

Taenia Infections

Taeniasis,
Cysticercosis,
Neurocysticercosis,
Coenurosis,
Neurocoenurosis

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IOWA STATE UNIVERSITY®

College of Veterinary Medicine
Iowa State University
Ames, Iowa 50011
Phone: 515.294.7189
Fax: 515.294.8259
cfsph@iastate.edu
www.cfsph.iastate.edu



INSTITUTE FOR
INTERNATIONAL
COOPERATION IN
ANIMAL BIOLOGICS

Iowa State University
College of Veterinary Medicine
www.cfsph.iastate.edu/IICAB/

Etiology

Taenia spp. are long, segmented, parasitic tapeworms (family Taeniidae, subclass Cestoda). These parasites have an indirect life cycle, cycling between a definitive and an intermediate host. The following *Taenia* species are zoonotic, with humans serving as the definitive host, the intermediate host, or both. Non-zoonotic species of *Taenia* also exist.

Taeniasis

The adult tapeworms live in the intestines of the definitive hosts. This infection is called taeniasis. Humans are the definitive hosts for *Taenia solium* (the pork tapeworm) and *T. saginata* (the beef tapeworm). Humans are also the definitive hosts for *T. asiatica*, a newly recognized tapeworm found in Asia. It is currently uncertain whether *T. asiatica* is a subspecies of *T. saginata* (*T. saginata asiatica*) or a separate species. Animals are the definitive hosts for *T. crassiceps*, *T. ovis*, *T. taeniaeformis*, *T. hydatigena*, *T. multiceps*, *T. serialis* and *T. brauni*. *Taenia* larvae are found in the muscles, central nervous system (CNS), and other tissues of the intermediate hosts. Larvae are more likely to cause disease than the adult tapeworms. There are two forms of larval infection, cysticercosis and coenurosis.

Cysticercosis

Infection with the larval form of *Taenia solium*, *T. saginata*, *T. crassiceps*, *T. ovis*, *T. taeniaeformis* or *T. hydatigena* is called cysticercosis. The larvae of these organisms are called cysticerci (singular: cysticercus). At one time, the larvae and adult tapeworms were thought to be different species. For this reason, the larval stages are sometimes called by a different name: The larval stage of *T. solium* is sometimes called *Cysticercus cellulosae*. The larval stage of *T. saginata* is sometimes called *Cysticercus bovis*. The larval stage of *T. crassiceps* is sometimes called *Cysticercus longicollis*. Humans can be intermediate hosts for *T. solium*, *T. crassiceps*, *T. ovis*, *T. taeniaeformis* and *T. hydatigena*. *T. solium* is often found in humans; the other four species are very rare. *T. solium* is the only *Taenia* species for which humans are both the definitive and an intermediate host. Animals can be intermediate hosts for these five species as well as for *T. saginata* and *T. asiatica*.

Coenurosis

Infection with the larval forms of *T. multiceps*, *T. serialis* and *T. brauni* is called coenurosis. The larval stage is called a coenurus (plural: coenuri). The larval stage of *T. multiceps* is sometimes called *Coenurus cerebralis*. The larval stage of *T. serialis* is sometimes called *Coenurus serialis*. The larval stage of *T. brauni* is sometimes called *Coenurus brauni*. Humans can be intermediate hosts for *T. multiceps*, *T. serialis* and *T. brauni*. Animals can also be intermediate hosts for these three species.

Geographic Distribution

T. solium, *T. saginata*, *T. taeniaeformis*, *T. hydatigena* and *T. ovis* are found worldwide. Cysticercosis, which is mainly caused by *T. solium*, is most common in Latin America, Southeast Asia and Africa. It is particularly prevalent in rural areas where domestic pigs are allowed to roam freely. It is diminishing in eastern and southern Europe, and is very rare in Muslim countries.

T. asiatica has been described in Taiwan, Ethiopia, Indonesia, Madagascar, Thailand and the Republic of Korea. *T. crassiceps* has been reported from Canada and the northern U.S. *T. multiceps* has been documented in scattered foci throughout the world, including the Americas and parts of Europe and Africa, and is probably distributed worldwide. It is more common in temperate regions. *T. serialis* has also been found in a number of locations, including North America, Europe and Africa. To date, *T. brauni* has only been reported in Africa.

Transmission and Life Cycle

Definitive Hosts - Taeniasis

The definitive hosts for *Taenia* spp. are usually carnivores. A definitive host becomes infected when it eats tissues from the intermediate host that contain larvae.

