

Chapter 21 - Tapeworms: Pseudophyllideans and Cyclophyllideans

O. Pseudophyllidea

Typically have a scolex with 2 longitudinal bothria

Bothria may be equipped with hooks

Genital pores may be lateral or medial

Vitellaria are always follicular and scattered throughout the proglottid

Testes are many

The life cycles of pseudophyllideans usually involves a crustacean as a first intermediate host and fish as second intermediate hosts

Family Diphyllbothriidae

Diphyllbothrium latum

Diphyllbothrium latum, the broadfish tapeworm, parasitizes several species of fish eating mammals (including humans), particularly in Scandinavia, the USSR and parts of temperate SA

The adult reproductive system possesses a common genital atrium into which male and female genital pores open on the midventral surface of each proglottid

Sperm enter the female pore and pass down the vagina to the oviduct, where fertilization occurs

The bilobed ovary lies in the posterior portion of the proglottid

The oviduct, arising from the ovary, continues anteriorly as a coiled uterus, opening to the exterior through the midventral **uterine pore**

Eggs enclosed in tanned eggshells are expelled via the uterine pore

The follicular cells constituting the vitellaria are scattered throughout the cortical fields of the proglottid, and numerous testes are medullary in their distribution except for an area along the midline of each proglottid

The worms are large and their extraordinary size is partially due to anapolyosis - the retention of terminal proglottids

Life Cycle

The adult worm is attached to the mucosal lining of the small intestine

Eggs are released from the uterine pore on the ventral surface of the proglottid

The eggs must lie dormant in the water for approximately 8-12 days or longer to complete embryonic development

The hexacanth embryo is covered by a ciliated embryophore and is called a **coracidium**

Soon after hatching, the motile coracidium must be ingested by a FW copepod
 In the digestive tract of the copepod, the ciliated embryophore is shed and the naked hexacanth larva bores through the intestinal wall into the hemocoel

The hexacanth embryo metamorphoses into an elongated **proceroid** larva
 The prominent cercomer, containing the 6 larval hooks, projects posteriorly

When the infected copepod is ingested by a plankton-feeding FW fish, the proceroid penetrates the intestinal wall and migrates to the body muscles
 Here it develops into a long, solid, pseudosegmented **plerocercoid** larva with an adult scolex at one end

The plerocercoid of *D. latum* is coiled and at times encapsulated, or more commonly, lying free in muscle tissue

When it invades the muscles of the body wall, encapsulation rarely occurs
 However, when it settles in or on the viscera, encapsulation is common

Infection of the definitive host results from the ingestion of plerocercoids in poorly cooked, steamed, smoked, pickled, or raw fish
 Upon entering the small intestine of the definitive host, it attaches to the mucosa and begins to grow

Epidemiology

Human infection with *D. latum* is primarily, although not exclusively, limited to areas where fresh fishes are commonly eaten or where cleaning and handling of fishes is done
 A number of cold water, FW fishes (including pike, salmon, trout) can serve as second intermediate hosts

In addition to being ingested with raw or improperly cooked fish, plerocercoids may be accidentally ingested when they cling to the hands of fish cleaners

Symptomatology and Diagnosis

Rarely is more than a single worm found in an infected human, and many victims display few if any symptoms

There may be abdominal pain, weight loss, weakness, and nervous disorders

Many of these symptoms are attributable to the patient's reaction to the parasite's metabolic wastes, to degenerating proglottids or to irritation of the intestinal mucosa
 Occasionally, the worm is found in the upper portions of the jejunum, in which case it can compete successfully with the host for ingested vitamin B12

Since this vitamin is important in the synthesis of hemoglobin, deprivation causes an anemia in the human host similar to pernicious anemia

Other Pseudophyllideans Found in Humans

Sparganosis

When procercoids of some species are accidentally ingested (e.g. swallowing copepods while drinking water) they can migrate from the gut and develop into plerocercoids. This infection is called **sparganosis**. It can cause some rather severe pathology.

Another pseudophyllidean is *Ligula intestinalis*, found in the body cavity of carp, suckers, and shiners – causes substantial changes in host behavior. Adult worms often occur with mergansers.

Order Cyclophyllidea

Possess scolices with 4 suckers
A rostellum that usually has hooks
Have a single compact, postovarian vitelline gland
Number of testes varies from one to several hundred
Most tapeworms of birds and mammals belong to this group

Family Taeniidae

Taenia solium (“human pork tapeworm”)

Humans are the only known natural definitive hosts. It is common in areas where raw or improperly cooked pork is a regular element of the diet.

Its scolex is armed with 2 circles of 22 to 32 rostellar hooks. The hooks are of 2 sizes and alternate in the 2 circular rows.

Life Cycle

The proglottids may rupture either in the host intestine or after it leaves the host. When eggs are ingested by pigs, the liberated oncospheres, using their hooks and penetration glands, penetrate the intestinal wall, gain access to the circulatory system, and are carried by the blood or lymph to muscles, viscera and other organs, where they develop into cysticerci.

