

Class Digenea (Trematoda) - The Flukes

- A. The information on the Platyhelminthes provided in the previous section should be reviewed, as it still applies.
- B. Adult trematodes are parasites of vertebrates. All have complex life cycles requiring one or more intermediate hosts. Most are hermaphroditic, many capable of self-fertilization.
- C. Eggs shed by the adult worm within the vertebrate host pass outside to the environment, and a larva (called a miracidium) may hatch and swim away or (depending on species) the egg may have to be ingested by the next host.
- D. Every species of trematode requires a certain species of molluscan (snail, clam, etc) as an intermediate host. A complex series of generations occurs in the mollusk, resulting ultimately in the liberation of large numbers of larvae known as cercariae.
- E. To reach the vertebrate host, cercariae (depending on species):
 - 1. Penetrate directly through skin and develop into adults.
 - 2. Enter a second intermediate host, and wait to be ingested (they are now called metacercariae).
 - 3. Attach to vegetation, secrete a resistant cyst wall, and wait to be eaten (now called metacercariae)
- F. Members classification
 - 1. Intestinal
 - a. *Fasciolopsis buski*
 - b. *Heterophyes heterophyes*
 - c. *Echinostoma ilocanum*
 - d. *Metagonimus yokogawai*
 - 2. Liver / Lung
 - a. *Clonorchis sinensis*
 - b. *Opisthorchis viverrini*
 - c. *Fasciola hepatica*
 - d. *Paragonimus westermani*
 - 3. Blood
 - a. *Schistosoma mansoni*
 - b. *Schistosoma haematobium*
 - c. *Schistosoma japonicum*
- G. General adult's appearance
 - 1. Body is non-segmented, flattened dorsal-ventrally, leaf-shaped, and covered with a cuticle which may be smooth or spiny.
 - 2. Attachment organs are two cup-shaped suckers, two cup-shaped suckers, - oral and ventral. Tegument is metabolically active.

3. Oral cavity leads to muscular esophagus, from which intestines branch to form 2 caecae, which run parallel to each other ending blindly near the posterior end of the worm.
4. Simple digestive system, no anus - waste products are regurgitated.
5. Reproductive system
 - a. Uterus is usually the largest organ with a single ovary, two testes & a series of glandular structures that produce shell material that covers the ovum.
 - b. Uterus may be filled with thousands of eggs.
6. Trematode eggs
 - a. Trematode eggs usually have a smooth, hard, transparent, yellow - brown shell and eggs may have "shoulders" and/or spines.
 - b. Size varies greatly with species, ranging from less than 30 microns to nearly 175 microns.
 - c. Most have an operculum (escape hatch for the miracidium).
 - d. Trematode eggs cannot successfully be concentrated using flotation techniques (due to size and weight). The formalin-ether (ethyl-acetate) concentration procedure is recommended; although eggs may rupture (they are still recognizable).

H. *Fasciolopsis buski* – The Giant Intestinal Fluke



Fasciolopsis buski adult (anterior)



Fasciolopsis/Fasciola egg

1. Epidemiology - Found in China, including Taiwan, Vietnam, Thailand, and in parts of Indonesia, Malaysia, and the Indian subcontinent. Infection rate may be as high as 20 - 40% especially in agricultural areas if practices promote life cycle in which pigs act as definitive host. It is the most common intestinal fluke in the orient.
2. Life cycle - Human infection through ingestion of metacercariae on uncooked water plants. Encysted metacercariae hatch & attach to intestinal wall, develop into adult worms; eggs passed in feces - miracidium hatches, penetrates snail - cercariae emerge and encyst on aquatic plants.
3. Diagnosis
 - a. Demonstrating eggs in feces specimens.

- b. Eggs are difficult, if not impossible, to differentiate from those of *Fasciola hepatica*. Diagnosis of species often depends upon clinical signs, travel history and/or recovery of adults.
4. Morphology of eggs
 - a. size - Oval, yellow-brown eggs measure 150 x 90 microns on average.
 - b. operculum – the transparent shell has a small operculum at the more pointed end (sometimes seen “popped open”)
 5. Major pathology - the adult worm attaches to the intestinal wall, producing local inflammation possibly leading to hemorrhage, ulceration and abscess formation. Light infections are likely asymptomatic; moderately heavy infections result in abdominal pain and diarrhea; heavy infections can lead to bowel obstruction. Absorption of worm metabolites can produce toxic or allergic reactions (edema, ascites).
 6. Distribution - Eastern Asia (China, Vietnam, Thailand) and southwest Pacific.

