स्वाध्याय स्वमन्थन स्वावलम्बन

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उत्तर प्रदेश सरकार का एकमात्र मुक्त विश्वविद्यालय

।। सरस्वती नः सुभगा मयस्करत् ।।

PGZY-101 (N)

Disease Biology and Parasitology

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संदेश

प्रयागराज की पवित्र भूमि पर भारत रत्न राजर्षि पुरुषोत्तम दास टण्डन के नाम पर वर्ष 1999 में स्थापित उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय, प्रयागराज उ0प्र0 का एकमात्र मुक्त विश्वविद्यालय है। यह विश्वविद्यालय उ0प्र0 जैसे विशाल जनसंख्या वाले राज्य में उच्च शिक्षा के प्रत्येक आकांक्षी तक गुणात्मक तथा रोजगारपरक उच्च शिक्षा के अवसर उपलब्ध कराने में निरन्तर अग्रसर एवं प्रयत्नशील है। तत्कालीन देश की सामाजिक एवं आर्थिक परिस्थितियों में एक वैकल्पिक व नवाचारी शिक्षा व्यवस्था के रूप में भारत में मुक्त एवं दूरस्थ शिक्षा प्रणाली का पदार्पण हुआ था, परन्तु वर्तमान परिस्थितियों तथा तकनीकी का सार्थक प्रयोग करते हुये मुक्त एवं दूरस्थ शिक्षा आज की सर्वोत्तम पूरक शिक्षा व्यवस्था के रूप में स्थापित हो चुकी है।

वर्तमान शिक्षा प्रणाली के सामने व्याप्त पाँच मुख्य चुनौतियों - (i) पहुँच (Access), (ii) समानता (Equity), (iii) गुणवत्ता (Quality), (iv) वहनीयता (Affordability) तथा (v) जवाबदेही (Accountability) को केन्द्र में रखकर घोषित देश की राष्ट्रीय शिक्षा नीति (NEP-2020) के प्रस्तावों को क्रियान्वित करने में उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय कृत संकल्पित है। उ0प्र0 की माननीय राज्यपाल एवं कुलाधिपति की सद्इच्छाओं के अनुरूप उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय, शैक्षिक दायित्वों के साथ-साथ सामाजिक दायित्वों के निर्वहन में भी लगातार नवप्रयास कर रहा है। चाहे वह गाँवों को गोद लेकर उनके समग्र विकास का प्रयास हो या ग्रामीण महिलाओं, ट्रान्सजेन्डर व सजायाफ्ता कैदियों को शुल्क में छूट प्रदान कर उनमें आत्मविश्वास जागृति व उच्च शिक्षा के प्रति अलख जगाने का प्रयास हो ।

राष्ट्रीय विकास को बढ़ावा देने के लिए शिक्षा एक मूलभूत जरूरत है। ज्ञान-विज्ञान एवं तकनीकी के क्षेत्रों में हो रहे तीव्र परिवर्तनों व वैश्विक स्तर पर रोजगार की परिस्थितियों में आ रहे परिवर्तनों के कारण भारतीय युवाओं को विभिन्न क्षेत्रों में गुणवत्तापूर्ण शैक्षिक अवसर उपलब्ध कराने पर ही भारत का भविष्य निर्भर करेगा। इसीलिए विभिन्न क्षेत्रों में सफलता हेतु शिक्षा को सर्वसुलभ, समावेशी तथा गुणवत्तापरक बनाना समसामयिक अपरिहार्य आवश्यकता है। वर्तमान परिस्थितियों ने परम्परागत शिक्षा को और भी सीमित कर दिया है जिसके कारण मुक्त एवं दूरस्थ शिक्षा व्यवस्था ही एकमात्र पूरक एवं प्रभावी शिक्षा व्यवस्था के रूप में सार्थक सिद्ध हो चुकी है। ऐसी स्थिति में विश्वविद्यालय का दायित्व और भी बढ़ जाता है। इस दायित्व को एक चुनौती स्वीकार करते हुए विश्वविद्यालय ने प्राचीन तथा सनातन भारतीय ज्ञान, परम्परा तथा सांस्कृतिक दर्शन व मूल्यों की समृद्ध विरासत के आलोक में सभी के लिए समावेशी व समान गुणवत्तायुक्त शिक्षा सुनिश्चित करने तथा जीवन पर्यन्त शिक्षा के अवसरों को बढ़ावा देने के लिए अपने शैक्षिक कार्यक्रमों में जागरूकता में प्रमाणपत्र, डिप्लोमा, परास्नातक डिप्लोमा, स्नातक, परास्नातक तथा शोध उपाधि के समसामयिक शैक्षिक कार्यक्रमों की संख्या तथा गुणात्मकता में वृद्धि की है।

शैक्षिक कार्यक्रमों में संख्यात्मक वृद्धि, गुणात्मक वृद्धि तथा रोजगारपरक बनाने के साथ-साथ प्रत्येक उच्च शिक्षा आकांक्षी तक पहुँच सुनिश्चित करने के लिए अध्ययन केन्द्रों व क्षेत्रीय केन्द्रों के विस्तार के साथ-साथ प्रवेश परीक्षा, प्रशासन तथा परामर्श (शिक्षण) में आनलाइन व्यवस्थाओं को सुनिश्चित किया गया है। विश्वविद्यालय कार्यप्रणाली में पारदर्शिता तथा जवाबदेही सुनिश्चियन की दृष्टि से तकनीकी के प्रयोग को बढ़ाया गया है। 'चुनौती मूल्यांकन' की व्यवस्था सुनिश्चित करने का कार्य किया गया है, तो शिक्षार्थी सहायता सेवाओं में भी वृद्धि की जा रही है। शिक्षार्थियों की समस्याओं के त्वरित निस्तारण हेतु शिकायत निवारण प्रकोष्ठ को सुदृढ़ करने के साथ-साथ पुरातन छात्र परिषद को गतिशील किया गया है।

"गुरुकुल से छात्रकुल" के सूक्त वाक्य को आत्मसात करते हुए विश्वविद्यालय ने शिक्षार्थियों को विश्वविद्यालय द्वारा तैयार किये गये गुणवत्तापूर्ण स्वअध्ययन सामग्री उपलब्ध कराने के साथ-साथ विश्वविद्यालय की वेबसाइट पर भी उपलब्ध कराया गया है। छात्रहित को ध्यान में रखते हुए शिक्षकों द्वारा तैयार व्याख्यान को भी ऑनलाईन उपलब्ध कराया गया है।

शोध और नवाचार के क्षेत्र में अग्रसर होते हुए विश्वविद्यालय अनुदान आयोग (UGC) नई दिल्ली तथा माननीय राज्यपाल एवं कुलाधिपति, उ0प्र0 की अनुमति से विश्वविद्यालय में शोध कार्यक्रम पुनः प्रारम्भ किया गया है तथा वर्ष पर्यन्त समसामयिक विषयों पर व्याख्यान, सेमिनार, वेबिनार तथा आनलाइन संगोष्ठियों आदि की शृंखला भी प्रारम्भ की गयी है। विभिन्न क्षेत्रों में रिसर्च प्रोजेक्ट सम्पादन पर भी ध्यान केन्द्रित किया गया है। पुस्तकालय को अत्याधुनिक तथा सुदृढ़ बनाने हेतु कदम उठाये गये हैं। शिक्षकों व कर्मचारियों के स्वास्थ्य तथा कल्याण की योजनायें क्रियान्वित की गयी हैं।

प्रो0 सत्यकाम
कुलपति

Master of Science

PGZY-101 (N)

Uttar Pradesh Rajarshi Tandon

Open University

Disease Biology and Parasitology

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Course Introduction

The living beings on the earth are represented by plants and animals. They require proteins for body building, carbohydrates provide active energy and fats provide reserve energy. A part from them they need water, minerals and vitamins. Plants are autotrops as they undergo photosynthesis to manufacture carbohydrates in the presence of sunlight, while animals are heterotrops as they consume plants and other animals to fulfil their needs. It requires sufficient labour and time to find capture and devour them.

To save the time, labour and energy many animal species have developed a method to be dependent on other living being for such needs. Hence they have started living on or inside their body to obtain their needs for their growth and life processes. In doing so they generally do a lot of damage to such species. The species which follow this mode represent the parasite.The species on or in which a parasite lives is termed as host. The relation of a parasite and its host is termed as parasitism and the science related to parasitism is called as parasitology. As parasitism is an easier method of livelihood, it is very common in animal kingdom. It is rarely seen in plant kingdom.

This course is divided into two blocks.

Block-1 –Pathogen and Transmission of parasite-I (unit 1 to 6)

Block-2 - Pathogen and Transmission of parasite-II (unit 7 to 12)

Block-1 – Pathogen and Transmission of Parasite-I

Parasitology is the branch of biology concerned with the phenomenon of dependence of one living organism to another. It's study of parasites, host and the relationship between them. The species on or in which a parasite lives is termed as host.

This block is divided into six (06) units (1 to 06).

Unit-1: This unit deals with the brief introduction of parasitism, parasite, parasitoid and vectors and also deals with host parasite relationship, mode of transmission of parasite, host specificity and parasitic adaptation.

Unit-2 This unit deals with basic principles and concept of parasitic protozoa. It covers the classification, morphology, lifecycle, epidemiology, pathogenicity diagonosis prophylaxis,and treatment of *Leishmania donovani, Trypanosoma, Giardia lamblia*.

Unit-3 This unit deals with the distribution, habitats, classification, morphology, life cycle, pathogenicity, diagnosis prophylaxis and treatment of malaria parasitie *Plasmodium vivax*.

Unit-4 This unit deals with the general account of Trematoda followed by classification of Trematoda upto order level with the popular examples, Primary and secondary hosts of Trematoda. It includes the life cycle of Monogenea and Digenea.

Unit-5 This unit deals with general account of cestode followed by the classification of class cestode upto order level with the popular examples; primary and secondary hosts of cestode. It gives the life cycles of *Diphyllobothrium latum*, *Taenia solium* and *Echinococrus granulosus*.

Unit-*6* This unit deals with classification*,* morphology life cycle*,* pathogenicity treatment and prophylaxis of *Fasciolopsis buski and schistosoma haematobium.*

Objectives:

After studying this block you should be able to know-

- Introduction to Parasitology
- Parasitic Protozoa
- Parasitic Platyhelminthes
- Parasitic Nematoda

Unit-1 Introduction to Parasitology

Structure

1.1 Introduction

Objectives

1.2 Commensalism, Parasitism, Parasites, Parasitoids and Vectors

1.3 Host Parasite Relationship, Host specificity

1.4 Effect of Parasite on the host

1.5 Modes of Transmission of Parasites

1.6 Parasitic adaptions

1.7 Summary

1.8 Terminal Questions

1.9 Answers

1.1 Introduction

This unit cover's the introduction to Parasitology. In this unit we will discuss about the Parasitism, parasite, parasitoid and vectors. Commensalism is an association between two associate species in which one species gets benefit from the association while the other is neither benefited nor harmed. A parasite is represented by a species which is totally dependent on another species known as host for its food and shelter. Parasitoids occure only in insects with complete matamorphosis (eg. Hymenoptera and Diptera). In this unit we will also discuss about the host parasite relationship and host specificity.

Objectives

After studying this unit you should be able to

- Explain the Parasitism, parasite, parasitoid and vectors.
- Explain the host parasite and host specificity.

