NATIONAL OPEN UNIVERSITY OF NIGERIA

NSC 106

Medical Mircobiology and Parasitology

Module 5

NSC 106 (Medical Microbiology and Parasitology) Module 5

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Unit 1 Digenetic Trematodes

1.0 Introduction

The phylum Platyhelminthes comprises six classes which include the free living forms and those that are of zoological, medical and economic importance. The medically important groups are the trematodes and cestodes. Trematode also called flukes cause various clinical infections in humans which occur worldwide. The parasites are so named because of their conspicuous suckers, the organs of attachment (trematos means "pierced with holes"). All the flukes that cause infections in humans belong to the group of digenetic trematodes.

The class Trematoda comprises 3 subclasses

Subclass 1 – Aspidogastrea: They have large ventral adhesive organ subdivided by longitudinal and transverse septa into sucking discs. They are parasites of turtles, fishes and mollusks

Subclass 2 – Didymozoidea: These are tissue-dwelling parasites of fish. They are greatly elongated, dioecious, with sexual dimorphism. No complete life cycle is known

Subclass 3 – Digenea: This contains parasites of medical and economic importance to man and therefore will be dealt with more extensively.

2.0 Objectives

At the end of this unit, you should be able to

- identify the striking features of digenetic trematodes
- describe the morphology of the egg, larva, and adult stage of various digenetic trematodes
- explain the general transmission patterns of some trematodes.

3.0 Main Content

3.1 The Adult Digenean Fluke

The basic body form of the adult trematode takes a number of different forms, some of which are illustrated below;

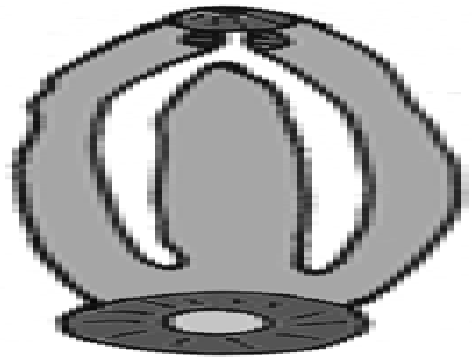


Fig 1.1: Amphistomee

These have Large Fleshy Bodies, with a Prominent Sucker at the Posterior of the Body (e.g. Gastrodiscoides Hominis).

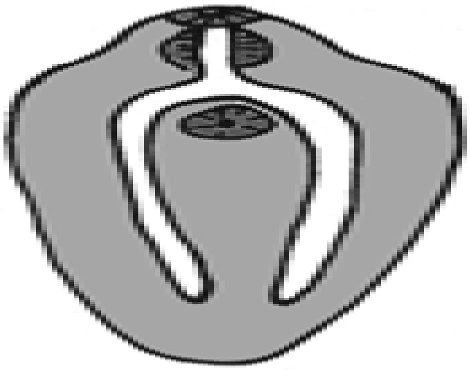


Fig 1.2: Distome

These are the most Common Type, with the Mouth Surrounded by the Oral Sucker and a Ventral Sucker, Present Anywhere on the Ventral Surface Except the Extreme Posterior (e.g. Fasciola Hepatica)

Fig 1.3: Echinostome

Similar to the Distomes, Except that the Oral Sucker Is Surrounded by a Prominent Collar, Equiped with Spines (e.g. Echinostoma Sp.)

Fig 1.4: Monostome:

In these there is either only One Sucker Present (Usually only the Oral Sucker), or there are Two Suckers, but One Very Reduced, or in some Cases no Suckers (e.g. Notocotylus Attenuatus).

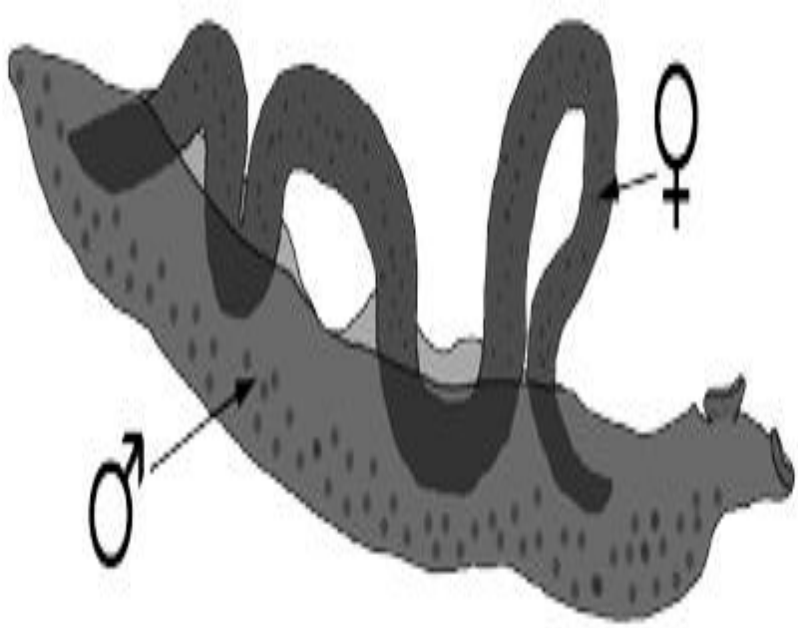


Fig 1.5: Schistosome

Elongate trematodes, with separate sexes, the male generally larger, holding the female within a groove formed by a folding of the male body (the gynaecophoric canal). Found within the circulatory system. (e.g.Schistosoma mansoni).

There are other forms as well, for example the 'Holostome' type, where the body of the trematode is divided into two distinct regions, the anterior of which may hold an additional adhesive organ, (e.g. Diplostomum sp.), and the 'Gasterostome', where the gut is a very simple, sac like, structure, attached to a mouth situated near the centre of the body (reminiscent of the arrangement of some of the free living platyhelminthes).

3.2 The Basic Lifecycle of the Major Groups of the Digeneans

Most digeneans are hermaphroditic (the major exception being the schistosomes, and one other group). In the majority of these parasites self fertilisation may occur, but cross fertilisation between different individuals is more generally the rule. The sperm enter the female system, either via the Laurers canal or more commonly through the common genital atrium, which opens into the uterus.

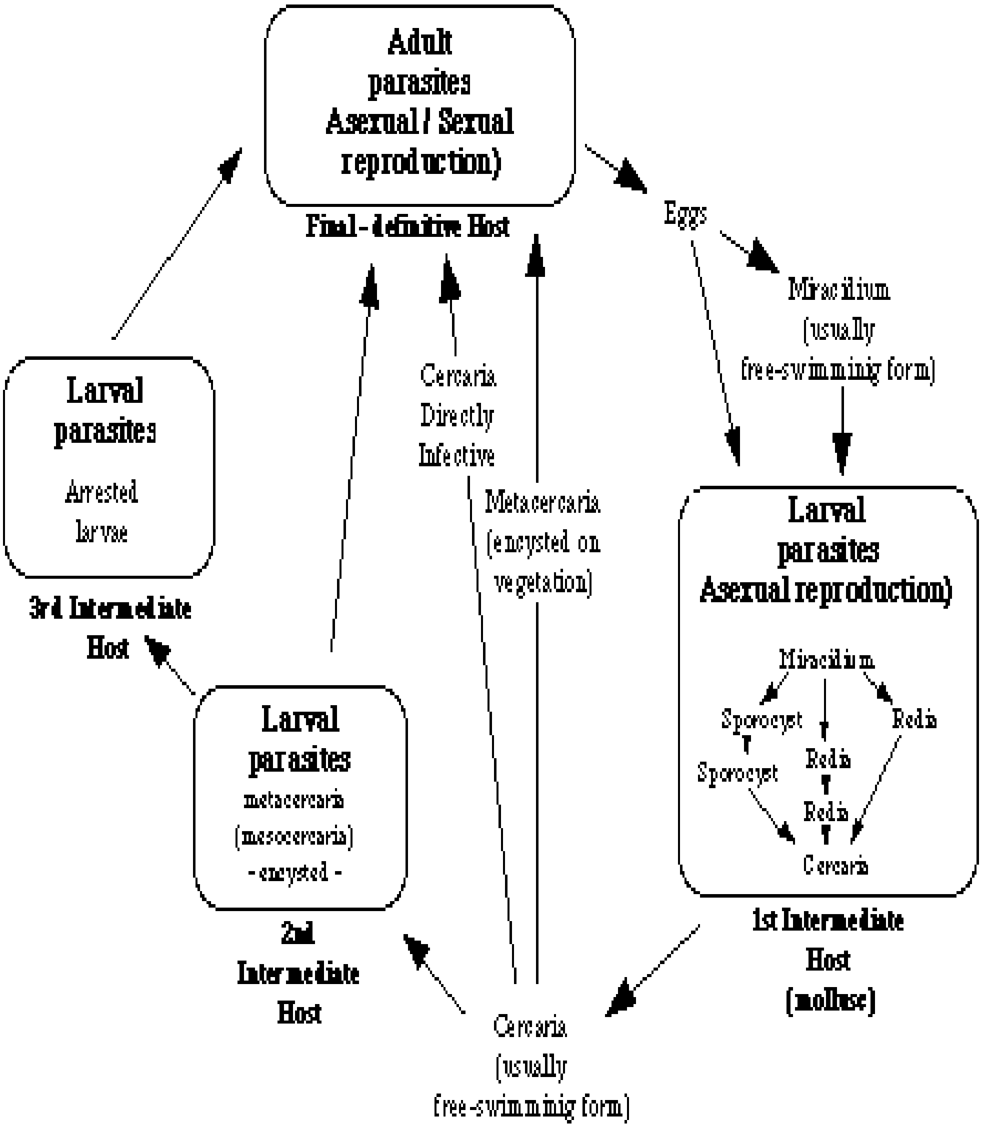


Fig 1.6: The Generalised Life Cycle of Digenetic Trematodes (Imgarcade.Com)