Taenia Infections

The larvae attach to the small intestine and develop into adult tapeworms. *T. saginata* matures in 10 to 12 weeks, and *T. solium* in 5 to 12 weeks. The mature worm consists of a scolex, which is attached to the intestine, followed by a neck and immature, mature and gravid proglottids (segments). Gravid proglottids containing eggs detach from the worm and are shed in the feces. The proglottids of some species also crawl through the anal sphincter to the environment. The eggs are immediately infective.

In humans, taeniasis is caused by eating inadequately cooked pork (*T. solium* and *T. asiatica*) or beef (*T. saginata*).

Adult *T. solium* are 2-7 m long and may live for up to 25 years. Although up to 25 tapeworms have been recorded in a single person, there is usually only one. The eggs are generally shed inside the proglottid, which remains in the fecal bolus and disintegrates in the environment. The eggs may be disseminated by rain and wind and can contaminate vegetation and water. *T. solium* eggs can survive in the environment for a few weeks or months.

Adult *T. saginata* can be 4-25 meters long, although most are 5 meters or less. They can live for 5 to 20 years or more. The gravid proglottids of *T. saginata* are usually more motile than those of *T. solium*. They move away from the feces and adhere to grass. *T. saginata* eggs can survive for several weeks or months in water and on grass. In the highlands of Kenya, *T. saginata* eggs have been reported to survive for up to a year.

In animals, taeniasis is caused by *T. crassiceps*, *T. ovis*, *T. taeniaeformis*, *T. hydatigena*, *T. multiceps*, *T. serialis* and *T. brauni* and is acquired by eating tissues from a variety of intermediate hosts including ruminants, rabbits and rodents.

Intermediate hosts – Cysticercosis and Coenurosis

Intermediate hosts are usually herbivores, but larvae are also reported occasionally in dogs and cats. An intermediate host becomes infected when it ingests eggs (or proglottids containing eggs), that were shed in the feces of the definitive host. The eggs can be carried on fomites, and may be disseminated by coprophagous insects and birds. Grazing animals can acquire the eggs on pastures, in vegetation, or in contaminated water. Humans usually ingest tapeworm eggs on fruits and vegetables or acquire them directly from the soil. They can also be infected by contaminated water.

Humans who carry adult *T. solium* in the intestines can infect themselves with the eggs shed in their own feces, resulting in cysticercosis. Autoinfection by reverse peristalsis of eggs or proglottids in the intestines may be possible, but has not been proven. Children who play on contaminated dirt may inoculate the larvae of *T. multiceps*, *T. serialis* or *T. brauni* directly into the conjunctiva or skin. Hatching usually occurs only if the eggs have been exposed to gastric secretions followed by intestinal secretions. The

eggs hatch in the intestine, penetrate the intestinal wall, and are carried in the blood throughout the tissues. Within the tissues, the larvae (also called metacestodes) develop into either cysticerci or coenuri.

Cysticercosis

The larval form of *Taenia solium*, *T. saginata*, *T. crassiceps*, *T. ovis*, *T. taeniaeformis* or *T. hydatigena* is called a cysticercus. Cysticerci are fluid-filled vesicles that contain a single inverted protoscolex. In tissues other than the eye, the cerebral ventricles or the subarachnoid space of the brain, this cyst is surrounded by a capsule of fibrous tissue. Cysticerci are usually oblong and approximately 1 cm or less in diameter, but *T. solium* cysticerci can grow up to 10-15 cm in areas such as the subarachnoid space of the brain. A host may have one to hundreds of cysts.

A proliferating form, called racemose cysticercosis, is occasionally seen. This larva, which occurs mainly at the base of the brain, consists of a grape-like mass containing several connected bladders of various sizes. The protoscolex, if any, is usually dead. It is uncertain whether racemose cysticercosis is an aberrant *T. solium* cysticercus, the cysticercus of another species, or a sterile coenurus.

Cysticerci do not usually stimulate a inflammatory response while they are alive, or after they have died and become calcified; however, while they are degenerating they can become inflamed. In cattle, *T. saginata* cysticerci begin to die within a few weeks and, after 9 months, most are dead and calcified. Other species can survive for years. Cysticerci in various stages of viability can occur simultaneously in a host.