1.2 Commensalism, Parasitism, Parasites, Parasitoids and Vectors

Innumerable species belonging to different phyla exist on the surface of earth. In the process of evolution interactions have appeared many times between the members of different species. Such interaction has been termed as symbiosis which may be in the form of commensalism, mutualism and parasitism.

Commensalism is an association between two associate species in which one species gets benefit from the association while the other is neither benefited nor harmed. A number of such associations exist in nature. In mutualism both the associates derive some advantage from the association. Many such examples also exist in nature. Parasitism is an association in which one of the associates derives benefit from the other to the extent that it gets harmed. This condition may generate from a state of commensalism known as inquilinism in which one of the associates gaining advantage from the other accidently or intentionally starts getting more and more advantage to the tune that the other associate gets harmed. A good example of such a condition is that of a copepod and ascidian association in which the copepod living in the pharynx of ascidian normally feeds upon micro-organisms brought in by the respiratory current of ascidian but sometimes the copepod manages to enter the epicardial tube and the stomach of ascidian where it does a lot of irreversible damage by becoming parasitic.

Early evolution of parasitism can not be traced as the invertebrates without exoskeleton and endoskeleton have left no clue to their ancestry, but as they have evolved with the vertebrate hosts it may shed some light on the evolution of parasites.

It is believed that pathogenic species of parasites are those which have been parasites, for a short period of evolutionary time since they have yet to evolve to the stage where they incite little or no response on the part of the host. Theolder and better adopted parasites have increasingly eliminated the antigens which were foreign to the host. Thus they became non-pathogenic. Such parasites possess a number of common antigens with those of the host.

Host-parasite interaction is a significant feature of parasitism. During the evolution of host-parasite relationship it is likely that many biological and morphological characters of both may have been lost or gained. The degree to which such changes took place would depend on the kind of host parasitized, site and environment of the host. Normally the parasite competes with the host for food and vitamins. A good example of such a condition is competition for vitamin B12 between *Diphyllobothrium* and human beings which may lead to shortage of vitamin B12 in the latter leading to anaemia. Such competition may lead to decreased food utilization, reduced appetite or increased passage of food through alimentary canal of the host. It may lead to changes in the absorptive surface of intestine of the host causing efflux or influx of water, sodium the chlorine ions in the bowel and many biochemical and morphological changes in epithelial cell and microvilli of host intestine, The host tissue may undergo destruction by mechanical action during migration of the adult and larvae of the parasite or attachment of adhesive organs, of the parasite like suckers, hooks and scolex which get inserted in the host tissue for attachment. The increase in the size of the parasite within a host organ leads to destruction of particular organ of the host as seen in case of hydatid cysts of *Echinococus* or blockage of ducts and lymph vessels by the nematode *Filaria*. Nematodes like *Ascaris* may rupture the host intestine. Tissue destruction of host may also be caused by fibrosis of a leison as seen in cirrhosis caused by *Fasciola hepatica* infection or any malignant condition.More so over the immune response of a parasite plays a significant role in the pathology of the infection.

Occurance of parasitism is a common feature in the animal kingdom. Parasites have appeared in the evolution of most of the phyla. In Protozoa all the classes are represented by parasitic species. The class sarcodina is represented by *Entamoeba histolytica* which is causative organism of amoebic dysentery. The class flagellata is represented by *Leishmania*, *donovani*, *Trypanosoma gambiens* and *Giardia lamblia* respectivly causing leishmaniasis, sleeping sickness and dysentry. The class ciliata is represented by *Opalina* sp., *Balantidium* sp and *Nyctotherus* sp, which are parasitic in intestine of frogs. Apart from that all the species of the class sporozoa have gone parasitic in some host or the other. In Platyhelminthes all the species of class Trematoda and Cestoda have gone parasitic. In Aschehelminthes the members of the class Nematoda are represented by a number of parasites like *Ascaris lumbricoides*, *Wuchereria bankrofti* and *Dracunculus medinensis* as human parasites. A number of nematode species have gone parasite on plants doing a lot of damage to agriculture. Class polychaeta of Phylum Annelida represented by *Myzostoma* sp which is ectoparasite of starfishes and crinoids.The class Hirudinea is represented by leeches which have gone parasitic on fishes, frogs, cattle and human beings. Class Crustacea of Phylum Athropoda is represented by *Sacculina* which has gone parasite on crabs. Class insecta of Phylum Arthropoda is represented by parasites like *Cimex* sp (bed bug), *Pediculus humanis* (head louse) and *Pulex* sp (human flea). Class Arachnida of the phylum Arthropoda is represented by ectoparasites like ticks and mites.

Evolutionary success of eutherian mammals is based on the viviparity in which as the result of fetilization the zygote gets established in the uterus of the females for further development. Thus the developing infant passes through a parasitic life being totally dependent on the mother for food and shelter.

SAQ-1

1. Commensalism is an association between two associate species in which one species gets benefit from the association while the other is neither .... nor ---------------.
2. During the evolution of host-parasite relationship it is likely that many ---------- and --------------- characters of both may have been lost or gained.
3. The class sarcodina is represented by *Entamoeba histolytica* which is causative organism of ---------------------.

Parasites

A parasite is represented by a species which is totally dependent on another species known as host for its food and shelter. It remains metabolically dependent to a greater or lesser extent on its host species.

A parasite is considered as obligate when it can not complete its life cycle without it's host. Thus the availibility of the host is vary essential for its survival. Contraty to it if the parasite does not absolutily rely on the availibility of the host for its survival it is termed as a facultative parasite. The species like *Fasciola hepatica* or *Taeniasolium* represent an obligate parasite while the bacteria *Botrytis cinerea*, *Rhizoctonia* and rotting bacteria *Corotororum* are good examples of facultative parasite.

The parasites of animal hosts are called as zooparasites while those of plant hosts are known as phytoparasites. The parasites whose life cycle passes through only one hast are termed as monogenetic, those who pass through two hosts are known as digenetic parasites. Monogenetic parasites are represented by *Ascaris lumbricoides* while digenetic parasite is represented by *Fasciola hepatica* whose adult lives in sheep while the larva in a snail host. A parasite is termed as pathogenic if it generates pathological conditions in the host eg. *Fasciola hepatica* causing the disease liver rot in sheep. A non-pathogenic parasite does not generate a marked pathological condition in the host eg.*Entamoeba gingivalis* living in the gums of human beings. A parasite inhabiting the body surface of its host is called as ectoparasite eg.*Diplozoon* living on the surface of gills of fishes. If the parasite inhabits the interior of its host it is termed as endoparasite eg.*Taenia solium* living in the intestinal cavity of human beings. The endoparasites may be of following kinds

1. Cytozoic parasites reside within a body cell eg. sporozoites of *Plasmodium* living in liver cells of human beings.

2. Histiozoic parasites live between the body cells.
3. Coelozoic parasites live in a cavity of the body eg. *Taenia solium* within alimentary canal of human beings,*Paragonimus westermani* within the lung *Schistosoma haematobium* within blood vessels and *Trichomonas vaginalis* in human female genital tract. Generally the adults of many species are parasitic but in some cases the larvae also lead a parasitic life as seen in *Fasciola hepatica* whose larvae, sporocyst, redia and cercaria live as an endoparasite in the body of pond snails.

The parasites which live and reproduce on or within the body of their host are said to be permanent parasites while those visiting the host for feeding only are termed as casual parasites as examplied by leeches living in water feed on the blood of cattle and human beings.

Parasitoids

Parasitoids represents an animal species which is intermediate between a parasite and a predator. At first it operates as a parasite avoiding the vital organs of the host. Later it acts as a predator and consumes the host.Parasitoids occure only in insects with complete matamorphosis eg. Hymenoptera and Diptera.They attack all stages of insect host . eggs, larvae, nymphs, pupae and adults. They may be monophagous attacking single host species, oligophagus attacking restricted range of hosts or polyphagous attacking many host species.

a. **Monophagous:** , *Perillus bioculatus* attacks only colorado potato beetle.
b. **Oligophagous:***Opius* sp. attacks only Dipteran insects.
c. **Polyphagous:***Trichogramma evanescens* attacks more than l00 varid species.

A good example of such a parasitoid is the insect *Dermatobia*, *hominis* commonly known as Bot fly.

Dermatobia hominis

Classification: Phylum: Arthropoda

Class: Insecta

Order: Diptera

Family: Oestridae

Genus: *Dermatobia*

Specs: *Dermatobia hominis*.

Morphology

- Its body is divided in a head, thorax and abdomen.
- The head bears one pair of antenna and one pair of compound eye.
- The thorax bears three pairs of jointed legs and one pair of wings.
- Abdomen shows normal segmentation.

Feeding: The adult fly does not feed. It depends upon the food stored during the larval period for nourishment.

Egg laying. The female fly after copulation and fertilization deposits its eggs on damp clothes or it captures a mosquito or a blood sucking fly and deposits a batch of eggs on its abdomen. When the mosquito or the blood sucking fly alights on a warm blooded host and punctures its skin during blood sucking these eggs get deposited near the wound.

Hatching of eggs: It occurs within six days and the larvae are released .The larvae now find entry in the punctured spot of host skin to become parasitic.

Common mammalian hosts are cattle, dogs, cats, sheep, rabbits and even human beings

Fate of larva: Within the wound the larva grows. It produces, a painful blister with a central opening for its breathing.

After 5 to 10 weeks of parasitic life the larva escapes out and pupates on the ground for about the same period and gives rise to a new adult fly.

Zoonosis: The painful condition of the disease is termed as myiasis.:

Treatment: In cattle and other animals the wound is washed regularly with DDT or BHC after which Toxophene is applied.

In human beings surgical removal of the larva is recommended.

Vectors

A vector is a species which transmits a pathogen or its transmitting stage from an infected host or a location to a fresh host. It transfers infections either actively or passively during it's life. It is represented by both invertebrates and vertebrates. Some important invertebrates which act as vectors are house fly, mosquito and tick.

1- Housefly -

It is cosmopolitan, found within the houses and a number of filthy locations. It feeds on human excreta, sputum and manuers on one hand and or our food material on the other. While sitting on a solid food it releases its saliva to digest it in liquid state before sucking. During sitting on the filthy objects the germs and bacteria get attached its hairy body surface and the legs.Upon the arrival on human food it releases them. Thus a fresh human being gets the infection

It transmits pathogens causing many diseases as typhoid, diarrhoea, cholera, amoebic dysentery, poliomyletis, tuberculosis, leprosy, trochoma, bubonic plague, conjunctivitis. At times it lays eggs on rotten fruits. When they are eaten by a person, its young larvae enter the gut causing very painful condition. It carries eggs of the tapeworm, *Echinococcus* from faeces of dogs to human body through food intake causing hydatid disease.

2. Mosquitos:

(i) Aedes transmits, chikenguniya, Zika, Dengue, Yellow fever

(ii) Anopheles transmits malaria and Filariasis

(iii) Culex transmmits west nile fever, Japanese encephalitis and filariasis

3- Ticks (Ixodes sp) spread borelia, babesia, enrichia, anaplasma, and babesia.

4-Among vertebrates rodents perform a significant role as a vector. Their saliva, urine and droppings may contain pathogens which cause leptospirosis, lassa fever, plague and salmonellosis.

In a particular area transmission effeciency of a vector species depends on vector density, its life time survival, biting rate and pathogen incubation period in its body.

For counter adopting to pathogens and vectors following factors play important role.

1. Immune resistance of the fresh host.
2. Behavioural defence of the fresh host against vector.
3. Resistance against pathogen transmitted by the vector.
4. Colour pattern of fresh host which prevents vector bite.