3.3 The Digenean Trematode Egg

The formation of the digenean egg follows that described for the platyhelminthes as a group. Briefly, as the egg enters the öotype of the fluke it becomes surrounded by a predetermined number of vitelline cells, the number of which will be specific for different parasites, which form the food reserve of the egg. These vitelline cells produce globules of a mixture of proteins and phenols, which are extruded to the outer surface of the developing egg. Here the phenols oxidise to form quinone, which then coalesces with the protein, reacting to form scleratin, a hard inert Yellowish substance, making up the egg shell.

As the eggs of different species may vary in thickness, their colours may vary from yellow; to a dark brown. The digenean egg is usually operculate, in common with other platyhelminthes. Exceptions to this may occur however, the most important being with the schistosomes. Here the eggs are non-operculate, and are ornamented with spines, the appearance of which are characteristic for different species of schistosome.

Fig 1.7: Operculate Egg

The eggs hatch of operculate eggs involves the release of the opercular cap. This takes place under a variety of conditions, modified according to the particular species of trematode. For example some trematode lifecycles involve the ingestion of the egg before hatching (e.g. Dicrocoelium dendriticum, the lancet fluke), whilst others such as those of Fasciola hepatica, (the liver fluke), hatch in water.

For the eggs that hatch in the external environment, a number of factors may be important, for example light, temperature and changes in osmotic pressure. Again the exact details of these environmental requirements will be optimised for the particular conditions which will maximise the chances of completion of the parasite lifecycle.

In all cases the egg hatches to release the miracidium.

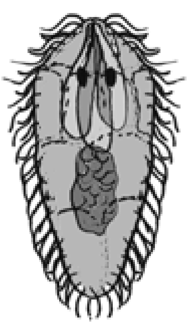
3.4 The Larval Digeneans

The Miracidium

The miracidium is the name of the ciliated larval stage that is hatched from the digenean egg. In comparison with the other larval platyhelminthes, it is very similar to the larvae of the monogeneans, (the oncomiracidium) and the larval cestodarian, or lycophore. In most cases the miracidium is usually a free swimming stage, that seeks out the primary, and in some cases only, intermediate hosts of these parasites. In all cases these primary, or 1st intermediate hosts are molluscs.

In the few examples where the miracidium is not a free swimming stage the eggs are ingested, as with the lancet fluke Dicrocoelium dendriticum. Here the eggs hatch in the intestine of the mollusc liberating the miracidium, from where it immediately penetrates the intestinal wall to invade the molluscan tissues. In the free swimming miracidia the larval parasite exhibits distinct behavioural responses that enable it to enter the environment of or detect the presence of its hosts. These behavioural responses have principally been studied in the case of the schistosome miracidium.

Morphologically, the surface of the miracidium is covered with a series of ciliated plates, which may be clearly seen using electron microscopy after the removal of cilia. These ciliated epidermal plates (in some species the cilia being replaced by spines) are discontinuous, not being in contact with each other but being separated by extensions of the underlying subepidermal layer. The whole structure is being illustrated below.



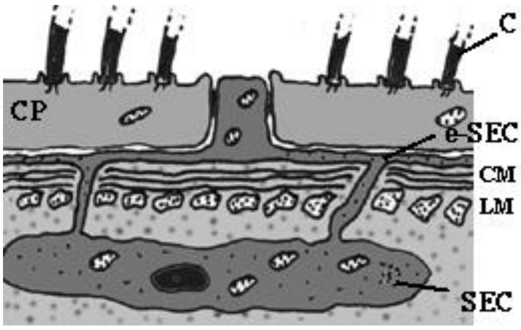


Fig 1.8

CP = Ciliated Plate
C = Cilia
SEC = Sub-epithelial cell
e-SEC = extension of subepithelial cell
CM = Circular Muscle
LM = Longitudinal Muscle

The plates themselves show a definite arrangement, being placed in four to five transverse rows, the exact arrangement of which may vary between different trematodes. Beneath the plates are layers of muscle fibres. At the anterior end of the larvae is a non-ciliated conical projection, the terebratorium, (or anterior papillae), bearing apertures of the apical and penetration glands. These they are found at the anterior end of the body. Miracidia possess a number of sensory organs, the most important of which are the dorsaly situated eye spots, beneath which is found the cerebral mass. Other sensory organs are situated within folds of the terebratorium. Below all of the structures is found the miracidium's large rounded germinal cells, which are often grouped in clusters called germ balls.

Finally the miracidia possess a protonephridial excretory system, basically similar to that found in the adult parasites. On examination of eggs containing mature miracidia, it is clearly seen that flame cell activity is the first sign of the initiation of hatching of the egg. On invasion of the molluscan tissue the miracidium sheds its ciliated plates, in almost all cases rapidly transforming into an endoparasitic form, the sporocyst, although in a few unusual groups the miracidium may contain a fully developed redia.

The Sporocyst
The sporocyst develops within the molluscan host as a hollow fluid filled germinal sac, into which protrude germinal masses. At the conical anterior of the sporocyst body a birth pore is located, from which subsequent generations of larvae emerge. The germinal masses develop internally into either daughter sporocysts, which are essentially the same as their parent sporocysts, or into a second larval stage, the redia.

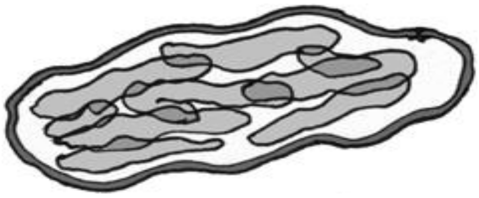


Fig 1.9: The Sporocyst

The Redia

The redia are the second larval form to develop within the molluscan host (but may be absent in some groups, such as the schistosomes). They are similar to sporocysts, containing germinal masses within a fluid filled sac, which may develop into either second generation daughter redia, or more commonly into the final larval stage within the mollusc, the cercaria.

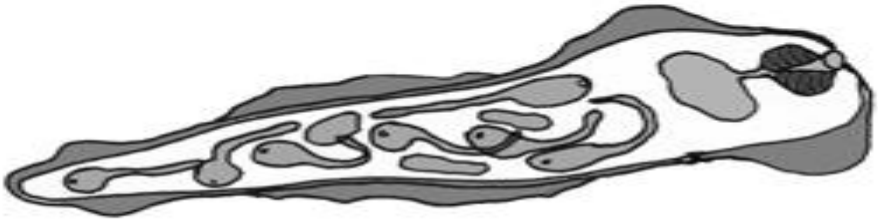


Fig 1.10

They differ from the sporocysts however, in that they are a much more active form, and importantly they possess simple gut. The tissue they feed on is predominantly molluscan in origin, but the redia of some groups (e.g. those of the echinostomes) may actively seek out the developmental stages of other trematodes (e.g. schistosome sporocysts) within the same intermediate.

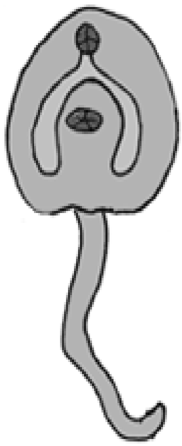
The gut itself consists of a mouth, opening into a large muscular pharynx, which in turn opens into a simple rhabdocoel like intestine. Externally, behind the mouth many redia have a ridge-like collar, below which the birth canal opens and from which either cercariae or daughter redia emerge. Further along the body are lobelike extensions of the body, which are thought to aid the movement of the parasite within its host's tissues.

An interesting exception to the general rule that cercaria are produced by the redia is found in a few tremadodes where the redia produce progenetic metacercaria, fully capable of producing viable eggs. In these few very unusual cases, the trematode may only have a single molluscan host, although the metacercaria may still be capable of developing in a second host as well. Exceptions such as these, and those described above involving miracidia containing fully developed redia is evidence of the evolutionary past of these organisms.

