COURSE GUIDE

BIO 212
HELMINTHOLOGY

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CONTENTS

INTRODUCTION

BIO 212: Helminthology is a one-semester, 2 credit- hour course in the Department of Biological Sciences, Faculty of Science. It is a 200 level, second semester undergraduate course offered to students admitted in the Faculty of Science, Faculty of Education that are offering Biology or related programmes. This course is designed primarily for students in Biology disciplines to expose them to parasites relationships and interactions especially helminths, their benefits or otherwise and theeir economic importance in respect to host-parasite relationship. Also students should be acquainted with the evolution of parasitic associations and the different groups and classes that constitutes the parasitic helminths, including the parasitic arthropods. Parasitic helminths includes the trematodes, cestodes and nematodes. At the end of this course, students should be able to have a clear knowledge of the parasitic helminths and essentials of parasitic arthropods, their general classifications and characteristics, modes of transmission, amongst others.

The course guide tells you briefly what the course is all about, what or some course materials you will be using and how you can work your way through these materials. It gives you some guidance on your Tutor- Marked Assignments.

There is/are Self-Assessment Exercise(s) within the body of a unit and/or at the end of each unit. The exercise(s) is/are an overview of the unit to help you assess yourself at the end of every unit.

COURSE COMPETENCIES

This course is to provide a generalized survey of the parasitic helminths and the essentials of parasitic arthropods with reference to their classifications, morphological characteristics, life cycle, ecological adaptation, ecological and economic importance.

COURSE OBJECTIVES

In addition to the course competencies, the course sets an overall objective which must be achieved. In addition to the course objectives, each of the units has its own specific objectives.

You are advised to read properly the specific objectives for each unit at the beginning of that unit. This will help you to ensure that you achieve the objectives.

As you go through each unit, you should from time to time go back to these objectives to ascertain the level at which you have progressed.

By the time you have finished going through this course, you should be able to:

- Have a clear knowledge of what parasitic helminths are and their different classifications
- Have a clear understanding of the parasitic helminths in respect to their morphological characteristics
- Be clearly introduced to the essentials of parasitic arthropods
- Have a good understanding of parasitic helminths and their biological significance
- Be able to differentiate between the various classifications of parasitic helminths
- Be able to differentiate between the various species of parasitic helminths within their groups.
- Have a good knowledge of the different groups of the helminths

WORKING THROUGH THIS COURSE

In this course, you will be advised to devote your time in reading through the material. You would be required to do all that has been stipulated in the course: study the course units, read the recommended reference textbooks and do all the unit(s) self-assessment exercise (s) and at some points, you are required to submit your assignment (TMAs) for assessment purpose. You should therefore avail yourself of the opportunity of being present during the tutorial sessions so that you would be able to compare knowledge with your colleagues.

STUDY UNITS

This course is divided into 3 modules with a total of fifteen units which are divided as follows:

MODULE 1 EVOLUTION OF PARASITIC ASSOCIATION

Unit 1 Association in organisms
Unit 2 Classification of Parasitic Host Organisms in Relation the Lifecycle of the Parasitic Helminths
Unit 3 Human Helminth Infections- Nematodes
Unit 4 Human Helminth Infections- (Digenean) Trematodes
Unit 5 Human Helminth Infections- (Cestodes) Tapeworms

MODULE 2 TREMATODES AND CESTODES

MODULE 3 *NEMATODES* AND PARASITIC ARTHROPODS

REFERENCES AND FURTHER READINGS

You would be required to do all that has been stipulated in the course: study the course units and read the recommended reference textbooks in each unit of the course material.

PRESENTATION SCHEDULE

Presentation schedule for this course will be uploaded on the online course page.

ASSESSMENT

You are required to submit your assignment (TMAs) for assessment purpose.

How to Get the Most from The Course?

The course comes with a list of recommended textbooks. These textbooks are supplement to the course materials so that you can avail yourself of reading further. Therefore, it is advisable you acquire some of these textbooks and read them to broaden your scope of understanding.

further references with web links are provided in each section/module or unit. Similarly, the course has facilitation session that will provide information on any grey areas.

ONLINE FACILITATION

Online facilitation for this course will hold at least an hour once in a week for a period of eight weeks. The duration of facilitation is usually at least one hour for the period of eight weeks

COURSE INFORMATION

Course Code: BIO 212
Course Title: Helminthology
Credit Unit: Two (2)
Course Status: Elective
Semester: Second Semester
Course Duration: Eight weeks
Required Hours for Study: At least One hour per week

UNIT STRUCTURE

MODULE 1 EVOLUTION OF PARASITIC ASSOCIATION

Unit 1 Association in organisms
Unit 2 Classification of Parasitic Host Organisms in Relation the the Lifecycle of the Parasitic Helminths
Unit 3 Human Helminth Infections- Nematodes
Unit 4 Human Helminth Infections- (Digenean) Trematodes
Unitt 5 Human Helminth Infections- (Cestodes) Tapeworms

MODULE 2 TREMATODES AND CESTODES

Unit 1 Digenetic Trematodes
Unit 2 Classification of digenetic trematodes according to their habitat
Unit 3 Basic body plan of a cestode
Unit 4 Tapeworms of man

MODULE 3 *NEMATODES* AND PARASITIC ARTHROPODS

MAIN COURSE

MODULE 1 EVOLUTION OF PARASITIC ASSOCIATION

Module Structure

In this module we will discuss about the evolution of parasitic association with the following units:

Unit 1 Association in Organisms

Unit Structure

1.1 Introduction

Organisms frequently associate together, often closely. There are a number of "motives" for these associations, including protection, nutrition, and as an aid to the dispersion (both geographically and temporally) of the organism. There are four main ways that animals of different species may be associated to one another; Symbiosis, Mutualism, Commensalism and Parasitism. These classifications however, on closer inspection, may become blurred, one type taking on the aspects of another, for example over time as the relationship evolves. However, as a general guide these terms are still very useful.

1.2 Intended Learning Outcomes

By the end of the study, students should be able to

- Explain the various types of association existing between organisms
- Give examples of various types of association
- Understand the concept of parasitism and types of parasites

1.3 Main Content

1.3.1 Types of Association

Here both organisms are dependent on each other. Examples being the association of flagellate protozoa in the gut of termites, where termites are dependent on the protozoa for breaking down their food stuffs, and the protozoa are dependent on the termites as host organisms. Another good example here which is often cited is the association between clown fish and anemones in tropical reefs; where the fish is dependent on anemone for protection and food while the anemone does not appear to gain anything from the association, except possibly cleaning. However, it has been observed that in some cases, in the absence of the fish partner the anemones tend to disappear from their reef home, indicating a true symbiotic rather than a mutualistic or commensal relationship.

Another well-known example is found with the lichens, symbiotic association composed of fungi and algae. These associations may become very close, and it is thought that the eukaryotes as a group evolved as a result of such an association. Intracellular organelles such as the mitochondria and chloroplasts appear to have their origin as intracellular symbiotes of early eukaryotes, (some extremely primitive eukaryotes, such as the intestinal parasite *Giardia lamblia*, lack these organelles). Other forms of symbiosis may be much less close, for example an organism that uses another organism purely as a means of dispersal. For example, bacterial or fungal spores on the legs of flies, or coelentrates and barnacles on the carapaces of marine crustaceans. This particular form of symbiosis is sometimes called Phoresis. Define Symbiosis

Mutualism

Here the associates may or may not be dependent on each other for their existence, but both benefit when they are associated. A good example of this occurs with the association of sea anemones on the backs of crabs. Both gain from the association (the anemone providing some food for the crab, which in turn gives extra motility to the anemone), but both can survive on their own.

Another less well known example is found between certain species of ants and the caterpillars of some of the Lycaenidae butterflies (particularly the 'Blues'), where the caterpillar is protected by the ants within their nests, in return for which the caterpillar secretes a honeydew which the ants collect. In this case from the point of view of the ant, it benefits from the association, but does not appear to need it, (i.e. the association is facultative, or opportunistic). However, from the point of view of the caterpillar, this association is required for its survival (i.e. the association is obligatory).

This illustrates that these definitions may become blurred, and, over time, one form of association may evolve into another. Define Mutualism

Self-Assessment Exercise 1

- In one sentence, differentiate between symbiosis and mutualism

Commensalism **either organism is dependent** on the other for its existence, but in this case **only one of the partners benefits** from the association, the other being unaffected. An example of this, found in humans, are the non-pathogenic obligate commensal protozoa such as the amoebae *Entamoeba gingivalis*, commonly found in the mouth, feeding of bacteria, dead epithelial cells and food particles. Purely commensal relationships tend to be rather rare, as on a closer inspection element of mutualism or parasitism may become apparent. Define Commensalism

Parasitism

Here one of the associates live either partly or wholly at the expense of the other associate, the other partner (the host organism) not gaining anything from the association. This association may give rise to extreme pathology in the host, or the parasitism may be generally not very pathogenic.

Parasitism is carried out by many organisms, the main groups including viruses, bacteria, protozoa (these usually being endoparasitic), and various metazoan groups (multicellular eukaryotic animals), these being mostly groups of helminths (often endoparasitic), and arthropods (usually ectoparasitic), as well as some higher organisms, such as ectoparasitic lampreys and hagfish.

Generally however, for partly historical reasons, the term parasitology generally only refers to the study of infection with eukaryotic protozoan, and invertebrate metazoan parasites, not bacteria, viruses or the higher chordate parasites, even though these are parasites in the true sense.

Classification of the parasitic organism

Organisms in these associations may either be on the outer surface of the host organism, (in which case the prefix **Ecto-** is used), or inside the host organism, (in which case the prefix **Endo-** is used).

These prefixes may be used with any of the animal associations listed above. For example, the flagellate protozoa in the termite guts are **Endosymbionts**, while the anemone can act as an **Ectocommensal** with the crab. Parasites may act as both **ecto-** and **endoparasites**. Parasites may also be classified according to the closeness of the relationship. For example **Facultative Parasites** (such as many bacteria) are those where the parasitic lifestyle is only taken up opportunistically, whereas **Obligate Parasites** (such as all viruses, and most of the helminth parasites described below) are those in which the organism must parasitise another organism. These parasites may often cause diseases, in which case they are referred to as **Pathogenic Parasites**.

In a somewhat wider interpretation of the term parasitism, some organisms exhibit parasitic behaviour only early in their life cycle, these being referred to as **Brood Parasites**. Examples of these include caterpillars of the Large Blue butterfly, which chemically mimic other caterpillars with mutualistic associations with ants (see above), but both fail to produce honeydew as compensation and consume ant grubs, and may in fact destroy the nest, (thereby acting as a pathogenic parasite for the ants). In this case, the parasitic lifestyle probably evolved from the mutualistic lifestyle of the other, related butterflies, again illustrating how one form of association may change into another. Another well known example of a brood parasite is a bird, the cuckoo.

Some parasites establish themselves in hosts in which they do not ordinarily live. These are called the **Incidental Parasites. A temporary parasite** is free-living during part of its existence and seeks its host intermittently to obtain its nourishment whereas **Permanent Parasite** remains on or in its host's body from early life until maturity, sometimes for its entire life. Parasite that has passed through the alimentary tract without infecting the host are called **Coprozoic or Spurious Parasite.**

Parasites often lack the necessary organs for assimilation of raw materials and depend upon the host for predigested food. An adequate supply of moisture is assured inside the host, but during the free-living existence of the parasite, inadequate moisture may either prove fatal or prevent the larval development. Temperature is likewise important. Each species has an optimal temperature range for its existence and development. Both high and low temperatures are detrimental and even lethal.

Define Parasitism

Self-Assessment Exercise 2

- Give one example in each case of the following associations (a) symbiosis (b) mutualism
- What are falcutative and obligate parasites?

1.4 Summary

Organisms interact with each other at different degrees. While some are solely dependent on each other, however, some are opportunistic and can adopt different means for their survival. One association can evolve into the other. An example is seen in commensalism which can evolve into mutualism or parasitism. Some parasites recide within their hosts while others are outsides.

Obligate parasites live in living tissues whereas the facultative parasites are more successful in that they are capable of taking other sources of nutrition. Pathogenic parasites are of great medical concern because they cause diseases. The survival of a parasite in its habitat/microhabitat can be influenced by moisture and temperature.

1.5 REFERENCE/FURTHER READINGS/Web Sources

Brown, H.W. and Neva, F.A. (1983). Basic Clinical Parasitology (5th edition). pp1-17
https://books.google.com.ng/books?id=UILMlQpNVCYC&dq=INTRODUCTION+TO+PARASITOLOGY&lr=&source=gbs_navlinks_s
https://youtu.be/AvHFC2x8-Ug, https://youtu.be/7IAFpX97afo,
https://youtube.com/shorts/RMrisZWsrpQ?feature=share,
https://youtu.be/ZOLCXWvRt2I,

1.6 POSSIBLE ANSWERS TO Saes

Answer to SAEs 1

Symbiosis is an association between organisms where both benefits and are dependent on each other while mutualism is an association between organisms where both organisms may not be dependent on each other but they benefit from each other

Answer to SAEs 2

1. Symbiosis

An example of this association is the association of flagellate protozoa in the gut of termites, where termites are dependent on the protozoa for breaking down their food stuffs, and the protozoa are dependent on the termites as host organisms.

b. Mutualism

An example of this association is the association of sea anemones on the backs of crabs. Both gain from the association (the anemone providing some food for the crab, which in turn gives extra motility to the anemone), but both can survive on their own

2. **Facultative Parasites** (such as many bacteria) are those where the parasitic lifestyle is only taken up opportunistically. **Obligate Parasites** (such as all viruses, and most of the helminth parasites) are those in which the organism must parasitise another organism. These parasites may often cause diseases, in which case they are referred to as Pathogenic Parasites.

Unit 2 Classification of Parasitic Host Organisms in Relation to The Lifecycle of The Parasitic Helminths

Unit Structure

2.1 Introduction

Parasitic helminths may have either simple or complicated lifecycles. The terms used to describe the hosts is in relation to the different stages of the lifecycles of the parasitic helmiths at which the hosts harbours the helmiths, the degree of damage done to the hosts is however varied. For example, in definitive host, the greatest harm is seen being the one the adult stage of the parasite is found.

Sometimes, a host might assume dual functions, and therefore could be difficult to classify strictly into one type. Human host during infection by malarial parasite is one of such. Human could be classified as the definitive host being the one in which greatest harm is seen. Also, intermediate host because human harbours the asexual stages of the parasite (merozoites and trophozoites). A clear understanding of the relationship between host and parasite and function of host in survival and transmission of parasite is therefore necessary for a better classification.

2.2 Intended Learning Outcomes

By the end of this study, the students should be able to:

- Explain the different types of parasites' host
- Distinguish between an intermediate host and a vector

2.3 Main Content

2.3.1 Types of Hosts

Definitive Host

The adult parasites are found in the **definitive host**. This is where the parasite's sexual cycle usually takes place, with either cross or self fertilisation with hermaphroditic parasites, or sexual reproduction if the parasites have separate sexes, followed by production of eggs, or more rarely with viviparous helminths, larvae. The greatest harm is usually seen in this host.

Intermediate Host

In many cases the parasites larvae are found in different hosts, these are called the **Intermediate Hosts**. Parasitic helminth larvae may have one, two or more intermediate hosts in their lifecycles, or they may have no intermediate hosts. Often asexual stages of reproduction occur in these intermediate hosts, (for example with Platyhelminth parasites). Note that when describing hosts of parasitic protozoa, these terms are slightly different owing to the asexual characteristics of many of these organisms. With parasitic protozoa the vertebrate host is generally referred to as the definitive host, whilst the invertebrate is the intermediate host. Some parasitic nematodes (e.g.

Strongyloides stercoralis) are Facultative parasites, having completely free living lifecycles in addition to parasitic ones. The two terms definitive and intermediate host are the most important in Parasitology when referring to the type of host. A **vector** however, should not be mistaken for intermediate host. A **vector** actively transmits infection to a host without necessarily harbouring the asexual stage of the parasite e.g. the vector of African trypanosomiasis *Glossina* spp. These groups of vectors pick up parasite (the infective stage) from the reservoir hosts during blood meal and transmit it to a susceptible definitive host. However, some vectors can still serve as intermediate hosts harbouring the asexual or the larval forms of the parasite e.g. certain *Anopheles* mosquitoes that harbour the microfilariae of filarial worms. Most parasites larvae are found in definitive host. True/False

Accidental Host

Accidental hosts are those in which the parasite do not normally develop (due, for example to lack of exposure to infective forms of the parasite), but when occasionally chance infections occur, the parasite is able to complete its lifecycle. Hosts where the parasite can complete its lifecycle are called **Permissive hosts**, and include true definitive and intermediate hosts as well as many accidental hosts. Examples here include such parasites as *Fasciola hepatica*, where the normal definitive hosts are ruminants, but humans and other animals may also be infected and viable adult parasites develop. Another example is human infection with the nematode *Angiostrongylus cantonensis* in the far East.

In comparison another form of the accidental host is the **Non-Permissive host** where the parasite, although it may develop to some extent, reaches effectively a dead end, the parasite not being able to complete its lifecycle and eventually dying within the host. These forms of infection often occur where the parasite has intermediate hosts which may be accidentally ingested by animals other than the true definitive host. For example, with various marine ascarids of the family Anisakidae such as *Anisakis* sp., which give rise to the condition of 'Anisakiasis' on ingestion of raw infected fish.

Self-Assessment Exercise 1

- In one sentence, what is a permissive host?

Paratenic Host

Paratenic hosts may also be included in parasitic helminth lifecycles. In these forms of infection, the parasites undergo an arrested development on infection, larval forms accumulating in these hosts until they have a chance of infecting the definitive host (e.g. in the Pseudophyllidean tapeworms). These hosts are therefore not essential to completion of the parasites lifecycle. This is in contrast to the case with true intermediate hosts whose ingestion is essential to the lifecycle, for example *Echinococcus* sp.

Reservoir Host

These are accidental hosts and hosts of parasites which have zoonotic patterns of infection (i.e. normally infect a wide range of hosts), may act as **Reservoir Hosts** for the parasite. These are also a form of permissive hosts as fully viable infections develop, and a more accurate term would be alternative definitive hosts (though this is not in fact used). The term reservoir host is usually only used when describing the epidemiology of human infections. An example of parasites with zoonotic infections is *Schistosoma japonicum*. This parasite, as well as infected man, can also infect other mammals as definitive hosts, including rodents, cats, dogs, domesticated ruminants such as water buffalo and a wide range of other mammals. In Human African Trypanosomiasis (HAT), the reservoir host are cattle which serve as **sources of active infection** to man. The presence of these **Zoonoses** has implications for the control of the parasite in the field. List the different types of parasitc hosts

Self-Assessment Exercise 2

- In one or two sentences, differentiate between definitive host and intermediate host
- In one or two sentences, differentiate between a vector and a host.

2.4 Summary

The host of a parasite is the organism that harbours the parasite. The intermediate host is the one in which part of the developmental stages in the life cycle of the parasite takes place, usually the larval or the asexual stage. A vector actively transmits an infective stage of parasite harboured by the reservoir host which serves as source of active infection to the definitive host. The definitive host harbours the adult or the sexual stage of the parasite and often experiences the greatest harm during the life cycle of the parasite.

2.5 Reference/Further Readings/Web Sources

Brown, H.W. and Neva, F.A. (1983). Basic Clinical Parasitology (5th edition). pp1-17

https://en.wikipedia.org/wiki/Host_(biology), https://www.google.com/search?q=types+of+parasitic+hosts&oq=types+of+parasitic+hosts&aqs https://youtu.be/nhj4I6YdVBo, https://youtu.be/hkeYsYm2HMg, **https://youtu.be/ZNVc_K7nNXs ,** https://youtu.be/ZOLCXWvRt2I,

26. Possible Answers To Saes

Answers to SAEs 1

Hosts where the parasite can complete its lifecycle are called **Permissive hosts**

Answers to SAEs 2

- Defintive host mostly harbours the adult parasites while the intermediate host mostly harbours the larvae parasites
- A vector actively transmits infection to a host without necessarily harbouring the parasite while a host harbours the parasites

Unit 3 Human Helminth Infections- Nematodes

Unit Structure

3.1 Introduction

This unit aims to introduce the student to the diversity of helminth infections in man especially the nematodes, and even more importantly, to the numbers of individuals that harbour these infections in all regions of the world. There are three major groups of helminths containing members that have man as their main hosts. These are the **Roundworms (Nematodes)**, **Digenean Flukes or trematodes** and the **Tapeworms (Cestodes)**. In this unit, we shall be looking at the human heminth infections by the nematodes (roundworms)

3.2 Intended Learning Outcomes

By the end of this unit, the student should be able to:
Explain the distribution of parasitic nematodes and their infections.

