators at the Oregon Agricultural Experiment Station to be *Goniobasis plicifera* var. *silicula*). After the miracidia penetrate into the snail they undergo certain changes and develop into small wormlike structures known as rediae. Within the body of the rediae are developed tadpolelike larvae known as cercariae. When the cercariae escape from the rediae they pass out of the snail into the water. On coming in contact with fish belonging to the salmon family, the cercariae penetrate into the fish and become encysted (enclosed in protective structures) in the flesh and various organs. When infected fish are eaten by dogs or other suitable hosts the encysted parasites, called metacercariae, are liberated in the small intestine, where they develop into mature flukes in 5 to 10 days.

Salmon poisoning in many respects resembles canine distemper. The first symptoms following the eating of infected fish occur in 7 to 10 days, or about the time the flukes reach maturity. The onset of the disease is sudden and is accompanied by a temperature of 105° to 107° F. The animal is depressed, refuses to eat, shows increased thirst, and frequently has a discharge from the eyes. In many cases the face is swollen, causing the eyes to appear sunken. After 24 to 48 hours the temperature drops, and diarrhea sets in, the feces at first being tinged with blood and later consisting almost entirely of blood. As the disease progresses, the animal becomes weak and emaciated; in about 6 to 8 days the temperature drops below normal, and death follows 1 to 2 days later. From 50 to 90 percent of untreated animals die. Those that recover are not susceptible to subsequent infection.

Salmon poisoning has been shown to be a disease associated with fluke infection but not actually caused by the parasite. The causative agent of the disease appears to be a virus associated with the cellular elements of the blood.

A fluke, *Nanophyetus schikhobalowi*, which appears to be indistinguishable from that associated with salmon poisoning in dogs, has been reported in man in southeastern Siberia. No symptoms attributable to the presence of the parasite were observed, however.

**TAPEWORMS**

The tapeworms infecting dogs and cats in the United States may be roughly divided into two general groups, the armed forms and the unarmed forms. Species of both groups resemble each other in having a head, neck, and chain of segments. In the armed forms the head
is provided with four suckers and a rostellum, or prominence, bearing two or more rows of hooks. The segments have one or two sets of genital organs, and the genital openings or pores are located on the lateral margins of the segments. In the unarmed species the head is provided with a pair of sucking grooves instead of suckers, the segments have only a single set of genital organs, and the genital pores are located on the ventral, or under, surface of each segment. A further difference between the armed and the unarmed tapeworms is that the armed species require only a single intermediate host for the development of the larval stages, whereas the unarmed forms require two intermediate hosts.

**The Armed Tapeworms**

For convenience of discussion the armed tapeworms may be subdivided into the double-pored species, belonging to the genus *Dipylidium*, and the single-pored forms, represented by the genera *Taenia*, *Multiceps*, and *Echinococcus*.

The double-pored tapeworm that is of common occurrence in dogs and cats in the United States is *Dipylidium caninum*. The adult tapeworm rarely exceeds 1 foot in length. The head is armed with 4 or 5 rows of tiny hooks, and the segments are shaped like cucumber seeds.

The single-pored tapeworms are, as a rule, much larger than the double-pored species. The head is armed with two rows of relatively large hooks, and the segments are more or less rectangular in shape (fig. 1). The size of these tapeworms varies considerably. The smallest species, *Echinococcus granulosus*, is about one-fourth inch or less in length and consists of a head and only three segments. The other species may vary from 6 inches to 16 feet in length and consist of a head and numerous segments. The single-pored tapeworms are not so frequently encountered as the double-pored form and are more common in rural areas than in cities.

The life histories of the armed tapeworms are all similar in that, as already noted, only one intermediate host is required for the development of the infective larval stages.

The intermediate hosts of the double-pored tapeworm are usually dog and cat fleas, and occasionally the biting dog louse. The infective larva of this tapeworm develops in the body cavity of the flea or louse and consists of little more than a head.

The infective larvae of the single-pored tapeworms develop in mammals, not in fleas or lice, and are usually referred to as bladder worms. The bladder worm consists of one or more tapeworm heads invaginated into a bladder, or vesicle, filled with fluid. Different names are given to the bladder worms, depending on their appearance and the number of heads they contain, as follows: A larva consisting of a bladder containing a single head is called *Cysticerus*; when the bladder contains several heads it is *Coenurus* or *Multiceps* (fig. 2); and when the larva consists of one or more bladders containing brood capsules composed of numerous heads it is *Echinococcus*, or a hydatid. When any of these larvae are eaten by the final host, the entire larva
except the head is digested in the small intestine. The tapeworm head becomes attached to the gut wall, and in time, usually in about 2 months, a chain of segments is developed.

The names of the common single-pored tapeworms of dogs and cats, their intermediate hosts, and the locations of their larvae are given in table 1.
The injury produced by the armed tapeworms in their respective hosts is not well understood. When only a few tapeworms are present, and even in some cases of heavy infection, no injury or symptoms may be detected. In some instances, however, there may be digestive disturbances, a disposition to vomit, general restlessness, and cramps. Nervous symptoms and skin eruptions have been attributed to tapeworm infections, but the connection between the presence of the parasites and such symptoms has not been well demonstrated. Tapeworm-infected dogs, especially house pets, are often a nuisance because the segments are frequently passed involuntarily by the animal and soil the floors, rugs, furniture, clothing, and bedding. Such detached segments are frequently referred to as pinworms; this is not a correct designation because dogs and cats do not harbor the true pinworms, which are a special kind of roundworms. The passage by dogs of a segment or a chain of segments through the anus often causes irritation, which is manifested by the animal's sitting down and dragging itself forward on its haunches.