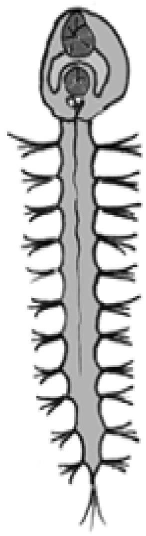
It has been noted that the redia bears some resemblance to some of the more advanced turbellarians, and as described above, this stage is a very active form of the parasite, fully capable of actively ingesting host material, and in some cases even predation of competing parasites within their hosts. It has been postulated that the group as a whole emerged from an ancestral parasitic turbellarian, with a single molluscan host, after the development of internal division and asexual reproduction, later developing specialised forms to exploit the varying environments that these organisms have to cope with.

The Cercaria

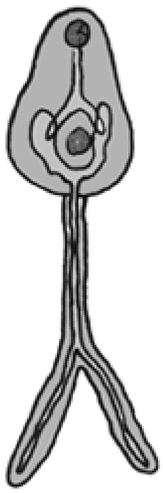
Some of the types of Cercariae



Gymnocephalus (e.g. *Fasciola* sp.)



Trichocercous (e.g. *Donax* sp.)



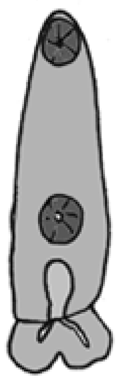


Fig. 1.11: Furcocercous (e.g. Schistosoma Sp.)   Microcercous (e.g. Bithynia Sp.)

In almost all species of trematode, it is the cercarial stage that emerges from the mollusc, and is the infective form for the vertebrate host, although there may be exceptions to this general rule. For example in some cases a sporocyst, modified to have a thickened internal wall resistant to the environment, emerges, to be ingested by a second intermediate host, (e.g. as is the case in the trematode Dicrocoeloides petiolatum). Other exceptions, involving redia producing progenetic metacercaria, have already been described above.

The trematode cercaria exhibits considerable variations in structure, which is very important taxonomically, and reflects in many cases adaptations to the specific lifecycle of the parasite involved. Because of this great diversity of form, a system of cercarial classification has evolved, based on the gross morphology of these larval forms. Firstly cercariae may be divided into three major groups;

- Monostome Cercariae - These lacks a ventral sucker, and have simple tails. These forms develop within rediae
- Amphistome Cercariae - In these the large ventral sucker is situated at the base of a slender unbranched tail. These forms develop within rediae.
- Distome Cercariae - This is the commonest cercarial form, with the ventral sucker

  lying some distance from the posterior end, in roughly the anterior third of the body.

These distome cercariae may themselves be divided into a large number of subgroups, based on other morphological features, particularly the form that the cercarial tail takes. Some of these forms are described below;

a) Leptocercous Cercariae - These cercariae have straight slender tails, which are much narrower than the cercarial body. This form is further subdivided into;

Gymnocephalous Cercariae - In these, the suckers are equal in size. This is a common form, represented within such species as Fasciola hepatica, and develops within rediae

Xiphidiocercariae - These are similar to the gymnocephalous forms, but in these the oral sucker is equiped with a stylet, used in penetration of their next hosts, and they generally develop within sporocysts

Echinostome Cercariae - In these there is a ring of spines at the anterior end of the larvae, as in adult forms of these parasites. These are found within trematodes of the genus Echinostoma, and develop within rediae.

b) Trichocercous Cercariae - These forms have long tails, equiped with rings of fine bristles. They are usually found in marine trematodes.

c) Cystocercous Cercariae - In these the end of the tail is highly enlarged, with a cavity into which the larval body may be retracted. These usually develop within sporocysts.

d) Microcercous Cercariae - Cercaria with vestigial tails, and which may develop within both rediae and sporocysts.

e) Cercariaea Cercariae - Cercaria with no tails, where the cercaria is not a free swimming form, and may develop within both rediae and sporocysts.

f) Furcocercous Cercariae - In these the tails are forked at the end. The cercaria of the most important group of trematodes, the schistosomes, has cercariae of this form. This form develops within sporocysts.

Otherwise, both externally and internally the structure of the body of the cercaria resembles that of the adult trematode into which they grow. For example, the ring of spines found at the anterior end of echinostome cercariae is also present in the adult flukes.

The outer surface of the cercaria is a tegument, which may however differ from that found in the adult form in a number of ways. For example in the schistosomes the tegument is covered with a trilaminate plasma membrane, (as opposed to the two bi-lipid membranes found in the adult), on the outer surface of which there is a glycocalyx, (absent in the adult).

However, many other features of this tegument appear similar to that of the adult, the differences almost certainly being adaptations due to the differing environments that these two lifecycle stages experience. For example, spines found on the surface of both forms of tegument, and the overall structures of a syncytium conected to subtegumental cells are the same. Within the cercarial body a number of different types of gland cells may be found, including cystogenous gland cells, used by the larvae to secrete a cyst wall during the formation of the metacercarial stage, and penetration gland cells, used by the cercaria to penetrate its next host, either a second intermediate host, or in some groups the definitive host, (such as the schistosomes), where the cercaria is the final larval stage.

The cercariae released from their molluscan intermediate host are usually a free swimming form. These must then locate either their next, and usually final intermediate host, their definitive host which they actively penetrate (e.g. in members of the family Schistosomatidae), or locate a suitable solid substrate to encyst upon, or be ingested by their definitive host (members of the family Azygiidae).

To locate these various targets the cercariae are equipped with a variety of sensory organs. These commonly include two or more eye spots, as well as touch receptors, and allow specialised cercarial behaviour, designed to bring the cercariae into an environment giving the maximum probability of infecting their next hosts. For example, the cercariae of the schistosomes exhibit negative phototrophy (swimming to the surface of the water), and positive thermotrophy and thigmotrophy, being attracted to warm objects moving in the water.

As well as these behavioural responses within the free swimming cercariae, the parasite exhibits definite circadian rhythms in terms of shedding from the molluscan host, again being shed at times optimal for bringing them into contact with their next host. For example, the schistosome cercariae are generally shed during daylight, in the morning, whilst those of other species emerge only at night.

In a few groups such as Alaria spp, however, the parasite employs three intermediate hosts. In these cases the cercaria penetrates the second intermediate host to form a resting stage, the mesocercaria described below. In these cases this second intermediate host is in turn ingested by a third intermediate host, where it encysts to form a metacercaria.

The Mesocercaria

The mesocercaria is essentially a resting stage within the parasitic life cycle, employing a second intermediate host in a parasite lifecycle utilising four hosts. The mesocercaria is a definite prolonged stage in the adult generation of strigeate trematodes, which closely resembles the cercarial body, from which it develops in the second intermediate host, and which does not possess metacercarial features; it develops in turn into the metacercaria in another host.

In parasites having this larval stage the mesocercaria are capable of infecting and surviving within a very wide range of paratenic hosts which may ingest the second intermediate host, thus in effect increasing the number of hosts which the parasite may use in its lifecycle. For example, amphibians infected with mesocercaria of Alaria may themselves infect a wide variety of other amphibians, reptiles, birds and mammals if they are ingested by these animals.

The Metacercaria

This is a much more common "resting" larval stage of the trematode parasitic lifecycle, formed either in a final intermediate host (when a mesocercaria, or more commonly a cercaria enters its body), or on a solid substrate in the external environment. The final intermediate host may be a fish (e.g. Opisthorchis sinensis), an arthropod (e.g. Dicrocoelium dendtriticum, employing an ant second intermediate host, and Paragonimus westermani employing a crustacean), or another mollusc, as with some of the echinostomes. As stated above, some trematodes however do not have second intermediate hosts, but either encyst as metacercariae on solid substrate's, such as aquatic vegetation or on shells of aquatic organisms, which will in turn be ingested by the parasites definitive host, or in some groups such as the schistosomes, as already described, the cercariae directly penetrate the skin of, and infect, the parasites definitive host.

Although generally the metacercariae are inactive encysted forms, the metacercaria of some species do remain free and action. In most other metacercariae however, encystment does occur. The structure of the cyst wall itself varies considerably, though generally it is a complex mixture of tanned proteins, lipids and polysaccharides. Within the cyst wall the morphology of the larva usually closely resembles that of the cercarial body, although as described above, in some groups sexual maturation may occur either fully or partially. To continue further the metacercaria must be ingested, either along with the body of the intermediate host it inhabits by a carnivorous definitive host, or along with the vegetation it has encysted on by a herbivorous or omnivorous host.

The Larval Digeneans - the Juvenile Adult Stages
On ingestion the metacercaria (or cercaria) must transform into the adult form. The precise details of this process will vary considerably, depending on how the definitive host was infected. For example, in some species the adult flukes are found within the alimentary tract. In these cases the metacercarial cyst wall is broken down to release what is essentially a young fluke, which only has to migrate a short distance to reach their preferred site within the hosts body.