3.3 Main Contents

3.3.1 Human Helminth Infections-Nematodes

Enterobius vermicularis - *Pinworm.*

E. vermicularis infection, an extremely common nematode infection, particularly in temperate areas such as Western Europe and North America, (being relatively rare in the tropics) and particularly in children. It has been estimated that the annual incidence of infection is over 200 million, this probably being a conservative figure. Samples of Caucasian children in the U.S.A. and Canada have shown incidence of infection from 30% to 80%, with similar levels in Europe.

Ascaris lumbricoides **-** The Large Human Roundworm.

Again the incidence rates for this parasite are very high with > 1500 million cases of infection annualy, of which about 210 million cases are symptomatic.

Trichuris trichiuria – Human Whipworm.

The incidence rates for this parasite are also very high, with estimates of about 1300 million cases of infection annualy, of which >133 million cases are symptomatic.

Ascaris lumbricoides – is a roundworm found in goats and cattles. True/False

The Hookworms.

These are represented by two parasites, *Necator americanus* in the tropics and sub tropics worldwide and the S. E. states of the U.S.A., and *Ancylostoma duodenale*, again with a worldwide distribution in the tropics and sub tropics as well as the Mediterranean region. There are > 1200 million cases of hookworm infection annually, of which about 100 million cases are symptomatic.

Lymphatic filariasis - Elephantiasis

This disease is caused principally by two parasites, *Wuchereria bancrofti* with an annual rate of infection of about 106 million cases, and *Brugia malayi* with an annual rate of infection of about 12.5 million. The total number of people infected with other types of lymphatic filarial worms is much smaller, at about 1.5 million cases. These lymphatic filarial worms, along with the related filarial parasite *Onchocerca volvulus*, are unusual among the nematodes in that they develop with, and are transmitted by insect vector intermediate hosts.

Self-Assessment Exercise 1

- State the parasites that causes elephantiasis disease in Man

Onchocerca volvulus - *River Blindness*

The incidence rates for this parasite are not as high as some of the previously described parasites, with an annual rate of infection of about 18 million, however, due to the extreme pathology associated with this parasite, often with all adult members of affected villages losing their sight, along with severe skin conditions, the infection is significant.

Dracunculus medinensis - *Guinea Worm*

The incidence rates for this parasite are much lower, with an estimated annual rate of infection of about 100 000. This is much lower than in the recent past, when up to 50 million people were infected. This reduction in incidence illustrates how successful helminth control programmes can be effective in reducing the disease caused by these organisms.

Other important nematode infections include; ***Trichinella spiralis***, ***Strongyloides stercoralis***, and a number of more **rare infections**. Nematodes that normally infect other animals may still cause disease in man. These include ***Toxocara canis*** and a number of nematodes causing ***anisakiasis***.

State two diseases caused by parasitic nematoders

Self-Assessment Exercise 2

- List three parasitic nematodes that causes infections in humans

3.4. Summary

One of the groups of parasitic helminths is the parasitic nematodes. The nematodes are the most diversified among the groups. Parasitic helminths infect a wide range of hosts, ranging between man, domestic animals and wild animals. Morbidity is often high leading to death of several thousands of people.

3.5. Reference/Further Readings/Web Sources

Ukoli, F.M.A. (1990). Introduction of Parasitology in Tropical Africa. John Wiley and Sons Ltd., Chichester.

https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/nematode-infection,

https://www.infectiousdiseaseadvisor.com/home/decision-support-in-medicine/infectious-diseases/intestinal-nematodes-roundworm/,
https://en.wikipedia.org/wiki/Nematode_infection,
https://youtu.be/T13cIxaG4CU, https://youtu.be/O1qf3R3zMB0,
https://youtu.be/Hhds68fkx6k,

3.6. Possible Answers to Self Assessment Questions

Answer to SAEs 1

Wuchereria bancrofti and Brugia malayi

Answer to SAEs 2

Ascaris lumbricoides- roundworm, Enterobius *vermicularis* – pinworm, **Trichuris** *trichiuria* – whipworm

Unit 4 Human Helminth Infections- Digenean Trematodes

Unit Structure

4.1 Introduction

This unit aims to introduce the student to the diversity of helminth infections in man especially the digenean trematodes. In this unit, we shall be looking at the human heminth infections by the digenean trematodes

4.2 Intended Learning Outcomes

By the end of this unit, the student should be able to:

Explain the distribution of digenean trematodes and their infections.

4.3 Main Contents

4.3.1 Digenean Trematode Infections

Schistosomiasis - Bilharzia.

Schistosomiasis is caused by *Schistosoma mansoni, S. haematobium, S. intercalatum, S. japonicum* and *S. mekongi*. This disease is the most important human helminthiasis in terms of morbidity and mortality. The numbers of people infected are lower than those of many of the nematode infections, with an estimated annual incidence of infection of > 200 million cases. In terms of active disease however, the parasite is much more important, with an estimated annual mortality rate of about 1 million deaths directly due to infection with these parasites. Schistosomiasis disease is also known as bilharzia. True/False

Opisthorchis sinensis - The Chinese Liver Fluke

This is also a very important trematode infection, with an estimated annual incidence of infection of about 20 - 30 million cases, mostly in the Far East, in Japan, China, Taiwan and South East Asia.

Paragonimus spp. - The Lung Fluke

This fluke causes a pulmonary disease, the adult parasites living in the lungs of their definitive hosts (e.g. man). There are a number of different species of this parasite, the most well documented being *P. westermani* in the Far East. It may however, be locally very common, with up to 40 to 50% of the population infected.

There are a number of other digenean trematode infections. These include various **Echinostome** infections as well as a number of other flukes. In addition, there are a number of these parasites that usually infect domesticated animals, but also cause well known human infections as well.

These include ***Fasciola hepatica*** and ***Dicrocoelium dendriticum***. Fasciola hepatica infects only human and doesn't infects domestic animals. True/False

Self-Assessment Exercise

- List the causative parasites of Schistosomiasis

4.4. Summary

Parasitic helminths are grouped into nematodes, cestodes and trematodes. The digenean trematodes which was discussed in this unit are also known as the digenean flukes. They infect both humans and domestic animals, and are also widely spread.

4.5 References/Further Readings/Web Sources

Ukoli, F.M.A. (1990). Introduction of Parasitology in Tropical Africa. John Wiley and Sons Ltd., Chichester.

https://emedicine.medscape.com/article/230112-overview, https://www.ncbi.nlm.nih.gov/books/NBK8037/,
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https://www.msdmanuals.com/professional/infectious-diseases/trematodes-flukes/introduction-to-trematodes-flukes,
https://youtu.be/Hhds68fkx6k, https://youtu.be/hWBsmNpX7R4,

4.6 Possible Answers to SAEs

Answer to SAEs

Schistosoma mansoni, Schistosoma haematobium, Schistosoma intercalatum, Schistosoma japonicum and *Schistosom7 mekongi*.

Unit 5 Human Helminth Infections- Tapeworms (Cestodes)

Unit Structure

5.1 Introduction

This unit aims to introduce the student to the diversity of helminth infections in man especially the tapeworms. In this unit, we shall be looking at the human heminth infections by the tapeworms in the cestode group.

5.2 Intended Learning Outcomes

By the end of this unit, the student should be able to:

Explain the distribution of important tapeworms and their infections.

5.3 Main Contents

5.3.1 Human Helminth Infections-Tapeworm (Cestodes)

Cestode (Tapeworm) Infections

Taenia saginata **-** The Beef Tapeworm

This only causes very limited pathology in man, but the annual incidence of infection is high, at an estimated 50 million cases.

Taenia solium - The Pork Tapeworm

This has a similar estimated annual incidence of infection of about 50 million cases. However, in this case the consequences may be more severe, due to the added risk of contracting infection with the larval metacestode, (cysticercosis). This may have extreme consequences in terms of the pathology associated with infection, with an estimated annual mortality rate of about 50,000 deaths.

For the cestodes, these annual incidence rates are based on detection of infection with the adult parasite. This is achieved by examination of faeces, urine or sputum for **parasite eggs**. Diagnosis of infection with larval metacestode parasites, such as ***Echinococcus*** sp. is very difficult, due to the lack of noninvasive diagnostic techniques. It is in consequence very difficult to estimate annual rates of infection, even though these metacestodes may be very important pathogens. With examples, mention one cestode parasite that you know

Self-Assessment Exercise

- Which of these tapeworms have limited pathology or consequences in man?

  A. Taenia solium B. Taenia saginata

5.4. Summary

Parasitic helminths are grouped into nematodes, cestodes and trematodes. The parasitic tapeworms or cestodes which was discussed in this unit can have severe consequences on humans especially *Taenia solium*. They infect both humans and domestic animals, and are also widely spread.

5.5 References/Further Readings/Web Sources

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5.6 Possible Answers to SAEs

Answer to SAEs

A. Taenia solium

Glossary

- Phoresis: less close organisms e.g. organisms that uses another organism purely as a means of disposal
- Brood parasites: organisms that exhibit parasitic behavior only early in their life cycle
- Incidental parasites: parasites that establish themselves in hosts in which they do not ordinarily live
- Coprozoic Parasite: parasites that passed through the alimentary tract without infecting the host
- Intermediate host: parasites found in different hosts
- Permissive hosts: hosts where the parasites can complete the life cycle

End of the Module Questions

- Differentiate amongst the different types of associations in organisms
- Explain the different types of parasitic host
- Itemize the different types of infections/diseases associated with human helminths

MODULE 2 TREMATODES AND CESTODES

In this module we will discuss about the tremadoes and cestodes with the following units:

Unit 1 Digenetic Trematodes

Unit Structure

1.1 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 molluscs

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.

1.2. Intended Learning Outcomes

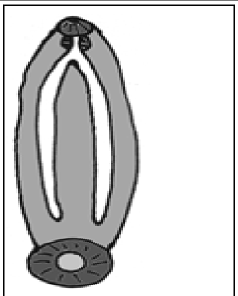
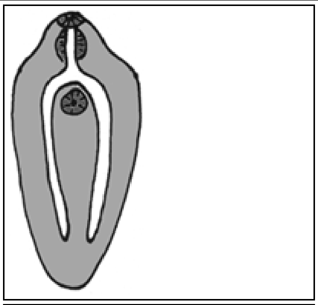
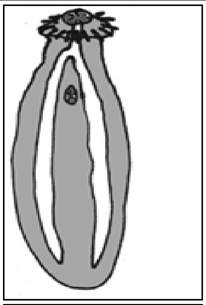
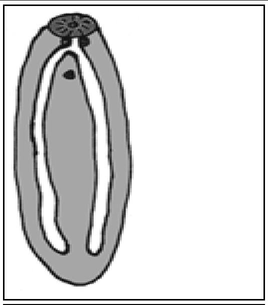
By the end of this unit, students will be able to:

- Identify the striking features of digenetic trematodes
- Describe the morphology of the egg, larva, and adult stage of various digenetic trematodes
- Understand the general transmission patterns of some trematode

1.3 Main Contents

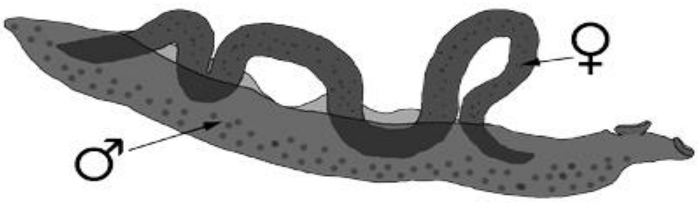
1.3.1 The Adult Digenean Fluke

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

			
	Distome	Echinostome	Monostome

Amphistome			
These have large fleshy bodies, with a prominent sucker at the posterior of the body (e.g. *Gastrodiscoides hominis*)	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*)	Similar to the distomes, except that the oral sucker is surrounded by a prominent collar, equiped with spines (e.g. *Echinostoma* sp.)	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 1.1a: Different body forms of Digenean Nematodes (Source: Ukoli, F.M.A. 1990).



Schistosome

Figure 1.1b: Form of an elongated Trematode-Schistosoma (Source: Ukoli, F.M.A. 1990).

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). The most common type of the body forms of digenean trematode is –

Basic Lifecycle of the Major Groups of the Digenean Trematode

Most digenean trematodes are hermaphroditic (the major exception being the schistosomes, and one other group). In the majority of these parasites self-fertilization may occur, but cross fertilization 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.

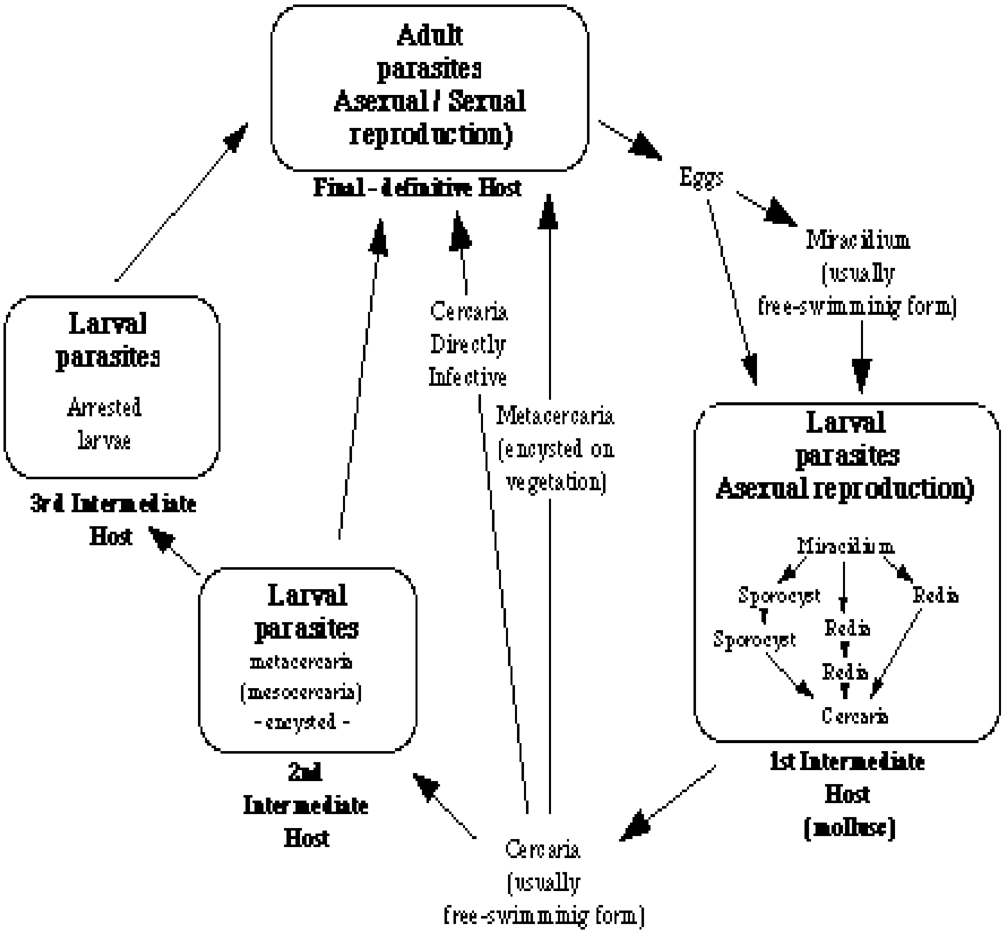


Fig 1.2 The generalised life cycle of digenetic trematodes (Source: Ukoli, F.M.A. 1990).

Digenean trematodes are non-hermaphroditic. True/False

Self-Assessment Exercise 1

- State the different body forms of an adult trematode

1.3.2 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. 3 Egg of the dige dige

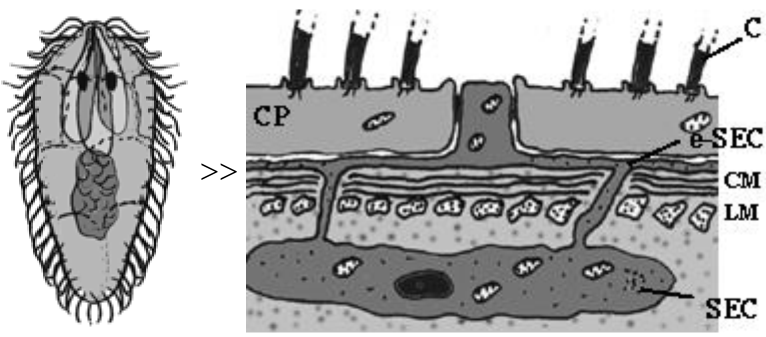
Digenean trematode (Source: Ukoli, F.M.A. 1990).

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. The digenean trematode egg is usually operculate, common with other platyhelminthes including the Schistosomes

1.3.3 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.



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

LM = Longitudinal Muscle

Fig 1.4 Ciliated larval of a trematode called Miracidium Miracidium (Source: Ukoli, F.M.A. 1990).

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 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 ciliated larval stage that is hatched from the digenean egg.is called --------

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.

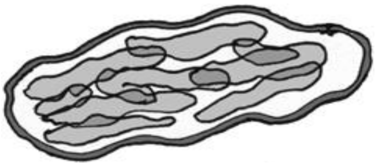


Fig 1.5 The sporocyst of a digenean trematode (Source: Ukoli, F.M.A. 1990).

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, called Cercaria.

Fig 1.6 The second larval form of a digenean trematode- Redia (Source: Ukoli, F.M.A. 1990).

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 lobe-like 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

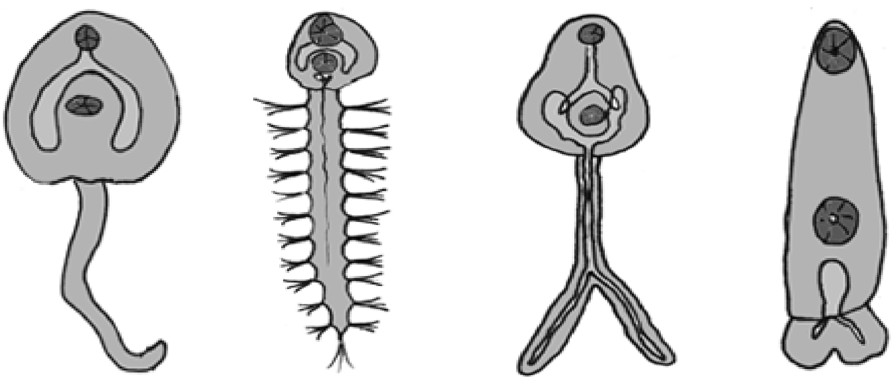
host, although the metacercaria may still be capable of developing in a second host as well. Exceptions such as these, and those described above involving miracidia containing fully developed redia is evidence of the evolutionary past of these organisms. It has been noted that the redia bears some resemblance 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 redia is less active than the sporocyst. True/False

Self-Assessment Exercise 2

- What is the similarity between redia and sporocyst of a digenean trematode?

The cercaria

Some of the types of Cercariae



Gymnocephalus (e.g. *Fasciola* sp.)	Trichocercous (e.g. *Donax* sp.)	Furcocercous (e.g. *Schistosoma* sp.)	Microcercous (e.g. *Bithynia* sp.)

Fig 1.7 Different forms or types of Cercaria of a digenean trematode (Source: Ukoli, F.M.A. 1990).

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 lack 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;

- ***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 develop 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. iii) *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.

- ***Trichocercous Cercariae*** - These forms have long tails, equiped with rings of fine bristles. They are usually found in marine trematodes.
- ***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. ***Microcercous Cercariae*** - Cercaria with vestigial tails, and which may develop within both rediae and sporocysts.
- ***Cercariaea Cercariae*** - Cercaria with no tails, where the cercaria is not a free swimming form, and may develop within both rediae and sporocysts.
- ***Furcocercous Cercariae*** - In these the tails are forked at the end. The cercaria of the most important group of trematodes, the schistosomes, have 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.