1.3 Host Parasite Relationship, Host specificity

A parasite lives on or within the body of its host. The micro parasites are represented by viruses and bacteria while the macroparasites belong to almost all classes of phylum Protozoa, class Trematoda and Cestoda of phylum Platyhelminthes, Class Phasmida of phylum Nematoda, class Hirudinea of phylum Annelida, class Arachnida, Insecta and Crustacea of phylum Arthropoda.

A host is a species which harbours a parasite. Generally some higher invertebrates and most of the vertebrates represent a host, Bacteria serve as the host of viruses.

Host parasite relationship can be defined as the influence of each partner by the activity of the other. This relationship can be analysed in relation to following factors.

The adult parasites show following variations in relation to their hosts:

A. Some species are extremely specific for their host as the protozoan *Trypanosom alewisi* in rats, the trematode *Parastrigearo busta* in ducks, the costode *Amoebotaenia sphenoides* in fowl, the nematode *Ascaris suum* in pigs.

B. Some species are capable of infesting closely related species of hosts as the nematode *Heterakis gallinarum* found in fowl, guinea fowl, pea fowl turky and goose, the trematode *Cotylophoron cotylophoron* and the cestode *Moniezia expansa* inhabits sheep, goats and cattle .

C. Sometimes a parasitic species shows a tendency of infesting unrelated species of vertebrate hosts as the trematode *Parogonimus westermani* is found in dogs, pigs, goats and human beings and the cestode *Diphyllobothrcum latum* infests intestine of dogs, pigs, cats, polar bear and human beings.

Host specificity occurs in relation to the age of the host and the sex of the host.

Immune reactions of the host also play significant role in the relation of a parasite with its specific host. The larve of trematoda also show the phenomenon of host specificity for snail host.

1.4 Effect of Parasite on the host

The effect of a parasite on its host varies from non-detectible symptoms to very serious state leading to its death as seen in case of *Trypanosoma brucei* which generates no effect on antelopes but in domestic cattle it may cause sleeping sickness and even its death.

Harmful effects of a parasite on its host may be of following kinds

Mechanical damage of host tissue as damage of liver cells by sporozoites and RBC by merozoites of human host by *Plasmodium* sp.

Interference in the normal function of host. It may be mechanical eg. blocking of intestine by heavy infection of *Ascaris* sp in human beinge .It may be physiological also asinfection of *Diphyllobothrium latum* generates anaemia in human beings.

Production of toxic substance which interferes with the normal metabolism of the host eg. release of haemozoin by merozoites of *Plasmodium* sp. in R.B.C. upon their bursting causes high fever in malarial patient

Change in the resistance of the host which may lead to secondary infection eg infection of *Fasciola hepatica* in human liver induces bacterial infection of *Clostridium* sp. to causes black disease.

Response of the host to the parasite infection

It may be of two kinds.

1- Abnormality in the tissue of the parasite may lead to inflammation resulting in its growth.It may be of three kinds.

  (i) Hyperplesia showing increase in rate of cell division.

  (ii) Metaplesia showing change in one type of tissue to another type.

  (iii) Neoplasia showing tumor formation which may lead to cancerous state

Antigen produced by the parasite induces the production of antibodies by the host lymphocytes generating a condition known as immunity in which the parasite looses its attachment to host or its growth gets shunted or it is killed.

1.5 Modes of Transmission of Parasites

A parasite is a species which is totally dependent on another species called as host for its food and shelter. In some cases a parasite passes its life cycle only in one host, in other cases the life cycle passes through two or more hosts. The host in which the adult stage of parasite lives, is called as primary host or definitive host. In most of the cases it is represented by a vertebrate. In cases where two or more hosts are present the life cycle of the parasite passes from a definitive host to the intermediate host, from which its larval forms are released. Such hosts are represented by the invertebrates.

Transmission is the mode of parasitic infection of the primary host to the intermediate host and vice versa.

(A) In cases where the life cycle of the parasite passes only through one host and there is no role of any intermediate host the transmission of the adult stage (trophozoite) of parasite occurs as under:

(i) During the normal life activity of the host eg. kissing each other in human beings transfers the protozoan parasites *Trichomonas buccalis* and *Entamoeba gingivalis* from buccal cavity of one to that of the other. Similarly *Trichomonas vaginalis*, parasitic in vagina of human females is transmitted through copulation. Similarly copulation between two earthworm performs transmission of *Monocystis* in seminal vesicle of one to the other.

(ii) In Some cases the parasite forms uninucleate (eg.*Giardia lamblia*) or quadrinucleate (eg. *Entamoeba*) cysts at one stage of the life cycle which passout along with the faecal matter of host. These cysts contaminate the food and drinks through which new hosts get the infection.

(iii) In human beings the nematode infection of pinworm (*Enterobius* sp) occurs in the intestine, caecum and appendix. Its gravid female with eggs migrates to anus during night. It causes feeling of itching. When the host uses its fingers during itching, the eggs get attached to the nails and fingers, through which the person contaminates the food of other persons and so the infection is transmitted. This behaviour in children leads to reinfection of the parasite.

(iv) In some nematode infections (eg *Ascaris lumbricoides*) of human beings the eggs are passed out along with the faecal matter in soil. They contaminate the food and drinks and thus enter the intestine of a new host where their larvae are released. Such larvae migrate through different host tissues and finally settle in intestine as adult.

(v) In other nematode of human beings (eg.*Ancylostoma* sp.) the eggs are passed on along with the faecal matter in the soil where they hatch to form rhabdiform lervae which later on get converted to filiform larvae in the soil. During barefoot walking of a fresh human being these larvae penetrate the skin between toes to infect the person. They undesgo two more moults and finally settle in intestine.

(vi) A monogenian trematode *Polystomum* sp. lives as an ectoparasite on skin and urinary bladder of frog. It releases eggs in surrounding water. After sometime the egg forms a larva which soon attacks the gills of a frog tadpole. When the tadepole metamorphoses if moves to the normal location. after loosing cilia and eyespots and developing an opisthaptor.

(B) In cases where the life cycle passes through a definitive and an intermediate host the transmission occurs as under

(1) A condition where the intermediate host lives on the body of definitive host is seen in *Trypanosoma lewisi*. Its intermediate host ratflea lives on the body of definitive host, the rat. The rat harbours the parasite in its blood stream. The flea sucks the blood of rat and gets the infection. In its stomach the parasites undergo binary fission and increase in number. They move to the rectum of the flea and are released out with its excreta.When a fresh rat eats such excreta it gets the infection.

(2) (a) A condition where the intermediate host lives away from the body of the definitive host is seen in *Trypanosoma gambiens* and *Leishmania donovani*. In T.*gambiens* Tse Tsefly (*Glossina palpaies*) and in L *donovani* sandfly (*Phlebotomous* sp) which are blood suckers, serve as the intermediate. They receive infection during blood sucking from an infected human host. The parasite multiplies fast in their body by asexual reproduction. The daughter forms travel upto the mouthparts of the fly.In T.*gambieus*they settle as infective *Leishmanial* stage, respectively in salivary gland and proboscis. During blood sucking these infective stages get passed into the body of a new human host.

(b) In some nematodes (eg. *Wuchereria bankrofti*) the life cycle shows definitive host eg. human being and an intermediate host, culicine mosquito. Transmission of parasite from difinitive host to intermediate host occurs, when the female mosquito suks the blood of an infected person. It is performed from mosquito to human being when a mosquito with macrofilaria in its proboscis inject them in the host body.

(c) A similar condition is seen in *Plasmodium* sp whose intermediate host in female Anopheles mosquito which is also a blood sucker. The mosquito gets the infection during blood sucking of an infected human being by ingesting the male and female gamonts in its stomach where these gamonts form male and female gametes which undergo fertilization producing an amoeboid zygote (ookinits) thus undergoing sexual reproduction. The ookinite enters the stomach wall forming an oocyst and sporocyst in which asexual reproduction (sporogony) occurs leading to the formation of innumerable sporozoites which are released upon the bursting of sporocyst to haemocoel from where they move anteriorly to infect the salivary gland. During blood sucking of a new human host these sporozoites find entry along with the saliva of the mosquito.

(3) In digenatic trematode parasites the primary host is a vertebrate and the intermediate host is a snail, common examples are *Fasciola hepatica* and *Schistosoma* sp.

In such fllukes the adult undergoes sexual reproduction and produces eggs which are passed out along with its faecal matter. On coming in contact with water each egg releases a larve called as miracidium which swims for sometime. On coming in contact with a specific snail species it enters in its body and gets converted in a sporocyst. The sporocyst produces many primary redia larva which in their turn form many secondary redia or cercaria larvae. The cercaria emerges out from the snail body and swims freely. It either settles on an aquatic vegetation forming a cyst like metacercaria (eg. *Fasciola* sp.) or it penetrates in the body of the specific vertebrate host. In other cases a specific vertebrate host gets the infection upon eating the metacercarial encysted on a vegetation.

4(a) In Taenioidea (eg. *Taenia solium*) the life cycle passes through a definitive host and an intermediate host both of which are represented by a vertebrate. During the life cycle the egg contains an oncosphere with 3 pairs of hooks. It remains within the uterus of gravid proglottids of the cestode which when released out contaminates the food of the definitive host in whose body the onchosphere forms a cysticercus larva with an invaginated scolex which forms the adult.

(b) In Pseudophyllidea eg.*Diphyllobothrium latum*the life cycle passes through a definitive host and two intermediate hosts, the first is represented by an arthropod, the second as a fish or a vertebrate. The definitive host is always a carnivorous fish or a carnivorous bird or a mammal. During the life cycle the egg forms an onchosphere with 3 pairs of hooks. It is eaten by an arthropod in whose body cavity it forms a larval stage known as procercoid which a waits to be eaten by the second intermediate host which is usually a fish or a vertebrate. Procercoid punctures the instestinal wall and reaches its coelom, liver or any other organ where it develops as the next larval stage known as pleurocercoid for further development. The second hosts has to be eaten by the definitive host which is normally a carnivores fish or a bird or a mammal.

SAQ-2

1. Annelida represented by *Myzostoma* sp which is ectoparasite of ---------- and -------------.
2. The class Hirudinea is represented by leeches which have gone parasitic on fishes, ------------- and ----------------.
3. Class Crustacea of Phylum Athropoda is represented by ----------------
4. which has gone parasite on crabs. Class insecta of Phylum Arthropoda is represented by parasites like ----------------------
5. Arachnida of the phylum Arthropoda is represented by ectoparasites like ----------------------------.
6. Parasitoids represents an animal species which is intermediate between a ------------------------------.

1.6 Parasitic adaptions

Most of the parasitics are represented by invertebrates belonging to phylum Protozoa, Platyhelminthes, Aschalminthes (Nematoda) and Arthropoda. Some of them represent phylum Annelida, Mollusca or Chordata.

The parasites living on the body surface of their host are termed as ectoparasites while those living within are termed as endoparasites. Ectoparasites are represented by order Monogenea of class trematoda, class Hirudinea of phylum Annelida, class Crustacea, Insecta and Arachnida of phylum Arthopoda. Endoparasites are mainly represented by Protozoa belonging to class Sarcodina, Mastigophora, Ciliata and Sporozoa, trematoda of the order Digenea and almost all species of cestoda and class Nematoda of Aschalminthes.

For leading a successful parasitic life these parasites have shown a number of adaptations which are as under.

I- Presence of adhesive organs

A parasite living on or inside the body of its host has to manage its attachment to the specific area of its host, which is performed by these organs. Some significant adhesive organ are as under.