In other groups however the adult forms are located in other sites within the body. In these cases the liberated young fluke must penetrate the gut wall, or in the case of the schistosomes penetrate the hosts skin. Then they must undergo a migration through the hosts body. This is usually via the circulatory system, but again the precise details of the migratory path will vary considerably.

3.5 Features of Digenetic Trematodes

- Digenetic trematodes are unsegmented leaf-shaped worms that are flattened dorsoventrally.
- They bear 2 suckers, one surrounding the mouth (oral sucker) and another on the ventral surface of the body (ventral sucker). These serve as the organs of attachment.
- The sexes of the parasites are not separated (monoecious). An exception is schistosomes, which are diecious (unisexual).
- The alimentary canal is incomplete, and no anus is present.
- The excretory system is bilaterally symmetrical. It consists of flame cells and collecting tubes. These flame cells provide the basis for the identification of the species.

- The reproductive system consists of male and female reproductive organs and iscomplete in each fluke.
- The flukes are oviparous. They lay operculated eggs. An exception is schistosome eggs, which are not operculated.
- All have complicated life cycles, with alternating asexual and sexual developments in different hosts.

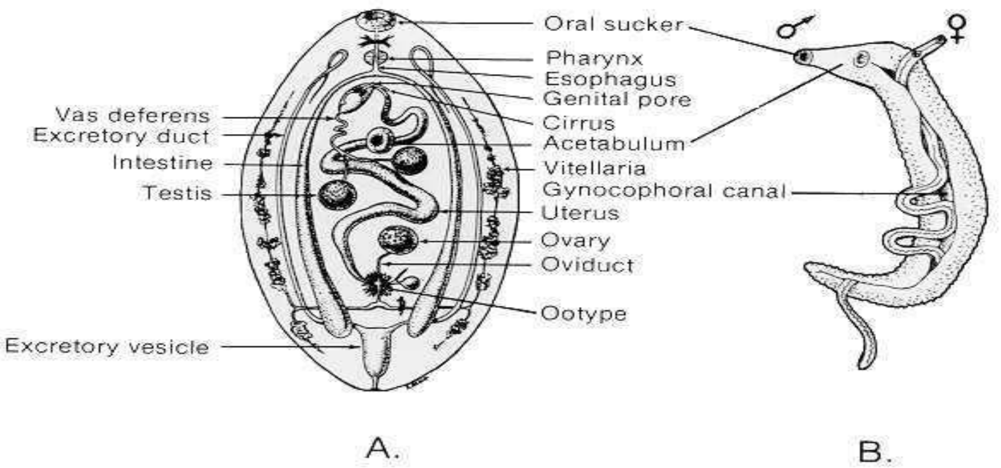


Fig1.12 Structure of Digenetic Flukes. (A) Hermaphroditic Fluke. (B) Bisexual Fluke.

4.0 Conclusion

In this unit, we have learnt that digineans are medically important trematodes. The digenea are unsegmented leaf-shaped worms that are flattened dorsoventrally with two suckers (the oral sucker and ventral sucker). The digeneans have heteroxenous life cycles having one or more intermediate hosts. The adult worms lay eggs within the definitive host which hatch miracidia in water medium. Miracidia develop within the snail intermediate hosts of particular species. The life cycles continue following a specific pattern depending on the parasites' species giving rise to other larval stages like sporocysts, rediae, cercariae and metacercariae.

5.0 Summary

In this unit, you have learnt about the following:

- The adult digenean fluke
- The basic lifecycle of the major groups of the digeneans
- The digenean trematode egg
- The larval digeneans
- Features of digenetic trematodes.

6.0 Self-Assessment Exercise

Activity: Observe the larval digeneans under a microscope and report your findings in the log book.

Answer the following questions:

1. What are the striking features of digenetic trematodes (LO1)?
2. Outline the features of digenetic trematodes (LO3)With a well labeled diagram describe the generalised life cycle of digenetic trematodes (LO2)
3. Write short note on the following:
    a. The miracidium
    b. The sporocyst
    c. The redia
    d. The cercaria
    e. The mesocercaria
    f. The metacercaria
    g. The juvenile adult stages (LO2)

7.0 References/ Further Reading

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Unit 2 Classification of Digenetic Trematodes According to Their Habitat

1.0 Introduction

The digeneans are a group of specialised endoparasitic platyhelminthes. A common feature is that all have complex lifecycles, involving one or more intermediate hosts, the first of which is always a mollusc, which is usually aquatic. As adults they are found in most vertebrates groups, including fish, amphibians, reptiles, birds, and mammals, acting as definitive hosts, where they may be highly pathogenic. They may be located in most of the internal organs of these definitive hosts, including the lungs, bladder and blood stream, although the majority are found in the gastrointestinal tract, or closely associated organs such as the bile duct and liver. They exhibit a flattened leaf-like body, structurally similar to many of the free living turbellarians. The digeneans are classified below based on their locations in the definitive hosts.

- Blood flukes - Schistosoma haematobium, S. mansoni, S. japonicum, S. mekongi and S. intercalatum
- Liver flukes - Fasciola hepatica, F. gigantica, C sinensis, Opisthorchis felineus, O viverrini, Dicrocoelium dendriticum, and D. hospes
- Pancreatic flukes - Eurytrema pacreaticum, E. coelomaticum, and E. ovis
- Lung flukes -Paragonimus westermani, P. mexicana, and P. skrjabini
- Intestinal flukes – Fasciolopsis buski, Metagonimus yokogawai, Echinostoma ilocanum, Watsonius watsoni, Heterophyes heterophyes, and Gastrodiscoides hominis.

2.0 Objectives

At the end of this unit, you should be able to;

- explain the transmission cycles of digenetic trematodes
- describe types of digeneans with examples
- identify the factors responsible for transmission of digenetic trematodes
- identify the control measure to be taken to prevent transmission of digenetic trematodes
- identify each parasite using the diagnostic features of the eggs
- explain the pathology caused by parasite.

3.0 Main Content

3.1 Blood Flukes (Schistosoma Species)

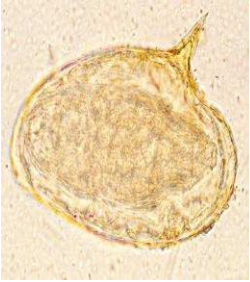
Schistosomiasis, or bilharzia, is a tropical parasitic disease caused by blooddwelling fluke worms of the genus Schistosoma. Over 200 million people are infected in at least 75 countries with 600 million or more people at risk of infection. The main schistosomes that infect human beings include S haematobium (transmitted by Bulinus snails and causing urinary schistosomiasis in Africa and the Arabian Peninsula), S mansoni (transmitted by Biomphalaria snails and causing intestinal and hepatic schistosomiasis in Africa, the Arabian peninsula, and South America), and S japonicum (transmitted by the amphibious snail Oncomelania and causing intestinal and hepatosplenic schistosomiasis in China, the Philippines, and Indonesia).

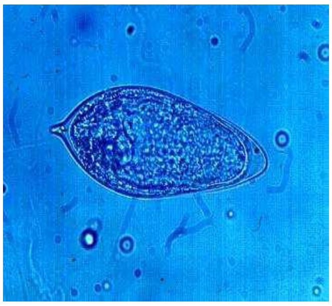
S. intercalatum and S. mekongi are only of local importance. S. japonicum is a zoonotic parasite that infects a wide range of animals, including cattle, dogs, pigs, and rodents. S. mansoni also infects rodents and primates, but human beings are the main host. A dozen other schistosome species are animal parasites, some of which occasionally infect humans. Unlike other trematodes, schistosomes have separate sexes, but males and females are found together. The male is short and stout and holds the relatively long female worm in its gynaecophoric canal, a groove like structure.

With S.haematobium, both male and female live together in the veins that drain the urinary bladder, pelvis, and ureter, whereas S. japonicum and S. mansoni live in the inferior and superior mesenteric veins, respectively. Hence, these flukes are known as blood flukes. These species are distinguished from the other Schistosoma species based on the morphology of their eggs and their adult and cercarial forms. S. haematobium eggs have a terminal spine, whereas S. mansoni and S. japonicum eggs have lateral spines and central spines, respectively.

Morphology
The adult males measure up to 15 millimetres in length and females up to 10 mm. The schistosomes remain in copula throughout their life span, the uxorious male surrounding the female with his gynaecophoric canal. The male is actually flat but the sides roll up forming the groove. The cuticle of the male is covered with minute papillae. The female only possess these at the anterior and posterior end as the middle section being covered by the male body. Oral and ventral suckers are present, with the ventral one being lager serving to hold the worms in place,preventing them from being carried away by the circulatory current.