I. *Fasciola hepatica* – The Sheep Liver Fluke



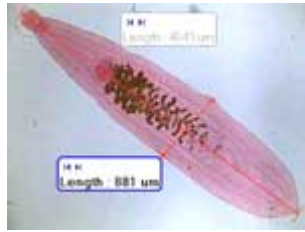
Fasciola hepatica adult (anterior)



Fasciola/Fasciolopsis egg

1. Epidemiology - rare in the USA, probably due to our diet not including the plants (wild grown) containing metacercariae. Common in sheep, cattle, & goats around the world.
2. Life cycle - similar to that of *F. buski*; the difference being that hatching metacercariae do not attach to wall of intestine, rather, they penetrate the intestinal wall and migrate through peritoneal cavity until coming in contact with liver. They penetrate the liver & migrate to bile ducts where they grow to adult worms.
3. Pathology and Clinical Manifestations - migration through liver causes damage and symptoms proportionate with worm burden. Fever, abdominal pain, diarrhea, and eosinophilia may be experienced. Heavy worm burdens later result in extensive inflammation, epithelial hyperplasia, and fibrosis around the adult worms. This can lead to obstruction of the bile ducts.
4. Distribution - Cosmopolitan distribution in sheep-and cattle-raising countries.

J. *Clonorchis sinensis* – The Oriental or Chinese Liver Fluke



Clonorchis sinensis adult



Clonorchis sinensis egg

1. Life cycle
 - a. Human eats undercooked fish containing the metacercaria.
 - b. The immature worm migrates to liver and bile duct.
 - c. Adults develop in the bile duct (not recovered in stool specimens).
 - d. The adult worm produces 2400 eggs/day/worm. Eggs are passed intermittently.
 - e. Eggs reach fresh water to be consumed by suitable snails (first intermediate host). This results in the development of large numbers of cercariae.
 - f. Released cercariae seek the second intermediate host, a fish, and penetrate beneath the scales and migrate to underlying muscles to transform into the infective metacercariae. Only fresh water fish serve as intermediate hosts.
2. Diagnosis - detection of eggs in feces.
3. Morphology of eggs - in reality, these cannot be distinguished from eggs of *Heterophys*, or *Metagonimus*. Eggs are small (~15 x 35 microns), flask-shaped, with a small operculum on the narrow end. A small “comma-shaped” extension can often be seen on the abopercular end.
4. Pathology and Clinical Significance
 - a. Light infections are usually asymptomatic
 - b. Heavy infections can result in jaundice, hepatomegaly, abdominal pain, diarrhea and anorexia.
 - c. Patients may have severe hepatic complications in chronic cases with heavy worm burdens from repeated infections.
 - d. Distribution - Far East, especially China.

K. *Heterophyes heterophyes* and *Metagonimus yokogawai*

1. Life cycle

- a. Eggs in feces hatch in water and undergo complex life cycle. Eggs of all species in this group of worms are essentially identical to that of *C. sinensis*. These worms are primarily parasites of dogs, cats and carnivores, but will infect humans.
- b. Man eats undercooked fish, which contain encysted metacercaria under the scales in the flesh.
- c. Adults are found in the small intestine. Adults not found in feces until after treatment.
- d. Morphology of eggs - very similar to those of *C. sinensis*. Somewhat narrower, with less distinctive "shoulders" on the opercular end; the abopercular is absent the "comma-shaped" knob.

2. Diagnosis

- a. Recovery and identification of eggs in feces
- b. Difficult to differentiate from each other and from *C. sinensis* unless adult worms can be recovered.
- c. A patient history is helpful since the infections are more common in one country or another. These are intestinal flukes, therefore, no liver involvement and symptoms would be expected. The treatment is same for both.