Each white, ovoid, fluid filled cysticercus, contains a single invaginated scolex. When infected, or mealy pork is consumed by a human, the scolex evaginates and attaches to the intestinal wall.

Epidemiology

The prevalence of pork tapeworm infection in humans varies by region

The very low incidence in the US can be attributed to the isolation of pigs from human feces

Religious dietary proscriptions forbidding pork consumption render human infection very rare in Moslem countries and in Israel

However, it is common in other parts of Africa, India, China, and several countries in SA and Central America

Symptomatology and Diagnosis

Usually only a single adult tapeworm infects a human

The armed scolex may cause irritation of the mucosal lining, and there have been cases in which the scolex perforated the intestine, leading to peritonitis

However, the greatest hazard to human health associated with this parasite is infection with the cysticercus, causing a disease known as **human cysticercosis**

While common sites for infection of humans by cysticerci are the skeletal muscles and the brain, they can develop in practically any organ of the body, including the eyes and lungs, and heart

Cysts are well tolerated in muscles and subcutaneous tissues, although heavy infections can cause muscle spasms, weakness and general malaise

Developing cysts elicit a host inflammatory response often resulting in fibrous encapsulation

Calcification of the cyst may occur after 1 year, after which time the disease may become asymptomatic

The most serious symptoms arise about 5-10 years after the infection as a result of dead and dying cysticerci

The degenerating parasite tissues and associated fluid also elicit a host inflammatory reaction that can be very severe, even fatal

Cysts developing in the CNS, sense organs, or heart can exert mechanical pressure and cause severe neurological symptoms

Violent headaches, convulsions, local paralysis, vomiting and optic disturbances are common

Taeniarchynchus saginatus (“the beef tapeworm”)

Scolex is unarmed; no rostellum or hooks

The morphology of the mature proglottids in this species is similar to that of *T. solium* except that *T. saginatus* has a bi-lobed ovary and about twice as many testes as *T. saginata*

Life Cycle

Adults reside in the intestine of humans and gravid proglottids detach singly from the strobila and pass to the outside with the feces

The eggs are then ingested by an appropriate intermediate host (e.g. cattle or some kind of ungulate)

The liberated oncosphere then penetrates the intestinal wall and is carried by the lymphatic or blood circulatory system to intramuscular connective tissue and develops into a cysticercus

Humans become infected by eating cysticerci in beef, particularly the muscles of the head and heart

Following evagination of the scolex and subsequent attachment to the intestinal wall the worm develops to maturity

Epidemiology

T. saginatus is distributed throughout the world

Humans acquire infection by eating raw or improperly cooked beef infected with cysticerci

Cattle develop cysticerci by grazing in fields upon which human excrement has been deposited either through fertilization with “night soil” or from poor sanitation

Symptomatology and Diagnosis

T. saginatus taeniasis in humans is often characterized by such symptoms as abdominal pain, greatly diminished appetite, and weight loss

These symptoms are especially common with patients already debilitated by malnutrition or some other illness

Echinococcus (E. granulosus)

Adult worms inhabit the small intestine of a wide variety of canines and occasionally cats
The juvenile forms of these worms are huge and are capable of infecting humans, resulting in a series disease called **hydatidosis**

Eggs reach the exterior by elimination of gravid proglottids with the host's feces
The eggs are released when the proglottids disintegrate and each one contains a fully developed oncosphere

These get into the intermediate host by the intake of either water or forage contaminated with egg-containing feces

The usual intermediate host for *E. granulosus* is sheep, but cattle and other herbivores are sometimes utilized

Note:

Humans can be infected with the eggs as the result of intimate contact with dogs, particularly when dogs are allowed to lick faces after grooming themselves

Humans can also ingest eggs by putting contaminated fingers into the mouth or by eating raw plants contaminated with feces from infected foxes, cats or dogs

Once swallowed, eggs pass through the stomach and hatch in the small intestine

The freed oncospheres penetrate the intestinal wall, enter the mesenteric venules and become lodged in capillary beds of various visceral organs

In humans, the developing **hydatid cyst** (=a fluid filled vesicle containing secondary cysts or **brood capsules** that in turn contain a series of invaginated scolices) favors the liver, although other tissues (lungs, spleen, heart, muscles, brain, etc.) may be invaded

Within the fully formed cyst, minute larvae with inverted scolices develop

Since these immature, 4 suckered scolices lack individual bladders they are called **protoscolices** - not bladder worms or cysticerci which contain a single scolex

In humans and some domestic animals, the formation of hydatid cysts represents a dead end for the parasite

However, many wild animals, such as infected rabbits and moose are potential intermediate hosts since the cysts are ingested when predators feed on these kinds of animals

Upon reaching the small intestine of the definitive host (the predator), each protoscolex develops into an adult worm