Cysticerci may be found almost anywhere, but each species has a predilection for certain tissues. In pigs, *T. solium* cysticerci are found mainly in the skeletal or cardiac muscles, liver, heart and brain. In humans, this species is most often found in the subcutaneous tissues, skeletal muscles, eyes and brain. Serious disease is almost always caused by cysticerci in the CNS (neurocysticercosis) or heart.

- *T. saginata* in cattle and *T. ovis* in sheep are found mainly in the muscles.
- *T. asiatica* and *T. taeniaeformis* cysticerci are usually found in the liver, while *T. hydatigena* is also found in the abdominal cavity.
- *T. crassiceps* larvae are usually found in the subcutaneous tissues, and peritoneal or pleural cavities. Asexual replication of *T. crassiceps* larvae occurs in rodent intermediate hosts.

Coenurosis

The larval form of *T. multiceps*, *T. serialis* and *T. brauni* is called a coenurus. A coenurus is a vesicle that contains multiple inverted protoscolices, attached to the internal membrane of the cyst. Daughter cysts may be seen inside some coenuri, either floating freely or attached by a

stalk. The presence of daughter cysts varies with the tissue: coenuri in the eye and subcutaneous tissues are usually unilocular, but coenuri in the CNS are often multilocular. Each protoscolex can mature into a tapeworm if it is ingested by the definitive host.

- *T. multiceps* coenuri are usually 2-6 cm in diameter and contain a few to more than a hundred protoscolices. In humans, these larvae are usually found in the brain (neurocoenurosis), eye or subcutaneous tissues. CNS infections are more common in temperate regions, and ocular or subcutaneous infections are more common in the tropics. In animals, *T. multiceps* coenuri are usually found in the CNS.
- *T. serialis* coenuri are usually found in the subcutaneous tissues, muscles and retroperitoneally. In humans, a few larvae have also been found in the brain.
- *T. brauni* larvae tend to be found in the subcutaneous tissues and the eye.

Disinfection

T. solium and *T. saginata* are inactivated by 1% sodium hypochlorite or 2% glutaraldehyde. Cysticerci can be killed by cooking meat to 56°C throughout. Freezing can also kill the cysticerci; current guidelines should be consulted for specific recommendations. Undercooked, smoked or pickled meat can be infective.

Infections in Humans

Incubation Period

Cysticerci and coenuri often become symptomatic only when they are dying or become large enough to interfere with vital organs. The incubation period for cysticercosis caused by *T. solium* is 10 days to more than 10 years.

Clinical Signs

Taeniasis

Taeniasis is usually asymptomatic, except for the passage of proglottids in the stool and, in the case of *T. saginata*, active migration of the proglottids through the anus. Mild abdominal symptoms occur in some cases; they may include abdominal pain, diarrhea or constipation, nausea, decreased or increased appetite, and weight loss. The abdominal symptoms are more common in children than adults, and are typically relieved by eating small amounts of food. Infants may experience vomiting, diarrhea, fever, weight loss and irritability. Nonspecific signs such as insomnia, malaise and nervousness have also been reported.

T. saginata proglottids can occasionally travel to organs such as the appendix, uterus, bile ducts and nasopharyngeal passages, and cause appendicitis, cholangitis or other syndromes. Rare cases of intestinal

obstruction or perforation have been reported. *T. solium* proglottids are less active than those of *T. saginata* and are less likely to be found in aberrant locations.

Cysticercosis

The symptoms of cysticercosis vary with the location and number of larvae. Most symptoms are the result either of inflammation during larval degeneration or a mass effect from the parasite. Healthy or dead, calcified larvae do not stimulate inflammation and may be asymptomatic.

Neurocysticercosis is the most serious form of cysticercosis. In some cases, the symptoms are insidious. In others, they occur suddenly, as the result of events such as blockage of the CSF by a floating cysticercus. Chronic headaches and seizures are the most common symptoms. Other signs may include nausea, vomiting, vertigo, ataxia, confusion or other changes in mental status, behavioral abnormalities, progressive dementia, and focal neurologic signs.

Cysts can also cause strokes or symptoms of hydrocephalus, which may be intermittent. Complications may include intracranial herniation, strokes or status epilepticus. Permanent brain damage is possible. Spinal neurocysticercosis, which is rare, can result in spinal cord compression, transverse myelitis, meningitis and nerve root pain. Some cases of neurocysticercosis are fatal.