Cats infected with the cat tapeworm, *Taenia taenioformis,* may show loss of appetite, transient diarrhea followed by constipation, excessive salivation, and, occasionally, persistent vomiting. In kittens the abdomen may be distended, and the animals may exhibit evidence of acute abdominal pain.

Some of the armed tapeworms of dogs are of considerable importance as a cause of loss to the livestock industry, because of the presence of the larval stages in the muscles and other organs of food animals. Some are also of importance as parasites of man. The double-pored tapeworm is sometimes encountered in human beings, especially children, and the hydatid stage of *Echinococcus granulosus* may also occur in man; a total of 391 cases of hydatid infection in man in the United States had been reported up to 1938.

The unarmed tapeworms of dogs and cats belong to the genus *Diphyllobothrium,* the best known species being the broad or fish tapeworm, *D. latum.* This species occurs in dogs and other carnivores in the Great Lakes region, where the parasite is endemic (that is, always present in the region) in man. A related species, *D.*
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*mansoni*, is of frequent occurrence in the West Indies and other tropical parts of the world. In some parts of Puerto Rico practically all cats and a high percentage of dogs are infected with this tapeworm. So far as is known, *D. mansoni* has not become established in continental United States. A third species of unarmed tapeworm, *D. mansonoides*, occurs in cats in New York and Louisiana, and has been found in dogs.

The life histories of these species are essentially the same. They require two intermediate hosts, the first of which are small crustaceans, or crayfishlike animals (*Cyclops* or *Daphnia*); the second intermediate hosts may be fish, as in the case of *Diphyllolothrium latum*, or amphibians, reptiles, and mammals, as in the case of *D. mansoni* and *D. mansonoides*. In Puerto Rico the usual second intermediate host of *D. mansoni* is the common water frog, *Leptodactylus albilabris*, about 25 percent of which in some areas are infected. Dogs and cats acquire these tapeworms by eating the second intermediate hosts containing the infective larvae.

Little is known of the effects on dogs and cats of infections with these tapeworms. Usually no symptoms of importance are noted, but symptoms similar to those caused by the armed tapeworms have been reported. Mueller (18) reports that infections with *Diphyllolothrium mansonoides* produce a marked effect on cats, stating that “Infected animals become emaciated, and the belly hangs down in a flabby condition. The coat is rough, with much shedding, and pronounced hunger and nervousness appear in hitherto gentle animals.” This author writes further that “If the cat is promptly wormed on appearance of symptoms it makes a marked recovery. Animals which have been kept infected over long periods of time, however, are definitely stunted, and even after worming fail to regain weight.”

**ROUNDWORMS**

The nematodes, or roundworms, are the most injurious of all the parasites of dogs and cats. Those species, such as hookworms and large roundworms, which do not require intermediate hosts, are the most injurious to young animals. They infect animals at an early age before any resistance to infection is acquired and may be responsible for the loss of entire litters. Such roundworms as heart worms and esophageal worms are usually found in mature dogs; these parasites require intermediate hosts for their development, and the time necessary for the larvae to become infective and for the worms to reach maturity is usually greater than in the species with direct life histories. Death seldom results from infection with worms requiring intermediate hosts, but the usefulness of the animals may be partly or entirely destroyed.

**HOOKWORMS**

The hookworms are the most destructive of all the parasites of dogs and cats. Three species, *Ancylostoma caninum*, *A. braziliense*, and *Uncinaria stenocephala*, may be encountered. The first is the
most widespread in its distribution and is accordingly the most important. *A. braziliense* occurs in the warmer parts of the world and is occasionally found in the South and Southwest. *U. stenoecephala* is more northerly in its distribution; it occurs occasionally in dogs in the colder parts of the United States and in Canada, where it is a common parasite of foxes.

The hookworms (fig. 3, A) are relatively small worms; the males rarely exceed half an inch in length, while the females are somewhat larger. The head end is curved upward and the mouth is provided with teeth or some other armature. The only certain way to distinguish between the different species is by microscopic examination of the head end. The mouth of the common dog and cat hookworm, *Ancylostoma caninum*, is provided with three pairs of large curved teeth; *Ancylostoma braziliense* has one pair of large and one pair of small teeth; and *Uncinaria stenocephala* has a cutting plate on each side of the mouth opening.
The life histories of the hookworms are relatively simple. The females produce numerous eggs, which pass out in the feces. In about 36 hours under favorable conditions a wormlike, active embryo has formed in the egg. In the course of 3 to 6 days the egg hatches and liberates the first-stage larva. In about 3 more days this larva molts, or sheds its skin, and becomes what is known as a second-stage larva, which again molts in about 8 days to become the third-stage, or infective, larva. Infection of the host animal may take place either through the mouth or through the skin. When the larvae enter the host animal through the skin they get into the circulation and ultimately reach the lungs, are coughed up, swallowed, and finally reach the intestine, where they develop to maturity. When the larvae are swallowed with contaminated food and water they pass directly to the intestine. After reaching the intestine the larvae undergo two more molts and become mature, eggs appearing in the animal’s feces in 3 to 6 weeks.

