Summary

Roundworms or nematodes:

- Separate sexes
- Adult in intestine lumen or larvae in tissue
- Some species have lung passage of larvae
- Transmission faecal-oral (directly or indirectly, e.g. via food), transcutaneous
- Filaria are part of the nematodes

Tapeworms or cestodes:

- Hermaphrodite adults in the intestine or larvae in the tissues
- Transmission faecal-oral or via food

Flukes or trematodes:

- Most are hermaphrodite, except blood flukes (= schistosomiasis)
- Are found in blood vessels, the intestine, biliary tract, lungs
- Transmission via food (distomatoses) or transcutaneous (schistosomes)
- First intermediate host is always a freshwater snail

Worms, Life cycles

All intestinal roundworms (nematodes) have a fairly complex cycle, but almost always without an intermediate host (*Capillaria phillipinensis* is an exception = mainly through the ingestion of raw fish). The lack of an intermediate host which can only live in a well-defined ecosystem, explains the cosmopolitan character of intestinal nematodes. All intestinal nematodes have separate sexes and lay eggs which can be found in faeces. Sometimes only the female survives in the intestine. In *Strongyloides* larvae hatch before they arrive in the outside world. The larvae of nematodes have several consecutive development stages.

Larval tissue nematodes: The larvae of some nematode species infect various human tissues. These are accidental infections and do not represent the natural life cycle of the

parasite

* The larvae of canine and feline roundworms (*Toxocara* sp.) and also those of *Gnathostoma* may penetrate humans “by mistake” and cause visceral larva migrans. The larvae migrate through the liver, eyes, brain and so on, where they cause a granulomatous inflammatory reaction.

Trichinella larvae are found in the muscles and the heart.

- Filaria are a separate group. They are live-bearing (do not lay eggs) and generally their intermediate hosts are insects.

All flukes (trematodes) have a cycle with an obligatory intermediate host. The first intermediate host of these flatworms is always a freshwater snail. The larvae which comes from the snail then, depending on the species either infects a second intermediate host (fish, crab), encysts on certain plants or penetrates the final host directly through the skin. It is precisely the presence of the intermediate host which determines whether a particular fluke can be present or not in any given area. All food-borne trematode infections are zoonoses. Infestations by flukes are always via larval forms, never via eggs. Except for schistosomes all trematodes are hermaphrodite (no separate sexes).

All tapeworms (cestodes) are parasites which are found in the intestinal lumen as adults. They are hermaphrodites. Each animal has both testes and ovaries. They have a head (scolex) and body segments (proglottids). There is generally only one adult worm in the intestinal tract (Fr.: ver solitaire = tapeworm) but multiple infections do occur. The larval forms of these worms (hydatid, cysticercus) may be located in various organs.

Worms, Transmission

Several ways of infection are possible:

Oral transmission

Human faeces. Faecal-oral transmission is important in several worm infections. Soiling by

infected human faeces is responsible for infestation by *Ascaris*, *Enterobius*, *Trichuris*, cysticercus larvae (larval *T. solium*). Larvae from hookworms and *Strongyloides* may also be ingested orally.

Animal faeces. Humans become infected with the eggs of *Toxocara* (visceral larva migrans) and *Echinococcus granulosus* (hydatid cysts) by eating products which have been contaminated by animal excreta.

Infected meat. Eating raw or insufficiently cooked meat which contains larvae, leads to infection by *Trichinella*, adult *Taenia* and *Gnathostoma*.

Infected fish. Eating raw or insufficiently cooked fish [Latin American ceviche, Japanese sushi and sashimi, Dutch maatjesharing (herring), Norwegian gravlax (salmon), Hawaiian lomi-lomi (raw salmon), Spanish boquerones (anchovies in vinegar)] may lead to infection with: (1) nematodes such as *Anisakis* or *Pseudoterranova* larvae, *Capillaria philippinensis*, *Gnathostoma*; (2) cestodes such as *Diphyllobothrium* (fish tapeworm) and *Diplogonoporus*; (3) trematodes such as *Metagonimus* and *Heterophyes* (small intestinal flukes), *Clonorchis* and *Opisthorchis* (liver flukes).