The ova of S. mansoni are 114-175 µm long by 45-68 µm wide. They are light yellowish brown, elongate and possess a lateral spine. The shell is acid fast when stained with modified Ziehl-Neelsen Stain.





A b c

***Fig 1*: Saline Smear Of (A) S. Mansoni (B) S. Japonicum (C) S. Haematobium Ova showing their Spine Position; A Good**

Distinguishing Feature when Identifying Schistosome Ova

Comparative Features of Major Human Schistosoma Species

Stages	S. haematobium	S. mansoni	S. japonicum
Adult			
Body surface of Male	Finely tuberculate	Grossly tuberculate	Nontuberculate(smooth)
Testes	4-6, in a cluster	6-9, in a cluster	7, in a linear series
Position of ovary	Posterior to middle of body	Anterior to middle of body	Posterior to middle of body
Number of eggs in uterus	20-30	1-4	50-300
Egg Size and shape	110-170 µm long 40-70 µm wide Terminal spine	114-175 µm long 45-68 µm wide Lateral spine	70-100 µm long 50-65 µm wide Central spine
Cercaria Cephalic glands	2 pairs, oxyphilic	2 pairs, basophilic 4	pairs, oxyphilic

Life Cycles and Transmission of Schistosomes

Once the eggs are laid by the adult female worms, the majority of them first pass through the veins of the blood vessel in which the worm is living, and then into the lumen of the intestine and are passed in the faeces (S. mansoni and S. japonicum) or into the lumen of the bladder, and are then passed in the urine (S.haematobium). Those eggs that reach fresh water hatch, releasing a miracidium which, to develop further must infect a specific snail species within 24 hours. The eggs of each species are markedly different but each produce virtually identical miracidium. A single miracidium can multiply in the snail to produce nearly 100,000 cercariae.

Asexual multiplication takes place in the snail, and results in the release of cercariae (minute in size with forked tails, 200mm long) into the water about 3 – 6 weeks later. Cercariae actively swim around and when they have located, or come into contact with a definitive host, they actively penetrate the skin. They can stay active looking for a host for 24-48 hours after which if they don't find a host they will die.

The head of the cercariae migrates to the liver and develops into either adult male or female worms (flukes), where they pair up and then migrate to their region of the venous blood system (species specific sites). The females leave the males and moves to smaller venules closer to the lumen of the intestine or bladder to lay her eggs (about 6 weeks after infection). The majority of adult worms live from 2-4 years, but some can live considerably longer.

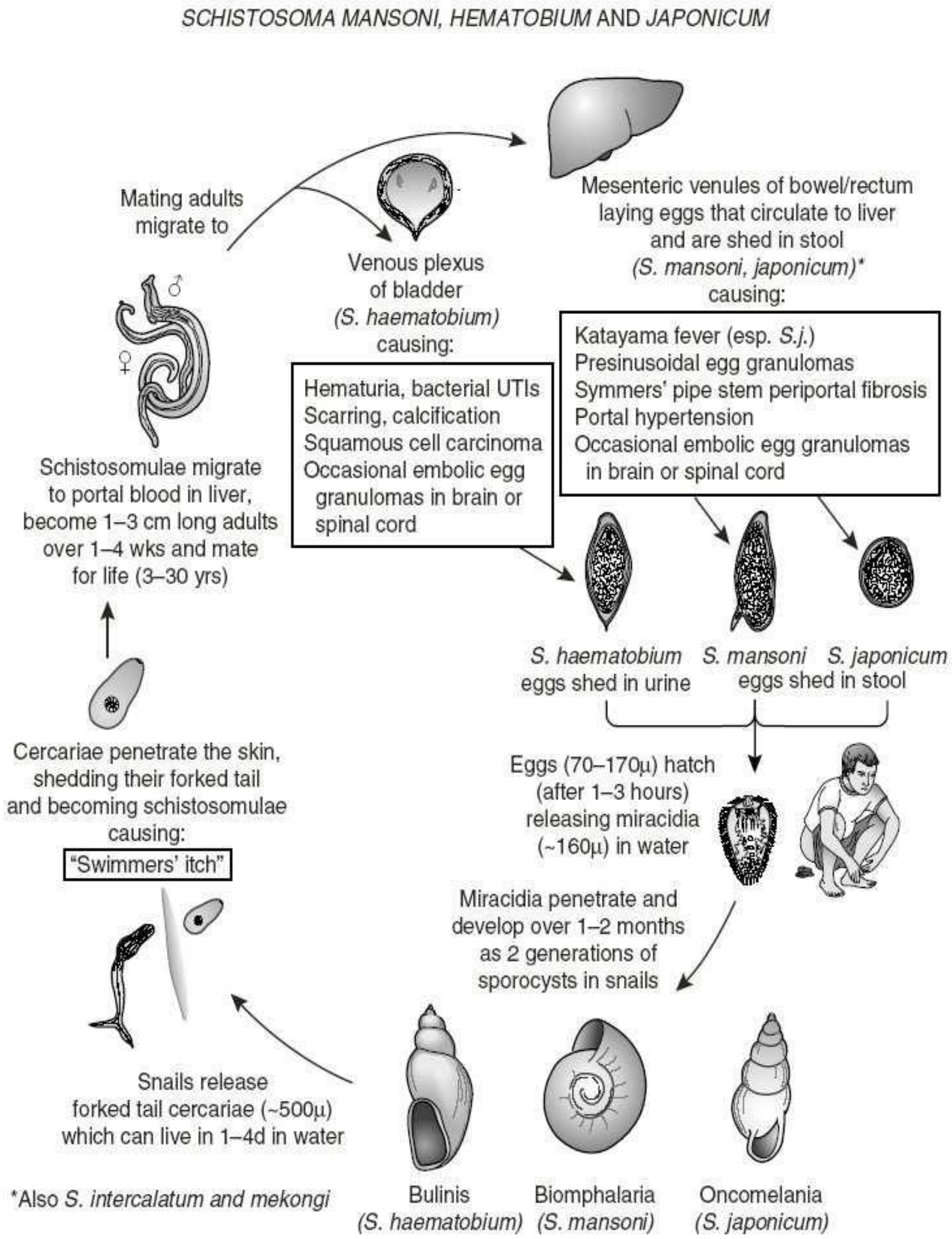


Fig. 2: Life Cycle of Schistosoma spp

Vectors and Geographical Areas Associated with Certain Trematode Types

Snail Host	Geographical Area	Trematode

Biomphalaria glabrata	Brazil	S. mansoni
Biomphalaria pfeifferi	Nigeria	S. mansoni
Bulinus globosus	Nigeria	S. haematobium
Bulinus truncates	Iran	S. haematobium
Oncomelania hupensis nosophora	Japan	S. japonicum
Thiara granifera	China	Paragonimus westermani
Semisulcospira libertine	China	Paragonimus westermani
Pirenella conica	Egypt	Heterophyes heterophyes
Lymnaea truncatula	England	Fasciola hepatica
Lymnaea natalensis	Nigeria	Fasciola gigantic

Pathology and clinical symptoms
Acute Manifestations

- Cercarial dermatitis, also known as swimmer's itch, is an allergic reaction caused by the penetration of cercariae in persons who have been exposed to cercariae in salt water or fresh water. Cercarial dermatitis manifests as petechial haemorrhages with oedema and pruritus, followed by maculopapular rash, which may become vesicular. The process is usually related to avian schistosomal species of the genera Trichobilharzia, Gigantobilharzia, and Orientobilharzia, which do not develop further in humans.
- ii. Katayama syndrome corresponds to maturation of the fluke and the beginning of oviposition. This syndrome is caused by high worm load and egg antigen stimuli that result from immune complex formation and leads to a serum sickness –like illness. This is the most severe form and is most common in persons with S mansoni and S japonicum infections. Symptoms include high fever, chills, headache, hepatosplenomegaly, lymphadenopathy, eosinophilia, and dysentery. A history of travel in an endemic area provides a clue to the diagnosis.

Chronic Manifestations

- Symptoms depend on the Schistosoma species that causes the infection, the duration and severity of the infection, and the immune response of the host to the egg antigens.
- Terminal haematuria, dysuria, and frequent urination are the main clinical symptoms of urinary schistosomiasis.
- The earliest bladder sign is pseudotubercle, but, in long-standing infection, radiography reveals nests of calcified ova (sandy patches) surrounded by fibrous tissue in the submucosa.
- Dysentery, diarrhoea, weakness, and abdominal pain are the major symptoms of intestinal schistosomiasis.
- A reaction to schistosomal eggs in the liver causes a periportal fibrotic reaction termed Symmers clay pipestem fibrosis.
- Haemoptysis, palpitation, and dyspnea upon exertion are the symptoms of schistosomal cor pulmonale that develops as a complication of hepatic schistosomiasis.

- Headache, seizures (both generalised and focal), myeloradiculopathy with lower limb and back pain, paresthesia, and urinary bladder dysfunction are the noted symptoms of CNS schistosomiasis due to S.japonicum infection.