Adults live about 5 months

Hydatid Cyst

At maturity, the cyst wall contains 2 layers: a thick, laminated, noncellular outer tegument called the **ectocyst**, and an inner, germinal epithelium that produces the protoscolices called the **endocyst**

Brood capsules attached to the germinal epithelium by the stalk, the **pedicel**, extend into the fluid filled cavity of the cyst

In large cysts, these capsules may rupture, and the freed protoscolices, which sink to the bottom of the bladder, are commonly known as hydatid sand

Each brood capsule contains 10-30 protoscolices

If a cyst ruptures within a host, each liberated protoscolex can produce a daughter cyst

Symptomatology and Diagnosis

The presence of unilocular cysts elicits a host inflammatory reaction that results in encapsulation of the cyst

The primary pathology of the cyst is impairment of the organs from mechanical pressure

Increased pressure resulting from cyst growth may cause the surrounding tissues to atrophy

Thus, the symptoms are not unlike those caused by a slow growing tumor

The brain, kidneys, spleen and vertebral column may also be invaded, producing symptoms ranging from seizures to kidney dysfunction

Protoscolices, freed by the rupture of cysts, enter the circulatory system and are transported to tissues throughout the body where they produce secondary echinococcosis

The rupture of cysts also releases hydatid fluid which sometimes causes severe allergic reactions

If a significant amount of fluid enters the bloodstream it can cause anaphylactic shock

Treatment

Surgery remains the preferred treatment for unilocular hydatidosis

Following drainage of the cyst fluid, replacement with 2% formalin for 5 min kills the protoscolices and the germinal epithelium

In any surgical procedure for cyst removal, care should be taken to avoid rupturing the cyst

Symptoms of allergic reaction, respond best with antihistamines

Benzimidazoles has been used to successfully reduce the size of unilocular cysts

Family Hymenolepididae

This is a large family that occurs in both birds and mammals
Only 2 species *Vampirolepis nana* and *Hymenolepis diminuta* infect humans

Vampirolepis nana

Known as the dwarf tapeworm of mice and humans
Mature proglottids are much broader than they are long
Male system has 3 spherical testes, bi-lobed ovary

Life Cycle

The life cycle of *Vampirolepis nana* represents a modification of the typical cyclophyllidea life cycle pattern in that the parasite requires only one host to complete its development

Natural definitive hosts, in addition to humans, are rodents like mice and rats
Gravid proglottids from adult worms rupture, releasing oncosphere containing eggs into the host intestine to be eliminated with the feces
The eggs are infective upon release
Upon being ingested by a new host, the oncosphere, freed in the small intestine penetrates a villus
There it sheds its 6 hooklets and in a few days becomes a modified cysticercoid larva known as a **cercocystis**
It erupts from the villus into the lumen of the small intestine, attaches itself to the mucosal lining, and develops into the sexually mature adult

In the case of rodents, an insect (flour beetle) may serve as an intermediate host
In this case, when the insect host is ingested by a rodent the cysticercoid attaches to the intestinal wall and develops to maturity

Autoinfection can exacerbate the condition by increasing the number of worms
Eggs released from gravid proglottids, instead of passing to the exterior to infect new hosts, hatch in the small intestine and re-infect the same host
The freed oncosphere penetrates a villus and repeats the cycle

Vampirolepis nana is cosmopolitan in distribution and possibly the most common cestode parasite of humans in the world, especially among children
The usual mode of transmission in humans is hand-to-mouth, although infection may also occur through ingestion of contaminated food

Hymenolepis diminuta

Hymenolepis diminuta is a common parasite of rats throughout the world, occasionally parasitizing humans

It exhibits a typical 2 host life cycle, utilizing a grain-ingesting insect such as a flour beetle as an intermediate host

Insects are infected when they consume rodent feces containing either gravid proglottids or eggs

The oncosphere penetrates the intestinal wall of the insect and enters the hemocoel where it develops into the cysticercoid stage

The most common intermediate hosts are grain beetles belonging to the genus *Tribolium* or *Tenebrio*

Humans acquire infections by eating cereals, dried fruits, etc. that contain infected insects

Family Dilepididae

Dipylidium caninum

A common tapeworm of dogs, cats and humans

It is easily recognizable because each proglottid has 2 sets of reproductive organs with a genital atrium on each lateral edge

The eggs are encapsulated in egg capsules; each capsule contains 8-25 eggs

Life Cycle

Adults live in the small intestine of the definitive host where large gravid proglottids separate from the strobila in groups of 2-3

Proglottids are passed with feces

Eggs and capsules are ingested by larva of fleas or by the dog louse

The oncospheres hatch in the gut of the arthropod, burrows through the wall, and develops into a cysticercoid in the hemocoel when the flea or louse matures

When the infected insect is ingested by a suitable definitive host, the cysticercoid is liberated in the small intestine and develops into an adult

Epidemiology

Transmission to humans usually results from accidental ingestion of infected fleas or lice or from allowing dogs and cats to lick the mouths of children soon after the pet has bitten an infected arthropod