(1) In the body of Monogenea the body shows a prohaptor at its anterior end and an opisthaptor of the posterior end. These structures posess one or many suckers, hooks or spines.

(2) In the body of Digenea are present an oral sucker at anterior end, around mouth and a ventral sucker (acetabulum) in middle to posterior region. A sucker is a muscular depression which attaches to the body of host by creating a suction pressure.

(3) In Cestoda the body posesses an anterior organ known as scolex which bears suckers and spines. The scolex remains embedded the submucosa of host intestine.

(4) The leech (phy. Annelida) also possesses an anterior sucker and a powerful muscular posterior sucker for temporary attachment to the body surface of a mammal during blood sucking.

(5) The parasitic arthropods possess spines, claws and cones for attachment to their host.

II Feeding adaptations

These adaptations help the parasite to procure their specific food from the body of their host. They are as under.

(1) Sharp, blade like ectoplasmic pseudopodia of *Entamoebas* help it to scrape off the mucosa and other tissues of submucosa on which it feeds.

(2) With the presence of a suctorial pharynx the parasitic living in the intestinal cavity of host sucks the predigested food. It is seen in *Ascaris*. Leach also uses its suctorial pharynx to suck the blood of its host.

(3) In some blood feeding insects like female mosquitos the mouth parts modified to puncture the host and suck the blood.

(4) The blood sucking parasites have developed the ability to release anticoagulant during this process as seen in leeches and female mosquitos.

(5) The availability of a suitable host to a blood sucking parasite is always uncertain as in case of a leech. Such parasites have developed additional structures in their alimentary canal to store as much blood as possible in one attempt for example a leech stores blood of its host, in its 10 pairs of caeca, for about 12 moults in one attempt.

(6) A number of parasites absorb nutrients through their general body surface for example *Leishmania*, *Trypanosoma* and sporozoites and merozoites of *Plasmodium*. This ability has been developed by cestode parasites which have lost their alimentary canal.

III Tremendous ability of Reproduction

For the parasites it is always a chance factor to get a proper host at a specific time of its life cycle. To compensate this draw back most of the parasites show the ability to undergo increased ability of reproduction. It is seen as under.

(1) The protozoan parasites undergo frequent binary fission as seen in *Entamoeba*, *Leishmania* and *Trypanosoma*. If they undergo cyst formation to cope up with unsuitable environmental conditions they produce multinucleate cysts. A good example of it is the production of quadrinucleate cyst in *Entamoeba*. On the return of favourable conditions each cyst produces 4 amoebulae at a time to compensate the loss of reproduction during unfavourable conditions.

(2) The trematode and cestode parasites have gone hermaphroditic (bisexual) which gives facility for self fertilization in a condition when cross fertilization is not possible. These parasites produce immense number of eggs during their life.

(3) The cestode parasites show proglottid formation. Thus they form a chain of many bisexual individuals undergoing cross or self fertilization as the result of which each mature proglottied gets converted into a gravid proglottied which appears as a bag full of tremendous number of eggs.

(4) Nematode parasites are unisexual still they produce enormous number of eggs eg. *Ascaris* produces thousands of eggs per day.

(5) Similarly the arthropoid parasites also produce enormous number of eggs during their life time.

IV Degenerate features

The main aim of a parasite is to produce immense number of eggs for which it requires a lot of energy. The parasites save energy for this purpose in following ways.

(1) As an ecotoparasite or endoparasite does not need locomotion hence it looses the organs of locomotion in its body. However it is not applicable for annelid and arthropod parasites.

(2) As the trematodes living in alimentary canal of their host get predigested food, their alimentary canal is simple lacking the anal opening. The cestodes have gone one step ahead by showing total loss of alimentary canal. They absorb nutrients through their general body surface. In this way they save a lot of energy which was to be utilized in the digestion of food.

(3) Most of the endoparasites have developed anaerobic mode of respiration hence

they have lost the respiratory organs.

(4) As the endoparasites do not come in contact with external stimuli, they show poorly developed sense organs and nervous system.

(5) Extreme degeneracy of organs is seen in the crustacean ectoparasite *Sacculina* which has lost all adult crustacean characters and appears as a sac like body attached to ventral surface of abdomen of a crab. It sends some branched threads in the body of the host crab for obtaining nutrients. It shows only functional ability of reproduction.

1.7 Summary

4. Commensalism is an association between two associate species in which one species gets benefit from the association while the other is neither benefited nor harmed.
5. Host-parasite interaction is a significant feature of parasitism. During the evolution of host-parasite relationship it is likely that many biological and morphological characters of both may have been lost or gained.
6. In Aschehelminthes the members of the class Nematoda are represented by a number of parasites like *Ascarislumbricoides*, *Wuchereriabankrofti* and *Dracunculusmedinensis* as human parasites.
7. A parasite is represented by a species which is totally dependent on another species known as host for its food and shelter. It remains metabolically dependent to a greater or lesser extent on its host species.
8. A vector is a species which transmits a pathogen or its transmitting stage from an infected host or a location to a fresh host.

1.8 Terminal Questions

Question1-describe brief introduction of parasitism.

Question2-describe in details parasite and parasitoid.

Question3-describe in details host parasite relationship.

Question4- explain mode of transmission of parasite.

Write short notes on—

a-Parasitic adaptation

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b-Host specificity

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c-Vectors

1.9 SAQ Answers

SAQ-1

1. Benefited, harmed
2. Biological, morphological.
3. Amoebic dysentery

SAQ-2

1. starfishes and crinoids.
2. frogs, cattle and human beings.

3. *Sacculina*
4. *Cimex* species
5. ticks and mites.
6. parasite and a predator.

Unit-2 Parasitic Protozoa –I (Basic principles and Concept of Protozoa)

Structure

2.1 Introduction

Objectives

2.2 Basic principles and Concept of Protozoa

2.3 Classification morphology and Life cycle of *Leishmania*

2.4 Classification morphology and Life cycle of *Trypanosoma*

2.5 Classification morphology and Life cycle of *Giardia*

2.6 Summary

2.7 Terminal Questions

2.8 Answers

2.1 Introduction

This unit deals with basic principles and concept of parasitic protozoa. It covers the habit, habitat, morphology, life cycle. Zoonosis classification treatment and prophylaxis, Mastigophoran parasites of human beings like *Leishmania donovani,Trypanosoma gambiens* and *Giardia lamblia*.

Objectives

After studying this unit you should be able to

- Explain the principles and Concept of parasite Protozoa.
- To learn about the classification morphology, life cycle of *Leishmania donovani*, *Trypanosoma gambiens* and *Giardia lamblia*.

2.2 Basic principles and Concept of Protozoa

These animals were discovered by Antoni Van Leeuwenhock. Their body shows acellular organization. Some authors consider them as unicellular

The metabolic activities of these microscopic animals are carried out by different organelle, which are temporary or permanent formations performing their specific functions as under.

1. Nucleus: It is generally single but in some cases it may be more than one, may be two or even more. It is of two kinds. It may be vesicular or compact. A vesicular nucleus shows a nuclear membrane which binds nucleoplasm containing endosome in which DNA remains absent. The chromatin lies on inner surface of nuclear membrane. In a compact nucleus large amount of chromatin and small amount of nucleoplasm is present.

2. Cytoplasm: It covers the area between nucleus and outer limiting membrane. It is divisible in outer homogenous and hyaline ectoplasm and innergranular endoplasm with vacuoles and some pigments.

3. The metabolic activities performed by different organelle are as under

Locomotion: It is the process of movement of the body performed by following organelle.

a) ***Pseudopodia***: They are temporary formations of both endoplasm and ectoplasm or only of ectoplasm.

b) ***Flagella***: They are filamentous permanent formations arising from a kinetic body. They may be single or more than one. In some cases a flagellumremains attached to cytoplasm by an undulating membrane.

c) ***Cilia***: They are short fine, hairlike formations arising from kinetic body present in ectoplasm.

Nutrition: It is the process of obtaining nourishment for body activities and growth.

Kinds of nutrition: These animals show three kinds of nutrition

(1*) Holophytic*: It is plant like mode in which photosynthesis occurs.

b. Holozoic: It is animal like mode in, which body captures food from other living beings

c. Saprozoic and Saprophytic: It is a mode in which the body absorbs nutrients through its general body surface.

2. Capture of food: It is done by pseudopodia, or cilia or through an opening known as cytosome in food vacuoles.

3**. Digestion and absorption:** Digestion and absorption of food is done by food vacuoles present in endoplasm. During absorption of food the vacuole performs a specific movement in endoplasm known as cyclosis. During this process the food vacuole gets reduced in size.

4. Egestion of waste matter is done by a temporary opening of food vacuole or at a permanent opening called as cytopyge.

5. Storage of food is done by glycogen granules and chromatin material.

6. Excretion: It is the process of discharging nitrogenous wastes and undigested food matrials to outside. It is done by three organelle.

a) Body surface

b) Contractile vacuole

c) by temporary or opening of food vacuole or permanent opening known as cytopyge.

Reproduction: It is the process of giving birth to new members of the species. Is done by following ways:

a) Binary fission: It is division of the body in two equal halves either longitudinally or transverslly. Nuclear division occurs before cytoplasmic division. It is a common method.

b) Multiple Fission (Schizogony): In this process nucleus divides many times before cytoplasmic division of parental cytoplasm. The dividing form is called as schizont and the daughter forms as merozoites.

c) Budding. It shows unequal fragmentation of nucleus and cytoplasm producing two or many buds which get separated and grow to parental size.

d) Conjugation: It is sexual reproduction occurring in ciliata only. During this process two organism pair and exchange their nuclear material. The individuals separate and become rejuvenated.

e) Syngamy: It is sexual reproduction in which male and female gametes are produced which fuse to forms a zygote. The gametes may be similar (isogamy) and dissimilar (anisogamy).

f) Sporogony: It occurs after syngamy in which a number of sporozoites are formed within a cyst.

Parasitc forms occur in almost all classes of the phylum. All the four orders of the group Zoomastiginea of class Mastigophora have gone parasitic. The subclass Rhizopoda of the class Sarcodina has gone parasitic

Some representatives of the class Ciliata have gone parasite as *Balantidium, Opalina* and *Nyctotherus* while majority is free living. The class Sporozoa are represented by hundred percent parasites.Thus it can be concluded that parasitism is of common occurrence among Protozoa.

SAQ-1

1. Parasitc forms occur in almost all classes of the phylum Protozoa. All the four orders of the group ....of class ....have gone parasitic.
2. .... habitually feeds upon the blood of mammal inducing human beings.
3. During feeding these infective stages look like leishmanial forms. They enter the ....

2.3 Classification morphology and Life cycle of Leishmania

Classification:

Phylum: Protozoa

Subphylum: Plasmodroma

Class: Mastigophora

Order: Zoomastigophora

Genus: *Leishmania*

Species : *Leishmania donovaní*

Habit: It is parasitic

Habitat: It inhabits the reticuloendothelial system of human beings as amastigote form and pharyngeal and buccal cavity of sand fly as promastigote form.

Shape: Amastigote form is round or ovalwhile the promastigote form is elongated slender and spindle shaped.

Body wall: It is made up of a thin, delicate elastic and firm pellicle.

Cytoplasm. It is homogenous, not divisible in ectoplasm and endoplasm.