Eggs of the dog hookworm sometimes appear in the feces of puppies as soon as 13 days after birth, this early maturity being accounted for by the fact that infection took place before birth. This has been demonstrated to be possible in experiments conducted by Foster (5).

Hookworm infection in puppies and young dogs gives rise to a condition sometimes spoken of as kennel anemia. In the early stages of infection there may be digestive disturbances and diarrhea in which the feces are streaked with blood. In severe infections the diarrhea may be severe, and the feces may consist almost entirely of pure blood. A marked anemia, evidenced by the pale appearance of the mucous membranes of the mouth and eyelids, also occurs. Infected puppies rapidly lose weight, the eyes are sunken, and there may be marked symptoms of depression. Often no marked symptoms appear until 2 or 3 days before death.

The symptoms of hookworm infection are largely due to the irritation of the small intestine caused by the bites of the worms, to the removal of blood, and to the bleeding that follows the bites. Wells (27) has shown that a single hookworm may take as much as 360 cubic millimeters of blood a day and that 1,000 hookworms in the course of 24 hours could withdraw 360 cubic centimeters—an amount equivalent to about 12 fluid ounces, or three-fourths of a pint. The amount may actually be much greater, since in this calculation no allowance was made for blood lost by direct hemorrhage at the points of attachment of the worms. That the anemia from hookworm infection is due to loss of blood rather than to some toxin, or poison, secreted by the parasites is supported by the findings of Foster and Landsberg (8), which show that hookworm anemia is of the type associated with chronic hemorrhage.

The hookworm most commonly found in cats is of the same species as the common dog hookworm, *Ancylostoma caninum*, but it has been shown to be a strain especially adapted to live in cats and not readily transmissible to dogs. The symptoms produced by heavy hookworm infection in cats are similar to those in dogs. Because cats are usually house pets and have cleaner habits than dogs, op-
opportunities for acquiring heavy infections are not so great, and clinical hookworm disease in cats is rarely observed.

The larvae of *Ancylostoma braziliense* in the superficial layers of the skin have been shown to cause a type of dermatitis in man known as creeping eruption. The disease is characterized by a linear or tortuous eruption accompanied by intense itching.

**LARGE INTESTINAL ROUNDWORMS**

The ascarids, or large intestinal roundworms, are the largest of the worm parasites occurring in the digestive tract of pet animals. These worms vary from about 1½ to 3½ inches in length, the males being considerably smaller than the females. On being passed by the host animal, the worms tend to coil in a springlike spiral, and apparently this is responsible for the name “spool worms” sometimes applied to them.

Two species of large roundworms, *Toxocara canis* and *Toxascaris leonina*, frequently parasitize dogs (fig. 3. B and C). The former is more commonly encountered in pups and young dogs and the latter in mature animals. Cats, especially kittens, are frequently infected with *Toxocara cati*, but they may also harbor *Toxascaris leonina*.

The life histories of the dog and cat ascarids are very similar to that of *Ascaris lumbricoides*, the large roundworm of man. Numerous eggs are deposited by the female worms in the intestinal tract of the host animals, and these are passed out in the feces. Under favorable conditions these eggs develop embryos in 2 to 6 days. The larvae undergo the first molt in the egg and the eggs then are infective. The infective eggs are swallowed by the host animal, and hatching takes place in the first part of the small intestine. The larvae of *Toxocara canis* and *T. cati* penetrate into the intestinal wall, enter the bloodstream, by which they are carried to the liver and thence to the lungs, and finally are coughed up and swallowed. The larvae of *Toxascaris leonina*, according to Wright (23), penetrate deeply into the intestinal mucous membrane, where they undergo considerable growth. After about 10 days they emerge and escape into the intestinal cavity, where they grow to fertile maturity.

Infection of pups before birth has been shown to be possible by Fülleborn (9) and by Shillinger and Cram (19). This accounts for the appearance of mature or nearly mature worms in very young animals.

The large roundworms are particularly injurious to pups and kittens. The commonest symptoms of roundworm infection are unthriftiness, digestive disturbances, and bloating. The hair coat is dead and lusterless, and the breath may have a peculiar sweetish odor. Large numbers of roundworms may cause obstruction of the intestine and even penetration of the intestinal wall. In heavy infections the worms may wander into the bile ducts, stomach, and even the lungs and upper respiratory passages. The occurrence of large numbers of larvae of *Toxocara canis* and *T. cati* in the lungs may cause pneumonia, especially in very young animals.
**Whipworms**

The dog whipworm, *Trichuris vulpis*, gets its name from its resemblance to a tiny whip. The front part of the worm is slender and hairlike, while the hind part is relatively thick. The total length of the worms rarely exceeds 3 inches. Whipworms are common parasites of dogs all over the world. They occur in the cecum, or blind gut, and sometimes, in extremely heavy infections, in the colon or large intestine.

The life history of the whipworm is direct, that is, no intermediate host is required for its development. The complete details of the life cycle are not well established. The eggs develop in much the same way as those of the large intestinal roundworms, except that the development of embryos requires from 2 weeks to several months, depending on temperature and moisture. When the infective eggs are swallowed by the dog, they hatch in the small intestine, and the larvae thus liberated ultimately reach the cecum, where they develop into mature worms. The time required for the worms to reach fertile maturity may be as long as 3 months.