Infected crabs and crayfish. Eating larvally infested, raw or insufficiently cooked crabs may lead to paragonimiasis (lung fluke).

Contaminated plants. Infection with the giant intestinal fluke (*Fasciolopsis*) occurs via the consumption of several kinds of raw plants e.g. waternut and water chestnut on which larvae are encysted. *Fasciola hepatica* (liver fluke) is transmitted via contaminated water cress.

Contaminated water. Drinking water containing *Cyclops* (small crustaceans) infected with *Dracunculus* leads to Guinea worm infection.

Skin Penetration

Larvae of *Strongyloides* and hookworm enter through the skin from the soil. They then penetrate deeper. The hookworm *Ancylostoma braziliense* also penetrates skin but cannot go deeper. It stays in the skin and give rise to cutaneous larva migrans. *Schistosoma* cercariae

penetrate the skin when humans come into contact with infested water.

Through a vector

Filaria are transmitted by the bite of various Diptera: mosquitoes and flies. *Dracunculus* has *Cyclops* as its vector a small crustacea.

Diagnosis

General

It is important to bear in mind that many worm infections may be diagnosed by simple examination of the faeces, sputum, urine, blood or skin. Helminths which produce a large numbers of eggs or larvae are naturally easier to identify than infections with only a few eggs or larvae. In the latter case it is helpful to enrich the volume of the parasitic material to be examined, by means of concentration techniques. In this way it is possible to make a diagnosis in many patients who have a low worm load.

The tests mentioned above cannot however produce a diagnosis in the following cases:

1. Infection with immature parasites. In acute Katayama fever no eggs are found early in the disease.
2. Infections with male worms. This is why it is important to know whether or not a parasite is hermaphrodite e.g. in infections with male *Ascaris lumbricoides*.
3. Infections with adult worms which are located in an enclosed space such as the brain.
4. Infections with larvae where the human is the intermediate host e.g. cysticercosis, echinococcosis and visceral larva migrans. Trichinellosis may also be included here.
5. Infections with old or damaged worms e.g. after use of anthelmintics.
6. Many patients with loasis do not have microfilariae in their blood

Microscopic recognition of worm eggs

Recognition of worm eggs requires training, practice and experience. Otherwise it is possible

to interpret a certain microscopic structure wrongly for years (quality control is important).

Size. Since infections with *Ascaris lumbricoides* are so common the size of a fertilised egg (60 µm) can be used as a reference measure. If no special microscopic eyepiece is available to carry out measurements, the relative size of a structure can be compared to a fertilized *Ascaris* egg.

1. Eggs much larger: Fasciola hepatica, Fasciolopsis buski, S. mansoni, S. haematobium
2. Eggs somewhat larger: Paragonimus, S. japonicum, Trichostrongylus orientalis, Hymenolepis diminuta, Ascaris unfertilised egg
3. Same dimensions: hookworms eggs, Hymenolepis nana, Diphyllobothrium latum
4. Eggs somewhat smaller: Trichuris, Enterobius, Taenia solium, T. saginata
5. Eggs much smaller: Clonorchis, Metagonimus, Opisthorchis.

Shape. Most eggs are symmetrical. The exceptions are those of *Enterobius*, *Trichostrongylus orientalis*, *Dicrocoelium dendriticum* and unfertilised *Ascaris*. The eggs of hermaphrodite trematodes often have an operculum this small structure is not always easy to see. Some other worms also have it (*D. latum*). Polar caps occur in *Trichuris trichiura* and *Capillaria* sp., giving them a lemon-like appearance. Some eggs, such as various schistosomes, have a spine. These may be large or small compared to the egg, and protrude either terminally or laterally.

Colour. Many eggs have a rather yellowish brown colour due to bile salts. Some are more or less colourless (hyaline), such as those of hookworms, *T. orientalis*, *E. vermicularis* and *Ascaris* (if there is no protein mantel on the egg).

Egg shell. This may be surrounded by a knobbly protein layer, as in *Ascaris*. In some worms the egg shell is thin, as in hookworms. In others it is thick, as in lung flukes.