Diagnosis

Intestinal schistosomes

- Laboratory confirmation of S. mansoni and S. japonicum infection can be made by finding the eggs in the faeces. When eggs cannot be found in the faeces, a rectal biopsy can be examined.
- Serological tests are of value in the diagnosis of schistosomiasis when eggs cannot be found. An enzyme linked immunosorbent assay (ELISA) using soluble egg antigen, is employed at HTD.

Urinary schistosome

The definitive diagnosis of urinary schistosomiasis is made by finding the characteristic ova of S. haematobium in urine. Terminal urine should be collected as the terminal drops contain a large proportion of the eggs. The urine can then be centrifuged and the deposit examined microscopically for ova. Eggs can sometimes be found in seminal fluid in males.

- A bladder biopsy is seldom necessary to make the diagnosis. A rectal snip may show the presence of ova as they sometimes pass into the rectal mucosa.
- Serological tests can be of value when eggs cannot be found in clinical samples. An enzyme linked immunosorbent assay using soluble egg antigen to detect antischistosome antibody is most sensitive.

Note: There is a marked periodicity associated with the time when most eggs are passed out. Higher numbers of eggs are encountered in urine specimens passed between 10 am and 2pm, presumably as a result of changes in the host's metabolic and physical activities.

Epidemiology of Schistosomiasis

The following factors are of epidemiological importance in the transmission of schistosmiasis:

- The presence of water bodies such as rivers, streams, lakes, dams suitable for the breeding of the snail intermediate hosts
- Presence of appropriate snail hosts necessary for the developments of the asexual stages and transmission of the infective stage to the human definitive host
- Contamination of natural water bodies with infected human urine and faeces
- Human water contact activities including swimming, laundry and fetching
- Factors that promote intramolluscan development of parasite and subsequent transmission to man
- Socio-economic status of the people such as good sanitary system and water supply

Control

- Reduction of human-water contact
- Improved sanitation by proper waste disposal

- Attacking the adult forms of parasite through chemotherapy to reduce the worm burden or egg production
- Eradication or reduction of snail population through the use of molluscicides
- Development of vaccine to induce immunity
- Modification of the ecology of the snail habitat
- Biological control through the introduction of competitors' snails into the snail habitat
- Education.

3.2 Lung Flukes (Paragonimus Species)

The genus Paragonimus contains more than 30 species that have been reported to cause infections in animals and humans. Among these, approximately 10 species have been reported to cause infection in humans, of which P. westermani is the most important. P. westermani, also known as the Oriental lung fluke is most common in China, Korea, Thailand, Philippines, and Laos. Isolated endemic foci have also been reported from the states of Manipur, Nagaland, and Arunachal Pradesh in India. A low prevalence has been reported from African countries of

Cameroon,Nigeria, where infections with Paragonimus Africanus and Paragonimus uterobilateralis were reported. Humans are infected by eating raw or partially cooked crab or crayfish or crabs soaked in wine as a food delicacy or by drinking juice from raw crabs or crayfish as a part of a food habit.

It inhabits parenchyma of the lung close to bronchioles in humans, foxes, wolves, and various feline hosts (e.g, lions, leopards, tigers, cats). Paragonimus species belong to the family 'Troglotrematidae' and they possess the following striking features:

- The adult worm is reddish brown fluke.
- The body of adult worm is thick, fleshy, and ovoid in shape
- The tegument is spiny or scaly
- Have weak suckers
- Testes lie side by side
- Uterus is short with a few tight uterine coils forming a 'rosette'
- Extensive vitellaria in lateral fields
- Cercariae are microcercous xiphidiocercariae
- The eggs are ovoid, brownish yellow, thick shelled and operculated.

Life Cycle and Transmission

The infection is typically transmitted via ingestion of metacercariae contained in raw freshwater crabs or crayfish. Additionally, consumption of the raw meat of paratenic hosts (e.g, omnivorous mammals) may also contribute to human infection. Freshwater snails and crabs are first and second intermediate hosts of Paragonimus species, respectively. In the duodenum, the cyst wall is dissolved, and the metacercariae are released. The metacercariae migrate by penetrating through the intestinal wall, peritoneal cavity, and, finally, through the abdominal wall and diaphragm into the lungs. There, the immature worms finally settle close to the bronchi, grow, and develop to become sexually mature hermaphrodite worms.

Adult worms begin to lay the eggs, which are unembryonated and are passed out in the sputum. However, if they are swallowed, they are excreted in the feces. The eggs develop further in the water. In each egg, a ciliated miracidium develops during a period of 2-3 weeks. The miracidium escapes from the egg and penetrates a suitable species of snail (first intermediate host), in which it goes through a generation of sporocysts and 2 generations of rediae to form the cercariae. The cercariae come out of the snail, invade a freshwater crustacean (crayfish or crab), and encyst to form metacercariae. When ingested, these cause the infection, and the cycle is repeated.

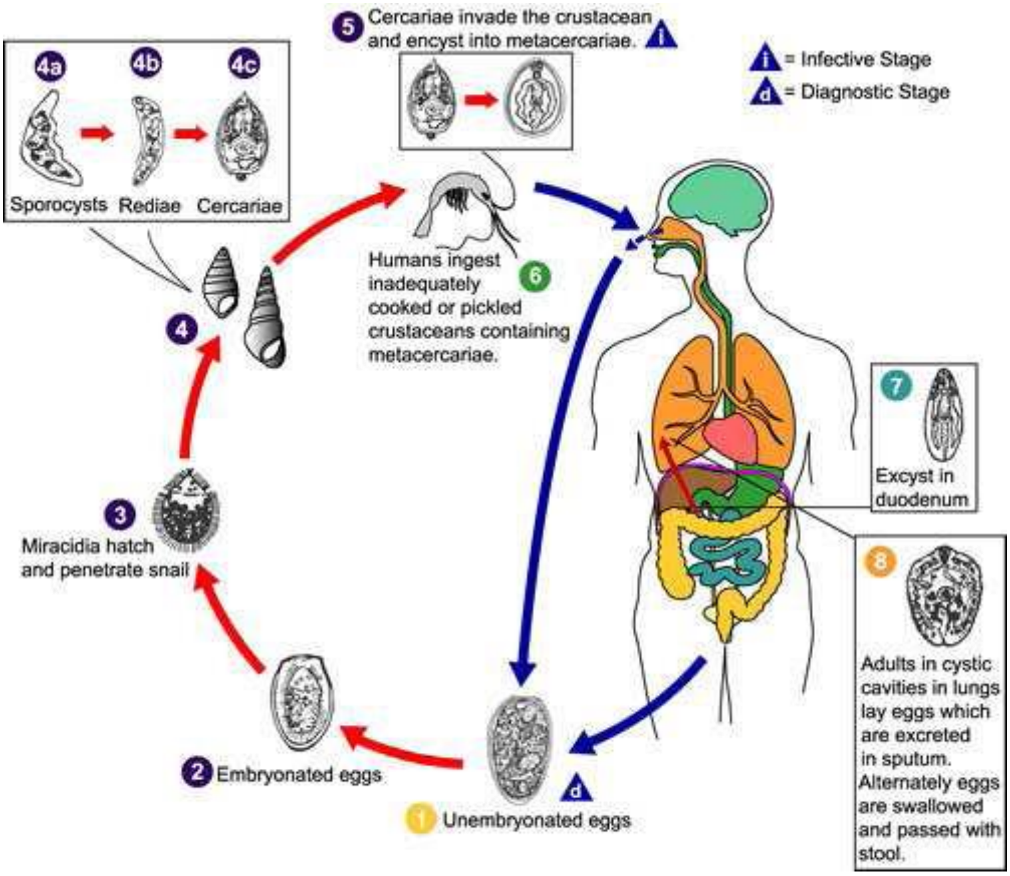


Fig. 3: Life Cycle of Paragonimus Spp

Pathology and Clinical Symptoms

- Acute Manifestations: Acute pulmonary infection is characterised by low-grade fever, cough, night sweats, chest pain, and blood-stained rusty-brown sputum.
- Chronic Manifestations: Lung abscess or pleural effusion develops in individuals with chronic infections. Fever, haemoptysis, pleurisy pain, dyspnea and recurrent attacks of bacterial pneumonia are the common symptoms. The condition mimics pulmonary tuberculosis.

- Fever, headache, nausea, vomiting, visual disturbances, motor weakness, and localised or generalised paralysis are the symptoms of cerebral paragonimiasis.

Diagnosis
Diagnosis is based on finding the characteristic eggs in brown sputum. The eggs can also be found in the faeces due to swallowing sputum. A chest x-ray may show cystic shadows and calcification. Serological tests, in particular, the ELISA method, are useful diagnostic tests.