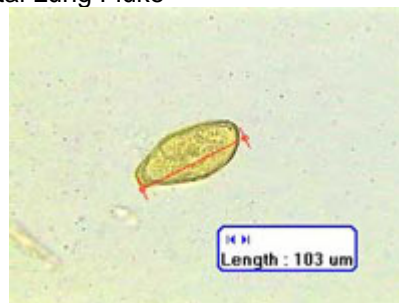
3. Pathology

- a. Asymptomatic in light infections.
- b. Chronic mucous diarrhea and abdominal pain in heavy infections.
- c. Eggs may travel into tissue causing granulomas and other tissue disorders.

L. *Paragonimus westermani* - The Oriental Lung Fluke



Paragonimus westermani adult



Paragonimus westermani egg

1. Life cycle (requires more than one intermediate host)
 - a. Eggs in sputum or feces get into fresh water and undergo several developmental stages. The miracidium hatches from the egg within 2 weeks, penetrates a snail, cercariae develop and escape the snail.

- b. Infective cercariae penetrate freshwater crabs or crayfish and encyst as metacercaria.
- c. Man eats metacercaria present in undercooked crab or crayfish.
- d. Immature fluke penetrates intestine, migrates through peritoneal cavity, diaphragm and into lung tissue. Worms tend to gather around bronchioles, where they discharge eggs into bronchial secretions.
- e. Eggs are found in sputum or, if sputum is swallowed, in feces.
- f. Infections may persist for years.

2. Morphology

- a. adults - 6 x 10 mm, plump, usually reddish-brown.
- b. eggs - 80 to 125 x 45 to 65 microns, opercular end is broader than the other end and has "shoulders", abopercular end often has marked thickening of egg shell.

3. Pathology

- a. Chronic chest pain, cough, blood tinged sputum, lung infiltration, nodules, abscesses.
- b. X-ray may resemble tuberculosis.
- c. Abdominal paragonimiasis is usually asymptomatic but common.

M. *Schistosoma* spp. - The Blood Flukes

1. Life cycle -

- a. Eggs are released into fresh water the where miracidia hatch.
- b. The miracidia enter a snail and undergo essential developmental stages and eventually leave the snail as free-swimming cercaria.
- c. Free-swimming cercariae penetrate the skin of humans while they are swimming or bathing.
- d. The cercariae lose their tails upon penetration of the skin, travel through body via the bloodstream and develop to maturity in appropriate vessels in the body of the host.

2. General characteristics

- a. Both males and females exist in this group of flukes. The female is long and slender, the male is shorter, cylindrical and characteristically in-curved to form a gynecophoral groove in which the female reposes. Adult males are 7 - 20 mm long; females a bit longer.

- b. The female leaves the male to lay eggs in small venules close to lumen of the intestine or bladder.
 - c. Eggs are firmly wedged in and spines present on the eggs facilitate their retention.
 - d. The release of enzymes along with necrosis of tissue causes release of eggs into the intestine or bladder. Expansion and contraction of the affected organ aids eggs in crossing the tissue barrier into the lumen for discharge.
3. Note - Schistosomiasis ranks second behind malaria as a cause of serious worldwide morbidity and mortality and is spreading and increasing because of recent new water-control projects, which provided increased snail-breeding areas.
4. *Schistosoma mansoni* - Manson's blood fluke



Schistosoma sp. Adults

Schistosoma mansoni egg

Schistosoma sp. cercaria

- a. Life cycle – see general life cycle above.
 - (1) After penetration of the skin the schistosomule travels through the blood vessels.
 - (2) The adults usually live in smaller branches of the inferior mesenteric vein in the region of the lower colon, but can be found elsewhere.
 - (3) *S. mansoni* lives on ingested blood. The female can ingest up to 330,000 rbcs/hour, the male 39,000/hour.
- b. Morphology of eggs - see the schematic in the life cycle diagram in the text. Eggs are non-operculate; measure 114 to 180 x 45 to 75 microns, and exhibit a prominent lateral spine (sometimes not seen due to the orientation of the egg). 100 - 300 eggs per worm per day are normally shed.
- c. Diagnosis
 - (1) Recovery and identification of eggs in stool or rectal biopsy (best to get 4 rectal snips in different areas of the bowel).
 - (2) Most of the eggs are swept into the liver where granulomas form. Periportal pipestem fibrosis may result in cirrhosis with little hepatocellular regeneration.