Which of the Cercaria types lack a ventral sucker, and have simple tails?

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.

Mesocercaria and Metacercaria of digenean trematodes are both resting stages. True/False

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.

The transformation of the cercaria into adult form is dependent on the definitive host. True/False

1.3.4 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 separate (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 is complete 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.

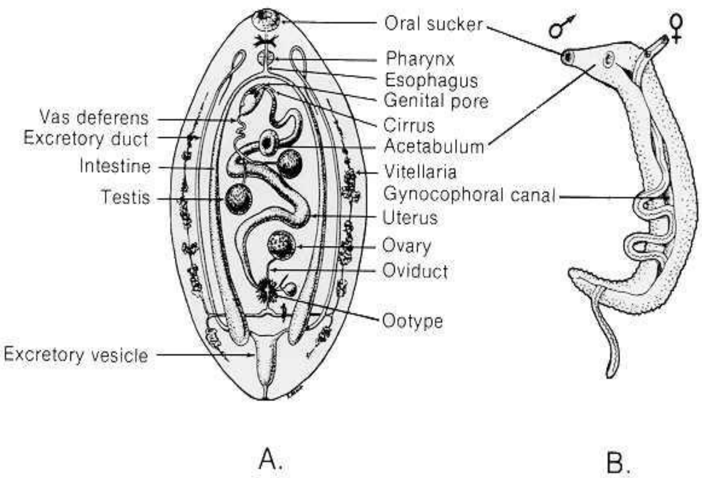


Fig 1.8 Structure of digenetic flukes. (A) Hermaphroditic fluke. **(B) Bisexual fluke**. (Source: Ukoli, F.M.A. 1990).

State if each of the following statements is True or False?

- Digenetic trematodes are segmented leaf-shaped worms that are flattened dorsoventrally**.**
- The sexes of all the parasites are not separate (ie. monoecious).

Self-Assessment Exercise 3

- The alimentary canal of a digenetic trematode is incomplete, but has anus. True/False
- All flukes are viviparous True/False

1.4 Summary

The medically important trematodes are the digineans. 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.

1.5 References/Further Readings/Web Sources

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1.6 Possible Answers to Saes

Answer to SAEs 1
Answer

- Amphistome
- Diastome
- Echinostome
- Monostome
- Schistosome
- Holostome
- Gasterostome

Answer to SAEs 2

Both redia and cercaria contains 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

Answer to SAEs 3

- False
- False

Unit 2 Classification of Digenetic Trematodes According to Their Habitat

Unit Structure

2.1 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*

2.2 Intended Learning Outcomes

By the end of this unit, student will be able to;

- Explain the transmission cycles of digenetic trematodes
- Identify the factors responsible for transmission and highlight what control measure to be taken to prevent transmission
- Identify each parasite using the diagnostic features of the eggs
- Explain the pathology caused by parasite

2.3 Main Contents

2.3.1 Blood flukes (*Schistosoma* species)

Schistosomiasis, or bilharzia, is a tropical parasitic disease caused by blood-dwelling 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. Schistosomiasis, or bilharzia, is a temperate parasitic disease. True/False

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.

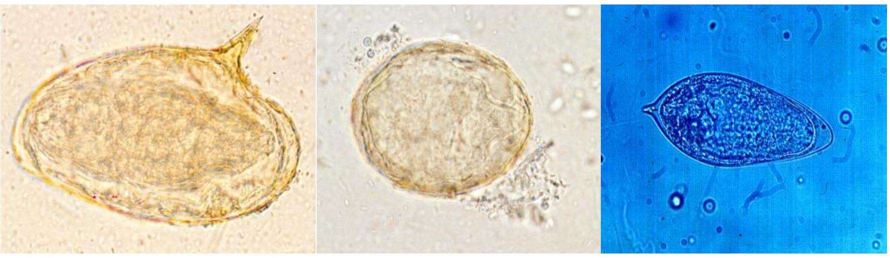


Fig 2.1 Saline smear of *S. mansoni*, *S. japonicum* and *S. haematobium* ova showing their spine position; a good distinguishing feature when identifying Schistosome ova (Source: Massoud *et al*., 2000).

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	Posterior to	Anterior to	Posterior to middle of

ovary	middle of body	middle of body	body
Number of eggs in uterus	20-30	1-4	50-300
Egg			
Size and shape	110-170 µm long	114-175 µm long	70-100 µm long
	40-70 µm wide Terminal spine	45-68 µm wide Lateral spine	50-65 µm wide Central spine
Cercaria			
Cephalic glands	2 pairs, oxyphilic	2 pairs, basophilic	4 pairs, oxyphilic

The cuticle of the male schistosoma is covered with a large papillae True/False

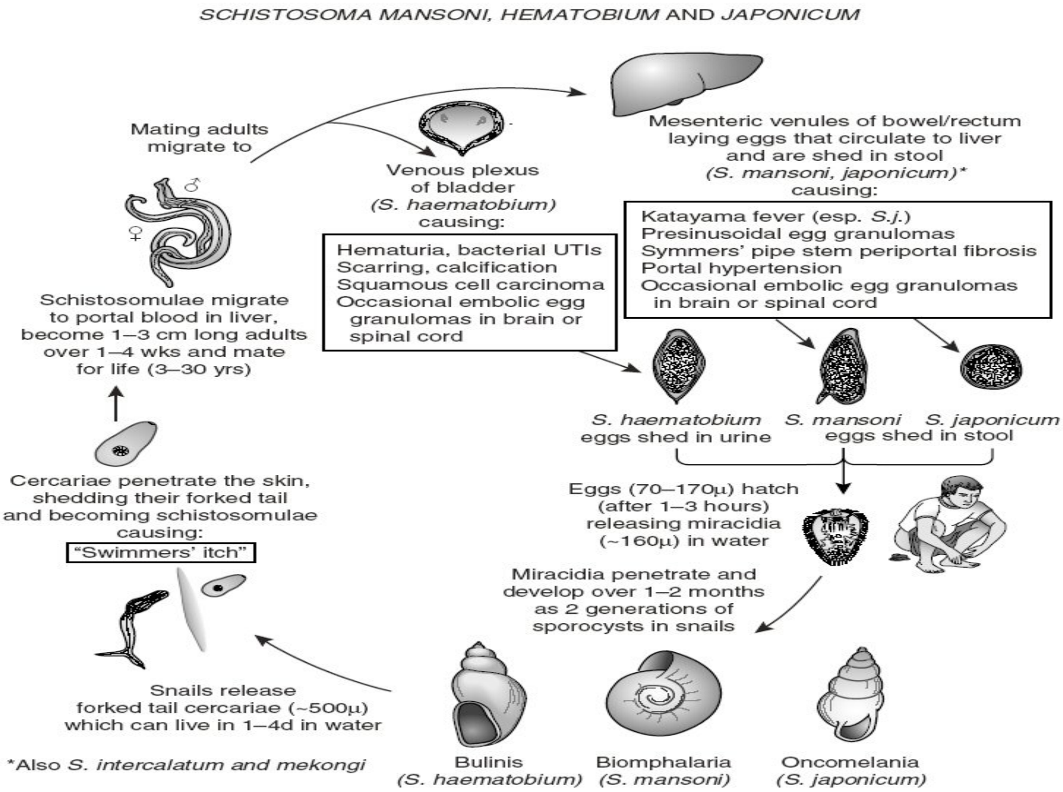
Life Cycles and Transmission of Schistosomes

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.



Life Cycle of *Schistosoma* spp

Fig. 2.2 diagrammatic description of the Life Cycles and Transmission of Schistosomes (Source: Massoud, A.A. *et al*, 2000)

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	*P. westermani*
Pirenella conica	Egypt	*Heterophyes heterophyes*
Lymnaea truncatula	England	*Fasciola hepatica*
Lymnaea natalensis	Nigeria	*Fasciola gigantic*

Asexual multiplication of Schistosomes takes place in the snail True/False

Self-Assessment Exercise 1

- Which of the species of Schistosoma produces the highest numbers of eggs?
- Which of the species of Schistosoma has its ovary positioned at the anterior side of the body?

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.

- 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 generalized 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.
- State two acute symptoms of schistosoma infection

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 competitor's snails into the snail habitat
- Education

- Contamination of natural water bodies with infected human urine and faeces is one of the epidemiological factors in the transmission of Schistosomiasis. True/False
- Reduction of human-water contact is not a factor for the control of Schistosomiasis True/False

2.3.2 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. gigantica*

- *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* is also larger

Fig 2.3 Egg of Fasciola (Echenique-Elizondo, M *etal*. 2005)

Figure 2.3 above showing the egg of *Fasciola.* Ova of *Fasciola* are ovoid in shape, quinone 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.

- Fascioliasis is a a zoonotic disease caused by infection with *F. hepatica.* True/False
- *Fasciola hepatica* and *Fasciola gigantica* are not similar in morphology. True/False

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 grazing. 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 involve

- 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
- Fascioliasis is prevalent where cattles grazes. True/False
- Eating of cooked green vegetables encourages the infection of Fascioliasis. True/False

Self-Assessment Exercise 2

- The liver flukes are large with flattened leaf-like form. True/False
- Fascioliasis is associated with the following except
- Economic losses b. liver condemnation c. reduced production of meat d. increase production of meat

2.4 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.

2.5 Reference/Further Readings/Web Sources

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2.6 Possible Answers To Saes

- False
- D. increased production of meat

Unit 3 Basic Body Plan of a Cestode

Unit Structure

3.1 Introduction
3.2 Intented Learning Outcomes
3.3 Main Contents
    3.3.1 The adult cestode parasite
    3.3.2 The cestode integument
    3.3.3 Metacestodes
3.4 Summary
3.5 References/Further Readings/Web Sources
3.6 Possible Answers to SAEs

3.1 Introduction

The cestodes consist of two separate subclasses: firstly, is the Cestodarians which are parasites of fish and other cold blooded vertebrates. These are non-segmented parasites, with only a single set of sexual organs. Secondly is the more well-known members of the Subclass Eucestoda which are parasites of both warm and cold blooded vertebrates, including mammals such as man. They resemble a colony of individual animals in that their bodies are divided into a series of segments (the proglotids), each with their own complete set of internal organs. There may be many hundreds of these proglotids, resulting in the complete parasite having a long, ribbon-like body. The appearance of this long body is the origin for the common name for these parasites, the tapeworms.

The common names of these parasites are often derived from their intermediate hosts, ingestion of which results in their infection, e.g. the Fish, Beef and Pork Tapeworms.

Alternatively, they may be named after the definitive host that the adult parasites are normally found in. For example, the Rat Tapeworm *H. diminuta* and the Dog Tapeworm *Dipylidium caninum*. The study of the morphology of the cestode body may be divided into two distinct areas. Firstly, the morphology of the adult cestode (the tapeworm) and secondly the morphology of the cestode larvae, or Metacestode.

3.2 Intended Learning Outcomes

By the end of this unit, students should be able to:

- Identify the striking features of cestodes
- Describe the egg, larva and adult stage morphology of common cestodes

3.3 Main Contents

3.3.1 The Adult Parasite

The body of the adult tapeworm may be divided into three regions:

The Scolex

This is the "head" and attachment organ of the parasite. There are four main types of scolex, by which the tapeworm may be taxonomically classified:

- **Scolices (No special attachment organs)**

The scolices of some tapeworms of the order Caryophyllidea (parasites of freshwater fish) have no special attachment organs. (NB. Some authors do not recognise this taxonomic order, placing these parasites within the Pseudophyllidea).

- **b) Bothria** -

This is composed of a pair of shallow, elongated, weakly muscular grooves. Tapeworms of the order Pseudophyllidea are equipped with bothria on their scolices.

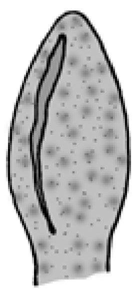


Fig. 3.1The bothria of Pseudophyllidea (Source: Ukoli, F.M.A. (1990)

- **Bothridia**

These are broad, leaflike muscular structure, exhibiting a large degree of variation.

Some bothridia are sessile, some are stalked, whilst others are hooked with accessory suckers. Tapeworms of the order Tetraphyllidea and others are equipped with bothridia.

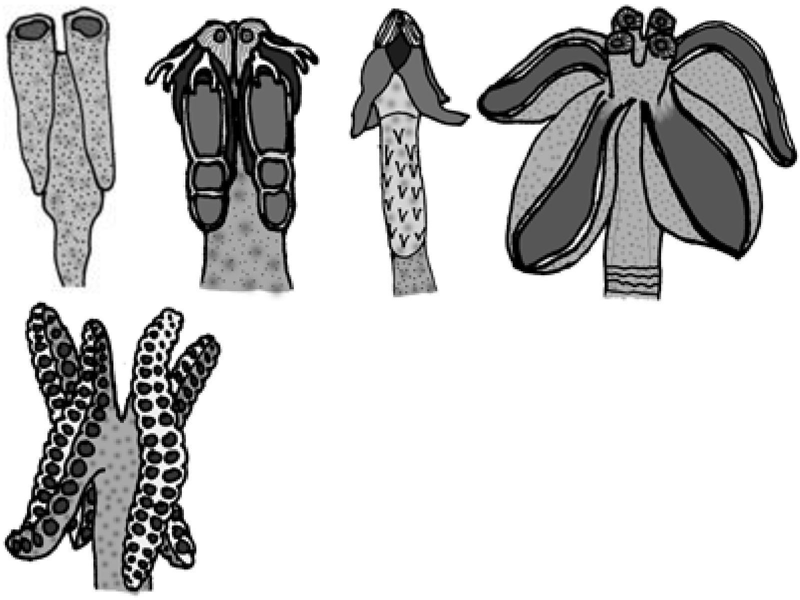


Fig 3.2 Types or Variations of Bothridia (Source: Ukoli, F.M.A. (1990)

- **Acetabulate Suckers –**

Tapeworms of the order Cyclophyllidea are equipped with four acetabulate suckers. Parasites in this order may also have additional features at the apex of the scolex such as

- Glandular areas
  Protrusiblesuckers
  Suckers armed with hooks
  Hooks (e.g. Taenia)

A rostellum, an eversible muscular proboscide, often coverewith hooks (e.g.

Hymenolepis, Echinococcus, Dipylidium)

A Myzorhynchus (a protrusible muscular mass).

The Neck

This is the area of proliferation of the parasite, from which the proglottids of the strobila grow.

The Strobila

This is composed of a series of proglottids. Each proglottid contains a complete set of male and female reproductive organs, although these organs usually mature at different rates. Usually the male organs develop before the female organs, and degenerate before the female organs mature. The large, gravid proglottids at the posterior end of the tapeworm are full of developing, or in the extreme terminal proglottids, mature eggs. State the different regions of the adult tapeworm

Self-Assessment Exercise 1

- Differentiate between the scolex and the neck of an adult tapeworm

3.3.2 The Cestode Tegument

This is a related cestodarians that also belong within the cestodes. It has a tegument that appears to be intermediate with that of the eucestodes and monogeneans. This is another piece of evolutionary evidence that indicates a monogenean origin for the tapeworms. In this case the surface of the cestodarian tegument is covered with numerous microvilli, similar in form to the eucestode microtriche (see below), but lacking the electron dense cap seen in these parasites.

The cesode tegument is a syncytial layer, showing many features typical of that found in other parasitic platyhelminthes.

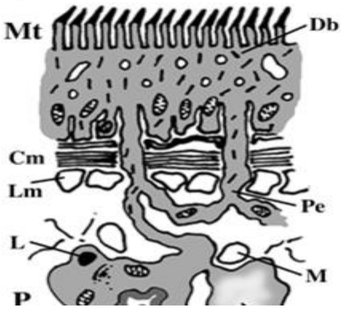


Fig 3.3 Diagram showing eucestode tegument (Source: Ukoli, F.M.A. (1990)

There are however, a number of distinguishing features present in these parasites. On the very outer surface of the tegument a surface glycocalyx is seen to cover the outer plasma membrane. Below this glycocalyx, a characteristic feature of the eucestode tegument is the presence of numerous microtriches (**Mt**), long spine like processes that are in fact a highly modified form of micovilli. Each microthrix has a hard, pointed, electron dense cap which is seperated from the rest of the microthrix by a crescent shaped membranous cap. The mirotriches are thought to serve two functions. Firstly, the tapeworms do not possess a gut and must absorb all of their nutrients across the surface tegument. The microtiches greatly increase the surface area of the parasite, and can be seen as an adaptation to maximise the amounts of nutrients available to the parasite. This is supported by the finding of microtubles in the shaft of the microtriches.

Secondly the spine like character of the microtriches probably help the parasite maintain its position in the gut. This can be more clearly seen by comparing the microtriches found in different regions of the parasite's body. It has been noted in many species that the microtriches found covering the scolex, the attachment organ of the parasite, were much longer than those covering the strobila, and in some species show special adaptations. For example, the microtriches covering the strobila of *E. granulosus* have been found to show curved hooks or sometimes even barbs. Below the layer of microtriches the main syncytial layer of the tegument is found. This has been seen to contain numerous vesicles and membrane bound, electron dense rod-like structures, refered to as disc-shaped bodies (**Db**). Finally, numerous mitochondria, mainly in the distal region of the tegument, may be seen. These are unusual in that they do not have many cristae, reflecting the anaerobic metabolism of the organism. The tegumental nuclei are however not located in this outer layer, but are found within subtegumental cell bodies (**StC**), located beneath the circular (**Cm**) and longitudinal muscle (**Lm**) layers, embedded within the parenchymal tissues (**P**) and mesenchymal musculature (**M**). These subtegumental cell bodies also contain other cellular elements such as golgi apparatus and lipid inclusion bodies (**L**) which are connected to the outer syncytium and areas of glycogen storage (**Gs**) by long protoplasmic extensions (**Pe**). The location of these important cellular elements away from the outer surface of the parasite, exposed to immunological attack by the parasites host, is an important adaptation to a parasitic lifecycle adopted by all of the parasitic platyhelminthes. The parenchymal tissues are similar to those of the trematodes and fill the spaces between the parasites internal organs (all cestodes and other platyhelminthes being acoelomate organisms). These tissues are a syncytial network formed by anastomosis of mesenchymal cells, with spaces filled with carbohydrate rich parenchymal fluid.

- The tegument of a Cestode does not appears to be intermediate with that of the eucestodes. True/False
- The Cestodes has a common monogean origin with the tapeworm. True or False

The Larval Cestodes

- **The Cestodarians**

The cestodarians larvae, or **lycophore** are free swimming, being covered in cillia. They have a set of ten hooks at the extreme anterior of the body, thus differing from the larval eucestodes, which are equiped with 3 pairs of hooks. Anteriorly they are armed with penetration glands. The bodily form of these larvae bears a marked resemblance to the larvae of the trematodes, such as the miracidium in the digeneans, and the larval monogenean, the oncomiracidium.

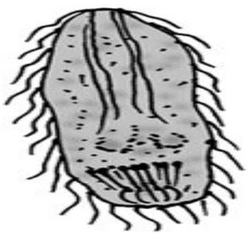


Fig 3.4 A lycophore (Source: Ukoli, F.M.A. (1990)

The Eucestodes (Tapeworms)

The eggs of Pseudophyllidean and Cyclophyllidean cestodes differ considerably. The egg of the pseudophyllidean tapeworm closely resembles that of the trematodes, having a thin shell wall, and an operculum, which on hatching opens to reseales the free swimming larvae. This illustrates the close relationship between the two major groups of platyhelminth parasites. In contrast, the egg of the cyclophyllideans tapeworms is very different, having a very thick, resistant egg shell, with no operculum.

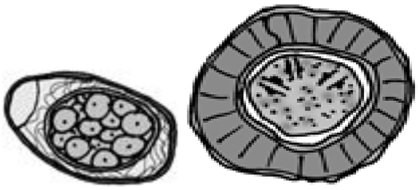


Fig 3.5 The pseudophyllidean and cyclophyllidean ova (Source: Ukoli, F.M.A. (1990)

The larvae emerging from these eggs also differ. The pseudophyllidean egg hatches to release a free swimming larvae called a coracidium. This has an outer layer of ciliated epidermal cells with which it swimms through the water before being ingested by the parasites first intermediate host. This is often a copepod. Inside the copepod the ciliated epidermis is shed, to release a larvae that initially resembles that of the newly hatched cyclophyllideans. This has 6 hooks, arranged in pairs, and is a common feature throughout the eucestodes. On the basis of the presence of these hooks, present in both the eucestodes and cestodarians, many authors believe that the cestodes originally evolved from an ancestor common to the extant monogeneans.