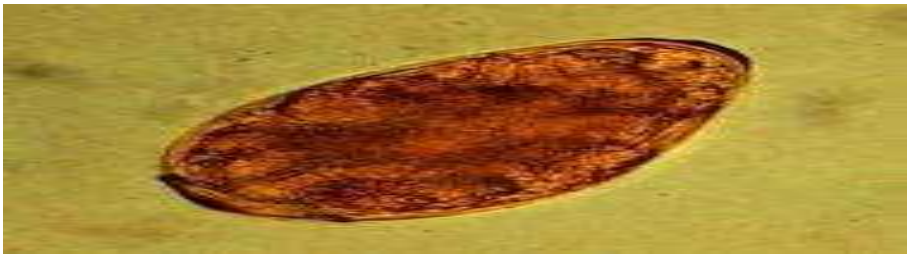


Fig. 4: Saline Smear of Paragonimus Westermanni Egg. The Egg Shells are thick and Operculated

Epidemiology
The epidemiology of the disease (Paragonimiasis) depends on one of the following

- Presence of appropriate snail, crab and mammalian reservoir hosts in the area
- Pollution of snail habitats with sputum and faeces of man as well as natural mammalian reservoir hosts infected with the parasite
- Consumption of metacercariae through eating of raw or undercooked crabs or through contamination of the fingers and cooking utensils with metacercariae while cleaning

Control
- Proper cooking of crabs before consumptions
- Proper waste disposal.

3.3 Liver Fluke (Fasciola Hepatica and F. Gigantica)

Fascioliasis is a a zoonotic disease caused by infection with F. hepatica. It is a major disease of livestock that is associated with important economic losses due to mortality; liver condemnation; reduced production of meat, milk, and wool; and expenditures for anthelmintics. The disease has a cosmopolitan distribution, with cases reported from Scandinavia to New Zealand and southern Argentina to Mexico. Also of importance is the West Africa species of Fasciola (F. gigantica).

The two share similar morphology, life cycle and pathogenicity. They belong to the family 'Fasciolidae' having the following major features;

- They are large with flattened leaf-like forms

- They have ramifying and complicated digestive and reproductive systems
- Most members of the family inhabit the liver and the bile duct. However, Fasciolopsis buski inhabits the intestine
- Cercariae are gymnocephalous
- Metacercariae encyst on vegetation thus establishing a two-host cycle.

Morphology of the Adult

- They are leaf-like with oral cone and shoulder at anterior end
- The intestinal caeca, testes and ovary are branched
- Tight and relatively short uterus is opposite to the ovary at the anterior end
- Vitellaria are extensive and are laterally distributed.

Distinctions between F. hepatica and F. gigantic

- F. gigantica is larger (75 by 12mm) while is smaller (30 by 13mm)
- F. gigantica is oblong with prolonged posterior end while F. hepatica is more or less triangular in shape
- The eggs of F. gigantica are also larger.

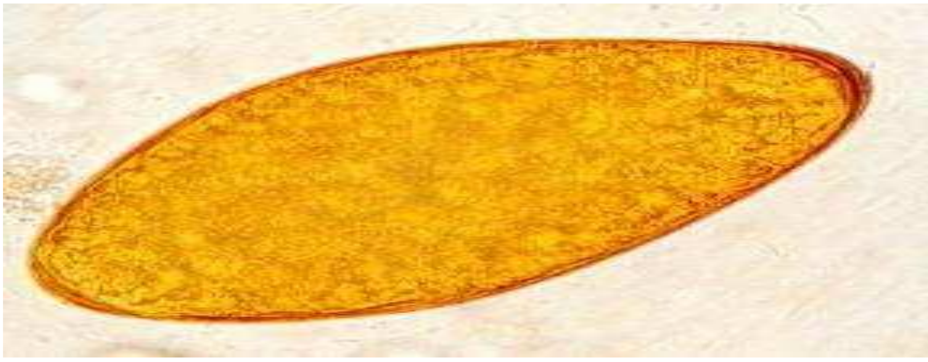


Fig. 5: Egg of Fasciola; ova of Fasciola are ovoid in shape, quinine colour and often showing an inconspicuous operculum. Fasciola hepatica ova measure 130 - 150μm by 63 - 90μm. There is much cross-over in ova size between all of the Fasciola species.

Life Cycle and Transmission

Opercular eggs are passed out from the faeces of the infected animal (cattle or sheep).The eggs embryonate in the presence of light as stimulus and hatch into miracidia which locate an appropriate snail intermediate host by a chemical response called chemotaxis. The snail host of F. hepatica is Lymnaea trucantula while that of F. gigantica is L. natalensis. The intramolluscan development of miracidium produces sporocysts which in turn develop rediae. The mother rediae produce second generation of rediae (daughter rediae) which later give rise to gynocephalous cercariae. This crawls out of the snail, locates submerged plant, loses its tail and encysts into metacercariae.

Infection occurs when sheep and cattle ingest plant with metacercariae during grasing. Metacercariae excyst in the duodenum and the emerging young adult punctures its way into the body cavity and wanders around until it locates the liver capsule. Its burrows into the tissues, feeding on the cells until it gets to the bile duct where it eventually attains maturity.

Pathology

- Pathology depends on the intensity of infection and duration of the disease.
- Fluke causes bilary obstruction. Because of pressure, toxic metabolic products, and feeding habits, the worms provoke inflammatory, adenomatous, and fibrotic changes of the bilary tract.
- Parenchymal atrophy and periportal cirrhosis develop.
- Severe headache, chills, fever, urticaria, a stabbing substernal pain, and right upper quadrant pains that radiate to the back and shoulders may be the first evidence of infection.
- As infection progresses, an enlarged tender liver, jaundice, digestive disturbance, diarrhoea and anaemia develops.

Laboratory Diagnosis

- Definitive diagnosis is made by observing the ova in faeces.
- Where identification cannot be made from the size of the ova, clinical information and the source of infection may help to provide a diagnosis. This includes an enlarged tender liver and a febrile eosinophilic syndrome
- Positive complement-fixation test and intracutaneous reactions with Fasciola antigens are used when direct faecal examination fails to reveal the eggs.

Epidemiology and Control

Fascioliasis is prevalent in areas where cattle or sheep graze and in areas where appropriate lymnaeid snail hosts flourish. Therefore control measures involves

- Treatment of animals to improve general condition and reduce egg output
- Breaking of transmission cycle by eradicating the snail hosts.

However, this is difficult to achieve on the field

- Infection in humans can be prevented by eliminating raw water cress and other uncooked green vegetable from the diets.
- A safe water supply is also necessary.

3.4 Intestinal Flukes (Fasciolopsis. Buski, Heterophyes Heterophyes, Metagonimus Yokogawai)

F. buski is the most common intestinal nematode that causes infections in humans. It is widely distributed in Asia and the Indian subcontinent, especially in areas where humans raise pigs and consume freshwater plants.The trematodes H.heterophyes and M. yokogawai are less-common causes of human infection.

Life Cycle

F. buski, known as the giant intestinal fluke, is found in the duodenum and jejunum of pigs and humans and is the largest intestinal fluke to parasitise humans. Humans are infected by eating freshwater aquatic plants such as water caltrops, water chestnuts, and water bamboo, which can harbour the metacercariae. In the intestine, the metacercariae excyst, attach to the duodenum or jejunum, develop, and grow into adult worms. They lay unembryonated eggs, which are excreted in the faeces.

In water, inside the egg, a ciliated miracidium develops, comes out, and penetrates a suitable snail host. Inside the snail, after several stages of asexual multiplication, large numbers of cercariae are produced. The latter emerge from the snail and encyst on the surface of aquatic plants to metacercariae. Ingestion of these plants causes infection in humans, and the cycle is repeated.