The injury produced in dogs by the whipworm is not well understood. The worm attaches itself to the cecum by “sewing” its front end into the mucous membrane. In many instances these parasites appear to cause little damage, even in heavy infections. Occasionally the mucous membrane of the cecum may be considerably reddened and thickened, and this may cause considerable pain. A great variety of symptoms of an indefinite sort have been ascribed to infections with this parasite, including digestive disturbances, diarrhea, loss of weight, and general unthriftiness, as well as nervousness and convulsions. Though such symptoms may result from a number of conditions, the fact that marked improvement in an animal’s health has in many cases followed surgical removal of the infected cecum lends support to the belief that whipworms are definitely injurious.

**Heart Worms**

The heart worm, *Dirofilaria immitis*, occurs most commonly in the dog but has been reported occasionally from cats and other hosts. The worms are slender and whitish in color. The males are 5 to 7 inches in length and the females about twice this size. They usually occur in the right ventricle (fig. 4) and in the pulmonary artery; in rare instances the adult worms may occur in other locations. This parasite is world-wide in distribution but occurs most frequently in warm climates. In the United States it is most abundant in the Southern States and those along the Atlantic seaboard as far north as New York. In most instances infection with this worm in dogs in the Northern States is traceable to the animals’ having at some time been in the South, but in some northern localities the parasites have become definitely established.

The life history of the heart worm is complex. Instead of the females depositing eggs, as in the case of the hookworms, roundworms, and whipworms, active larvae are discharged directly into
the blood stream. These larvae correspond to first-stage larvae of other nematodes and are, therefore, not infective for other dogs. The larvae are most abundant in the blood during the hours of darkness, but they may also be found during daylight. They continue to circulate in the blood stream until they are removed by some bloodsucking insect, such as a mosquito. Numerous mosquitoes belonging to the genera *Aedes*, *Culex*, and *Anopheles* have been shown to serve as satisfactory hosts for the development of heart worm larvae. These mosquitoes may not all be able to transmit heart worms, but the fact that the larvae can reach the infective stage in the insects, together with the fact that related worms are transmitted by mosquitoes, makes them the most likely vectors. Fleas have also been regarded as possible intermediate hosts and this possibility

**Figure 4.**—Heart of a dog, showing heavy heart worm infection.
has recently been strengthened by Brown and Sheldon (2), who found the infective stage of the heart worm in naturally infected fleas. While this observation is not conclusive, since experimental transmission of heart worms through the bites of fleas has not been demonstrated, it is extremely interesting and supports the contention of many dog owners and veterinarians that these insects may be important intermediate hosts. The time required for the development of the heart worm to maturity following the bite of an infected insect is not definitely known. Brown (1) has reported the finding of numerous larvae in the blood of an 8-month-old dog, which indicates that the worms reach maturity in less than 8 months.

The symptoms of heart worm disease in dogs may vary considerably, and in some instances no indication of infection may be detected until the blood has been examined. Usually, however, the first symptoms appear following vigorous exercise. The infected animal may tire easily, lie down, gasp for breath, and collapse. After a short rest the dog may recover and for a time appear normal. Coughing is also a common symptom. In cases of long standing, ascites, or abdominal dropsy, may develop and, because of poor circulation, the legs and other parts of the body may swell. Nervous symptoms, such as fixity of vision, fear of light, and convulsions have also been noted in infected animals.

The only way of making a definite diagnosis is by microscopic examination of the blood and the finding of active larvae. Finding larvae in the blood does not always indicate, however, that the adult parasites are present in the heart, since in many cases it has not been possible on post mortem examination to locate the worms in their customary habitat. This may mean that the worms responsible for the larvae are in some unusual location in the body or that they had died and become absorbed. The fact that larvae may persist in the blood after the parent worms have died is shown by the finding of Underwood and Harwood (20) that heart worm larvae could be detected in blood transfused from an infected dog into a noninfected animal for as long as 2½ years.

**Esophageal Worms**

The esophageal worm of dogs, *Spirocerca lupi*, is blood red in color and about half the size of the large intestinal roundworms. Esophageal worms usually occur in tumors of the esophagus and stomach; as many as 30 individuals may be found in a single tumor. The species is distributed throughout the world; in the United States it occurs commonly in dogs in the Southern States.

Like the heart worm, this parasite requires an intermediate host for its larval development. When the eggs pass out of the host in the feces they already contain wormlike larvae. These eggs are eaten by dung beetles, in which they hatch, and the larvae penetrate into the body cavity of the beetles, where they become encysted. In about 2 months the larvae are infective for the final host. Should infected beetles be eaten by some animal other than the dog or a related host, the larvae reencyst and remain infective. Such an
animal is known as a transfer host. When the infective larvae are swallowed by a dog with either the beetle or the transfer host, the young worms are liberated in the dog's stomach and migrate to their final location. Many, if not all, of the larvae reach their final location after taking a circuitous route through the walls of the larger blood vessels, including the aorta. In the walls of these vessels, particularly in the aorta, the injuries produced by the wandering larvae result in degeneration of the tissues, with resulting scarring and thinning of the vessel walls. In some instances the injured aorta may become dilated, and deposits of lime salts may occur in the vessel wall.