Morphology

i. Amastigote form which is microscopic, oval or round with a central eccentric nucleus, a kinetoplast, a bleferoplast from which arises an axoneme and a vacuole. It shows the absence of a free flagellum
ii. The Promastigote form which is microscopic, spindle like with a central

nucleus a kinetoplast, a bleferoplast from which arises an axoneme which continues as a free long flagellum. it shows a vacuole near the bleferoplast.

iii. Other cytoplasmic inclusions in both the forms are mitochondria, golgibodies, endoplasmic reticulum and ribosomes.

Life cycle and Reproduction:

The life cycle passes through human two hosts, human beings and sandfly (*Phlebotomus* species.)

Amastigote forms living in the reticule endothelial cells of human begins multiply continually by longitudinal binary fission till the cell gets fully packedwith the parasits. The infected host cell enlarges and ruptures thus liberating the parasites in the circulation. The parasites continually invades the fresh R.E cells thus the entire R.E System gets progresively infected.

During blood sucking the sandfly receives the infected granulocytes and monocyte. Within the gut of sandfy the amastigote forms develop into the promastigote forms which is undergo continued longitudinal binary fission in the midgut region of sandfly. The daughter forms move to anterior parts of alimentary canal as pharynx andbuccal cavity. They finally settlein proboscis of the sandfly.

The transmission to a new human being is effected through the bite of an infected sandfly. During the bite the sandfly causes a wound on human skin and the promastigote forms present in its proboscis are deposited in the skin near the wound. They crawl and find entry in the body through the wound.

Within the blood circulation of human beings many of them are destroyed by phagocytosis of neutrophils and monocytes while others take refuge in the R.E cells. They now change their form to amastigote form and undergo continued longitudinal binary fission to the state of general infection, causing the disease known as kala-azar or visceral leishmaniasis.

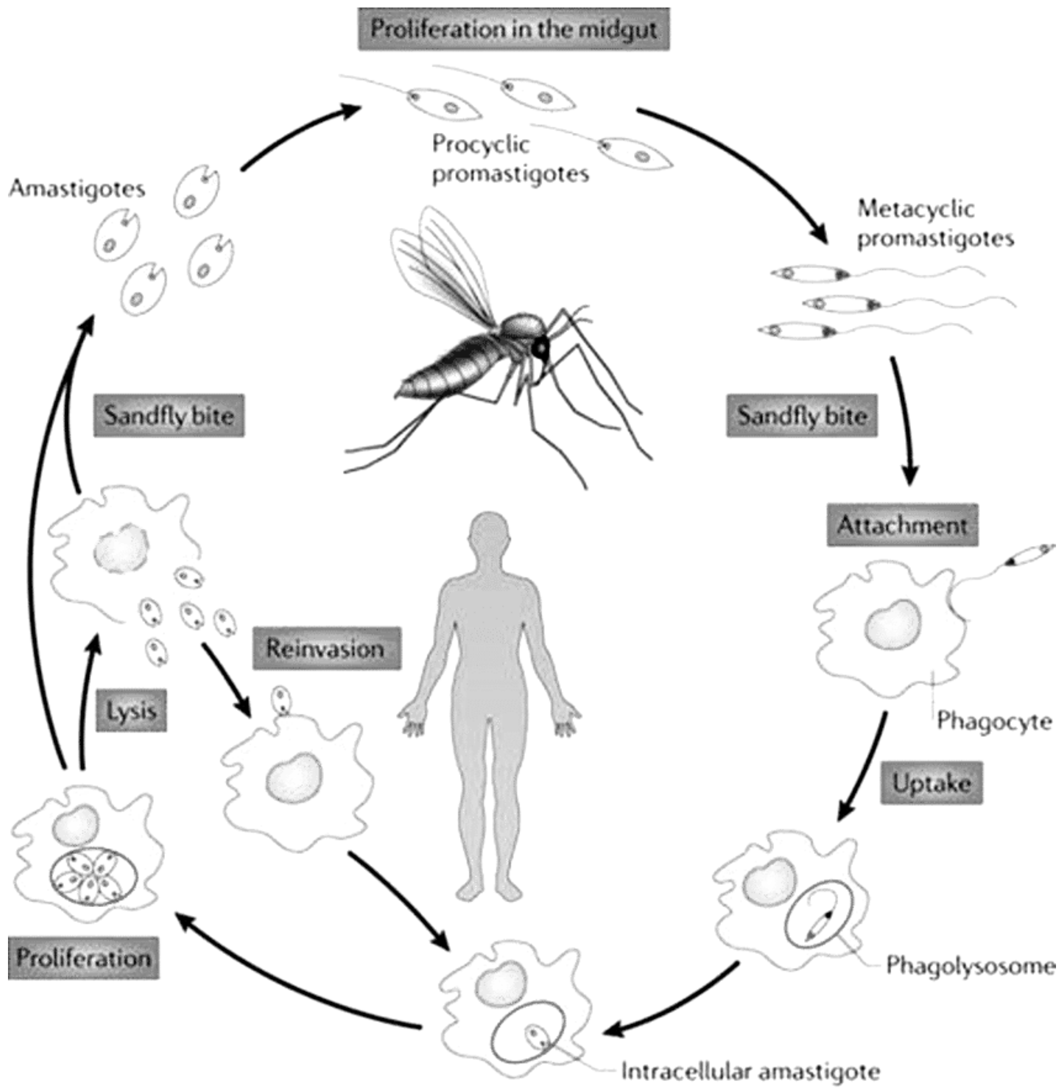


Figure 2.1: Life cycle of Leshmania

Sources: https://www.google.com/search?q=diagram+of+life+cycle+of+Leshmania&sca_esv

Zoonotic significance

Infection of *Leishmania Donovani* causes the disease Kala azar or visceral leishmaniasis in human beings. It shows following important symptoms

I. **Pyrexia:** The patient shows continuous or intermittent fever showing double rise in 24 hours.

II. **Splenic enlargement.** The spleen may often get enlarged to fill up the entire abdomen.

III. Liver enlargement is commonly seen.

IV. Bleeding from nose (Epitaxis) occurs.

V. Skin become dry, rough, harsh and often pigmented.

VI. Hair become brittle and fall.

VII. Pronounced immune suppressive effects lead to anemia, dysentry, pneumonia and pulmonary tuberculosis.

Treatment

For the treatment of Kala azar pentavalent antimony compounds like sodium antimony tartrate and gluconate, urea stibamine, aminostiburea and neostibosan are used-

Prophylaxis

Prophylaxis includes personal defence by avoiding the bite of sandfly by using mosquito nets and avoiding sleeping on ground floor. Apart from that eradication of sand fly is done by removing low trees and bushes and periodic fumigation of sleeping quarters by insecticides.

2.4 Classification morphology and Life cycle of *Trypanosoma*

Classification

Phylum: Protozoa

Subphylum: Plasmodroma

Class: Mastigophora

Order: Zoomastigophora

Genus: *Trypanosome*

Species: *Trypanosoma gambiens*

Habit: It is parasitic.

Habitat: It inhabits the blood plasmaof human beings and alimentary canal and salivary glands of tse-tse fly (*Glossina palpalis*)

Morphology: It is polymorphic showing 4 forms as under:

I. **Leishmania**: It is round or oval in shape with a nucleus, bleferoplast and kinetoplast. Its flagellum is reduced and embedded in cytoplasm.

II. **Leptomonas:** It is elongated in shape with a nucleus in the middle and anterior bleferoplast and kinetoplast. It shows a short anterioly directed flagellum arising from blepharoplast.

III. **Crithidia:**It is elongated in shape with a nucleus. The bleferoplast and kinetoplast are present near the nucleus in the middle. It shows an anteriorly directedflagellum arising from bleferoplast.

IV. **Trypanosomid**:It is elongated in shape. Its nucleus lies the middle. The bleferoplast and kinetoplast are located at the posterior end. From the bleferoplast arises a flagellum which is directed anteriorly. The flagellumremains attached to cytoplast forming an undulating membrane that helps the parasite to move.

Life- Cycle

Tse -Tse fly habitually feeds upon the blood of mammal inducing human beings. When an infected fly performs a bite on human skin it release infective stages of *Trypanosoma* present in its salivary glands along with the saliva to check the clotting of blood. During feeding these infective stages look like leishmanial forms. They enter the blood of human beings.

The leishmanial forms in human blood become elongated. They pass through leptmonad and crithidial stages to become typical long slender trypanosomid forms with flagellum and undulating membrane which help them to swim freely. Such forms undergo repeated longitudinal binary fission to increase their number. Later on they again become leishmanial in shape and form.

At this stage they are sucked by the fly in its alimentary canal. In the midgut of the fly the short leishmanial stages get converted into long slander trypanosomal form and undergo repeated longitudinal binary fission to increase their number.

At this stage they are sucked by the fly in its alimentary canal. In the midgut of the fly the short leishmanial stages are converted into long slender trypanosomal form and undergo repeated longitudinal binary fission to increase their number.

The trypanosomal forms move anteriorwards in alimentary canal to reach its salivary gland. In the cavity of salivary gland they again become leishmanial and passably through crithidialand leptomonad stages. At this stage the fly again becomes infected and becomes ready to transmit the infection to human beings.

Thus it can be noticed that the parasite undergoes multiplication by longitudinal binary fission both in the blood stream of human beings and cavity of alimentary canal of the fly. During longitudinal binary fission following changes occur:

1. The bleferoplast and kinetoplast divide to become two each.

2. One of the bleferoplast retains theold flagellum, while the other bleferoplast develops the new flagellum.
3. Nucleus divides mitotically in two daughter nuclei.
4. The body of the parasite divides longitudinally from anterior to posterior end.
5. Thus the parasite divides in two daughter forms.