In the eye, cysticerci are most often found in the vitreous humor, subretinal space and conjunctiva. One or both eyes may be affected. Common symptoms include blurring or decreased vision and severe pain. Blindness is possible.

Cysticerci in the muscles are usually asymptomatic. Large numbers of parasites may cause pseudohypertrophy, myositis, muscle pain, cramps and fatigue. Larvae in the heart can result in conduction abnormalities and myocarditis. In the skin, cysticerci may be visible as subcutaneous nodules. Rarely, larvae can cause vasculitis or obstruct small arteries, leading to a stroke.

Coenurosis

The symptoms of cysticercosis are very similar to those of coenurosis and vary with the location, size and viability of the coenurus. Coenuri are most often found in the CNS, subcutaneous tissues, and eye. Allergic or toxic symptoms have also been reported. One woman with coenurosis of the breast experienced fever, a recurrent rash, night sweats and lymphadenopathy.

Communicability

Humans with taeniasis can infect human or animal intermediate hosts via eggs and gravid proglottids passed in the feces. *T. solium* eggs can cause cysticercosis in humans, while *T. saginata* and *T. asiatica* eggs are only infectious for animal intermediate hosts. The prepatent period for taeniasis is approximately 8 to 14 weeks. Humans with

cysticercosis or coenurosis are not infectious to others by casual contact.

Diagnostic Tests

Taeniasis

Taeniasis can be diagnosed by demonstrating *Taenia* proglottids or eggs in the feces. Eggs may also be found in adhesive tape preparations taken near the anus. Repeated sampling may be necessary. *Taenia* spp. eggs cannot be distinguished from each other or other tapeworms such as *Echinococcus* by their morphology; however, enzyme-linked immunosorbent assays (ELISAs) and PCR can differentiate the eggs of *T. solium* from *T. saginata*, and morphology can be used to distinguish these proglottids.

Cysticercosis

Imaging studies including computed tomography (CT) scan and MRI are used to identify cysticerci in the brain. Inactive (calcified) cysts in various parts of the body including muscle and brain may be seen on x-ray. Biopsies may be used for subcutaneous nodules, and larvae in the eye can be found during an ocular examination. The species of larva can be identified post-operatively.

Serologic tests used in humans include enzyme-linked immunoelectrotransfer blot (EITB), ELISAs, complement fixation and hemagglutination. Antibodies may be found in serum or CSF. Cross-reactions occur with other parasites.

Coenurosis

Coenurosis is uncommon in humans and specific serologic assays have not been developed. With this exception, diagnosis is similar to cysticercosis.

Treatment

Adult tapeworms in the intestines can be killed with anthelmintics such as praziquantel, niclosamide, buccosamide or mebendazole. Rare complications such as obstructed bile ducts or appendicitis may require surgery.

In some cases, cysticercosis may be treated with anthelmintic drugs such as albendazole and praziquantel. Surgery may be used for cysticerci in locations such as the eye, cerebral ventricles, and spinal cord, as anthelmintic drugs can exacerbate the symptoms when the parasite dies. Asymptomatic infections and calcified cysticerci may not require treatment.

Treatment of coenurosis is mainly surgical, although anthelmintics may also be used.

Prevention

Prevention of taeniasis depends on avoiding raw or undercooked pork (*T. solium*), pork liver (*T. asiatica*) and beef (*T. saginata*). Potentially contaminated meat should be cooked to at least 56°C throughout the meat. Freezing can also be beneficial. Meat inspection reduces the risk of infection.

Prevention of cysticercosis or coenurosis depends on good hygiene, including hand washing. In endemic areas, people should avoid eating raw fruits and vegetables that cannot be peeled. Only bottled water, filtered water, or water that has been boiled for at least one minute should be drunk. Human sewage can contain *Taenia* eggs and should not be used to irrigate crops.

People carrying adult *T. solium* tapeworms in the intestines should be treated as soon as possible. They should also take special care with hygiene to prevent spreading cysticercosis to themselves or others.

No vaccines are available for humans.

Morbidity and Mortality

Worldwide, taeniasis and cysticercosis are common parasitic infections: 2-3 million people are thought to be infected with adult *T. solium*, 45 million with adult *T. saginata*, and 50 million with *T. solium* cysticerci. An estimated 50,000 people die annually from the CNS or cardiac complications. Cysticercosis and taeniasis are rare in the U.S. and most parts of Europe, and occur mainly in immigrants. In the U.S., the estimated incidence of cysticercosis is 1,000 cases per year.