The symptoms of esophageal worm infection depend on the location and size of the tumors. Tumors in the esophagus may cause constriction of that organ, resulting in difficult swallowing, vomiting, and loss of weight. Perforation of the tumors may occur, with the discharge of pus and eggs into the thoracic or abdominal cavities, and the infected animal may die from either pleurisy or peritonitis. If the tumors are located where they can press upon the windpipe or lung, coughing, difficult breathing, and suffocation may result. Sudden death may occasionally occur from rupture of the weakened aorta.

**Lungworms**

Lungworms are relatively rare in dogs and cats. Three kinds of lungworms are known to occur in this country, and in some districts the parasites may be of considerable importance. That little is known about them may be because they infect dogs and cats in rural areas, where the infections are not diagnosed.

One of the lungworms that infects dogs is known as *Filaroides osleri*. This parasite was first observed in Canada and has since been found in the United States. The worm is small and transparent and causes in the bronchial tubes wartlike tumors which may be sufficiently large and numerous to cause suffocation. Nothing is known of its life history or mode of transmission.

The cat lungworm, *Aelurostrongylus abstrusus*, is related to the dog lungworm and is common in some parts of the world. A few cases have been discovered in the United States, and the parasite is probably common in cats in rural districts. The worm is hairlike and occurs in the lung tissue. The females deposit their eggs in the air sacs, where they hatch, and the larvae thus liberated give rise to a pneumonia that may involve an entire lobe. According to Hobmaier and Hobmaier (15), the parasites require a snail intermediate host.

The capillarid lungworm, *Capillaria aerophila*, is related to the dog whipworm. It is primarily a parasite of foxes but also infects dogs and cats in fox-farming areas. The parasite is hairlike and whitish in color and lives in the large and small bronchial tubes. So far as is known, the life history is direct, and infection occurs through swallowing infective eggs with the feed and water.

The presence of lungworms in dogs and cats gives rise to a more or less persistent cough. The animals also wheeze owing to the accumu-
lation of mucus in the trachea and bronchi. Emaciation and general unthriftiness, together with wheezing and coughing, should be regarded as symptoms suggesting lungworm infection. Diagnosis can be made by microscopic examination of the feces and the finding of active larvae of *Filaroides* or *Aelurostrongylus* or of eggs of *Capillaria*.

**The Kidney Worm**

The so-called kidney worm, *Dioctophyma renale*, of dogs is the largest of the roundworms. It occurs in dogs and a number of other carnivores, especially mink, and has been reported in man on at least nine occasions. The fully mature parasite is blood red in color. The females may attain a length of 3 feet and the thickness of the little finger; the males are rarely half as large as the females. The kidney worm is not a common parasite of dogs in the United States.

The life history and the mode of infection of dogs are not known. The presence of this worm in the kidney causes pressure and destruction of the functional tissue. Only one kidney is affected, the other increasing in size to compensate for the additional work demanded of it. When the worms occur in the abdominal cavity, the commonest location, the eggs given off by the females cause a chronic peritonitis. The symptoms of kidney worm infection are not well known; dullness, incoordination of movement, and nervous symptoms have been reported in animals subsequently found to be infected. The infected dog may sometimes show evidence of abdominal pain and die suddenly following exertion. Diagnosis is impossible on the basis of symptoms alone, as symptoms similar to those reported may be associated with other conditions. If the parasite is in the kidney, a diagnosis is possible by finding the eggs of the worm in the urine on microscopic examination.

**The Eye Worm**

Only one species of eye worm, *Thelazia californiensis*, is known to occur in this country. This parasite has been described as occurring in dogs and has recently been reported in the cat, sheep, deer, and man. So far as is known, it occurs only in California. The worms are whitish and about half an inch long, and they live underneath the eyelids and in the tear ducts.

Nothing is known of the life history or mode of transmission. The parasite is related to Manson's eye worm of poultry, which is known to require an insect intermediate host.

The worms move about actively over the surface of the eyeball, causing considerable inflammation and a profuse flow of tears. Scarification (scratching) and ulceration of the eyeball may result from the activity of the worms, and opacity of the cornea and blindness may be the final outcome. In heavy infections the worms may easily be found under the eyelids or crawling over the surface of the eye, but when the infection is light a careful search is necessary before a diagnosis is warranted.
CONTROL OF PARASITISM IN DOGS AND CATS

GENERAL MEASURES

The control of parasites must obviously be based upon a knowledge of the organisms, their life cycles, and their resistance to physical and other factors inimical to their survival. Points that must be taken into consideration are the source of infection, whether the parasite requires one or more intermediate hosts, whether the route of infection is through the mouth or skin or by the bites of bloodsucking insects, the ability of the parasite in its infective stages to survive the action of sunlight and other natural physical agents, and the effect of chemicals and disinfectants on it during these stages.

The source of infection with parasites is for the most part contamination of the soil with feces or other excrements containing the eggs or infective stages of the organisms. Hence the most effective control measure is strict sanitation. In the case of such parasites as blood protozoans and filariids that are transmitted by insects, control consists in destroying the insects, protecting the host animals against their bites, or sterilizing the animal's blood by the use of medicinal agents. Where intermediate hosts become infected through eating infectious material passed by the definitive, or final, host, as in the case of tapeworms and some nematodes, control consists in strict sanitation and in preventing the final host from eating the infective stages of the parasite occurring in the intermediate host.