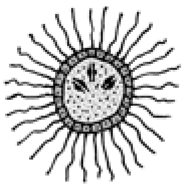


Fig 3.6 Coracidium larva (Source: Ukoli, F.M.A. (1990)

The larval cyclophyllidean, as with the pseudophyllidean, is equiped with 3 pairs of hooks. Both groups use these hooks to penetrate the gut wall of its intermediate host after being ingested, before developing into the other larval forms described below in more detail.

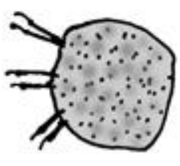
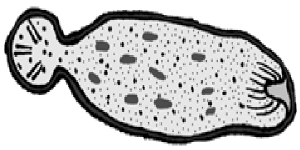


Fig 3.7 Larva of cyclophyllidean (Source: Ukoli, F.M.A. (1990)

The egg of the pseudophyllidean tapeworm does not resembles that of the trematodes. True/False

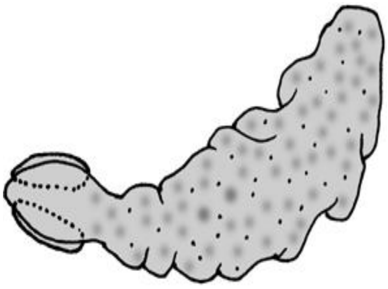
3.3.3 Metacestodes

A number of different larval forms of cestodes (metacestodes) are seen, these include the following; (Source: Ukoli, F.M.A. (1990)



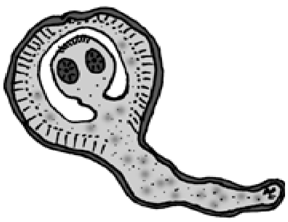
A Procercoid of **Pseudophyllidean (**e.g *D. latum***) Fig 3.8a**

A larval form of **Pseudophyllidean** cestodes, (e.g. *D. latum*, *Ligula intestinalis*). Here two forms of the procercoid are shown. Firstly an immature procercoid, and secondly a mature infective procercoid. In the lifecycle of these parasites there are two intermediate hosts. The procercoid being found in the first of these (usually a small crustacean e.g. *Cyclops*).In appearance these larvae have solid bodies with the remains of the embryonic hooks from the onchosphere larvae at the posterior of the parasite.



A Plerocercoid of **Pseudophyllidean (**e.g *D. latum*) **Fig 3.8b**

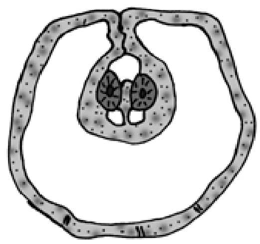
A larval form of **Pseudophyllidean** and other Cestodes, (e.g. *D. latum, Ligula intestinalis*). In the lifecycle of these parasites there are two intermediate hosts (see the cestode life cycle page). The plerocercoid being found in the second of these (usually a fish or amphibian). In appearance, these are elongated larvae with solid bodies which are much larger than the preceding procercoid larvae. In these stages the embryonic hooks are absent. The plerocercoids of some Pseudophyllideans already show the start of the development of the sexual organs (e.g. *Schistocephalus solidus, Ligula intestinalis*), whilst those of *Schistocephalus solidus* are also already divided into proglottids).



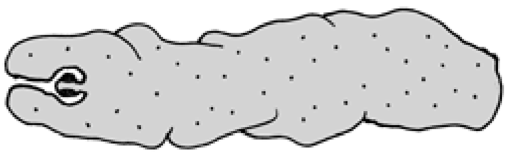
A larval form of **Cyclophyllidean** Cestodes, (e.g. *Hymenolepis* sp.)

Fig 3.8c

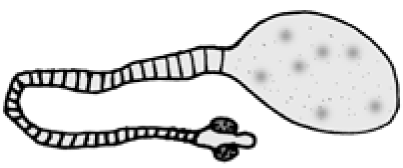
A larval form of **Cyclophyllidean** Cestodes, (e.g. *Hymenolepis* sp.). This larval form is usually found in species where the intermediate host is an invertebrate, usually an insect.



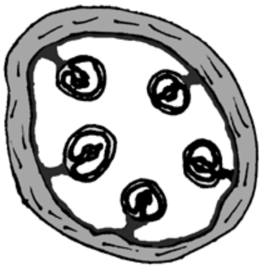
A larval form of **Cyclophyllidean** Cestodes, (e.g. *Taenia solium*) **Fig 3.8d**



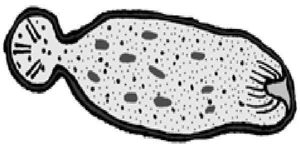
A larval form of **Cyclophyllidean** Cestodes, (e.g. *Mesocestoides* sp.). **Fig 3.8e**



A larval form of **Cyclophyllidean** Cestodes, (e.g. *Taenia taeniaeformis*). **Fig 3.8f**



A larval form of **Cyclophyllidean** Cestodes, (e.g. *Taenia multiceps*). **Fig 3.8g**



A larval form of **Cyclophyllidean** Cestodes, (e.g. *Echinococcus granulosus*). - Hydiatid cyst **Fig 3.8h**

The diagram above depicts …………

Self-Assessment Exercise 2

The diagram depicts ----------------------

3.4 Summary

The body plan of adult cestode is divided into scolex, neck and strobila. The scolices of the order Caryophyllidea (parasites of freshwater fish) have no special attachment organs while the Pseudophyllidea have weakly muscular grooves which are armed with bothria. The Cyclophyllidea have four acetabulate suckers. In addition to these are glandular areas, protrusible suckers and rostellum depending on the species of the cyclophillidean. The strobila is made up of proglottids containing the male and the female reproductive organs. The larvae of cestodes vary with species with some being ciliated and as such are free swimming. Some however, have operculum with thin shell wall. Others have thick shell wall with 6 hooks.

3.5 Reference/Further Readings/Web Sources

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https://youtu.be/gVt_a2eaHUw,

3.6 Possible Answers to SAES

Answer to SAEs 1

Scolex is the "head" and attachment organ of the parasite while "neck" is the area of proliferation of the parasite, from which the proglottids of the strobila grow

Answer to SAEs 2

A Coracidium larva

Unit 4 Tapeworms of Man

Unit Structure

4.1 Introduction

Two species from the genus *Taenia* are common parasites of man, these being *Taenia solium* (the Pork tapeworm) and *Taenia saginata* (the Beef tapeworm). *Taenia saginata* has a cosmopolitan distribution, with estimates of approximately 50 million cases of infection world-wide annually. As with *T. saginata* and *T. solium* this parasite has a cosmopolitan distribution, with estimates of approximately 50 million cases of infection world-wide annually. However, the incidence of infection may vary considerably, and may be influenced by a number of factors such as religious inhibitions on eating pork, as in many Islamic countries, or in other countries by high degrees of sanitation, limiting exposure of the intermediate hosts to human faeces. This parasite has pigs as the main intermediate host, but man may also act as an intermediate host for this parasite as well as being infected with the adult tapeworms. This aspect of the parasites lifecycle has important implications for the pathology associated with infection with this parasite.

4.2 Intended Learning Outcomes

By the end of this unit, student should be able:

- To describe the morphology and life cycle of a named Taenia *spp*.
- To explain the pathology, epidemiology and control of these parasites

4.3 Main Contents

4.4.1 Life cycle of *Taenia* spp (*Taenia solium and Taenia saginata*)

This parasite has cattle or related animals as its main intermediate hosts, although other animals such as camels, llamas and some antelopes may also occasionally be infected.

The larval form in these animals is a cysticercus in the muscles and heart. These are infected by ingestion of the eggs of the tapeworm, shed from the faeces of the carnivorous definitive host, in this case man. Once ingested the eggs hatch to release the hexacanth larvae, which migrate through the intestinal wall to reach the blood or lymphatic systems, from where it is carried to the tissues, particularly the heart and other muscles to develop into the cysticercus. Man is infected by ingestion of undercooked or raw meat, the bladder walls of the cysticercus being digested in the intestine to release the scolex of the parasite. This attaches to the intestinal wall and grows into the mature adult tapeworm.

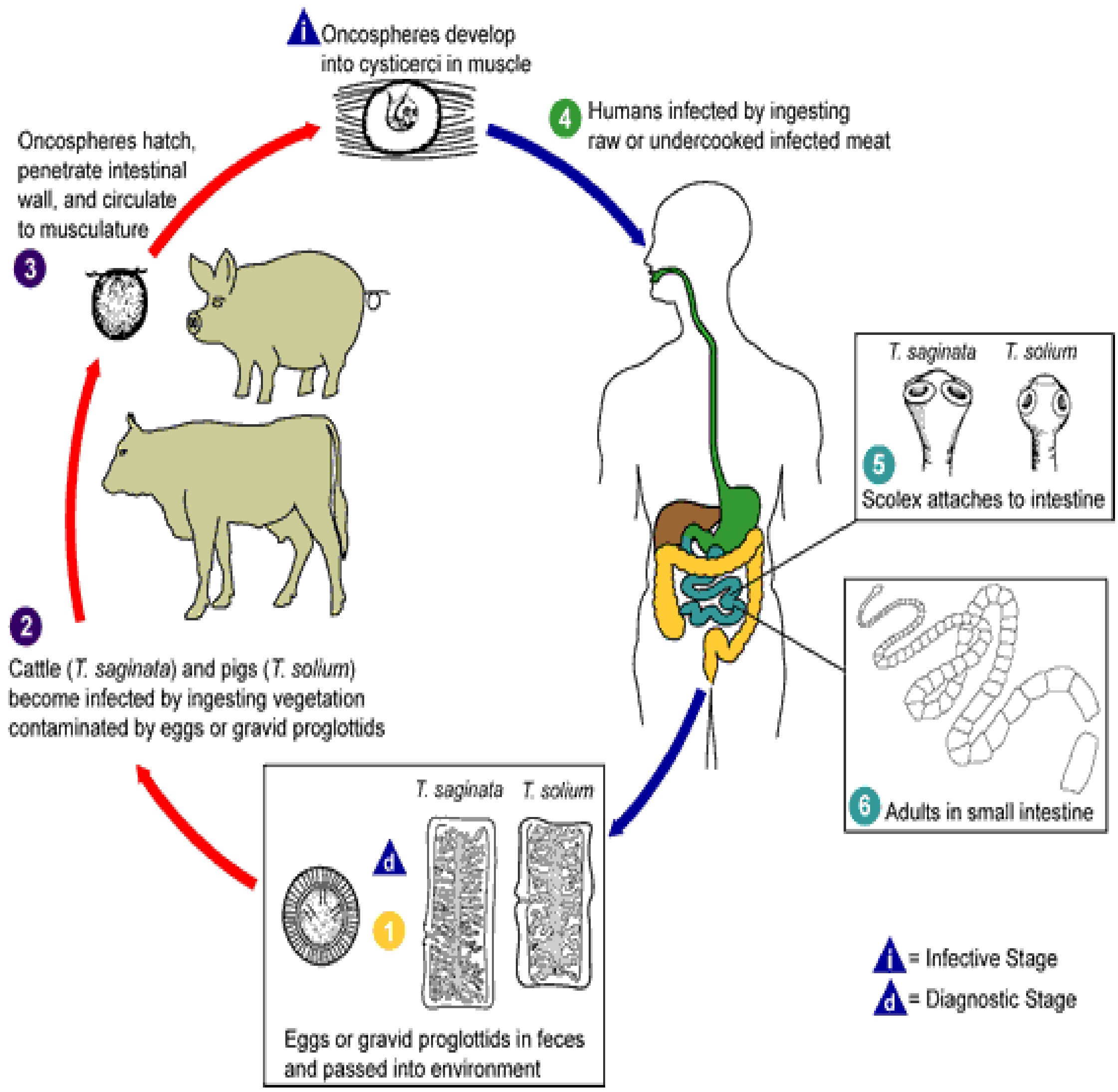

Fig 4.1 Life cycle of *T. saginata* and *T. solium* (Source: Khalil, L.*et al*. 1994).

Mention a well-known definitive host of Taenia spp.

4.3.2 Morphology of Taenia spp

Taenia saginata

Larvae - These cysticerci are approximately 7.5-10mm wide by 4-6mm in length.

Adults - The adult tapeworms have an average length of about 5 meters, consisting of approximately 1000 proglottids, but may grow up to 17 metres in length occasionally, and are therefore longer than the adult forms of *Taenia solium*. The mature proglottids have approximately double the number of testes that *T. saginata* has and are larger. The gravid proglottids are also larger, measuring approximately 20mm long by 6mm wide with a uterus with more lateral branches than *T. solium*. These gravid proglottids when detached from the strobila may be very active, not only crawling away from the faeces when passed, but often actively emerging from the anus to deposit eggs from the ruptured uterus around the perianal region. The scolex in this tapeworm may also be differentiated from *T. solium* as it is slightly larger, at approximately 2mm in diameter and is unarmed, without any hooks, although the 4 acetabular suckers are still present.

Larvae - These small cysticerci (refered to as *Cysticercus cellulosae*) areapproximately 6- 18mm wide by 4 - 6mm in length when found in the muscles or subcutaneous tissues (the normal sites for the larva of this parasite). The cysticerci may however be found in other tissues such as those of the central nervous system where they may grow much larger, up to several centimetres in diameter.

Adults - The adult tapeworms have an average length of about 3 meters, but may grow up to 8 metres in length occasionally, and follow the typical morphology of cestode tapeworms. The strobila consists of between 800 and 1000 proglottids. The mature proglottids having trilobed ovaries with a small central lobe in addition to the two lateral lobes and only approximately half the number of testes that *T. saginata* has. The gravid proglottids, measuring approximately 12mm long by 6mm wide, have a uterus with between 8 to 12 lateral branches, less than *T. saginata*. The scolex in this tapeworm may also be differentiated from *T. saginata* as it is equipped with a low rostellum with a double crown of approximately 30 hooks.

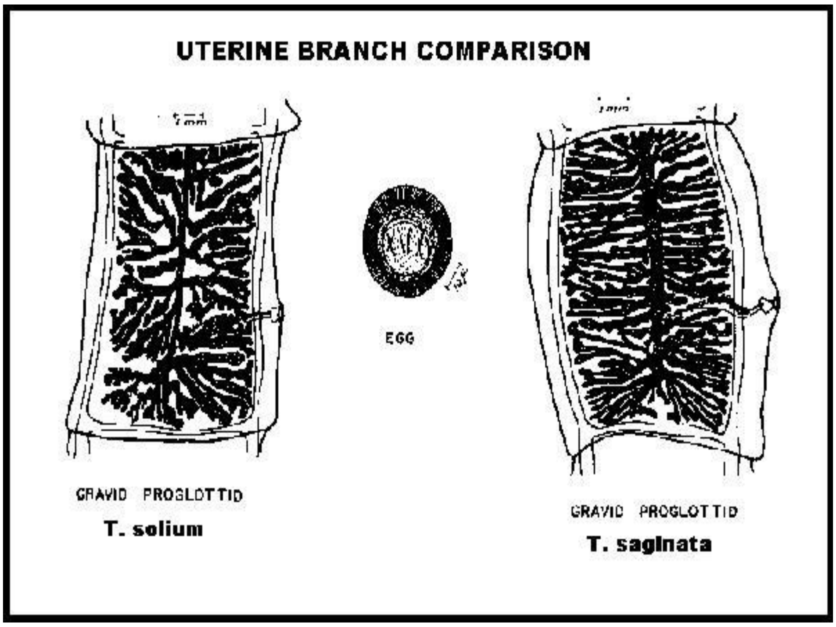

Fig 4.2 Figure showing the distinctions between the proglottid of *T. solium* and *T. saginata* (Source: Khalil, L.*et al*. 1994).

Major Differences between *T. saginata* and *T. solium*

Features	***T. saginata***	***T. solium***
Size	3-7m(sometimes Upto 25m) long	2-3m(sometimes up to 10m) long
No. of proglottids	1000-2000 (sheds 3-10 daily)	800-1000 (sheds 8-10 daily)
No. of eggs per proglottid	100000	40000
Scolex	Cuboidal, up to 2.0mm In diameter	Spheroid, about 1.0mm in diameter
Rostellum	Absent	Present, armed with two circlets of 22-32 hooks
No. of testes	800-1200	300-500
Shape of ovary	Bilobed	Trilobed
Gravid uterus	15-25 lateral branches on each side	7-13 lateral branches on each side
Vaginal sphincter	Present	Absent
Gravid proglottid	When detached, active and creep out through anus and craw about individually	When detached, passive

The larva of Taenia spp is called --------------

Self-Assessment Exercise 1

- Differentiate between *T. Solium* and *T. saginata* in terms of the number of proglottids

4.3.3 Pathology of Infection of Taenia spp

T. saginata

Larvae - Unlike *T. solium*, *T. saginata* does not utilise man as an intermediate host, and therefore pathology due to the larval form is not a feature in human disease. In cattle the cysticercus, refered to as *Cysticercus bovis* (named before the parasite life cycle had been determined, and the connection between the two forms had been established) is completely asymptomatic.

Adults - The pathology of infection with adult *T. saginata* is highly variable. Often infections are completely asymptomatic, but in other cases some degree of pathology may be seen, most seriously intestinal blockage. In some cases, vitamin deficiency may be the result of excessive absorption of nutrients by the parasite, although this aspect of tapeworm pathology is more a feature of infection with the fish tapeworm *D. latum*. In addition infection may be accompanied by a broad range of non-specific symptoms, including more commonly, (if seen at all), abdominal pain, digestive disturbances, excessive appetite *or* loss of appetite, weakness and weight loss.

T. solium

Larvae - Infection with the larval form of *T. solium Cysticercus cellulosae*, (called "Cysticercosis") may have severe consequences, the annual world-wide mortality due to cysticercosis having been estimated at approximately 50 000 cases. In man the cysticerci mainly develop in the subcutaneous tissues, but infections in both the Central Nervous System (C.N.S.) and ocular tissues are also very common. Infection of the C.N.S. may cause severe pain, paralysis, optical and/or psychic disturbances and epileptic convulsions, mainly due to mechanical pressure as the larvae develop. Later there may be loss of consciousness and even death. Infections involving the eye may give rise to discomfort, and can cause detachment of the retina.

Adults - Usually only a single adult specimen is present, which may cause a slight degree of mucosal inflammation. The actual effects on the host may vary considerably, often there are few symptoms, but in some cases a variety of non-specific symptoms such as constipation, epigastric pain and diarrhoea, are present. Very rarely there may be perforation of the intestinal wall, with subsequent peritonitis. However, more seriously, as detailed above, the presence of adult worms carries the risk of autoinfection due to reverse-peristalsis resulting in cysticercosis, it being estimated that approximately 25% of cases of *Cysticercus cellulosae* infections in man being acquired by this route.

Infection caused by the larval form of *Taenia solium* is called -------------

4.3.4 Diagnosis of Infection of *Taenia* spp

- Demonstration of scolex and proglottids in the faeces. However, scolex are rarely excreted in faeces

- The eggs of *T. saginata* and *T. solium* are similar. However, most laboratory diagnosis is through the observation of *Taenia* spp eggs in faecal sample.
- Examination of gravid uterus shows 15-25 lateral branches in *T. Saginata* and 7-13 lateral branches (counted from the main stem) in *T. Solium* when short chains of 5-8 proglottids passed out in faeces are pressed through glass slides.
- The scolex of *T. saginata* is easily distinguished from that of *T. solium* in that it has only 4 suckers but no hooks.
- Radiological examination of the intestinal tract may reveal tapeworm infection.