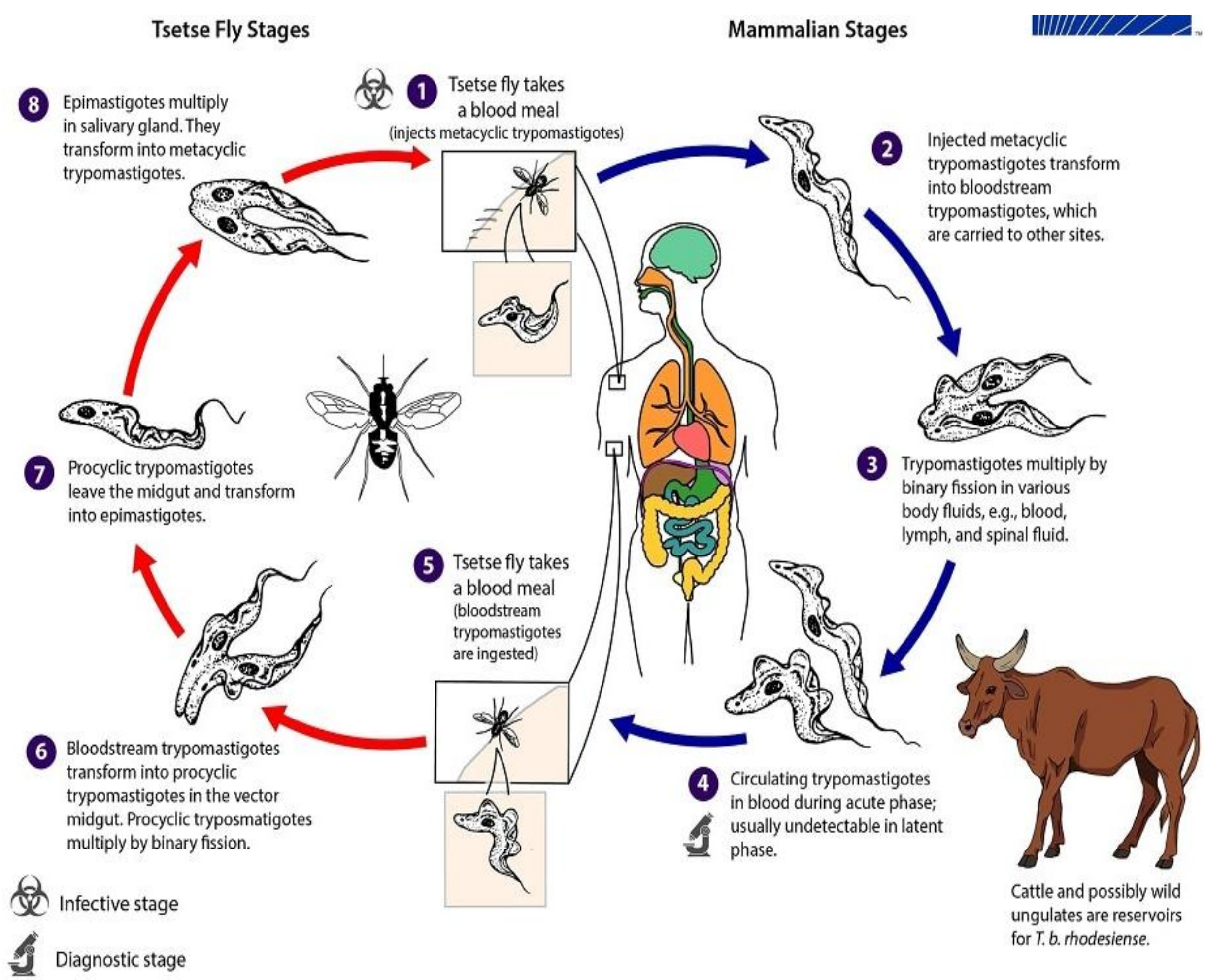


Figure 2.2: Life cycle of Trypanosoma

Sources: https://www.cdc.gov/dpdx/trypanosomiasisafrican/modules/SleepingSick_LifeCycle_lg.jpg

Zoonotic significance:

Infection of *Trypanosoma gambiense* causes Sleeping sickness in human beings. It is caused when the parasites invades the cerebrospinal fluid. It leads to the condition of sleep at short intervals, which may finally lead to the condition of coma and ultimate death of the patient.

Important symptoms appearing during infection are as under.

1. Itching at the place of bite.
2. Swelling of lymphatic glands.
3. Anaemia
4. Loss of weight
5. Severe headache

Treatment

Common drugs used in the early infection are as under.

1. Tryparsamide
2. Atoxyl
3. Germanin
4. Pentamidine
5. Melarsen oxide
6. Suramin sodium

In late stage when the parasite invades Cerebrospinal fluid and sleeping sickness starts it is very difficult to control.

Prophylaxis

Prophylaxis measures include

1. Control of the fly is done by the use of DDT over the bushes in the infected area. It can also be done by the removal of bushes and low tress in such areas.
2. Control of infection to the persons may be done by injecting Antrypolat intervals of a few months.
3. Pigs, buffaloes and some other mammals which serve as reservoir host of the parasite may be removed from the infected areas. Such host carry the infection without showing any symptom.

2.5 Classification morphology and Life cycle of *Giardia*

Classification:

Phylum: Protozoa

Class: Mastigophora

Order: Polymastigida

Genus: *Giardia*

Species: *Giardia lamblia*

Habit: It is parasitic

Habitat: It inhibits the duodenum and other parts of small intestine and occasionaly the colon of human being, especially the children.

Shape: It is pyriform to elliptical, with round anterior region and somewhat pointed posterior end. It shows convex dorsal and concave ventral surface. Posterior end remains slightly curved dorsally.

Morphology:

The parasite is 10µ to 18µ in length and 5µ to 10µ in width.

It shows a large concave disc near the anterior end.

Following organelle are present in its organization showing bilateral symmetry.

1. Two nuclei each with a prominent endosome.
2. Two long slender supporting rods in the medial region known as axostyle. They are directed posteriorly.
3. A pair of darkly staining bodies called as parabasal bodies in the medial region behind the nuclei which are attached toaxo styles by fine fibrils.
4. Eight flagella arranged in 4 pairs. They are also directed posteriorly.

Reproduction: The parasite undergoes longitudinal binary fission showing following changes

1. Each of the two nuclei divides once, thus forming four nuclei, two on each side.
2. Each of the axostyle divides longitudinally.
3. Each of the parabasal body divides once thus forming two bodies on each side.
4. The flagella also get doubled.
5. A medial longitudinal split occursdividing the parasite in two individuals which gradually grow to the normal in size.

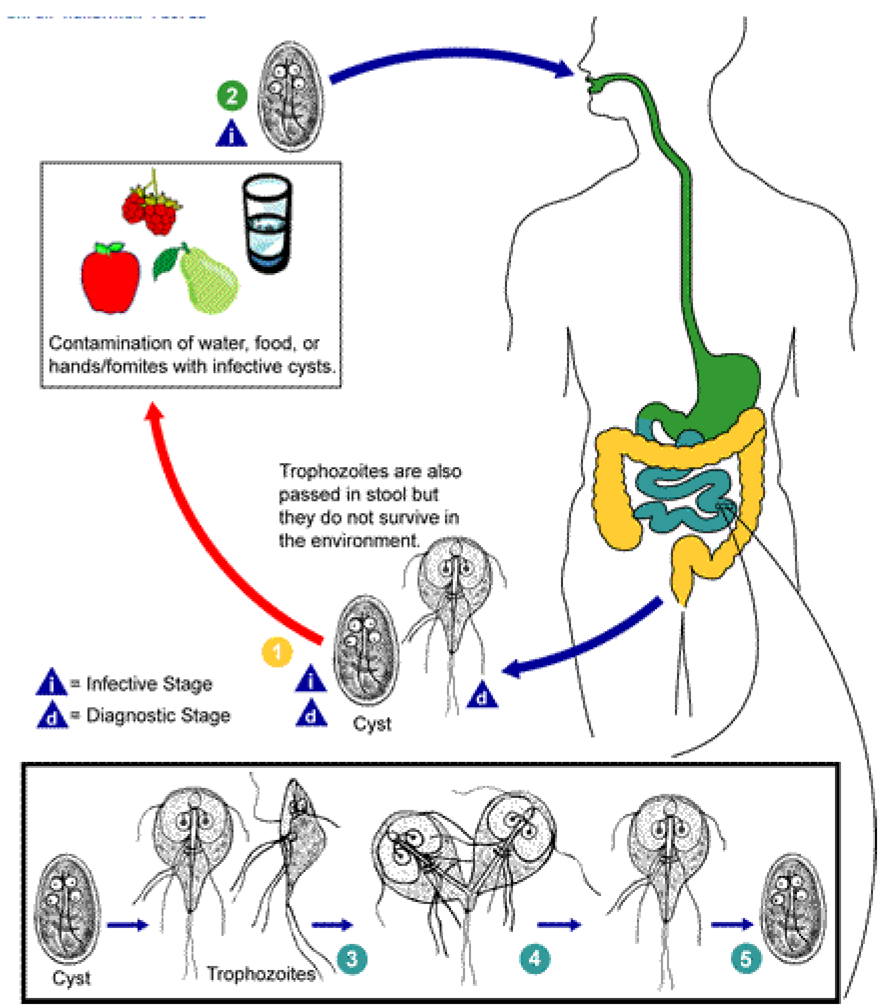
Transmission of the parasite occurs through the formation of oval cyss showing following characters.

1. Appearance of a cyst wall all around.
2. Appearance of 4 nuclei
3. Appearance of 4 axostyles
4. Appearances of 4 parabasal bodies

Such cysts are passed out along with the faecal matter of the host. They get disseminated in the soil or water and contaminate the food and drinks.

New host get the infection upon drinking contaminated water or eating contaminated food and raw fruit.

Such cysts pass through the stomach to reach oesophagus and other parts of intestine. They release their cyst wall and undergo longitudinal binary fission to take the form of the parasite. Each such parasite gets attached to the mucosal wall to lead the normal life.



Sources: https://www.google.com/search?q=diagram+of+life+cycle+of+giardia+lamblia&rlz

Pathogenecity: By covering the mucous membrane of the intestine, the parasites check the absorption of the food especially fats in the host. It leads to the condition of diarrhoea, which is the major symptom of the disease Giardiasis.

Prevention: It is done by developing the habit of cleanliness as washing hands before eating and thorough washing of fruits and vegetables. One should protect the food articles from dust, flies and cockroaches.

SAQ-2

1. When an infected fly performs a bite on human skin it release infective stages of *Trypanosoma* present in its .... along with the saliva to check the clotting of blood.
2. Infection of *Trypanosoma gambiense* causes .... in human beings.
3. Control of the fly is done by the use of .... over the bushes in the infected area.

2.6 Summary

- Parasitc forms occur in almost all classes of the phylum. All the four orders of the group Zoomastiginea of class Mastigophora have gone parasitic. The subclass Rhizopoda of the class Sarcodina has gone parasitic
- Tse -Tse fly habitually feeds upon the blood of mammal inducing human beings. When an infected fly performs a bite on human skin it release infective stages of *Trypanosoma* present in its salivary glands along with the saliva to check the clotting of blood.
- During feeding these infective stages look like leishmanial forms. They enter the blood of human beings.
- Infection of *Trypanosoma gambiense* causes Sleeping sickness in human beings.
- It is caused when the parasites invades the cerebrospinal fluid.
- It leads to the condition of sleep at short intervals, which may finally lead to the condition of coma and ultimate death of the patient.

2.7 Terminal Questions

Question-1 Describe in details classification and life cycle of *Trypanosoma*.

Question-2 Describe in details classification and life cycle of *Giardia*.

Question-3Explain concept of Protozoa.

Question-4 Describe in details classification and life cycle of *Leishmania*.

Question-5 Describe in details zoonotic significance of *Trypanosoma*

2.8 Answers

SAQ-1

1. Zoomastiginea, Mastigophora
2. Tse -Tse fly
3. Blood of human beings.

SAQ-2

1. salivary glands

2. Sleeping sickness
3. DDT

Unit-3 Parasitic Protozoa – II (Malaria parasites of human)

Structure

3.1 Introduction

Objectives

3.2 Malaria Parasites of Human Beings

3.3 Classification, morphology and Life cycle of *Plasmodium*

3.4 Symptoms and control of Malaria

3.5 Summary

3.6 Terminal Questions

3.7 Answers

3.1 Introduction

This unit deals with the distribution, habitat of malaria parasites and classification, morphology, life cycle, pathogenicity, treatment, control and prophylaxis of malaria parasitic, *Plasmodium vivax*. The causative organism of malaria in human beings is a Sporozoan parasite known as *Plasmodium.*It is represented by four species which are *Plasmodium vivax, Plasmodium falciparum, Plasmodium ovale and Plasmodium malariae.* Out of them *P. vivax* is most commonly found in most parts of Gangetic plains. In the last twenty years the incidence of *P. falciparum* has markedly increased.*P.malariae* is commonly found in foot hills of Orissa while the occurrence of *P.ovale* is very little.

Objectives-

After studying this unit you will learn about the

- Malaria parasites of human.
- Classification of Morhology, life cycle of *Plasmodium sp*.