The general control measures discussed here are applicable to kennels and catteries where the animals are confined and where sanitation and other measures can be carried out. Under farm conditions and in suburban districts where dogs and cats are allowed to roam at large, such measures are difficult to apply, and the control of most parasites is largely a matter of treatment of the infected animals with anthelmintic drugs as discussed later.

Protozoan diseases.—Piroplasmosis and coccidiosis require different control measures. Piroplasmosis is transmitted from one animal to another by ticks, and measures for the control of this disease must be directed toward eradicating the ticks in kennels and controlling them on the dog host; this problem is discussed elsewhere. The control of coccidiosis involves the same procedures as are recommended later for the control of certain of the roundworms, such as large roundworms and whipworms.

Flukes.—Prevention of infection with trematodes, or flukes, involves keeping raw fish away from dogs and cats, as the infective stages of the majority of the fluke parasites of these animals occur in fish.

Tapeworms.—The prevention of tapeworm infection may be summed up by saying: Do not permit dogs and cats to feed on infected intermediate host animals. Unfortunately, this recommendation is difficult to enforce when animals are allowed to roam at large and to have access to the carcasses of dead animals and to offal on the farm. House pets have little opportunity to become infected with tapeworms except the doubled-pored species, which is acquired through eating infected fleas and lice. Preventing infection with
Internal Parasites of Dogs and Cats

this tapeworm means controlling fleas and lice by destroying the breeding places of these insects and by the frequent use of insect powders and washes on flea- and louse-infested animals.

The armed tapeworms, such as Taenia hydatigena, T. ovis, Multiceps multiceps, and Echinococcus granulosus, are controlled to some extent through the enforcement of Federal and municipal meat-inspection regulations, which require condemnation and proper disposal of carcasses and offal of sheep, goats, cattle, and swine infected with larval tapeworms. The disposal by burning or burial of similar infected material on the farm should be practiced as a means of keeping dogs from becoming infected and later contaminating the fields and pastures with tapeworm eggs that may be picked up by livestock and develop into bladder worms.

Roundworms.—The control of roundworms, with the exception of the heart worm, depends primarily on the prompt disposal of feces, keeping the animals in clean quarters and on clean ground, and using only clean utensils for feed and water. The runs or pens should be on clay and be free from sod. Clay soil is preferable to other types since it is more impervious than sand or loam, and parasite eggs and larvae remain on or near the surface where they are exposed to the destructive effects of sunlight and drying. Shady runways and pens should be avoided; such places are damp, and moisture favors the development and survival of worm eggs and larvae. Pens provided with wire-mesh floors that prevent the accumulation of manure are being used by some dog raisers with good results. The floors of such pens should be sufficiently high to permit the ground underneath to be cleaned readily.

There is no chemical treatment of value for destroying the eggs of such parasites as the large roundworms, whipworms, capillarid lung worms, and esophageal worms in contaminated soil. The eggs of these worms are provided with such impervious shells that disinfectants or other chemicals cannot penetrate them.

Hookworm-infected soil may be sterilized by the use of strong salt brine, a treatment that was first used in Canada for the control of hookworms in fox pens. This treatment was subsequently found to be effective for the destruction of the larvae of the dog hookworm in soil. The brine is prepared by stirring common salt into boiling water at the rate of 1½ pounds of salt to a gallon of water. The brine is sprinkled over the surface of the soil in an amount sufficient to saturate the earth to a depth of ½ to 1½ inches; about 1 pint of brine for each square foot of soil surface is necessary to accomplish this. The interval between treatments with the brine depends on the amount and frequency of the rainfall.

The prevention of heart worm infection is largely a matter of keeping dogs from being bitten by mosquitoes by confining them in mosquito-proof kennels during the late afternoon, night, and early morning. The possibility of transmission by fleas, which has already been mentioned, cannot be ignored, and kennels and dogs should be kept free from these insects. Destruction of stray dogs that may serve as reservoirs of infection and mosquito-destruction campaigns are measures that will tend to reduce the frequency of heart worm disease.
No control measures other than sanitation can be recommended for such parasites as the kidney worm, eye worm, and other worm parasites, the life histories of which are unknown.

Proper nutrition is an important factor in the prevention of losses from parasites. Foster and Cort (6, 7) have shown that hookworm-infected dogs kept on an adequate diet showed increased resistance and in some instances lost the greater part of their hookworm burden. When the same animals were put on an inadequate diet they again become susceptible to infection. Somewhat similar results were obtained by Wright (23), who showed that old dogs may be more easily parasitized by one of the large roundworms, Toxocara canis, if maintained on a diet deficient in vitamin A.

THE USE OF MEDICINAL AGENTS

In most instances the control measures already discussed, based as they are on a knowledge of the life cycles and other facts regarding the various parasites, serve to keep the parasites in check. They cannot be relied upon entirely to prevent losses from parasites, however, but must be supplemented, as occasion demands, by treatment of the individual animals with vermifuges and other agents.

Drugs and chemicals with specific action against disease-producing organisms, including parasites, have been developed largely during the present century. In the development of such agents the dog has played an important role by serving as a test animal, and as a result there are more specific treatments for the removal and control of the parasites of dogs than for those of any of the other domestic animals. Some of these treatments, notably those for the removal of the dog hookworms, are now commonly used for the removal of hookworms from man.

In spite of the many drugs of value for removing parasites from dogs and cats, there remain a number for which no satisfactory treatment has been discovered, such as those occurring in the respiratory and urinary organs, in the body cavities, and in tissues, such as the intestinal mucous membrane.