Epidemiology and control

The prevalence of *Taenia* infection is on the increase due to the following factors;

- Intensification of animal production
- Development of meat industries in several developing countries
- Consumption of undercooked beef and pork by tourist visiting highly endemic areas
- Consumption of semi-cooked meat in manufactured food products like hamburgers, etc.
- Accelerating urbanisation with decreased efficiency of sewage systems
- Sewage farming
- In view of the above listed epidemiological factors that favour transmission, the following measures can be taken to reduce prevalence;
- Proper meat inspection services before usage in meat industries. Diseased meat should be condemned and destroyed
- Lightly infected beef with cysticerci can be rendered safe for consumption by freezing at -10^{o}C for at least 10 days
- Cooking of meat well before eating
- High standards of sanitation will reduce transmission
- Immunization against bivine cysticercosis.

Others *Taenia* spp which have man as accidental host are *T. taeniformis, T. bremneri, T. multiceps, T. serialis* and *T. glomerulatus*

Most laboratory diagnosis of Taenia spp is through -----------------------

Self-Assessment Exercise 2

- Give any two reasons why the prevalence of Taenia infection is on the increase and how it can be controlled

4.4 Summary

The two major tape worms infecting man are *Taenia saginata* (beef tape worms) and *T.*

solium (pork tape worm). Infections by these tapeworms often occur following the consumption of raw or undercooked beef and pork. Others *Taenia* spp which have man as accidental host are *T. taeniformis, T. bremneri, T. multiceps, T. serialis* and *T.*

glomerulatus. Proper cooking of beef and pork could prevent infection due to *T. saginata* and *T. solium* including good sanitary condition.

4.5 Reference/Further Readings/Web Sources

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4.6 Possible Answers to Saes

Answer to SAE 1

T. saginata has about 1000-2000 proglottids shed 3-10 times daily while *T. solium* has about 800-1000 proglottids shed 8-10 times daily

Answer to SAE 2

- Intensification of animal production
- Development of meat industries in several developing countries
- Control measures include Proper meat inspection services before usage in meat industries. Diseased meat should be condemned and destroyed

Glossary

- *T. solium*……………………. *Taenia solium*
- *T. saginata*…………………. *Taunia saginata*
- *Taenia solium*……………. Pork tapeworm
- *Taenia saginata*…………. Beef tapeworm
- Small Cysticerci…………. Cyst cercus cellulasae
- Cersticercosis……………… Infection caused by Cysticercus cellulasae
- C.N.S. ……………………… Central Nervous System

End of the Module Question

- Describe the different body forms of an adult trematode
- Outline the different human flukes and where they are found in the body
- What is cestode integument?
- Make an annotated diagram of the life cycle of a Taenia spp.

MODULE 3 NEMATODES

In this module we will discuss about the evolution of parasitic association with the following units:

Unit 1 General Features And Life Cycles Of Nematodes

Unit Structure

1.1 Introduction

Nematode infections in human include ascariasis, trichuriasis, hookworm, enterobiasis, strongyloidiasis, filariasis, and trichinosis, among others. The phylum Nematoda, also known as the roundworms, is the second largest phylum in the animal kingdom, encompassing up to 500,000 species. Members of Nematoda are elongated, with bilaterally symmetric bodies that contain an intestinal system and a large body cavity.

Many roundworm species are free living in nature. Recent data have demonstrated that approximately 60 species of roundworms parasitize humans. Intestinal roundworm infections constitute the largest group of helminthic diseases in humans. According to a 2005 report by the World Health Organization (WHO), approximately 0.807-1.221 billion humans have ascariasis, 604-795 million have trichuriasis, and 576-740 million have hookworm infections worldwide.

1.2 Intended Learning Outcomes

By the end of this unit, students should be able to:

- List the various examples of nematodes with thier common names
- Describe the general morphological features of nematodes
- Explain the life cycles of the major groups of nematodes

1.3 Main Contents

3.3.1 General features Nematodes

General Features

Nematodes are cylindrical rather than flattened; hence the common name roundworm. The body wall is composed of an outer cuticle that has a noncellular, chemically complex structure, a thin hypodermis, and musculature. The cuticle in some species has longitudinal ridges called alae. The bursa, a flap-like extension of the cuticle on the posterior end of some species of male nematodes, is used to grasp the female during copulation.

The cellular hypodermis bulges into the body cavity or pseudocoelom to form four longitudinal cords; a dorsal, a ventral, and two lateral cords which may be seen on the surface as lateral lines. Nuclei of the hypodermis are located in the region of the cords. The somatic musculature lying beneath the hypodermis is a single layer of smooth muscle cells. When viewed in cross-section, this layer can be seen to be separated into four zones by the hypodermal cords. The musculature is innervated by extensions of muscle cells to nerve trunks running anteriorly and posteriorly from ganglion cells that ring the midportion of the esophagus.

The space between the muscle layer and viscera is the pseudocoelom, which lacks a mesothelium lining. This cavity contains fluid and two to six fixed cells (celomocytes) which are usually associated with the longitudinal cords. The function of these cells is unknown.

The **alimentary canal** of roundworms is complete, with both mouth and anus. The mouth is surrounded by lips bearing sensory papillae (bristles). The oesophagus, a conspicuous feature of nematodes, is a muscular structure that pumps food into the intestine; it differs in shape in different species.

The intestine is a tubular structure composed of a single layer of columnar cells possessing prominent microvilli on their luminal surface.

The excretory system of some nematodes consists of an excretory gland and a pore located ventrally in the mid-esophageal region. In other nematodes this structure is drawn into extensions that give rise to the more complex tubular excretory system, which is usually H-shaped, with two anterior limbs and two posterior limbs located in the lateral cords. The gland cells and tubes are thought to serve as absorptive bodies, collecting wastes from the pseudocoelom, and to function in osmoregulation.

Nematodes are usually bisexual. Males are usually smaller than females, have a curved posterior end, and possess (in some species) copulatory structures, such as

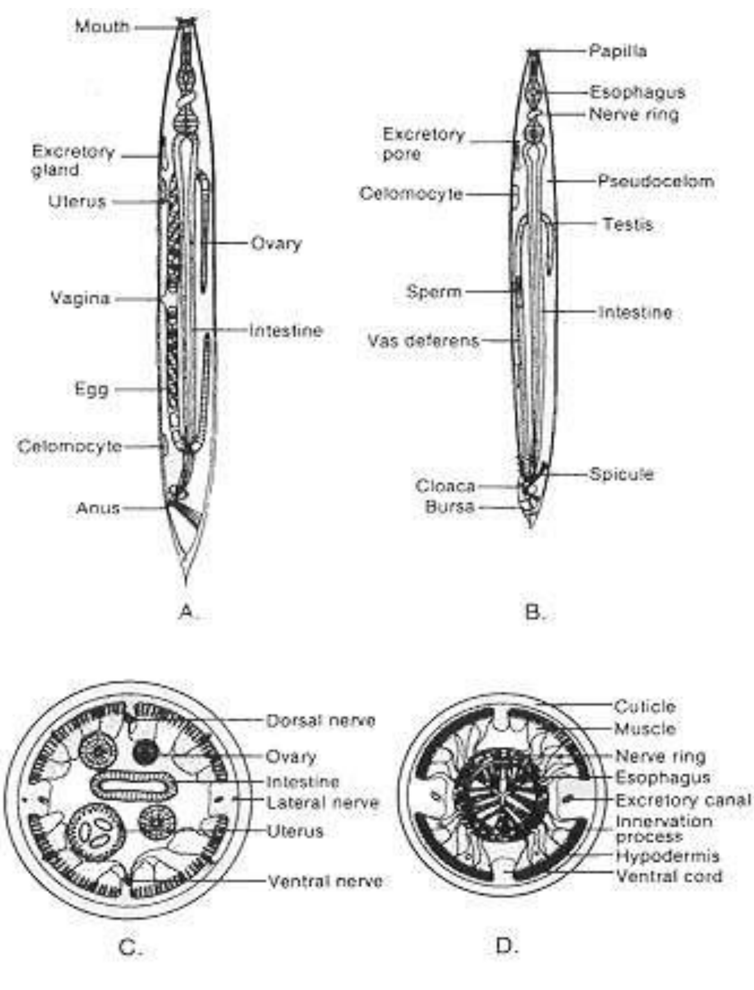

Fig 1.1 Structure of nematodes. (A) Female. (B) Male. Transverse sections through the mid region of the female worm (C) and through the esophageal region (D). (Source: Ukoli, F.M.A. 1990).

spicules (usually two), a bursa, or both. The **males** have one or (in a few cases) two testes, which lie at the free end of a convoluted or recurved tube leading into a seminal vesicle and eventually into the cloaca.

The **female** system is tubular also, and usually is made up of reflexed ovaries. Each ovary is continuous, with an oviduct and tubular uterus. The uteri join to form the vagina, which in turn opens to the exterior through the vulva.

Copulation between a female and a male nematode is necessary for fertilization except in the genus *Strongyloides*, in which parthenogenetic development occurs (i.e., the development of an unfertilized egg into a new individual). Some evidence indicates that sex attractants (pheromones) play a role in heterosexual mating. During copulation, sperm is transferred into the vulva of the female. The sperm enters the ovum and a fertilization membrane is secreted by the zygote. This membrane gradually thickens to form the chitinous shell. A second membrane, below the shell, makes the egg impervious to essentially all substances except carbon dioxide and oxygen. In some species, a third proteinaceous membrane is secreted as the egg passes down the uterus by the uterine wall and is deposited outside the shell. Most nematodes that are parasitic in humans lay eggs that, when voided, contain either an uncleaved zygote, a group of blastomeres, or a completely formed larva. Some nematodes, such as the filariae and *Trichinella spiralis*, produce larvae that are deposited in host. Nematodes are flattened organisms. True/False

Self-Assessment Exercise 1

- Copulation between a female and a male nematode is necessary for fertilization in all genus of nematodes. True/False
- Nematodes are usually bisexual. True/False

1.3.2 The Basic Life Cycle of the Major Groups of Nematodes

The life cycles of the parasitic species vary considerably, as would be expected from such a large and diverse group. There are however a number of common features:

- Firstly, the parasite undergoes a series of moults through larval stages (designated **L1** to the adult **L5** form).
- Secondly, in most (but not all) nematodes it is the **L3** larvae that is the infective form, important exceptions to this being the Ascarids, such as *Ascaris lumbricoides* and the pinworms, where it is either the **L1** larvae, or eggs containing **L1** or **L2** larvae that are infective.
- Thirdly the **L3** form onwards in all species undergoes a migration within the body of the definitive host as it matures into the adult parasite, usually via the bloodstream or lymphatic system to the heart, lungs, trachea, and then to the intestine.
- Finally, in most cases the parasite leaves the definitive host as thin walled eggs in the faeces, important exceptions being the viviparous filarial worms (where **L1** larvae infect intermediate hosts, usually in the blood meals of biting arthropods), *Strongyloides stercoralis*, (where the **L1** larvae are found in the faeces), and the viviparous *Trichinela spiralis*, where the larvae do not leave the body as such, but develop to the **L3** stage which then encysts in the muscles, infection being by ingestion of undercooked contaminated meat.
- Infection of the definitive host may be by a variety of routes, such as the oral route, where eggs are accidentally ingested, also many filarial worms are infective via the bite of flies, as previously decribed, and the **L3** larvae of many nematodes such as the hookworms and other related nematodes are directly invasive.

In terms of complexity, the simplest life cycles are those of the pinworms, where adults living in the colon mate and lay eggs which pass out in the faeces, infection being either by the oral route with eggs, or perianally, where eggs hatch around the anus and **L1** larvae migrate back through the anus.

The most diverse is probably that of *S. stercoralis*, where there are a number of alternative lifecycles which it may undergo, either as a completely free living soil nematode, or as the standard infective **L3** larvae with tissue migration to the intestine, or even occasionally full completion of the life cycle within the intestine, and finally in immunocompromised hosts a life-threatening disseminated infection can occur, with parasites found throughout the body.

We shall be looking at the respective or individual helminths or nematodes in the next few units. All nematodes are infective at **L3** larval form. True/False

Self-Assessment Exercise 2

- The alimentary canal of roundworms has both mouth and anus. **True/False**
- The male nematodes are usually larger larger than the female nematodes. **True/False**
- Copulation between a female and a male nematode is not necessary for fertilization. **True/False**
- In most cases the nematode parasite leaves the definitive host as thick walled eggs in the faeces. **True/False**
- Nematodes with the simplest life cycles are those of the -------------------

1.4 Summary

Nematodes are roundworms with pseudocoelom (lacking a mesothelium lining). The alimentary canal is complete having mouth and anus. The intestine is a tubular structure composed of a single layer of columnar cells possessing prominent microvilli on their luminal surface. The excretory system of some nematodes consists of an excretory gland and a pore with complex tubular excretory system, which is usually H-shaped.

Nematodes are usually bisexual. Males are usually smaller than females. Copulation between a female and a male nematode is necessary for fertilization except in the genus *Strongyloides*, in which parthenogenetic development occurs (i.e., the development of an unfertilized egg into a new individual). Parasite undergoes a series of moults through larval stages with L3 larva mostly being the infective stage. Infection of the definitive host may be by accidental ingestion of eggs, bite of flies and skin penetration by the infective L3 larval form as in the case of hookworms.

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1.6 Possible Answers to Saes

Answer to SAEs 1

- False
- True

Answer to SAEs 2

1. True 2. False (females are usually larger) 3. False (copulation is necessary in most cases) 4. False (they leave as thin as thin-walled egg) 5. Pinworms

Unit 2 Soil Transmitted Helminths-*Ascaris Lumbricoides*

Unit Structure

2.1 Introduction

Soil-transmitted helminth (STH) infection is highly endemic in tropical and subtropical areas of sub-Saharan Africa, Asia and Latin America, where up to 2 billion people have active infections. STH infection has remained largely neglected by the global health community because the people most affected are among the most impoverished and because the infection causes chronic ill health with insidious clinical presentations, rather than severe acute illness or high mortality. However, it is now recognized that STH infection causes significant morbidity worldwide with 39 million disability adjusted life years (DALYs) lost each year - more than those lost to malaria (36 million yearly) and approaching those lost to tuberculosis (47 million yearly). *Ascaris lumbricoides,* the large roundworm of man is one of these helminths.

2.2 Intended Learning Outcomes

By the end of this unit, the students should be able to

- Explain the morphology *Ascaris lumbricoides*
- Describe their life cycles with emphasis on the route of infection
- Describe the diagnostic features of the parasites

2.3 Main Contents

2.3.1 Morphology of *Ascaris lumbricoides*

Infection with this roundworm is extremely common, with estimates of the annual incidence of infection being greater than 1500 million cases, or around one quarter of the worlds population. In addition to the species in man, *Ascaris lumbricoides*, a morphologically indistinguishable species *Ascaris suum* is found in the pig. Other related genera include *Parascaris* in equines, and *Toxascaris* in a variety of domesticated animals.

The adult *Ascaris lumbricoides* are large white, or pinkish-white, cylindrical roundworms, slightly narrower at the head. The slenderer males measure between 10 to 30cm long and have a curved tail with two spicules, but no copulatory bursa. The females are very similar, being slightly larger at between 20 to 35cm long, a vulva approximately a third of the length of the body down from the head, and have a blunt tail. They are both characterised by having a smooth, finely striated, cuticle, and a mouth, which is characteristic of all of the Ascarids (e.g. *Toxocara*), having three lips each equipped with small papillae. Internally they follow the generalised body plan of all nematodes, and have a cylindrical oesophagus opening into a flattened ribbon like intestine.

The eggs consist of a thick transparent inner shell which is covered in a thick, warty, albuminous coat.

Fig 2.1 Eggs unfertilized (left) fertilized (right) of *A. lumbricoides*. (Source: Ukoli, F.M.A. 1990).

Mention the name of the roundworm found in Man

2.3.2 Life cycle of *Ascaris lumbricodes*

These parasites have a direct life cycle, with no intermediate hosts. The adult parasite lives in the lumen of the small intestine of man, usually only feeding on the semi-digested contents of the gut, although there is some evidence that they can bite the intestinal mucous membrane and feed on blood and tissue fluids. The female parasite is highly prolific, laying an estimated 2 million eggs daily. In the intestine, these only contain an unembryonated mass of cells, differentiation occurring outside the host. This requires a temperature less than 30°C, moisture and oxygen, before the development of the young L1 larvae after approximately 14 days. Eggs containing the L2 larvae take another week to develop, before they are infective to man, and may remain viable in the soil for many years if conditions are optimal. Infection occurs on ingestion of raw food, such as fruit or vegetables, that is contaminated with these infective eggs. The eggs then hatch in the small intestine, to release the L2 rhabditiform larvae (measuring approximately 250 by 15µm in size. These do not simply grow into the adult forms in the intestine, but must then undergo a migration through the body of their host. These L2 larvae penetrate the intestinal wall, entering the portal blood stream, and then migrate to the liver, then heart, then after between 1 to 7 days, the lungs. Here they moult twice on the way to form the L4 larvae, (measuring approximately 1.5mm long), then burrow out of the blood vessels, entering the bronchioles. From here they migrate up through the air passages of the lungs, to the trachea. They then enter the throat and are swallowed, finally ending up in the small intestine where they mature and mate, to complete their life cycle.

The roundworm, Ascaris lumbricoides has no ------------------- host

a. direct b. intermediate c. indirect d. permanent

Self-Assessment Exercise 1

- The adult parasites of Ascaris lumbricoides lives in the lumen of the ----------
- gall bladder b. Large intestine c. Stomach d. Small intestine
- Ascaris lumbricodes may feed on blood and tissue fluid. True/False
- The female Ascaris parasites doesnt produce much eggs. True/False

2.3.3 Pathology of Infection.

The majority of infections (~85%) *appear* to be asymptomatic, in that there is no gross
pathology seen. However, the presence of these parasites appears to be associated with the same general failure to thrive in their hosts seen with many of these intestinal nematodes. In terms of more easily identified pathology, this may be divided into three areas;

Pathology Associated with the Ingestion and Migration of Larvae

Severe symptoms of *Ascaris* infection may be associated with the migrating larvae, particularly in the lungs. If large numbers of these larvae are migrating through the lungs simultaneously this may give rise to a severe haemorrhagic pneumonia. More commonly, as is the case with most infections, the haemorrhages are smaller in scale, but still may lead to breathing difficulties, pneumonia and/or fever. A complication here is that many of the parasites proteins are highly allergenic. Due to this the presence of the migrating larvae in the lungs is often associated with allergic hypersensitivity reactions such as asthmatic attacks, pulmonary infiltration and urticaria and oedema of the lips.

Pathology Associated with Adult Parasites in the Intestine

The most common symptoms of infection are due to the adult parasite, and consist of rather generalised digestive disorders, such as a vague abdominal discomfort, nausea, colic (e.t.c.). These symptoms are dependent to some extent on the parasite's burden of the host, which in severe cases may consist of many hundreds or even thousands of parasites, although these are extreme cases. In the case of these heavy infections the presence of many of these large parasites may contribute to malnutrition in the host, especially if the hosts (often children) are undernourished. A more serious, and potentially fatal, condition may arise in these heavier infections, where the mass of worms may block the intestine and need to be surgically removed. This may also occur sometimes on treatment for other intestinal nematodes such as hookworms, where the curative drug dose for these parasites irritates the ascarids.

Pathology due to "Wandering" Adults outside of the Intestine

Adult parasites often leave the small intestine to enter other organs, (sometimes in response to anti-helminthic drugs used to treat other intestinal nematode infections), where they may cause various types of pathology, sometimes with severe consequences.

For example, adult *Ascaris* worms may migrate to the bile duct, which may then become blocked causing jaundice and a general interference in fat metabolism. Adult parasites may also migrate to the appendix, or through the intestinal wall, both conditions which may cause a fatal peritonitis as they may well carry intestinal bacteria to these sites.

They may, alarmingly, sometimes migrate forward through the intestinal tract, to be either vomited up or emerging through the nose. More seriously, if they enter the trachea they may cause suffocation. Severe symptoms of the migrating larvae of *Ascaris* in the lungs may be associated with the following infections except

- breathing difficulties b. pneumonia c. fever d. all of the options

Diagnosis

Definitive diagnosis is by demonstration of the characteristic eggs in faecal samples or by identifying adult worms passed out spontaneously by the host.

Epidemiology and Control

Infection occurs through ingestion of parasites' eggs in food. The eggs are highly resistant to adverse environmental conditions. This with other factors highlighted below are often associated with transmission of infection;

- Lack or inadequate waste disposal facilities
- Improper washing of hands before eating
- Improper washing of fruits and vegetables before consumptions
- Unkept rooms and dwelling places that harbour mechanical carriers of parasites, etc.
- Provision of good waste disposal system and good personal hygiene will help to control infections.