(3) Travels history as well as clinical signs and symptoms are important aids in determining possibility of infection.

d. Major pathology and symptoms -

(1) mostly due to the reaction to eggs being deposited in the liver.

(2) Dermatitis at the site of entry. Non-human schistosomes can cause a cercarial dermatitis in humans in the USA.

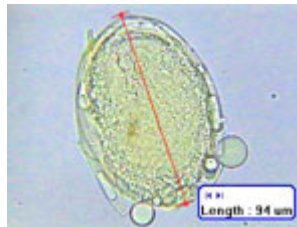
(3) Acute phase of first infection resembles typhoid fever.

(4) Cirrhosis of the liver, bloody diarrhea, bowel obstruction, hypertension, and toxic reactions owing to granulomas around eggs in the liver. The worm secretes metabolites, resulting in a hepatitis syndrome; acute cases experience a serum sickness-like syndrome (Katayama syndrome).

(5) Many chronic cases are asymptomatic in endemic areas.

e. Distribution - Africa, South and Central America, with foci in the Caribbean and West Indies.

5. *Schistosoma japonicum* – The Oriental Blood Fluke



Schistosoma japonicum egg

a. Life cycle - see general life cycle above.

(1) This organism is found in virtually all mammals exposed to infested water in endemic areas.

(2) After penetration and travel through the blood stream the parasite eventually inhabits the branches of the superior mesenteric vein adjacent to the small intestine.

(3) The inferior mesenteries and caval system may also be invaded, as the worms tend in time to migrate farther and farther from the liver.

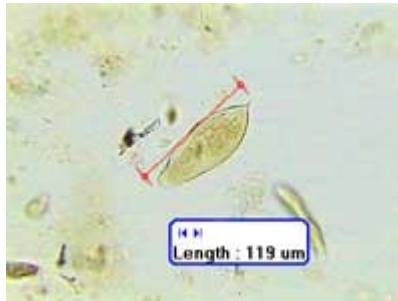
(4) This species produces more eggs than the other schistosomes. More eggs become free in the general circulation, to be filtered out in the liver, lungs or other organs.

b. Morphology of eggs - measures 55 to 85 x 40 to 60 microns; exhibit a

small lateral spine (may be absent).

- c. Diagnosis - based upon recovery and identification of eggs in stool samples or rectal biopsies.
- d. Major Pathology and Symptoms
 - (1) Infection with even a few worms of this species may be very serious. Cerebral atrophy can occur due to eggs becoming trapped in the brain.
 - (2) Hepatic and pulmonary cirrhosis are commonly seen in the chronic stage of this infection, and CNS symptoms may occur following lodgment of eggs in nerve tissue.
- e. Distribution is the Far East.

6. *Schistosoma haematobium* – The Bladder Fluke



Schistosoma haematobium egg

- a. Life cycle - see general life cycle above.
- b. After the worms mature in the sinusoids of the liver, they migrate from that organ where the majority of them reach vesicle, prostatic and uterine plexuses by way of the hemorrhoidal veins.
- c. Eggs are deposited in the walls of the bladder, or to a lesser extent in the uterus, vaginal wall, prostate, or other organs.
- d. Eggs deposited in the bladder may break through into the lumen and escape with urine. The spine on the egg, as well as the contraction & expansion of the bladder aids escape of eggs into the lumen of the bladder.
- e. Morphology of the eggs - measures 112 to 170 x 40 to 70 microns, exhibits a prominent terminal spine, and is non-operculate.
- f. Diagnosis
 - (1) Eggs in the urine.
 - (2) May have eggs in the feces due to contamination of specimen with urine. Worm also will rarely inhabit intestinal mesenteric vessels, resulting in eggs in feces.

g. Major pathology and symptoms

- (1) The bladder wall becomes increasingly infiltrated with eggs. Some escape in the urine, some encapsulate.
- (2) Bleeding occurs from the bladder wall as it contracts. As it becomes more involved papillomas and ulceration occurs.
- (3) Hematuria becomes more severe and calcification of the bladder and obstruction of ureters and the neck of the bladder lead to bacterial infections.
- (4) Death from renal failure may occur but damage is reversible if treated early enough.
- (5) Clinical correlation exists between *S. haematobium* infection and bladder cancer.

h. Distribution

- (1) Endemic in the Nile Valle.
- (2) Africa and the Middle East