Human coenurosis is much less common than cysticercosis. Approximately 100 or more cases have been reported worldwide, mainly in Africa and South America. Only a few cases have been documented in the U.S. and Europe.

Taeniasis is usually mild or asymptomatic. Cysticercosis and coenurosis are more likely to cause clinical signs, but this varies with the location, number and size of the larvae. Some post-mortem studies suggest that as many as 80% of all cases of cysticercosis may be asymptomatic. Morbidity and mortality are mainly related to CNS, ocular or cardiac disease. Permanent brain damage or blindness is possible. Cysticercosis is often cause of adult-onset epilepsy in endemic areas. Deaths are uncommon, and are seen mainly in cases with encephalitis, increased intracranial pressure or strokes. Racemose cysticercosis has a particularly poor prognosis.

Infections in Animals

Species Affected

Cysticercosis

Taenia solium

- Humans and are usually the definitive host. Adult tapeworms have also been found in some species of non-human primates.
- The usual intermediate hosts are domestic and wild pigs. *T. solium* larvae are occasionally found in other intermediate hosts, including sheep, dogs, cats, deer, camels, marine mammals, bears, non-human primates and humans.

Taenia Infections

Taenia saginata

- Humans are the definitive host.
- The intermediate hosts are cattle, buffalo, water buffalo, llamas and wild ruminants including giraffes.

Taenia asiatica

- Humans are the definitive host.
- The intermediate hosts are domestic and wild pigs, and occasionally cattle, goats or monkeys.

Taenia crassiceps

- Foxes are the most important definitive hosts. Infections have also been reported in dogs and other wild canids, including coyotes and wolves.
- The intermediate hosts are usually wild rodents, including mice. Infections have been reported in hamsters. Other species including cats, humans, non-human primates, and possibly dogs can also be infected.

Taenia hydatigena

- Dogs, wolves, coyotes, lynxes and, rarely, cats are the definitive hosts.
- Sheep, goats, cattle, pigs, reindeer and other domestic and wild cloven-hoofed animals are the usual intermediate hosts. Rabbits, rodents and humans are rarely infected.

Taenia ovis

- Dogs, wild carnivores and, rarely, cats are the definitive hosts.
- Sheep and goats are the usual intermediate hosts.

Taenia taeniaeformis

- Cats, lynxes, dogs, wolves and other canids and felids are the definitive hosts. Infections in cats are much more common than in dogs.
- Rodents including rats and mice are the usual intermediate hosts. Infections in humans are very rare.

Coenurosis

Taenia multiceps

- Canids including dogs, wolves, foxes and jackals are the definitive hosts.
- Sheep are the usual intermediate hosts. Goats, cattle, chamois, horses, hares, rabbits, deer, antelope, gazelles, other domestic and wild ruminants, non-human primates and humans can also be infected.

Taenia serialis

- Canids including dogs, coyotes, wolves and foxes are the definitive hosts.

- Lagomorphs, including both hares and rabbits, are the usual intermediate hosts. Infections have also been reported in squirrels, other rodents, cats and humans.

Taenia brauni

- Canids are the definitive hosts.
- Rodents, including gerbils and wild rodents are the usual intermediate hosts. Infections have been reported in humans.

Incubation Period

The incubation period for cysticercosis and coenurosis is variable. In young lambs, acute coenurosis (caused by migrating *T. multiceps* larvae) is usually seen about 10 days after the ingestion of the eggs. Most other infections become symptomatic only when the larvae either degenerate or become large enough to interfere with vital organs. Neurologic signs caused by established *T. multiceps* coenuri in sheep appear after 2 to 6 months.

Clinical Signs

Taeniasis

Clinical signs, except for the passage of proglottids, are uncommon in the definitive host. Symptoms, if any, are usually limited to unthriftiness, malaise, irritability, decreased appetite and mild diarrhea or colic. Intussusception, emaciation and seizures have been reported but are very rare.

Cysticercosis and coenurosis

The symptoms of cysticercosis and coenurosis are caused mainly by inflammation associated with degenerating larvae, or by the mechanical effects of the parasites. The type and severity of the clinical signs depend on the number and location of the larvae.