Assessment Exercise 2

- How do you diagnose the incidence or infection of *Ascaris lumbricoides*?

2.4 Summary

Infection of *Ascaris lumbricoides* (roundworm) is prevalent in areas with over-population and inadequate sanitation in tropical and sub-tropical countries, where the climate supports the survival of the parasite eggs or larvae in the warm and moist soil.

After infective larvae enter the human body they develop into adult worms and parasitize the gastrointestinal tract, sometimes for years. Some species of worms can produce up to 200,000 eggs per day. Eggs are excreted in the faeces and remain viable in the soil for several weeks or years depending on the species. *A. lumbricoides* may cause intestinal obstructions that require surgery

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2.6 Possible Answers Saes

Answer to SAEs 1

- D. small intestine
- True
- 3. false

Answer to SAEs 2

In *Ascaris lumbricoides,* definitive diagnosis is by demonstration of the characteristic eggs in faecal samples or by identifying adult worms passed out spontaneously by the host.

Unit 3 Soil Transmitted Helminths-Hookworm

Unit Structure

3.1 Introduction

The hookworms belong to the Order Strongylida, a very large order, and of great interest as it contains many important pathogens of man and domesticated animals. This order is further subdivided into three Superfamilies, the Strongyloidea (the hookworms in man), and two related groups, the Superfamily ‘Trichostrongyloidea’, intestinal nematodes which are of veterinary importance in many domesticated animals (e.g.

Haemonchus contortus in cattle and *Nippostrongylus brasiliensis* in rodents) and members of the Superfamily ‘Metastrongyloidea’ (the lungworms, in domesticated animals).

In man there are two species capable of causing intestinal infections, *Ancylostoma duodenale* native to parts of Southern Europe, North Africa and Northern Asia parts of Western South America, and *Necator americanus* in Central and Southern Africa, Southern Asia, Australia and the Pacific Islands. These are very important human pathogens. It has been estimated that there are 1200 million cases of hookworm infection in man annually, of which about 100 million of which are symptomatic infections with accompanying anaemia. In addition, the larvae of several species of hookworms infecting domesticated animals may penetrate human skin, causing pathology even though they do not develop to the adult parasites in man.

3.2 Intended Learning Outcomes

By the end of this unit, the students should be able to:

- Explain the morphology Hookworms
- Describe the life cycles of a hookworm
- Describe the pathology, epidemiology and control of the parasites

3.3 Main Contents

3.3.1 Morphology of Hookworms

The adult parasites are small cylindrical worms, 0.5-1.5mm long (*Ancylostoma duodenale* being slightly larger than *Necator americanus*). The posterior end of the male worm is equipped with a characteristic copulatory bursa, used to hold the female nematode in place during mating. The females themselves have a vulva situated near the center of the body, slightly anterior in *Necator* and slightly posterior in *Ancylostoma*. The anterior end of the parasites are formed into a buccal

Fig 3.1 Scanning electron micrograph of the mouth capsule of *Ancylostoma duodenale* (left), note the presence of four "teeth," two on each side and *Necator americanus* (right) (Bethony, J., S. *et al*. 2006)

capsule, absent in members of the other Strongylida superfamilies, by which the different genera and species within the group may be differentiated. For example, members of the genus *Necator* have capsules equipped with cutting plates on the ventral margins, and within the capsule itself small dorsal teeth. In contrast members of the genus *Ancylostoma* have pairs of teeth on the ventral margin of the capsule. The number of teeth will vary between different species of *Ancylostoma*, but is usually between one and four pairs.

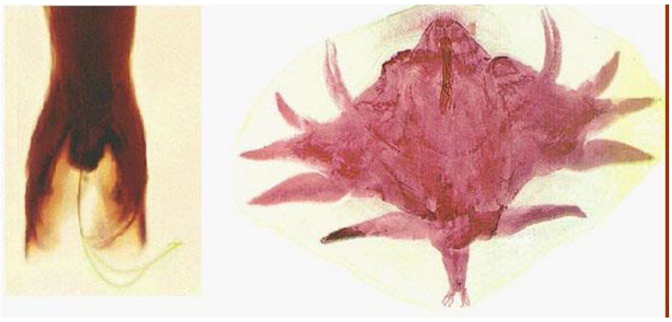

Fig 3.2 Left picture: Copulatory bursa and spines of *N. americanus* (a side view); Right picture: copulatory bursa of *A. duodenale* (a top view) n (Bethony, J., S. *et al.* 2006)

The eggs are bluntly rounded, thin shelled, and are almost indistinguishable between the different species, measuring approximately 60 by 40 µm, the eggs of *Ancylostoma* being slightly larger than those of *Necator*.

The Morphological Differences between Two species of Hookworms

Features	*A. duodenale*	*N. americanus*
Size	Larger	Smaller
Shape	single curve, looks like C	double curves, looks like S
Mouth	2 pairs of ventral teeth	1pair of ventral cutting plates
Copulatory bursa	circle in shape	oval in shape
Copulatory spicule	1pair with separate endings	1pair of which unite to form a terminal hooklet
Caudal spine	Present	No
Vulva position	post-equatorial	pre-equatorial

The posterior end of the male worm is equipped with a characteristic--------------, used to hold the female nematode in place during mating.

a. copulatory bursa b. copulatory integument c. copulatory ossicles d. copulatory vessicles

3.3.2 Life cycle of hookworm

The life cycles of all the hookworms are very similar. The eggs are passed in the faeces, once exposed to air they mature rapidly if conditions are right, with both moisture and warmth essential for development. When matured, they hatch to liberate a rhabditiform (i.e. having an oesophagus where a thick anterior region is connected via a neckline region with a posterior bulb) L1 larvae after a few days.

These larval nematodes feed on bacteria and organic material in the soil, where they live and grow for about two days before undergoing the first moult. After about five days more growth they moult again, to produce a much slenderer L3 larvae. The L3 larvae has a much shorter oesophagus, is a non-feeding form, and is the infective form of the parasite. Infection takes place by penetration of the skin, for example when walking with bare feet over contaminated damp soil, followed by entry into the circulatory system. Here they are carried to the heart, and then lungs. Once in the lungs, they are too large to pass through the capillary bed there. Instead they become trapped, and the burrow through the capillary epithelium, entering the air spaces. They then migrate up through bronchi and trachae, and are then swallowed. Once swallowed, they pass into the intestine and bury themselves between the intestinal villi. Here they moult to form the L4 larvae, equipped with a buccal capsule allowing adherence to the gut wall. After about thirteen days post-infection they moult for the final time, producing immature adult worms. These mature over three to four weeks (i.e. five to six weeks after infection), then mate and commence egg laying to complete the life cycle. These parasites show a very high fecundity, female *Necator americanus* producing up to 10,000 eggs daily, while female *Ancylostoma duodenale* produces up to 20,000 eggs daily.

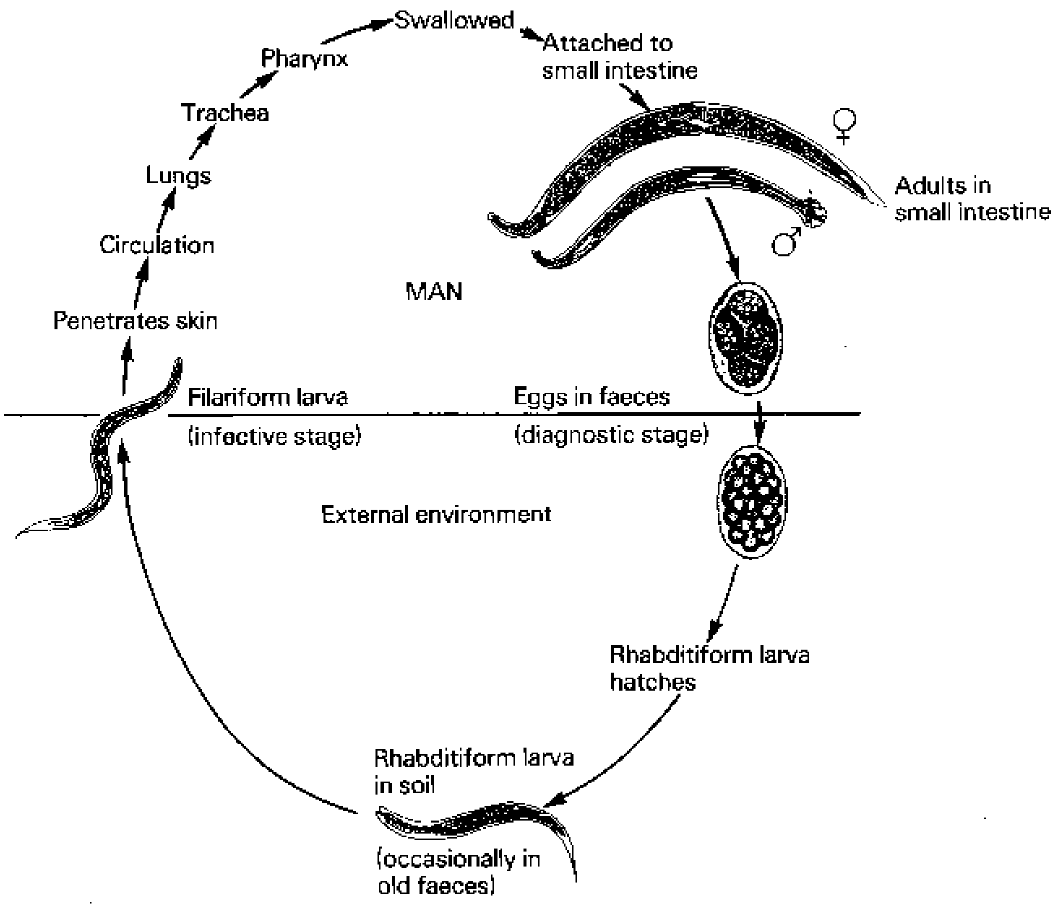

Fig 3.3 Life cycle of Human Hookworms (Bethony, J., S. *et al*. 2006)

In the life cycle of hookworm, the larvae with a much shorter oesophagus is the -----------------

Self-Assessment Exercise 1

- The human hookworm belongs to the family ------------------
- List the three super families found under the Order Stongylida
- Which of the three super families is an intestinal nematode of veterinary importance in domesticated animals?

3.3.3 Pathology of Infection.

The Pathology associated with hookworm infections may be divided roughly into two areas. Firstly, the pathology associated with the presence of the adult parasite in the intestine, and secondly the pathology associated with the penetration of, and migration of the larval worms within the skin.

The adult hookworms attach themselves to the intestinal wall using their buccal capsules. Their preferred site of infestation is in the upper layer of the small intestine, but in very heavy

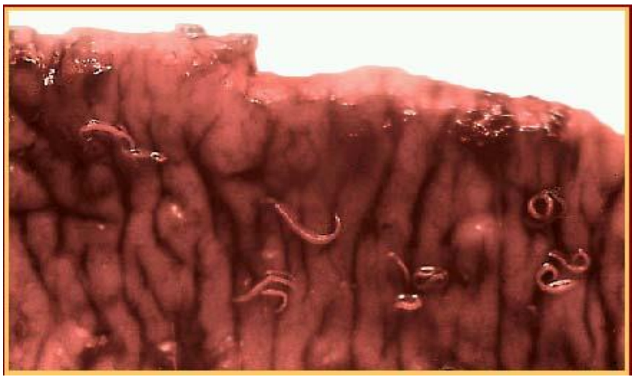

Fig 3.4 Adults in intestinal mucosa (Bethony, J., S. *et al.* 2006)

Infections (where many thousands of worms may be present) the parasites may spread down as far as the lower ileum. Once attached to the intestinal wall, the hookworm mouthparts penetrate blood vessels, and the parasites obtain nutrition by sucking blood.

A single *Necator americanus* will take approximately 30 µl of blood daily, while the larger *Ancylostoma duodenale* will take up to 260 µl. The gross pathology of the disease is very dependent on the intensity of infection. Light infections appear asymptomatic, but in heavy infections, the continuous loss of blood leads to a chronic anaemia, with down to 2gm of haemoglobin per 100ml of blood in extreme cases. Experiments carried out in the 1930's showed that in dogs infected with 500 *Ancylostoma caninum* a similar species to the human parasite, nearly a pint of blood a day was lost. This leads to permenant loss of iron and many blood proteins as well as blood cells. This in turn has consequences for further production of erythrocytes, which have been shown to contain less haemoglobin, as well as being reduced in size and smaller in numbers. This form of anaemia may be directly fatal, but more often, it induces more non-specific symptoms, the most noticeable being the severe retardation in growth and development, both physical and mental, in infected children, and a general weakness and lassitude, often wrongly interpreted as "laziness".

The preferred site of infestation by hookworm is in the upper layer of the small intestine only. True/False

Diagnosis

Identify characteristic eggs in feacal samples. Note the eggs of *N. americanus* and *A. duodenale* are morphologically identical.

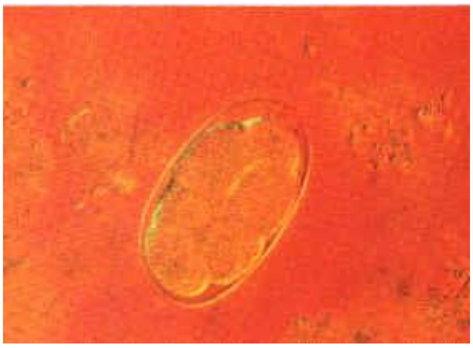

Fig 3.5 Egg of Hookworm (Bethony, J., S. *et al*. 2006)

Epidemiology and Control

The factors of epidemiological importance include;

- Poor sanitation through contamination of soil through direct defaecation on the ground.
- Skin exposure to infections e.g. by walking about bare-footed
- Favourable environmental conditions that enhance eggs and larval development.
- Loose, humus soil with reasonable drainage and aeration
- Even distribution of rainfall throughout the year.

Control is by improvement in the standard of sanitation, raising the nutritional status of the population especially in relation to iron content, and mass treatment with suitable worm expeller (vermifuge). Exposure of skin or walking bare-footed cannot facilitate the infection of hookworm**.** True/False

Self-Assessment Exercise 2

- The Pathology associated with hookworm infections may be divided roughly into two categories. State these categories

3.4 Summary

STH infection is caused by four major nematode species: *Ancylostoma duodenale* and *Necator americanus* (hookworms), *Ascaris lumbricoides* (roundworm) and *Trichuris trichiura* (whipworm). Infection is prevalent in areas with over-population and inadequate sanitation in tropical and sub-tropical countries, where the climate supports the survival of the parasite eggs or larvae in the warm and moist soil. After infective larvae enter the human body they develop into adult worms and parasitize the gastrointestinal tract, sometimes for years. Some species of worms can produce up to 200,000 eggs per day. Eggs are excreted in the faeces and remain viable in the soil for several weeks or years depending on the species. It is common for a single individual, especially a child, to be infected with all three types of worms. Although STH infection rarely causes fatality, chronic infection with high worm burden can lead to serious health consequences. Infection is typically most intense and debilitating in school-age children, resulting in malnutrition, physical and intellectual growth retardation, and cognitive and educational deficits. *A. lumbricoides* may cause intestinal obstructions that require surgery, and *T. trichuria* may cause chronic colitis. Hookworm infection causes iron-deficiency anaemia because the worms feed on the intestinal wall causing tissue damage and blood loss. Hookworm infection is a leading cause of morbidity in children and pregnant women, and can have adverse results for the mother, the foetus and the neonate.

3.5 Reference/Further Readings/Web Sources

Bethony, J., S. Brooker, M. Albonico, S. M. Geiger, A. Loukas, D. Diemert, and P. J. Hotez. (2006). Soil transmitted helminth infections: ascariasis, trichuriasis, and hookworm. Lancet 367:1521.

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3.6 Possible Answers Saes

Answers to SAEs 1

- Strongyloidea
- Strongyloidea, Trichostrongyloidea, Metastrongyloidea
- Trichostrongyloidea

Answers to SAEs 2

- The pathology associated with the presence of the adult parasite in the intestine,
- The pathology associated with the penetration of, and migration of the larval worms within the skin.

Unit 4 Blood And Tissue Nematodes

Unit Structure

4.1 Introduction

Filariasis is caused by nematodes (roundworms) that inhabit the lymphatics and subcutaneous tissues. Eight main species infect humans. Three of these are responsible for most of the morbidity due to filariasis: *Wuchereria bancrofti* and *Brugia malayi* cause lymphatic filariasis, and *Onchocerca volvulus* causes onchocerciasis (river blindness). The other five species are *Loa loa*, *Mansonella perstans*, *M. streptocerca*, *M. ozzardi*, and *Brugia timori*. (The last species also cause lymphatic filariasis).

Among the agents of lymphatic filariasis, *Wuchereria bancrofti* is encountered in tropical areas worldwide; *Brugia malayi* is limited to Asia; and *Brugia timori* is restricted to some islands of Indonesia. The agent of river blindness, *Onchocerca volvulus*, occurs mainly in Africa, with additional foci in Latin America and the Middle East. Among the other species, *Loa loa* and *Mansonella streptocerca* are found in Africa; *Mansonella perstans* occurs in both Africa and South America; and *Mansonella ozzardi* occurs only in the American continent.

Another tissue invading parasite is *Trichinella spiralis* whose larval form is found in the muscular tissue of the host animal. *Trichinella spiralis* is in fact a complex of three closely related worm species. They are morphologically identical, but differ in their host specificity and their biochemical characteristics. *T. spiralis spiralis* occurs in moderate regions and infects mainly pigs. *T. spiralis nativa* occurs in the polar regions (polar bear, walrus). These parasites are resistant to freezing which is important for meat storage. *T. spiralis nelsoni* occurs in Africa and southern Europe with a reservoir in wild carnivores and wild pigs. *T. britovi* and *T. pseudospiralis* rarely cause infections. *T.*

pseudospiralis can also infect some birds as well as mammals, unlike the other *Trichinella* species.

4.2 Intended Learning Outcomes

By the end of this unit, the students should be able to

- Give examples of blood and tissue invading parasites
- Describe their life cycles and clinical features associated with their infections.
- Describe the methods of diagnosis, epidemiology and control of their infections

4.3 Main Contents

4.3.1 Filarial worms

Wuchereria bancrofti

Different species of the following genera of mosquitoes are vectors of *W. bancrofti* filariasis depending on geographical distribution. Among them are: *Culex* (*C.*

annulirostris, *C. bitaeniorhynchus*, *C. quinquefasciatus*, and *C. pipiens*); *Anopheles* (*A.*

arabinensis, *A. bancroftii*, *A. farauti*, *A. funestus*, *A. gambiae*, *A. koliensis*, *A. melas*, *A.*

merus, *A. punctulatus* and *A. wellcomei*); *Aedes* (*A. aegypti*, *A. aquasalis*, *A. bellator*, *A. cooki*, *A. darlingi*, *A. kochi*, *A. polynesiensis*, *A. pseudoscutellaris*, *A. rotumae*, *A.*

scapularis, and *A. vigilax*); *Mansonia* (*M. pseudotitillans*, *M. uniformis*); *Coquillettidia* (*C. juxtamansonia*). During a blood meal, an infected mosquito introduces third-stage filarial larvae onto the skin of the human host, where they penetrate into the bite wound. They develop in adults that commonly reside in the lymphatics. The female worms measure 80 to 100 mm in length and 0.24 to 0.30 mm in diameter, while the males measure about 40 mm by .1 mm. Adults produce microfilariae measuring 244 to 296 µm by 7.5 to 10 µm, which are sheathed and have nocturnal periodicity, except the South Pacific microfilariae which have the absence of marked periodicity. The microfilariae migrate into the lymph and blood channels moving actively through lymph and blood. A mosquito ingests the microfilariae during a blood meal. After ingestion, the microfilariae loose their sheaths and some of them work their way through the wall of the proventriculus and cardiac portion of the mosquito's midgut and reach the thoracic muscles. There the microfilariae develop into first-stage larvae and subsequently into third-stage infective larvae. The third-stage infective larvae migrate through the haemocoel to the mosquito's prosbocis and can infect another human when the mosquito takes a blood meal.