3.2 Malaria Parasites of Human Beings

<u>Distribution and Habitat</u>

During the infection of these parasites the *P. vivax* causes benign tertian malaria in which the recurrence of fever occurs after each 48 hours. *P. ovale* causes mild tertian malaria in which recurrence occurs after each 48 hours. In the infection of *P. Malaria* occurrence of quart an malaria is seen in which fever recurves every 72 hours. *P. falciparum* causes malignant tertian malaria which shows recurrance of fever between 36 to 48 hours. In all these cases fever shows periodic attacks in 3 stages. They are cold stage showing chill and shivering, hot stage shows high fever, high pulse rate and quick respiration. It is followed by sweating stage when fever goes down producing profuse sweating. Such paroxims continue for several weeks with relapses. After a few paroxims the patient suffers from anaemia, enlargement of liver and spleen and jaundice and extreme weakness. The death rate is very high in malignant tertian malaria while in the other three cases it is low. The high death rate in malignant tertian malaria is because of the fact that during erythrocytic schizogony the RBC get clumped in masses thus blocking the fine blood capillaries of brain Spleen, lings and other organs. Such a condition may be mild or it may be sever leading to black water fever in which the patient undergoes distruction of RBC due to haemolysis in which haemoglobin passes through urine making it red. This condition leads to death of the patient.

Transmission of *Plasmodium*, is performed by the female *Anopheles* mosquito which is blood feeder of human beings. It receives the gamonts of *Plasmodium* along with the blood of an infected human beings. The gamonts in the stomach cavity form male and female gametes. As the result of fertilization of female gametes amoeboid zygotes, (ookinite) are formed which enter and settle in its stomach wall as sporocyst in which repeated multiplication leads to formation of large number of sporozoites which are liberated in the haemocoel upon the bursting of sporocyst. These sporozoites move upto salivary gland of the female mosquito. When such an infected mosquito sucks the blood of a fresh human beings the sporozoites enter its blood circulation from where they move upto liver and R.B.C causing malarial fever.

As the female Anopheles undergoes egg laying on a water body hence for understanding the distribution and habitat of *Plasmodium* one has to depend on the distribution and habitat of Anopheles. In the process of evolution *Anopheles* has been is represented by a number of species which habitually breed in water. They are present in following areas of south-east Asia as under.

i. *A. culipifacies* breeds in rain fed ponds and water stored for irrigation in complete gangetic plains of India. It is mainly responsible for spread of rural malaria.

ii. *A. stephensi* breeds in gangetic plains of India and plains of Pakistan in rain fed ponds and wells. It is mainly responsible for urban malaria.

iii. *A. fluvitilis* breeds in natural water currents present in foot hills of Nepal and India. It is also responsible for rural malaria. It is mainly responsible for the spread of *Plasmodiumfalciparum*.

iv. A. minimus breeds in water bodies of north-east India, Bangladesh and Bhutan máinly in forest area.

v.*Adirus* breeds in water bodies of north-east forests of India, chatgaon area of Bangladesh and hilly areas of Nepal. It also breeds in mud and rainwater stored in cavities of foot prints of elephants.

vi.*Asundicus* breeds in salty water bodies of Andman and Nicobar islands.

vii.*A maculatus* breeds in water currents of hilly areas and foot hills. It is mainly responsible for spread of malaria in Nepal.

viii. *A. aegipti* breeds in waterbodies specially of urban and industrial areas of complete south Asia It prefers water stored in coolers, tyres, cannesters and domestic plastic containers.

ix. *A albopictus* breeds. in water bodies present in forest areas of Nagaland.

3.3 Classification, morphology and Life cycle of Plasmodium

Classification :

Phylum : Protozoa

Subphylum : Sporozora

Class : Telosporia

Order : Eucoccidia

Suborder : Haemosporina

Genus : *Plasmodium*

Species : *Plasmodium vivax*

Habit : It is Parasitic

Habitat : It is habits the liver calls and RBC of human beings and stomach cavity, stomach lining, haemocoel and salivary glands of female *Anopheles* mosquito.

Morphology: Sporozoites : It is infective stage of the parasite present in the salivary gland of female Anopheles. It is small uninucleate and sickle shaped form.

Under electron microscope it shows following parts

1. Outer covering of elastic pellicle showing contractile microtubules.
2. An apical cap of concentric rings at anterior end
3. One pair of secretory organellesecreting a lytic juice opening at anterior tip on micropyle
4. Many convoluted tubules in whole body.
5. Single nucleus with a nucleolus.
6. Single mitochondrion with cristae

Trophozoite: It is present in R.B.C of human beings showing a round form. Under electron microscope it showsfollowing cell inclusions

i. A nucleus with a nucleolus.

ii. A few mitochondria.

iii. A few golgi bodies.

iv. A few vacuoles.

v. A few food vacuoles.

Life cycle:

Life cycle of the parasite passes through the intermediate host (female *Anopheles*) mosquito and human beings which serves as the definitive host.

The infected female Anopheles carries many sporozoites in its salivary gland. When the female mosquito bites a humanbeing for blood sucking it releases saliva containing anticoagulants, which checks the clotting of the blood during its feeding process. Along wilk the saliva the sporozoites. It entry in the blood stream of the human being. Through the blood circulation the sporozoites reach the liver region in which a single sporozoite invades a liver cell to undergo multiple fission known as Schizogony.

SAQ-1

- During the infection of these parasites the *P. vivax* causes benign -----------------.
- Tertian malaria the recurrence of fever occurs after each ----------------. *P.ovale* causes mild tertian malaria.
- In the infection of *P. malaria* occurrence of quart an malaria is seen in which fever recurves every ---------------------.

- *P. falciparum* causes malignant tertian malaria which shows recurrance of fever between --------------------------.
- Transmission of *Plasmodium*, is performed by the female *Anopheles* mosquito which is blood feeder of -----------------.

Schizogony in the liver cell is of four kinds:

1. Pre-erythrocytic schizogony is the first repeated multiple fission of the sporozoite within the liver cell forming a number of daughter forms termed as crypto merozoites which are released when the infected liver cell bursts under their pressure.
2. Exo-erythrocytic schizogony is the following stage of repeated multiple fissions when each crypto-merozoite attacks a fresh liver cell forming many daughter forms termed as meta-cryptomerozoites which are released upon the bursting of the affected cell. Each daughter meta-cryplomerozoite attacks a fresh liver cell to undergo multiple fission.
3. Erythrocytic schizogony: It begins when a meta-cryptomerozoite attacks red bloodcorpus in the blood stream. It enters a red blood corpuscle to form a trophozoite which gradually develops a large vacuole to become ring like. This stage is termed as signet ring stage. Gradually the vacuole disappears and the parasite takes amoeboid shape followed by a round shape. At this stage it showsrepeated fission to form a rosette stage in which the daughter forms remain clumped. At this stage the cytoplasm of the infected R.B.C shows the presence of haemozoin, which represents the waste toxic products of the parasite. Under the pressure of the released daughter forms known as merozoites the infected R.B.C bursts releasing haemozoin in the blood circulation which produces the state of fever in the patient. The released merozoites attack fresh R.B.C to undergo repeated erythrocytic schizogony for many times.
4. Post-erythrocytic schizogony: So often the merozoites released from R.B.C attack fresh liver cells to undergo multiple fission like pre and exo-erythrocytic schizogony.

Thus huge damage is done to the liver cell and the RBC of the human patient by the occurrance of schizogony. During erythrocytic schizogony due to some unknown reasons some merozoites get changed in the form of gamonts. At this stage when a female Anopheles sucks, a blood sample of an infected human patient the R.B.C infected with gamonts reach the stomach cavity of the mosquito to begin the phenomenon of gamogony.

Gamogony: It is the process of formation of male and female gametes with in the stomach cavity of female mosquito. The R.B.C containing the gamonts get digested releasing the gamonts which are of two kinds as microgametocytes and mega gametocytes. They undergo following changes during the formation of male and female gametes.

Formation of male gametes:- The nucleus of the microgametocytes undergoes a reduction division followed by two mitotic divisions thús producing 8 haploid nuclei which get arranged at equidistance below the periphery. Aganist each nucleus appears a process in which the nucleus moves. At this stage all the process get detetched undergoing exflagellation of 8 male gametes in the amen of stomach of female mosquito.

Formation of female gametes :- The nucleus of megagametocyte undergoes a reduction division forming two haploid nuclei. Out of themone forms the polar body of the female gamete thus produced.

Thus in the cavity of stomach appear many female gametes and about eight times more the male gametes The fertilization of the female gamete is performedby a male gameteconverting it into a zygote which develops pseudopodia and moves towards the stomach wall. Such amoeboid zygote is termed as ookinite. The ookinites thus formed enter the shomach wall in which they settle and develop a cyst wall termed as oocyst which grow in sizeand undergoes multiplication known as sporogony. It results in the formation of sporocyst.

Sporogony: In each of the sporocyst the nucleus divides three times producing 8 daughter nuclei. Some cytoplarm gathers around each nucleus to form a sporoblast. Within each sporoblast the nucleus further divides three times producing 8 daughter nuclei which get arranged below its periphery at equal distance. Against each nucleus the cytoplasm forms a finger like process in which the nucleus moves, thus producing 8 sporozoites. They undergo exflagellation, thus the sporocystgets packed with innumerable sporozoties. Ultimately the Sporocyst bursts towards outersidereleasing the sporozoitesin it haemocoel from where they move anterior wards and finally settle in the salivary gland of the female mosquito making it ready for infesting a fresh human hostduring blood feeding.

All the changes of schizogony, gamogony and sporogony occur only in the female Anopheles because it is blood feeder. The male mosquito does not perform these changes because it isnector feeder and not blood sucker, So the role of intermediate host of *Plasmodiums* performed by the female only.

<u>Treatment of malarial parasite</u>:-This method is known as cheino therapy. It is possible only by the use of. Use of some synthetic drugs which kill the parasite at several stages. Some of the drugs commonly used are as under.

1. Quinine in highly effective against the schizont stages, but is not effective against gametocytes. It has no effect on exoerythrocytic stages hence it can not stop relapse of the disease.
2. Following synthetic drugs are commonly used. They are as under

    a. Atebrine

    b. Paludrine

    c. Chloroquine

    d. Plasmochin

    e. Caemaquine

    f. Pentaquine

    g. Isopentaquine

    h. Camoprime

But no single drug, is effective against exoerythrocytic schizonts and erythrocytic gametocytes.

3. For prevention of infection Atabrine at the rate of 0.1gm per day in used mainly in malarial season. At present single pill of 0.15 gm Chloroquine once a week serves the purpose.