T. multiceps coenurosis ('gid') can cause neurological signs in ruminants. Acute coenurosis is seen most often in young lambs. The clinical signs are usually limited to transient fever, listlessness and mild neurologic signs such as a slight head tilt. More severe disease, including acute meningoencephalitis, convulsions and death can occur with large numbers of parasites. Symptoms from established *T. multiceps* coenuri appear more slowly, are most common in 16-18 month old sheep, and vary with the location of the parasite in the brain or spinal cord. They may include behavioral abnormalities, circling, ataxia, hypermetria, blindness, deviation of the head, paralysis, convulsions, hyperexcitability or other neurologic signs, as well as prostration and emaciation.

Neurologic signs have also been reported in animals infected by other *Taenia* species. *T. solium* cysticercosis is an uncommon cause of parasitic encephalomyelitis in dogs. Coenuri, mainly *T. serialis*, are reported occasionally in the CNS of cats. The symptoms are extremely variable, and depend on the location and number of the larvae. Multifocal

signs including ataxia, falling with episodes of extensor rigidity, lethargy, sudden aggression, visual impairment, and depression may be seen if the brain herniates.

Clinical signs are uncommon in pigs infected with *T. solium* and cattle infected with *T. saginata*. *T. solium* can occasionally cause hypersensitivity of the snout, paralysis of the tongue, seizures, fever and muscle stiffness in pigs. Large numbers of *T. saginata* larvae may result in fever, weakness, anorexia, and muscle stiffness in cattle. Deaths have been reported as the result of myocarditis during experimental infections.

Other *Taenia* species can occasionally cause abdominal distension, lethargy, weight loss or other signs related to abdominal or hepatic infections, particularly in hosts such as rabbits.

Communicability

The definitive hosts shed eggs and proglottids, which are immediately infective, in the feces. They can infect any susceptible intermediate host. Intermediate hosts can transmit *Taenia* spp. only if their tissues are eaten. *T. solium* and *T. saginata* cysticerci usually become infectious in 2 to 3 months.

Diagnostic Tests

In the definitive host, taeniasis can be diagnosed by finding the proglottids or eggs in the feces. While they are still moist, *Taenia* proglottids can be differentiated from other genera of tapeworms by their morphology. The eggs, which are spherical, brown and contain an embryo, may be found by fecal flotation. All taeniid eggs are very similar. Shedding of the proglottids and eggs may occur intermittently.

Diagnosis of cysticercosis is difficult in live animals. Imaging studies such as MRI may be used in small animals. In large animals, cysticercosis is usually diagnosed post-mortem at meat inspection. In sheep, *T. multiceps* coenurosis may be suspected if there is refraction upon palpation of the skull behind the horn buds. Cysticerci can also be detected sometimes in the tongues of swine or cattle by palpation. Serology is not used in animals.

Treatment

Taeniasis can be treated with praziquantel, epsiprantel, mebendazole, febantel and fenbendazole. Valuable animals with coenuri or cysticerci may be treated with surgery. There is little information on anthelmintic treatment of cysticercosis in animals. One dog with *T. solium* neurocysticercosis was successfully treated with albendazole and prednisone. As in humans, anthelmintics used alone may cause the death of the larvae and exacerbate the clinical signs.

Prevention

Cysticercosis and coenurosis in livestock can be decreased by preventing or treating taeniasis in the

definitive host. Dogs associated with livestock, particularly sheep, should not be allowed to eat the carcasses of animals with coenurosis, and should be dewormed regularly. Other dogs should not be allowed near the animals. To prevent infections with *T. solium*, *T. saginata* or *T. asiatica*, animals should not be exposed to human feces.

Taeniasis in cats and dogs can be decreased by not allowing dogs to hunt rodents or other intermediate hosts, and not feeding raw or undercooked carcasses.

No vaccines are currently available. A *T. ovis* vaccine was produced in the past but tapeworm vaccines have, in general, not been economically feasible.

Morbidity and Mortality

The prevalence of infection varies with the parasite. In some parts of the world, up to 43% of the pigs have antibodies to *T. solium*. Free-roaming pigs have a much greater risk of infection than pigs that are confined to pens. *T. solium* and *T. saginata* are both uncommon in livestock in the U.S. *T. multiceps* infection (gid) can be a common and important disease in some countries or regions, such as parts of the United Kingdom.

Reports of neurocysticercosis or neurocoenurosis in dogs and cats are uncommon and sporadic.

Taeniasis in the definitive host is typically asymptomatic or mild. More severe clinical signs and deaths may be seen in the intermediate hosts, but this varies with the location, number and size of the larvae. Deaths are usually associated with cysticerci or coenuri in vital organs such as the brain. Symptomatic *T. multiceps* coenurosis in ruminants is usually fatal without treatment, but *T. solium* and *T. saginata* are usually asymptomatic.