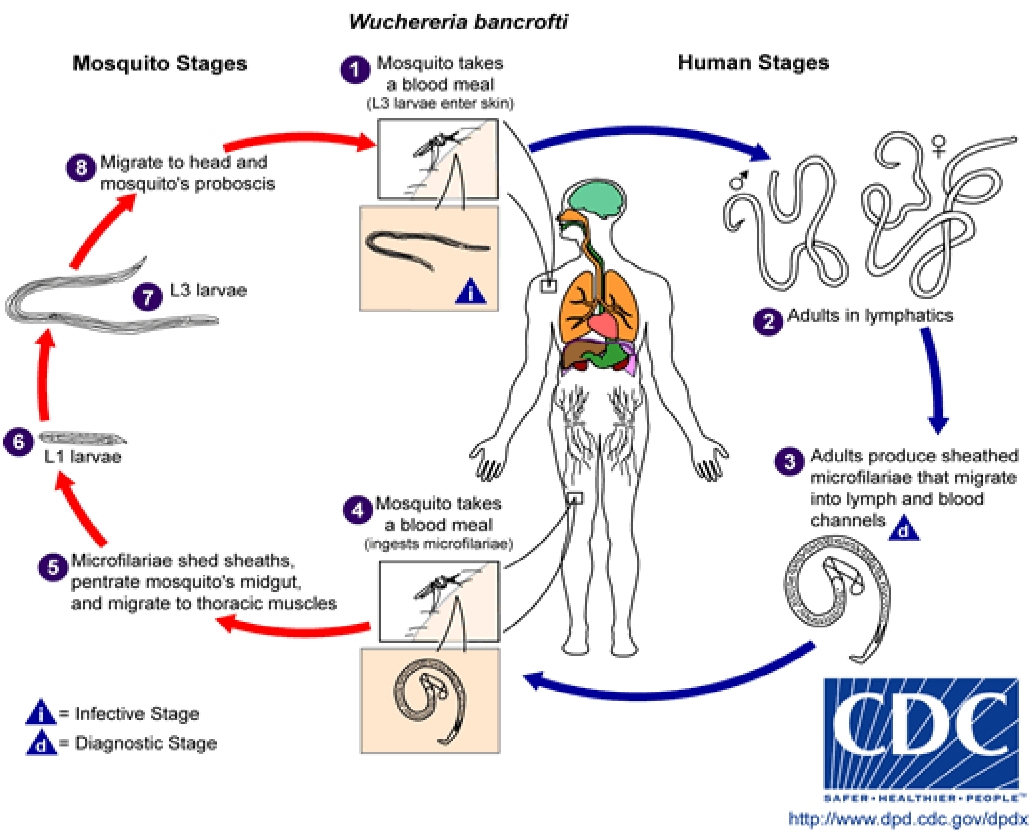

Fig 4.1a Life cycle of *W. bancrofti* (Source: Neva and Ottesen, 1978).

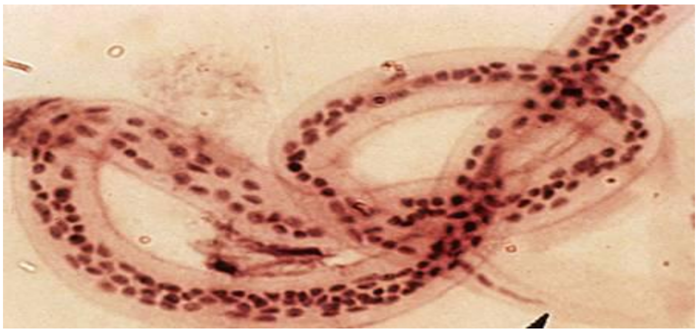

Fig 4.1b Microfilaria of *W. Bancrofti* (Source: Neva and Ottessen, 1978).

Mosquitoes are vectors of filariasis. True/False

Onchocerca volvulus

During a blood meal, an infected blackfly (genus *Simulium*) introduces third-stage filarial larvae onto the skin of the human host, where they penetrate into the bite wound.

In subcutaneous tissues the larvae develop into adult filariae, which commonly reside in nodules in subcutaneous connective tissues Adults can live in the nodules for approximately 15 years. Some nodules may contain numerous male and female worms. Females measure 33 to 50 cm in length and 270 to 400 µm in diameter, while males measure 19 to 42 mm by 130 to 210 µm. In the subcutaneous nodules, the female worms are capable of producing microfilariae for approximately 9 years. The microfilariae, measuring 220 to 360 µm by 5 to 9 µm and unsheathed, have a life span that may reach 2 years. They are occasionally found in peripheral blood, urine, and sputum but are typically found in the skin and in the lymphatics of connective tissues.

A blackfly ingests the microfilariae during a blood meal. After ingestion, the microfilariae migrate from the blackfly's midgut through the haemocoel to the thoracic muscles. There the microfilariae develop into first-stage larvae and subsequently into third-stage infective larvae. The third-stage infective larvae migrate to the blackfly's proboscis and can infect another human when the fly takes a blood meal.

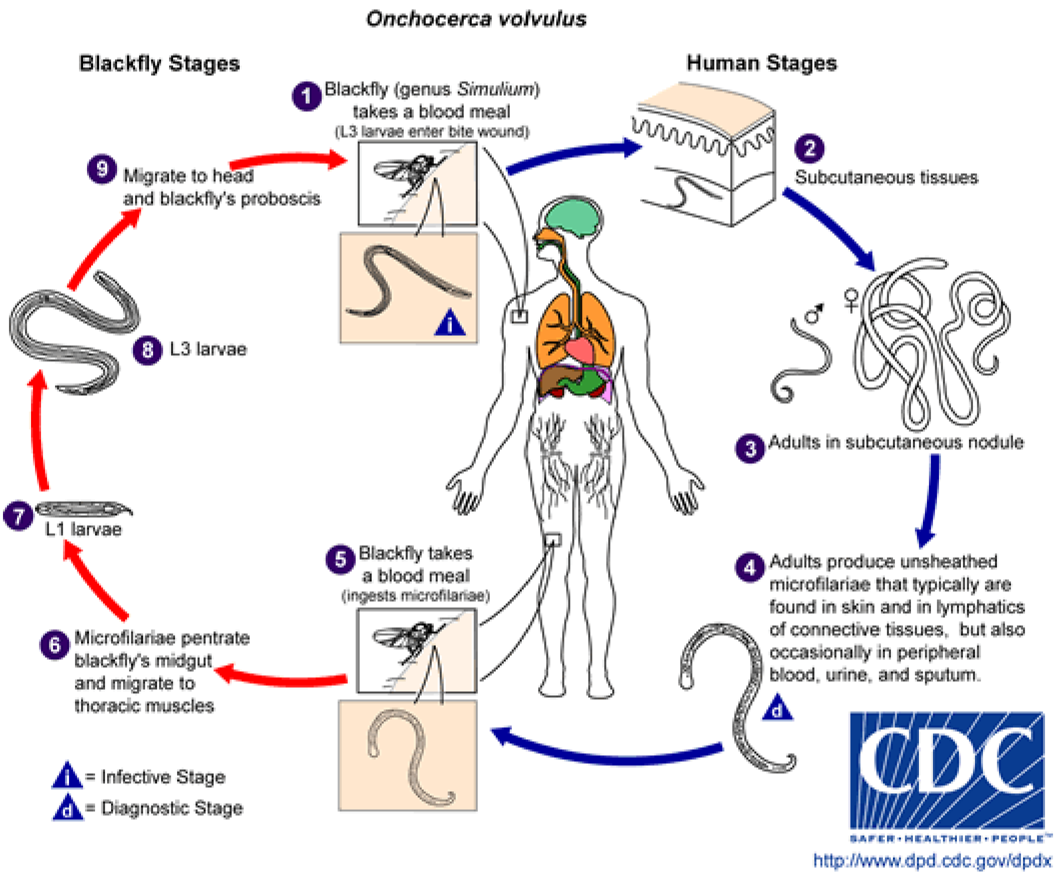

Fig 4.2 Life cycle of *O. Volvulus* (Source: Neva and Ottessen, 1978).

Subcutaneous tissues does not contribute to the development of filarial larvae into adult filariae. True/False

Self-Assessment Exercise 1

- List the genera of mosquitoes that are vectors of *W. bancrofti* filariasis

4.3.2 Clinical Features and Pathology

Lymphatic filariasis most often consists of asymptomatic microfilaremia. Some patients develop lymphatic dysfunction causing lymphedema and elephantiasis (frequently in the lower extremities) and, with *Wuchereria bancrofti*, hydrocele and scrotal elephantiasis. Episodes of febrile lymphangitis and lymphadenitis may occur. Persons who have newly arrived in disease-endemic areas can develop afebrile episodes of lymphangitis and lymphadenitis. An additional manifestation of filarial infection, mostly in Asia, is pulmonary tropical eosinophilia syndrome, with nocturnal cough and wheezing, fever, and eosinophilia. Onchocerciasis can cause pruritus, dermatitis, onchocercomata (subcutaneous nodules), and lymphadenopathies. The most serious manifestation consists of ocular lesions that can progress to blindness. Loiasis (*Loa loa*) is often asymptomatic. Episodic angioedema (Calabar swellings) and sub-conjunctival migration of an adult worm can occur. Infections by *Mansonella perstans*, which is often asymptomatic, can be associated with angioedema, pruritus, fever, headaches, arthralgias, and neurologic manifestations. *Mansonella streptocerca* can cause skin manifestations including pruritus, papular eruptions and pigmentation changes. Eosinophilia is often prominent in filarial infections. *Mansonella ozzardi* can cause symptoms that include arthralgias, headaches, fever, pulmonary symptoms, adenopathy, hepatomegaly, and pruritus.

Elephantiasis caused by infection by *W. Bancrofti* (Source: Neva and Ottessen, 1978).

Some patients develop lymphatic dysfunction causing lymphedema and ....

Treatment and control

Ivermectin is effective in killing the larvae, but does not affect the adult worm. Preventive measures include vector control, treatment of infected individuals and avoidance of black fly.

Laboratory Diagnosis of filarial worms

Identification of microfilariae by microscopic examination is the most practical diagnostic procedure.

Microscopy

Examination of blood samples will allow identification of microfilariae of *Wuchereria bancrofti*, *Brugia malayi*, *Brugia timori*, *Loa loa*, *Mansonella perstans,* and *M.*

ozzardi. It is important to time the blood collection with the known periodicity of the microfilariae. The blood sample can be a thick smear, stained with Giemsa or haematoxylin and eosin. For increased sensitivity, concentration techniques can be used. These include centrifugation of the blood sample lyzed in 2% formalin (Knott's technique), or filtration through a Nucleopore® membrane. Examination of skin snips will identify microfilariae of *Onchocerca volvulus* and *Mansonella streptocerca*. Skin snips can be obtained using a corneal-scleral punch, or more simply a scalpel and needle. The sample must be allowed to incubate for 30 minutes to 2 hours in saline or culture medium, and then examined for microfilariae that would have migrated from the tissue to the liquid phase of the specimen.

Preparing Blood Smears for Microscopy Examination

If one uses venous blood, blood smears should be prepared as soon as possible after collection (delay can result in changes in parasite morphology and staining characteristics).

Thick smears

Thick smears consist of a thick layer of dehemoglobinized (lysed) red blood cells (RBCs). The blood elements (including parasites, if any) are more concentrated (app. 30×) than in an equal area of a thin smear. Thus, thick smears allow a more efficient detection of parasites (increased sensitivity). However, they do not permit an optimal review of parasite morphology. For example, they are often not adequate for species identification of filaria parasites: if the thick smear is positive for filaria parasites, the thin smear should be used for species identification.

Prepare at least 2 smears per patient!

- Place a small drop of blood in the centre of the pre-cleaned, labeled slide.
- Using the corner of another slide or an applicator stick, spread the drop in a circular pattern until it is the size of a dime (1.5 cm^2).
- A thick smear of proper density is one which, if placed (wet) over newsprint, allows you to barely read the words.
- Lay the slides flat and allow the smears to dry thoroughly (protect from dust and insects!). Insufficiently dried smears (and/or smears that are too thick) can detach from the slides during staining. The risk is increased in smears made with anticoagulated blood. At room temperature, drying can take several hours; 30 minutes is the minimum; in the latter case, handle the smear very delicately during staining. You can accelerate the drying by using a fan or hair dryer (use cool setting). Protect thick smears from hot environments to prevent heat-fixing the smear.
- Do not fix thick smears with methanol or heat. If there will be a delay in staining smears, dip the thick smear briefly in water to haemolyse the RBCs.

Thin smears

Thin smears consist of blood spread in a layer such that the thickness decreases progressively toward the feathered edge. In the feathered edge, the cells should be in a monolayer, not touching one another.

Prepare at least 2 smears per patient!

- Place a small drop of blood on the pre-cleaned, labeled slide, near its frosted end.
- Bring another slide at a 30-45° angle up to the drop, allowing the drop to spread along the contact line of the 2 slides.

- Quickly push the upper (spreader) slide toward the unfrosted end of the lower slide.
- Make sure that the smears have a good feathered edge. This is achieved by using the correct amount of blood and spreading technique.
- Allow the thin smears to dry. (They dry much faster than the thick smears, and are less subject to detachment because they will be fixed.)
- Fix the smears by dipping them in absolute methanol.
- Thin smears consist of blood spread in a layer such that the thickness increases progressively toward the feathered edge. True/False

Diagnostic findings

▪ **Antigen detection** using an immunoassay for circulating filarial antigens constitutes a useful diagnostic approach, because microfilaremia can be low and variable. A rapid-format immunochromatographic test, applicable to *Wuchereria bancrofti* antigens, has been evaluated in the field. However, antibody detection is of limited value. Substantial antigenic cross reactivity exists between filaria and other helminths, and a positive serologic test does not distinguish between past and current infection.

▪ **Molecular diagnosis** using polymerase chain reaction is available for *W. bancrofti*.

▪ **Identification of adult worms** is possible from tissue samples collected during nodulectomies (onchocerciasis), or during subcutaneous biopsies or worm removal from the eye (loiasis). Identification of microfilariae by microscopic examination is not a practical diagnostic procedure. True/False

Self-Assessment Exercise 2

- State measures for the treatment, prevention or control of Filariasis

4.4 Summary

Filariasis is caused by nematodes that inhabit the lymphatics and subcutaneous tissues. Eight main species infect humans of which three of these are responsible for most of the morbidity due to filariasis: *Wuchereria bancrofti* and *Brugia malayi* cause lymphatic filariasis, and *Onchocerca volvulus* causes onchocerciasis (river blindness)

Infective larvae are transmitted by infected biting arthropods during a blood meal. The larvae migrate to the appropriate site of the host's body, where they develop into microfilariae-producing adults. The adults dwell in various human tissues where they can live for several years. The agents of lymphatic filariasis reside in lymphatic vessels and lymph nodes; *Onchocerca volvulus* in nodules in subcutaneous tissues; *Loa loa* in subcutaneous tissues, where it migrates actively; *Brugia malayi* in lymphatics, as with *Wuchereria bancrofti*; *Mansonella streptocerca* in the dermis and subcutaneous tissue; *Mansonella ozzardi* apparently in the subcutaneous tissues; and *M. perstans* in body cavities and the surrounding tissues. The female worms produce microfilariae which circulate in the blood, except for those of *Onchocerca volvulus* and *Mansonella streptocerca*, which are found in the skin, and *O. volvulus* which invade the eye. The microfilariae infect biting arthropods (mosquitoes for the agents of lymphatic filariasis; blackflies (*Simulium*) for *Onchocerca volvulus*; midges for *Mansonella perstans* and *M. streptocerca*; and both midges and blackflies for *Mansonella ozzardi*; and deerflies (*Chrysops*) for *Loa loa*). Inside the arthropod, the microfilariae develop in 1 to 2 weeks into infective filariform (third-stage) larvae. During a subsequent blood meal by the insect, the larvae infect the vertebrate host. They migrate to the appropriate site of the host's body, where they develop into adults, a slow process than can require up to 18 months in the case of *Onchocerca*.

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4.5 Reference/Further Readings/Web Sources

Duke (1972). Onchocerciasis. *Br. Med. Bull., 28*: 66-71

Neva and Ottessen (1978). Tropical (filarial) eosinophilia. *N. Engl. J. Med., 298*: 1129-1131

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https://youtu.be/Myn2drYQQ1M,

4.6 Possible Answers to Saes

Answers to Saes 1

- Culex
- Anopheles
- Aedes
- Mansonia

Answers to SAEs 2

Ivermectin is effective in killing the larvae of filarial worms, but does not affect the adult worm. Preventive measures include vector control, treatment of infected individuals and avoidance of black fly.

Unit 5 Air-Borne Nematode

Unit Structure

5.1 Introduction

The human pinworm *Enterobius vermicularis* is a ubiquitous parasite of man. It is estimated that over 200 million people are infected annually. It is more common in the temperate regions of Western Europe and North America, (it is being relatively rare in the tropics) and is found particularly in children. Samples of Caucasian children in the U.S.A. and Canada have shown incidences of infection of between 30% to 80%, with similar levels in Europe, and although these regions are the parasites strongholds, it may be found throughout the world, again often with high degrees of incidence. For example, in parts of South America the incidence in school children may be as high as 60%.

Interestingly non-Caucasians appear to be relatively resistant to infection with this nematode. As a species, and contrary to popular belief, *E. vermicularis* is entirely restricted to man, other animals harbouring related but distinct species that are non-infective to humans, but their fur may be contaminated by eggs from the human species if stroked by someone with eggs on their hands. In man anywhere where there are large number of children gathered together, (such as nurseries, play groups, orphanages etc.), especially if conditions are insanitary, are ready sources of infection, as one child may rapidly transmit the parasite to his or her fellows.

5.2 Intended Learning Outcomes

By the end of the unit, students should be able to:

Describe the morphology of the parasite, its life cycle, pathology, diagnosis and control.

5.3 Main Contents

Enterobius vermicularis **(the human pin-worm)**

5.3.1 Morphology

These creamy white coloured nematodes are relatively small, with the female measuring only approximately 10mm by 0.4mm wide. The females have a cuticular expansion at their anterior ends, with a long pointed tail. The male parasites, which are much less numerous than the females, are much smaller, measuring only up to 5mm long, and have a curved tail, with a small bursa like expansion, and a single spicule. The head has a mouth with three small lips

Fig 5.1 Adult Pinworm (Source: Brown, H.W. *et al*, 1983).

The females of human pinworm have a cuticular expansion at their anterior ends, with a long pointed tail. True/Female

5.3.2 Life cycle

The adult parasites live predominantly in the caecum. The male and females mate, and the uteri of the females become filled with eggs. The gravid females (each containing up to 15000 eggs) then migrate down the digestive tract to the anus. From here they make regular nocturnal migrations out of the anus, to the perianal region, where air contact stimulates them to lay their eggs, before retreating back into the rectum.

Eventually the female die, their bodies disintegrating to release many remaining eggs.

These eggs, which are clear and measure about 55 by 30µm, then mature to the infectious stage (containing an L1 larvae) over 4 to 6 weeks. To infect the host, typically these eggs must then be ingested. The ingested eggs hatch in the duodenum.

The eggs themselves are sticky, and have a characteristic shape, shared with all members of the group Oxyuridea, with an asymmetrical form, flattened on one side, (see below):

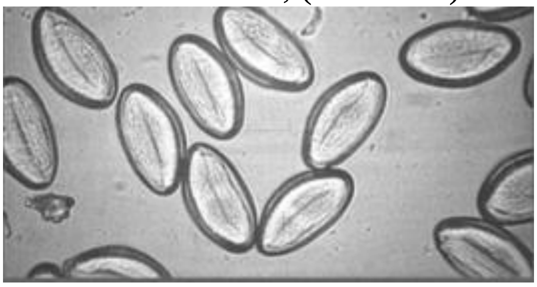

Fig 5.2 The ova of *Enterobius vermicularis* (Source: Brown, H.W. *et al*, 1983).

The larvae then undergo a series of moults, as they migrate down the digestive tract.