The advance of knowledge concerning the use of drugs in the control of parasites has led to considerable publicity regarding the value of such treatments. As a result, dog and cat owners have become "parasite conscious" and too often have felt that their pets should be dosed or wormed at regular intervals regardless of whether such treatments are necessary. Promiscuous dosing is a practice fraught with danger to the well-being of the animal. It should be remembered that all drugs for the destruction of parasites are poisonous to a certain degree and should be administered only when it is definitely known that the animal is suffering from parasitism. Diagnosis of parasitism is not always a simple matter. Many of the symptoms associated with parasitic infections also occur in connection with other diseases, and a laboratory examination may be necessary before a diagnosis of parasitism can be made. Consequently professional advice should be sought, and treatment for parasitism should be ad-
ministered by or under the direction of a veterinarian. This is especially true in the case of cats, which require essentially the same treatment for a given parasite as do dogs but are much more sensitive to the toxic effects of drugs.

Protozoan diseases.—Of the two protozoan diseases, piroplasmosis and coccidiosis, affecting dogs in this country, medicinal treatment is available in the case of the former only. Several drugs are known that are effective in varying degrees against the causative organisms in the blood. These treatments are administered as injections beneath the skin (subcutaneously) or into the blood stream (intravenously). The most recently developed and apparently the most effective of the treatments for piroplasmosis is acaprin, a synthetic drug known chemically by the rather formidable name of “N–N’-(bismethylchinolylium-methylsulfate-6-)urea.” Like most drugs administered intravenously, it is toxic, and the dose must be calculated accurately on the basis of body weight. Clarvoo (3) recommends that appropriate doses be injected every day for 2 or 3 days, depending on the response. He states that if the animal has not suffered serious tissue changes as a result of the disease, recovery is usually prompt.

No specific drug is available for use in the treatment of coccidiosis. The indicated treatment for this disease is good care and nursing.

Flukes.—The only disease of dogs in this country associated with fluke infestation that warrants medicinal treatment is salmon poisoning. This disease was formerly fatal to a large percentage of the animals affected. In 1938 sulfanilamide was found by Oregon investigators (4) to be a highly effective treatment. The drug was administered orally (by mouth) one to three times a day in doses of about 11 milligrams (0.7 gram) per pound of body weight.

Tapeworms.—The several species of tapeworms occurring in dogs and cats are not all removable by the same treatment. The most effective drug for the removal of the armed species is arecoline hydrobromide, the use of which was first advocated by Lentz (17) in 1921. This drug is a drastic purgative and acts within a few minutes to a half hour or so after administration. The treatment should be given in the morning after the animal has fasted overnight, and food should be withheld for about 3 hours after dosing. The drug is not so effective against the double-pored tapeworm as against the other armed species, and it may be necessary to repeat the dose, since some of the heads may not be removed by the first treatment and regeneration of the tapeworm may occur in a few weeks.

Arecoline is not entirely satisfactory for the removal of the unarm ed tapeworms, oleoresin of male fern being the most effective drug for use against these species. The drug should be given in appropriate doses after a fast of about 18 hours and should be followed by a purgative.

Both arecoline and oleoresin of male fern are toxic, and professional advice regarding the dosage, which must be computed carefully according to the kind of animal and its weight, should be sought before treatment with these drugs is attempted.
Large roundworms and hookworms.—Since the most injurious parasites of dogs and cats are the roundworms that occur in the intestinal tract, investigations to develop satisfactory remedies for their removal have been extensive. Following preliminary investigations by Hall and Foster (12), during which critical tests were carried out to determine the efficacy of drugs previously reported to have anthelmintic value, oil of chenopodium and mixtures of oil of chenopodium and chloroform were found to have considerable value for the removal of large roundworms and hookworms from dogs. Owing to the moderate efficacy of these drugs for the removal of hookworms, further experiments were carried out with compounds closely related to chloroform. These experiments resulted in the discovery that carbon tetrachloride (11), a chemical widely used as a noncombustible cleaning agent, in doses of 0.3 cubic centimeter per kilogram (2.2 pounds) of body weight was highly effective for the removal of both dog hookworms and roundworms. This chemical was soon adopted by veterinarians as the standard treatment for the removal of these parasites. After making tests on himself, Hall suggested that carbon tetrachloride be given a trial as a remedy for the removal of hookworms from man. This suggestion ultimately led to successful experiments, and the drug was adopted by many public-health officials as the best treatment for the removal of human hookworms.

Further tests carried out with other compounds resulted in the discovery by Hall and Shillinger (13) that tetrachlorethylene at the same dose rate was just as effective as the closely related carbon tetrachloride. Tetrachlorethylene soon supplanted carbon tetrachloride, as the latter drug was found under certain conditions to cause extensive and severe liver injury, and even death in some cases. Although tetrachlorethylene is much safer than carbon tetrachloride, it is less stable and, unless kept in a cool, dark place, may undergo a chemical change and become extremely toxic. Furthermore, in some animals it causes dizziness and even loss of consciousness. These effects, while quite alarming, are transitory, and the animal soon recovers if left undisturbed.