Post Mortem Lesions

Taeniasis

Adult tapeworms may be found in the intestines at necropsy. They are long, flat, segmented worms with a scolex, neck, and a series of proglottids, and may be one to several meters long. The species can be distinguished by their morphology, including the structure of the scolex and proglottids.

Cysticercosis

Cysticerci are clear, translucent, pearly white or white. They are usually round to ovoid and approximately 1 cm or less in diameter, but can grow larger in areas such as the subarachnoid space of the brain. Each fluid-filled vesicle contains a single invaginated protoscolex, which usually appears as a single dense white body. Except in the eye, cerebral ventricles, and subarachnoid space of the brain, they are surrounded by a fibrous capsule. An organ may contain one to hundreds of cysticerci.

Degeneration is associated with increasing opacity of the cyst wall. The fluid thickens and the cyst eventually

becomes filled with greenish or yellow, caseous material. Inactive larvae may be calcified.

Other lesions, such as myositis, myocarditis or damage to the CNS, may also be associated with the larvae.

- In pigs, most *T. solium* cysticerci are found in the skeletal or cardiac muscles, brain, liver and heart.
- *T. saginata* in cattle and *T. ovis* in sheep are found mainly in the muscles. In cattle, most *T. saginata* cysticerci are found in the masseter muscles, tongue, heart and diaphragm.
- *T. hydatigena* cysticerci are usually found in the abdominal cavity. They are generally attached to the omentum, mesentery and occasionally the surface of the liver. The migrating larvae leave hemorrhagic tracks in the liver that later become green/brown and finally, white and fibrotic. Some small cysticerci may also be found in the liver parenchyma, just below the capsule. They tend to degenerate and calcify early. In cattle and pigs, these lesions may resemble tuberculosis.
- *T. crassiceps* larvae are usually found in the subcutaneous tissues, and peritoneal or pleural cavities.
- *T. asiatica* and *T. taeniaeformis* cysticerci are usually found in the liver. *T. taeniaeformis* larvae are typically very small, and only several millimeters in diameter.

Coenurosis

Coenuri are usually larger than cysticerci and contain multiple protoscolices. Sometimes, they also contain internal daughter cysts.

- *T. multiceps* coenuri are usually 2-6 cm in diameter and contain a few to more than a hundred protoscolices. In animals, they are usually found in the CNS, particularly the brain. In sheep, the migrating larvae may leave reddish or gray purulent tracks in the brain, or cause meningoencephalitis. More mature larvae can compress the tissues of the brain or spinal cord or block the flow of cerebrospinal fluid (CSF). In cats, the lesions may include diffuse flattening of the cerebral hemispheric gyri, hydrocephalus and herniation of the cerebellum into the foramen magnum.
- *T. serialis* coenuri are usually found in the subcutaneous tissues, muscles and retroperitoneally. In rabbits, most of the coenuri are found in the lumbar muscles, muscles of the hind legs, and, rarely, the jaw muscles. The mature larvae are ovoid or round and up to 5 cm in diameter. The multiple protoscolices are each roughly the size of a rice grain.
- *T. brauni* larvae tend to be found in the subcutaneous tissues and the eye.

Internet Resources

Centers for Disease Control and Prevention (CDC)

<http://www.cdc.gov/ncidod/dpd/parasites/cysticercosis/default.htm>

<http://www.cdc.gov/ncidod/dpd/parasites/taenia/default.htm>

FAO Manual on Meat Inspection for Developing Countries

<http://www.fao.org/docrep/003/t0756e/t0756e00.htm>

International Veterinary Information Service (IVIS)

<http://www.ivis.org>

Material Safety Data Sheets – Canadian Laboratory Center for Disease Control

<http://www.hc-sc.gc.ca/pphb-dgsp/msds-ftss/index.html#menu>

Medical Microbiology

<http://www.ncbi.nlm.nih.gov/books/NBK7627>

The Merck Manual

<http://www.merck.com/pubs/mmanual/>

The Merck Veterinary Manual

<http://www.merckvetmanual.com/mvm/index.jsp>

World Organization for Animal Health (OIE)

<http://www.oie.int>

OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals

<http://www.oie.int/international-standard-setting/terrestrial-manual/access-online/>

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