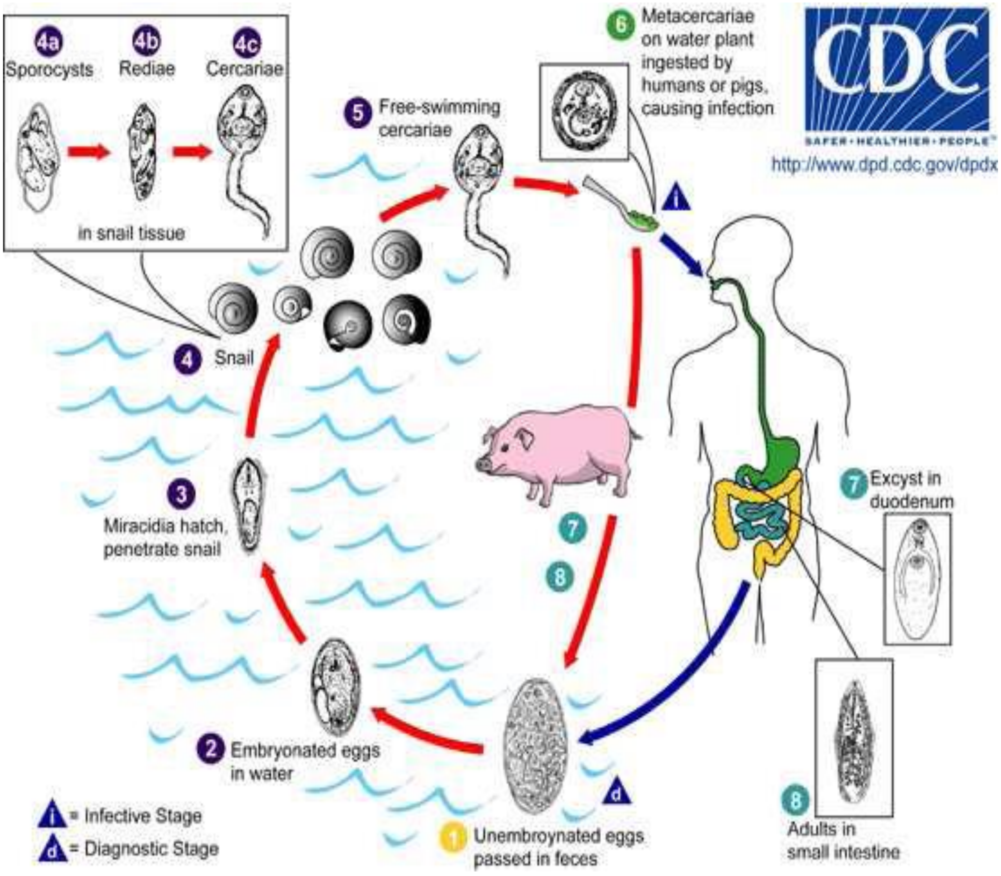


Fig. 6: Life Cycle of F.buski *(Source: http://www.dpd.cdc.gov/dpdx)*

Morphology

Eggs of Fasciolopsis buski are broadly ellipsoidal, operculated and measure 130-150 µm long by 60-90 µm wide. The eggs are unembryonated when passed in feces. The eggs of F. buski can be difficult to distinguish from Fasciola hepatica, although the abopercular end of the latter often has a roughened or irregular area. The adults of F. buski measure 20-75 mm long and have poorly-developed oral and ventral suckers. Adults reside in the intestine of the mammalian host.

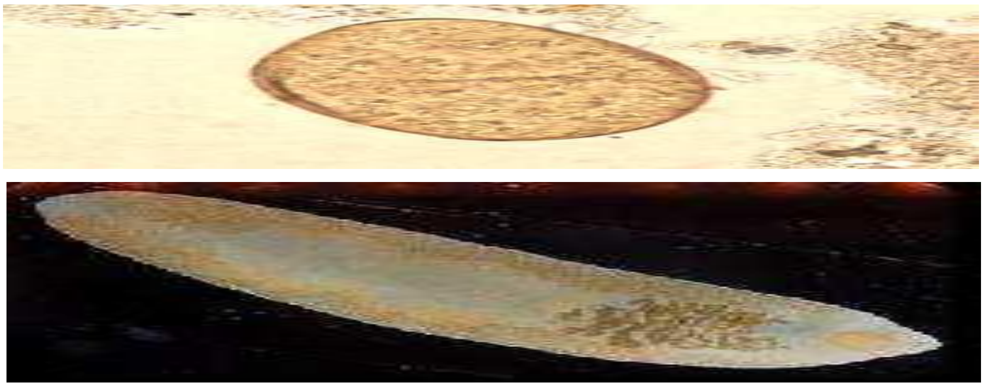


Fig.7: The Egg and the Adult Forms of F. Buski

Clinical Features

Most infections are light and asymptomatic. In heavier infections, symptoms include diarrhoea, abdominal pain, fever, ascites, anasarca and intestinal obstruction.

Laboratory Diagnosis

Microscopic identification of eggs, or more rarely of the adult flukes, in the stool or vomitus is the basis of specific diagnosis. The eggs are indistinguishable from those of *Fasciola hepatica*.

3.5 Pancreatic Flukes (Eurytrema Pancreaticum, E. Coelomaticum, E. Ovis)

These are widely distributed in China, Korea, Japan, Hong Kong, South America, etc. E. pacreaticum is a common parasite of pancreatic (or rarely bile) ducts of herbivorous mammals, i.e., cattle, sheeps, goats, monkeys, and camels.

Life Cycle

The adult flukes live in the pancreatic passages of the herbivores. Eggs are passed in the faeces and ingested by land snail, which is the first intermediate host (snail). The cercariae develop into infective metacercariae only if ingested by grasshoppers, the second intermediate host. The life cycle is completed when the infected insects are eaten by grasing herbivores. The metacercariae excyst and migrate to the pancreatic passage, where they develop into adults. Humans become infected when they accidentally swallow infected grasshoppers.

Morphology

The parasite (10~18 x 5~9 mm in size) is broad, flat, and oval to fusiform. The suckers are large; the oral sucker is larger than the ventral sucker. The eggs (50~80 x 35~40 ㎛) are embryonated in the uterus.

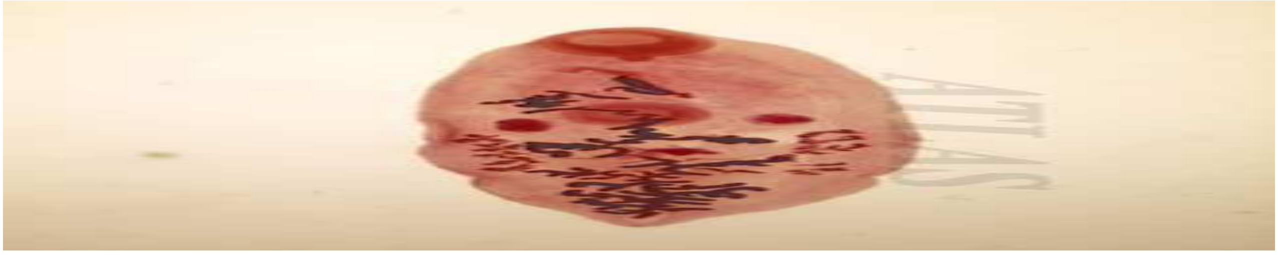


Fig.8: E. Pacreaticum: From Pancreas of Cattle, Acetocarmine Stain, X40

Pathology and Clinical Symptoms
Eurytremiasis is usually characterised by mild symptoms. Heavy infections, however, may be marked by gastrointestinal disturbances, including abdominal distress, flatulence, vomiting, diarrhoea or constipation. Jaundice an enlarged liver, and systemic symptoms. Eosinophilia is rare.

Diagnosis
Diagnosis is made by finding the characteristic eggs in faeces. Spurious infection must be ruled out by repeated examination. Eggs of the Dicrocoelium dendriticum and E. pancreatum are almost indistinguishable. Definitive diagnosis can be made by recovery of adult flukes at surgery or autopsy.

Prevention
Human infections are generally accidental.

4.0 Conclusion

In this unit, you learnt that Digenetic trematodes are the medically important groups of trematodes that inhabit different tissues and organs of their hosts. Hence, they are named according to their various locations in the parasitised hosts. Diagnosis is dependent on the route through which parasites' eggs are voided out of the host. Therefore, the faecal, urine and sputum samples are examined microscopically to identify the characteristic eggs. The pathological effects vary from mild to severe due to the parasite burden in the host. Proper waste disposal, and proper cooking of crabs, fishes and land snails which act as intermediate host are some of the control measures.

5.0 Summary

Digenetic trematodes are the medically important groups of trematodes that inhabit different tissues and organs of their hosts. Hence, they are named according to their various locations in the parasitised hosts. Diagnosis is dependent on the route through which parasites' eggs are voided out of the host. Therefore, the faecal, urine and sputum samples are examined microscopically to identify the characteristic eggs. The pathological effects vary from mild to severe due to the parasite burden in the host. Proper waste disposal, and proper cooking of crabs, fishes and land snails which act as intermediate host are some of the control measures.

6.0 Self-Assessment Exercise

Activity: Examine the eggs of the various diggenea trematode

Answer the following questions:

1. Describe blood flukes (Schistosoma species) (LO2).
2. What are the main schistosomes that infect human beings? (LO2).
3. Tabulate the comparative features of major human schistosoma species (LO2).
4. With a well labeled diagram describe the life cycles and transmission of schistosomes (LO1).
5. Explain the pathology and clinical symptoms of blood flukes (LO6).
6. Describe the diagnosis of blood flukes (LO5).
7. Enumerate the epidemiology of schistosomiasis (LO2).
8. How can schistosomiasis be controlled? (LO4)
9. Highlight the differences in the mode of transmission cycles of S.haematobium and H. heterophyes (LO3).
10. What are the morphological differences in the species of schistosomes? (LO5).

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