Later Wright and Schaffer (24) carried out extensive investigations of the halogenated hydrocarbons, the chemical group to which carbon tetrachloride and tetrachlorethylene belong, and showed that a number of compounds in this series possessed anthelmintic properties. Some were as effective for the removal of large roundworms and hookworms as tetrachlorethylene but were either too toxic or too expensive for general use. One of these compounds, normal butyl chloride, seemed to offer promise. Additional studies on this substance were undertaken (14) which showed that normal butyl chloride was as safe and effective as tetrachlorethylene. In addition to its effectiveness and safety, it did not appear to cause the alarming, though harmless, dizziness that often follows the administration of tetrachlorethylene. Normal butyl chloride is being tested extensively under practical conditions by veterinarians, and thus far encouraging results have been reported.
The amount of normal butyl chloride for dogs varies with the weight of the animal, and a schedule of suggested dosages is as follows:

<table>
<thead>
<tr>
<th>Amount of drug</th>
<th>Weight of dog (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 cc. (8 minims)</td>
<td>Less than 3</td>
</tr>
<tr>
<td>1 cc. (15 minims)</td>
<td>3 to 5</td>
</tr>
<tr>
<td>2 cc. (½ fluid dram)</td>
<td>5 to 10</td>
</tr>
<tr>
<td>3 cc. (¼ fluid dram)</td>
<td>10 to 20</td>
</tr>
<tr>
<td>4 cc. (1 fluid dram)</td>
<td>20 to 40</td>
</tr>
<tr>
<td>5 cc. (1¼ fluid drams)</td>
<td>More than 40</td>
</tr>
</tbody>
</table>

Whipworms.—Until recently there has been no satisfactory treatment for the removal of whipworms. These parasites live in the cecum, or blind gut, which is situated at the junction of the small and large intestines. To be effective in removing whipworms, a drug must enter the cecum and come in direct contact with the worms; but the entry of a drug into this location is largely accidental, and in order to increase the chances of its happening, large doses of a drug essentially harmless to the animal must be used. Normal butyl chloride, which had been ascertained to meet this requirement, was administered in large doses to whipworm-infested dogs, with the result that an average of about 60 percent of the whipworms present were removed (14). While this percentage of removal was not entirely satisfactory, it was greater than that attained by any other drug. The doses used were about four times greater than those effective for the removal of large roundworms and hookworms. The treatment may be repeated within a week if the results of the initial treatment prove unsatisfactory. Before treatment is undertaken the animal should be fasted for at least 18 hours; food may be allowed about an hour after dosing. Under ordinary conditions it is not necessary to administer a purge following treatment. If a heavy infestation of large roundworms is also present, a purgative dose of castor oil 1 hour after the administration of normal butyl chloride is recommended.

Another treatment for whipworms that appears to be promising was reported recently by Guthrie (10). It consisted of diphenylamine, in doses of 10 grams per animal, administered by mouth. This treatment removed 84 percent of 537 whipworms from 5 dogs. Additional experiments to standardize the dose and to determine its safety must be carried out before the drug can be recommended for general use.

Intestinal worms in general.—Whitney (22) has recently reported that hydrogen peroxide administered as an enema is very effective for the removal of all species of worm parasites commonly occurring in the intestinal tract of dogs. Since there is at present no single drug that will remove tapeworms, hookworms, large roundworms, and whipworms, this report is of interest. According to Whitney, a 1.5-percent solution of the drug is used. For dogs weighing 2 pounds a dose of 1½ ounces of the hydrogen peroxide solution was recommended, the amount being increased up to 24 ounces for dogs weighing 60 pounds. For successful treatment it is necessary that the animal vomit, and to facilitate this reaction a few ounces of the solution are administered by stomach tube just prior to the enema. This treat-
ment should be used with caution, however, especially in animals suffering from diseases of the heart or other vital organs.

Heart worms.—Treatment of heart worm disease is still somewhat of a problem. More or less satisfactory results have been obtained by the use of antimony compounds, but these treatments are toxic and expensive. Of the several antimony preparations reported to be of value against heart worms, the most generally used is fuadin, a compound known chemically as sodium-antimony-III-bis-pyrocatechin-disulfonate. Some dogs are peculiarly susceptible to antimony poisoning, and the treatment should not be attempted by the dog owner. Wright and Underwood (25) have shown, however, that the majority of animals can be treated successfully if the drug is administered carefully by a veterinarian. In appropriate doses it is administered either intramuscularly or intravenously daily over a period of 12 to 25 days, depending on the method used. There are a number of factors, such as the presence or absence of organic diseases of the heart, liver, and kidneys, the weight of the animal, and its tolerance for the drug, which must be considered before treatment is undertaken. If proper precautions are observed, about 90 percent of heart worm cases can be cured after one or two courses of treatment with fuadin. It should be remembered, however, that a mortality of about 5 percent may be expected even when the treatment is handled by competently trained individuals.

LITERATURE CITED

(2) ——— and Sheldon, A. J. 1940. Natural infection of fleas with the dog heartworm (Dirofilaria immitis). North Amer. Vet. 21: 230-231.
Internal Parasites of Dogs and Cats


(13) ——— and SHILLINGER, JACOB E. 1925. TETRACHLOROETHYLENE, A NEW ANTHELMINTIC FOR WORMS IN DOGS. North Amer. Vet. 6 (9): 41-52.


(21) WELLS, HERBERT S. 1931. AN OBSERVATION WHICH SUGGESTS AN EXPLANATION OF THE ANEMIA IN HOOKWORM DISEASE. Science 73: 16-17.