The adult worms then mature in the caecum, before copulating to complete the cycle (typically 6 weeks). Occasionally the eggs hatch in the perianal region itself, the resulting L1 larvae being fully infective, crawling back through the anus, then migrating up the intestine to the caecum (retroinfection). The adult parasites of pinworms live predominantly in the oesophagus. True/False

Self-Assessment Exercise 1

- Outline the symptioms of human pinworm infection

5.3.3 Pathology of Infection.

The majority of infections with this nematode are asymptomatic, although in some cases the emerging females and the sticky masses of eggs that they lay may causes irritation of the perianal region, which in some cases may be severe. As the females emerge at night this may give rise to sleep disturbances, and scratching of the affected perianal area transfers eggs to the fingers and under the finger nails. This in turn aids the transmission of the eggs, both back to the original host (autoinfection), and to other hosts.

Majority of infections with hookworms are symptomatic. True/False

5.3.4 Diagnosis

Because eggs are rarely passed out with faeces, examination of faecal samples may not reveal them. This may account for negative results of enterobiasis in many of the surveys for helminth infections involving faecal samples in tropical Africa. The most reliable diagnosis is by the cellophane tape swab. This involves the attachment of a piece of cellophane to the perianal region overnight. This is then examined for eggs under the microscope. Alternatively, the anus and perianal area can be examined under bright light at night, at which time adult worms can be seen glittening in the light.

5.3.5 Epidemiology and Control

The eggs of the parasite are air-borne, caught in clothing, household linen, curtain, carpets, etc. As such, infection is common in dry season than rainy season in the tropics. Maitenance of high standards of personal and domestic hygiene is therefore imperative for control and prevention.
Cellophane tape swab can be used in the diagnosis of hookworm infection. True/False

Self-Assessment Exercise 2

- How can you prevent and control the infection of hookworms

5.4 Summary

Enterobius vermicularis is an air-borne parasitic infection common mostly in the temperate regions of the world. Adult female worms lay eggs in the perianal regions wnd infection occurs through direct ingestion of eggs containing the L1 larvae. Infection is usually asymptomatic but sometimes the sticky eggs could cause irritation of the perianal giving rise to scratching and sleep disturbance. Maitenance of high standards of personal and domestic hygiene is imperative for control and prevention.

5.5 Reference/Further Readings/Web Sources

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5.6 POSSIBLE ANSWERS TO SAEs

Answers to SAEs 1

The emerging females and the sticky masses of eggs that they lay may causes irritation of the perianal region, which in some cases may be severe. As the females emerge at night this may give rise to sleep disturbances, and scratching of the affected perianal area, transfers eggs to the fingers and under the finger nails

Answers to SAEs 2

Personal and domestic hygiene is imperative for control and prevention of hookworms

Unit 6 Essentials of Parasitic Arthropod

Unit Structure

6.1 Introduction

Arthropods form a huge assemblage of small coelomate animals with “jointed limbs” (hence the name arthro-pods). They exhibit segmentation of their bodies (metamerism) which is often masked in adults because their 10-25 body segments are combined into 2-3 functional groups (called tagmata). They exhibit varying degrees of cephalization whereby neural elements, sensory receptors and feeding structures are concentrated in the head region. Arthropods possess a rigid cuticular exoskeleton consisting mainly of tanned proteins and chitin. The exoskeleton is usually hard, insoluble, virtually indigestible and impregnated with calcium salts or covered with wax. The exoskeleton provides physical and physiological protection and serves as a place for muscle attachment. Skeletal plates are joined by flexible articular membranes and the joints are hinges or pivots made from chondyles and sockets.

The main arthropod assemblages include crustaceans (crabs, lobsters, crayfish, shrimp), arachnids (spiders, scorpions, ticks, mites) and insects (beetles, bugs, earwigs, ants, bees, termites, butterflies, moths, crickets, roaches, fleas, flies, mosquitoes, lice). Most parasitic arthropods belong to 2 main classes: the 6-legged insects, and the 8-legged arachnids.

6.2 Intended Learning Outcomes

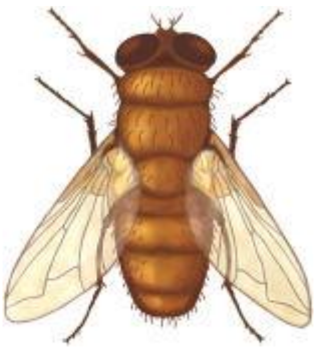
By the end of the study, students should be able to:

- Explain the meaning of parasitic arthropods
- Give examples of parasitic arthropods
- Outline the features of parasitic arthropods, their entomological importance and epidemiological measures of transmission

6.3 Main Contents

6.3.1 Features of Parasitic Arthropod

The main arthropod assemblages include crustaceans (crabs, lobsters, crayfish, shrimp), arachnids (spiders, scorpions, ticks, mites) and insects (beetles, bugs, earwigs, ants, bees, termites, butterflies, moths, crickets, roaches, fleas, flies, mosquitoes, lice) Most parasitic arthropods belong to 2 main classes: the 6-legged insects, and the 8-legged arachnids.



Insects

Arachnids

Fig 6.1 Diagram of an Insect and Arachnids **(Source:** https://parasite.org.au/para-site/contents/helminth-intoduction.html)

Insects

Insects have 3 distinct body parts, commonly called the head, thorax and abdomen. The head has 2 antennae and the thorax has 6 legs arranged in 3 bilateral pairs. Many insect species also have 2 pairs of wings attached to the thorax. Parasitic insect species include fleas, flies and lice which actively feed on host tissues and fluids at some stage in their life-cycles.

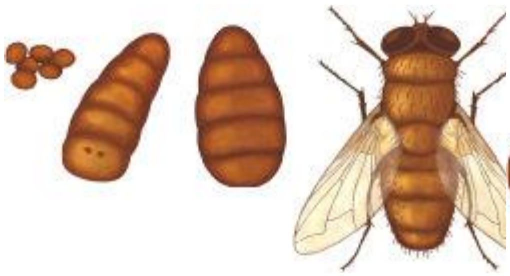
Arachnids

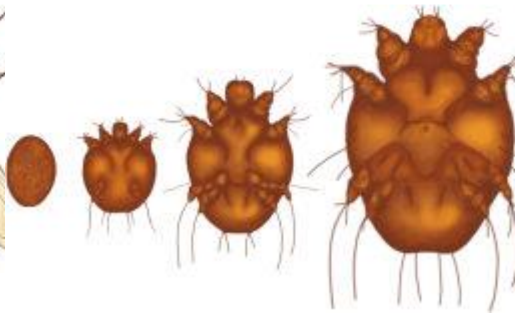
Arachnids have 2 body parts known as the prosoma (or cephalothorax) and opisthosoma (or abdomen). The cephalothorax has 8 legs arranged in 4 bilateral pairs and arachnids do not have wings or antennae. Important parasitic assemblages include the ticks and mites which bite into tissues and feed off host fluids.

Two main classes of parasitic arthropods are ---------- and -------------

6.3.2 Life Cycle of Arthropod

Adult arthropods are generally small in size, most are visible but some remain microscopic. Arthropod sexes are separate and fertilization is internal. A wide range of mating behaviours, insemination and egg production strategies are involved. In most species, the egg develops into a larva: i.e. a life-cycle stage that is structurally distinct from the adult and must undergo metamorphosis (structural reorganization) before becoming an adult. This metamorphosis may be complete (involving major changes during a pupation stage) or incomplete (involving gradual changes in nymph stages). For example, the grub-like larval stages of flies and fleas form cocoon-like pupae where they undergo complete metamorphosis and emerge as radically-different adult insects. In contrast, the larval instars (or nymphs) of lice, ticks and mites undergo incomplete metamorphosis through a series of moults gradually becoming more adult-like in appearance.





complete metamorphosis

hatch moult hatch
egg----------larva----------pupa----------adult

incomplete metamorphosis

Moult moult
hatch

egg----------larva----------nymph----------adult

All arthropods undergoes incomplete metamorphosis. True/False

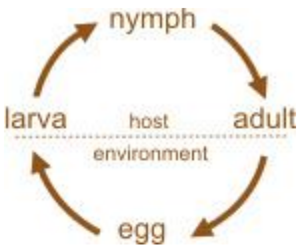
Self-Assessment Exercise 1

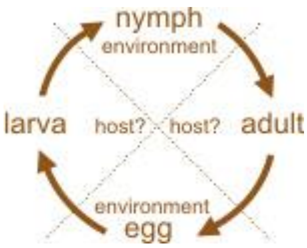
- In a sentence, describe complete metamorhosis in insects

6.3.3 Parasitic Relationships of Arthropod

Arthropods are involved in nearly every kind of parasitic relationship, either as parasites themselves or as hosts/vectors for other micro-organisms (including viruses, bacteria, protozoa and helminths). They are generally ectoparasitic on, or in, the skin of vertebrate hosts. Many species are haematophagous (suck blood) while others are histophagous (tissue-feeders) and bite or burrow in dermal tissues causing trauma, inflammation and hypersensitivity reactions. Infestations are transmitted from host-to-host either by direct contact or by free-living larvae or adults actively seeking hosts.

Direct	host-seeking (larva or adult parasitic)	host-seeking (all feeding stages parasitic)





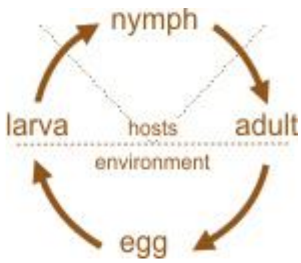


Fig 6.3: Parasitic Relationship of Arthropods
(Source: https://parasite.org.au/para-site/contents/helminth-intoduction.html)

>Direct transmission of infective stages occurs when hosts come into close contact with each other or share quarters, bedding or clothing. Larvae, nymphs or adults may cross from one host to another, while eggs or pupae may contaminate shared environments. Insects (fleas and lice) and arachnids (mites) rely on close contact between hosts.

>Many adult insects actively seek hosts in order to feed or lay eggs. Winged insects (mosquitoes, flies) fly to new hosts to feed while fleas jump onto passing hosts. Some adult flies (botflies) do not feed on their hosts but deposit eggs from which larvae emerge and feed on host tissues and exudates.

>Tick larvae actively seek hosts by climbing vegetation and questing for passing hosts. Some species complete their life-cycle on the same host (one-host ticks) while others detach after feeding and drop to the ground to moult before seeking new hosts as nymphs or

adults (two-host or three-host ticks).
Arthropods are involved in nearly every kind of parasitic relationship. True/False

Parasitic Species (Insects)

Insects exhibit extraordinary biodiversity, both in terms of species richness (numbers of species) and relative abundance (population sizes).

Most parasitic species belong to three main groups: the jumping fleas (Siphonaptera); the winged flies (Diptera); and the wingless lice (Phthiraptera).

>fleas are bilaterally-flattened wingless insects with enlarged hindlimbs specially adapted for jumping (up to 100 times their body length). Jumping feats are accomplished using elastic resilin pads which expand explosively when uncocked from the compressed state. Fleas undergo complete metamorphosis whereby grub-like larvae form pupae from which adult fleas emerge. The larvae are not parasitic but feed on debris associated mainly with bedding, den or nest material, whereas the adult stages are parasitic and feed on host blood. There are some 2,500 flea species, most parasitic on mammals (especially rodents) and some on birds. They vary in the time spent on their hosts ranging from transient feeders (rodent fleas) to permanent attachment (sticktight fleas and burrowing chigoes).

>flies and mosquitoes are winged insects with two pairs of wings attached to the thorax and a well-developed head with sensory and feeding organs. They undergo complete metamorphosis involving a pupation stage. Different species vary in their feeding habits, both as adults (parasitic or free-living) and larvae (parasitic or free-living). There are over 120,000 species belonging to 140 families. Two main suborders are recognized on the basis of structural differences, Nematocera (adult stages parasitic, larval stages often free-swimming) and Brachycera (adult stages parasitic or free-living, larvae stages often predaceous).

>lice are small wingless insects, dorsoventrally flattened, with reduced or no eyes and enlarged tarsal claws for clinging. All lice undergo gradual metamorphosis and there are no free-living stages. Eggs are cemented to hair/feathers whereas nymphs and adults cling to hair/feathers. Two orders of lice are recognized on the basis of

their mouthparts: the Mallophaga (chewing/biting lice) with some 3,000 species infesting birds and mammals; and the Anoplura (sucking lice) with 500 species found on mammals.

Fleas flies Lice

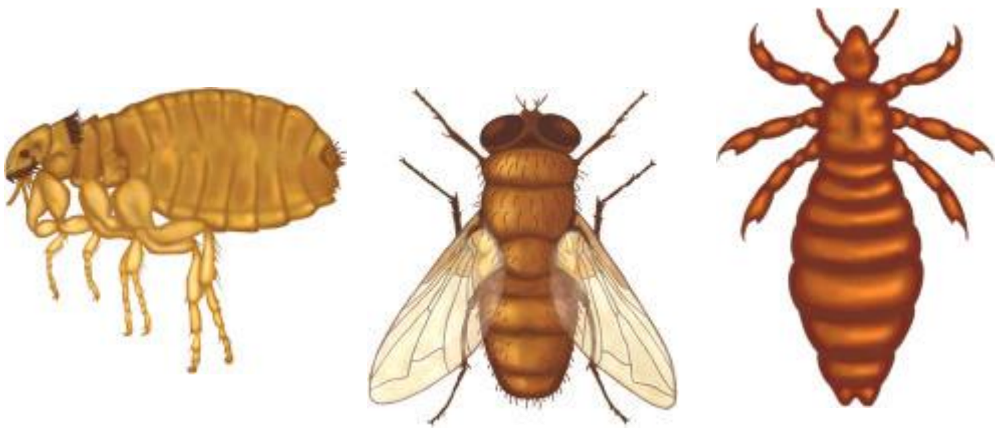


Fig 6.4: Diagram of Parasitic species of Insects b(Source: https://parasite.org.au/para-site/contents/helminth-intoduction.html)

Most parasitic species of insects belong to three main groups except:
a. the jumping fleas (Siphonaptera) b. the winged flies (Diptera) c. the wingless lice (Phthiraptera) d. Crustaceans

Parasitic Species (Arachnids)

Many non-spider arachnids (subclass Acari) are found as parasites on animal or plant hosts. They belong to two main groups: the macroscopic ticks and the microscopic mites. Many species are important in human and animal medicine as causes of disease or as transmission vectors for other pathogens.

> **Ticks**: are epidermal parasites of terrestrial vertebrates that may cause anaemia, dermatosis, paralysis, otoacariasis and other infections (transmit viral, bacterial, rickettsial, spirochaete, protozoal and helminth pathogens). They feed mainly on blood and their mouthparts are armed with small backward-facing teeth to aid in attachment. All ticks undergo gradual/incomplete metamorphosis whereby larval and nymphal instars resemble adults. The integument is relatively thick and respiration occurs via spiracles (usually only one pair) and trachea. Two major families of ticks are

recognized on the basis of many morphological features: the Ixodidae (hard ticks with a tough cuticle and a large anterodorsal scutum) with some 650 species that infest mammals, birds and reptiles; and the Argasidae (soft ticks with a leathery integument and no scutum) with 160 species that infest mainly birds and some mammals.

> **Mites:** are microscopic arachnids which undergo gradual or incomplete metamorphosis. Adults and nymphs have 4 pairs of legs whereas larvae have 3 pairs. Over 30,000 species of mites have been described, many are free-living species, some are plant parasites while others are parasitic on terrestrial and aquatic hosts. Most parasitic species feed on skin debris or suck lymph, some burrow into the skin, some live in hair follicles, and some in the ear canals. Their mouthparts are variable in form but the hypostome is never armed with teeth. The integument is usually thin and three orders are recognized on the basis of their respiratory systems: the Mesostigmata with respiratory spiracles (stigmata) near the third coxae; the Prostigmata (Trombidiformes) with spiracles between the chelicerae or on the dorsal hysterosoma; and the Astigmata (Sarcoptiformes) without tracheal systems as they respire through the tegument.

Ticks

Mites

Fig 6.5 Parasitic Species of Arachnids (Source: https://parasite.org.au/para-site/contents/helminth-intoduction.html)

Parasitic species of arachnids belongs to two main groups namely ------ and -------

Self-Assessment Exercise 2

- Every blood sucking parasitic arthropods are refered to as -----------------
- Every tissue-feeding parasitic arthropods are refdered to as ----------------

6.3.4 Some Diseases of Importance caused by Parasitic Arthropod

- **Mosquitoes**

○ **Anopheles**
Malaria, Malignant Malaria, Viral Encephalitis, Wuchereria Bancrofti & Malayi

○ **Culex**
Bird Malaria, Viral Encephalitis, Rift Valley fever (headache, swelling), Wuchereria Bancrofti

○ **Aedes**
Yellow (jaundice), Dengue (bone & joint pain), Rift Valley fevers.

- **Sandfly**

All types of Leishmaniasis, Carrion's disease (anemia, skin nodules), Sandfly fever, Harrara (severe allergic R to bite).

- **Simulidae**
  Onchocerciasis, Presbydermis, Hang Groin
- **Glossina(TseTse)**
  Human Sleep Sickness (Acute or Chronic)

- **Lice (Anoplura)**

○ Pediculus(Capitis&Corporis)

Vagamond's dse (dermatitis, hyperpigmentation), Typhus, Rickettsia, Trench & Epidemic Relapsing fevers.

- **<u>BedBugs(Cimex)</u>**
  Hepatitis B Virus (alleged), Biting at night –> nervousness & insomni.

- **<u>WingedBugs(Reduvida)</u>**
  Chaga's dse (by T. Cruzi)

- **<u>Fleas</u>**
  Plague (by Ant. station), Typhus Rickettsia (by Post. station), H. Nana & Diminuta (through Rat), D. Caninum (through Dog/Cat), Chigger's dse (nodular swelling, ulceration, 2ry bacteria infection), Dermatitis (due to biting)

- **<u>Ticks</u>**
  Tick Paralysis, Tick Dermatosis

- **<u>Mites</u>**
  - <u>ItchMite(Scabei)</u>
    Scabies (vesicles, scratching, 2ry B. infection)
  - <u>HairFollicleMite(D.Follicrum)</u>
    Acne, Black Heads, Blepharitis
  - <u>RedMite(T.Akamushi)</u>
    Dermatitis, Rash, Punched-out Ulcer
  - <u>HouseDustMites</u>
    Dermatitis, Bronchial Asthma, Rhinitis, Conjunctival Itching
  - <u>StorageMites</u>
    Dermatitis, Digestive & Respiratory Symptoms, Conjunctival Itching

6.4 Summary

Most parasitic arthropods belong to 2 main classes: the 6-legged insects, and the 8-legged arachnids. Parasitic insect species include fleas, flies and lice which actively feed on host tissues and fluids at some stage in their life-cycles. Important parasitic arachnids assemblages include the ticks and mites which bite into tissues and feed off host fluids. Arthropods are involved in nearly every kind of parasitic relationship, either as parasites themselves or as hosts/vectors for other micro-organisms (including viruses, bacteria, protozoa and helminths).

6.5 Reference/Further Readings/Web Sources

https://parasite.org.au/para-site/contents/helminth-intoduction.html
https://www.researchgate.net/publication/351221588_Parasitic_strategies_of_arthropods_of_medical_and_veterinary_importance,
http://assets.press.princeton.edu/chapters/s10163.pdf,

https://youtu.be/x9y61p8ZSzk, https://youtu.be/ioeAVzvs1wY, https://youtu.be/eaw_gnM4PG4,

6.6 Possible Answers to Self-Assessment Exercises

Answer to SAEs 1

Complete metamorphosis is a reproductive process or life cycle stages in insects that involves the egg , the larva, the pupa and the adult.

Answer to SAEs 2

1. Haematophagous 2. Histophagous

Glossary

- Assyptomatic ……………. When organisms show no sign of infection
- Arthropods………………… Any of a phylum of invertebrates (e.g Insects, arachnids) having a semented body, jointed limbs and exoskeleton of Chitin
- Filariasis …………………. Disease caused by by nematodes that inhabit the lymphatics and subcutaneous tissues
- WHO………………………. World Health Organization
- STH…………………………. Soil Transmitted Helminths
- Parthogenic…………………. Development of unfertilized egg

End of the Module Question

- Give an outline of the external features of a nematode
- State the factors that facilitates the transmission of Ascaris lumbricoides
- List the diseases caused by a named blood and tissue nematodes
- State some diseases of importance caused by parasitic arthropods