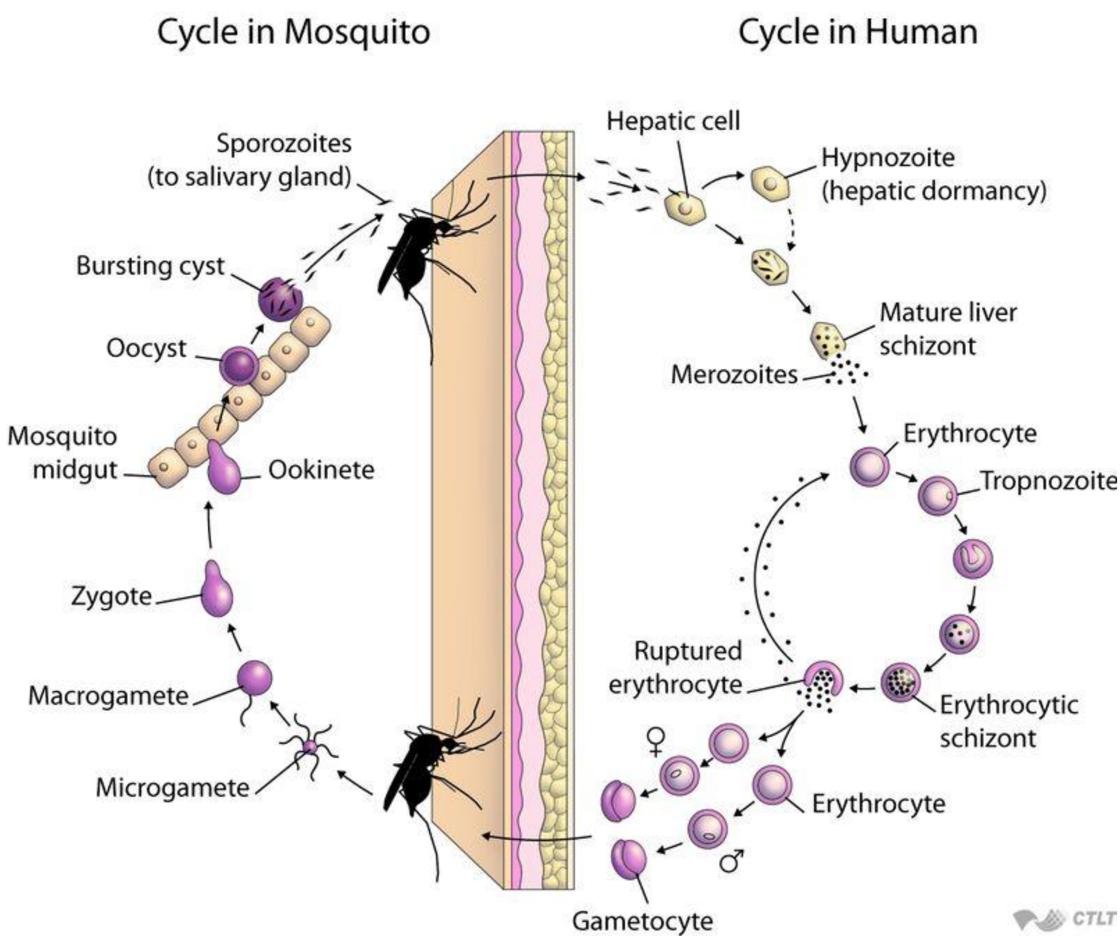


Fig.3.1: Life cycle of *Plasmodium*

Sources: https://www.google.com/search?q=life+cycle+of+plasmodium+image&rlz

3.4 Symptoms and Control of Malaria

Before the stage of fever the preliminary symptoms which appear in the patient are constipation, headache, nausea, muscular pain, pain in joints, insomnia, thickly coated tongue and chilliness. Chronic infection may lead to enlargement of liver and spleen, jaundice and pot belly in children while anaemia appears after a few paroxysm.

Control of Malaria-

It is performed by distruction of the mosquito Anopheles species, prevention of infection and the treatment of the patients.

Destruction of *Anopheles* species: It is done in following ways.

1. **Elimination of the breeding places:***Anopheles* habitually breeds in stagnant water represented by swamps, ponds, pools and ditches, tin cans, coolers and buckets within the house hold water filled. The large water bodies should be

filled up with soil after the removal of water. Within the household regular removal of stored water in the containers should be done. The water stored in coolers should be regularly drained off.

2. **Elimination of larvae and pupae**: Once the female *Anopheles* performs egg laying in a water body, the eggs develop as larvae and pupae which flourish in the water body. If regular removal of such stored water is done the larvae and pupae get washed away. In large water bodies like ponds and pools spraying of kerosine oil, paraffin oil or patrol makes a thin film on the water which prevents the larvae and pupaeto breath and they die, Larvicides like DDT and Benzene hexachloride may also be used for this purpose.

In large bodies of water larvicidal fishes like *Gambusia* and sickle backs may be introduced which regularly eat the larvae and pupae.

(iii.) Destruction of adult mosquitos. It is done by regular fumigation of pyrethrum, sulphur, and cresol which kill the adult mosquitos.

Prevention of Infection (Prophylaxis)

1. The mosquitoes must be prevented to enter the houses, especially the sleeping quarters by screening the doors, windows and ventilators.
2. The prevention is done by use of mosquito nets, repellant creams and coils.
3. Use of antimalarial drugs like Paludrine, Pyrimethanine and Daraprim may be taken in small weekly doses to check the establishment of sporozoits in liver.

SAQ-2

- Sporozoites infective stage of the parasite present in the .... It is small uninucleate and sickle shaped form.
- Pre-erythrocytic schizogony is the first repeated multiple fission of the sporozoite within the ....
- Exo-erythrocytic schizogony is the following stage of repeated multiple fissions when each crypto-merozoite attacks a fresh liver cell forming many daughter forms termed as .... which are released upon the bursting of the affected cell.
- Each daughter meta-cryplomerozoite attacks a fresh .... to undergo multiple fission.
- Post-erythrocytic schizogony: So often the merozoites released from

.... attack fresh liver cells to undergo multiple fission like pre and exo-erythrocytic schizogony.

3.5 Summary

- During the infection of these parasites the *P. vivax* causes benign tertian malaria.
- Tertian malaria the recurrence of fever occurs after each 48 hours. *P.ovale* causes mild tertian malaria in which recurrence occurs after each 48 hours.
- In the infection of *P. malaria*occurrence of quartan malaria is seen in which fever recurves every 72 hours.
- *P. falciparum* causes malignant tertian malaria which shows recurrance of fever between 36 to 48 hours. In all these cases fever shows periodic attacks in 3 stages.
- Transmission of *Plasmodium*, is performed by the female *Anopheles* mosquito which is blood feeder of human beings.
- It receives the gamonts of Plasmodium along with the blood of an infected human beings. The gamonts in the stomach cavity form male and female gametes.
- Sporozoites infective stage of the parasite present in the salivary gland of female Anopheles. It is small uninucleate and sickle shaped form.
- Pre-erythrocytic schizogony is the first repeated multiple fission of the sporozoite within the liver cell forming a number of daughter forms termed as crypto merozoites which are released when the infected liver cell bursts under their pressure.
- Exo-erythrocytic schizogony is the following stage of repeated multiple fissions when each crypto-merozoite attacks a fresh liver cell forming many daughter forms termed as meta-cryptomerozoites which are released upon the bursting of the affected cell.
- Each daughter meta-cryplomerozoite attacks a fresh liver cell to undergo multiple fission.
- Post-erythrocytic schizogony: So often the merozoites released from R.B.C attack fresh liver cells to undergo multiple fission like pre and exo-erythrocytic

schizogony.

3.6 Terminal Questions

Question-1 Describe in details classification and life cycle of *Plasmodium*

Question-2 Describe in details epidemiology of *Plasmodium.*

Question-3Explain the pathogenicity of *Plasmodium*.

Question-4 Describe in details diagnosis of *Plasmodium*.

Question-5 Describe in details prophylaxis and treatment of *Plasmodium.*

Question-6 Write shorts notes on:

- Sporozoites

- Trophozesites

- Pathogenicity

3.7 Answers

SAQ-1

- tertian malaria.
- 48 hours.
- 72 hours.
- 36 to 48 hours.
- Human beings.

SAQ-2

- Salivary gland of female Anopheles.
- Liver cell
- Meta-cryptomerozoites
- Liver cell
- R.B.C.

Unit-4 Parasitic Platyheminthes-I

Structure

4.1 Introduction

Objectives

4.2 General Account of Trematoda

4.3 Classification, morphology and Life cycle of Tematoda

4.4 Primary and secondary hosts of Trematodes

4.5 Summary

4.6 Terminal Questions

4.7 Answers

4.1 Introduction

This unit deals with general account of Trematoda followed by the classification of class cestode upto order level with the popular examples; Primary and secondary hosts of Trematoda. Trematodes are generally hermaphrodite showing well developed reproductive system. Monogenea possess many testes located in posterior region and single elongated and coiled ovary. In Digenea are present two round testes located one on each side or one behind the other and single round ovary which may be lobed or branched.

Objectives

After studying this unit you will able to

- Know about the Trematoda.
- Primary and secondary hosts of Trematoda
- Life cycle of Monogenea and Digenea

4.2 General Account of Trematoda

Tremetoda are ecto and endoparasites showing the absense of epidermis and cilia. Their body remains covered with thin or thick cuticle resting on mesenchyme.

Their body shape may be oval, round, discoid, elongated, Slender or broader than long. They prossess adhesive organs in the form of prohaptor and opisthaptor in Monogenea and oral sucker and acetabulum in Digenea. The subcuticular masculature shows outer circular muscle fibres, middle longitudinal muscle fibres and inner diagonal muscle fibres. The muscles may be weak or well developed. The suckers show powerful muscle bundles of radial fibres.The mesenchyme below the muscle layer shows syncitial meshwork of fluid filled spaces containing free cells as lymphocytes.They possess a digestive system with mouth at or ventral to anterior tip enclosed by an oral sucker, followed by prepharynx and round or elongated pharynx provided with radial muscles. Phanynx may possess internal or external glands. It is followed by a short or long oesophagus which may be absent in some cases. Oesophagus is followed by a sac like intestine or it may be divided in two intestinal caeca which may extend upto posterior end. They may possess lateral branches. The intestinal caeca may end blindly or may open seperately or get united to form a common anal opening.

The excretory system shows two proto nephridial tubes on each side. They unite in a bladder which may be oval or 'Y' shaped. It opens to outside by a single pore at the middle or posterior end. The protonephridial tubes get branched and rebranched. At their terminal ends lie the single nucleated flame bulbs.Thelymphatie system shows one to four blind longitudial tubes which remain unconnected. They send branches to intestine, reproductive organs and suckers. They contain fluid showing free lymph cells. These channels distribute food, respiratory gasses and excretory material.

Trematodes are generally hermaphrodite showing well developed reproductive system. Monogenea possess many testes located in posterior region and single elongated and coiled ovary. In Digenea are present two round testes located one on each side or one behind the other and single round ovary which may be lobed or branched. Each testi's leads to a sperm duct. The two sperm ducts unite to form a common sperm duct which enters the copulatory organ which may be simple muscular tube or highly muscular cirrus sac whose distal portion known as cirrus may be unarmed or armed with spines. Cirrus sac contains a seminal vesicle. Vitellaria appear in clusters on each side in whole body length. Vitelline ducts of each side join forming a yolk reservoir which leads to a short yolk duct. Oviduct receives the yolk duct and laurer's canal and gets widened to form an ootype, encircled by mehlis gland. It continues as a wide uterus which runs upto genital atrium. A seminal receptacle may be attached to the oviduct. Uterus appears as a simple or greately coiled long tube for storing eggs. Gonopore may be anterior or posterior.

As the result of copulation trematodes show cross fertilization but sometimes self fertilization may occur.

Nervous system shows a pair of cerebral ganglia connected by a broad commissure dorsally between oral sucker and pharynx. Three pairs of nerves run anteriorly and three pairs of nerve cords run posteriorly. Sense organs are ill developed and appear as tangoreceptors.

4.3 Classification, morphology and Life cycle of Tematoda

Class Trematoda have been divided in two orders Monogenea and Digenea.

Monogenea : They are ectoparasite on gills and skin of fresh water and marine fishes, Crustacea and Cephalopoda. Some of them are endoparasitic in nasal cavity, pharyngeal cavity, urinary bladder and ureter of fishes , Amphibia and Reptilia.

They have been divided in two suborders as Monopisthocotylea and Polyopisthocotylea. A comparision of the two is as under.

Monopisthocotylea	Polyopisthocotylea
i. Oral sucker absent or weak	i. Oral sucker present.
ii. Prohaptor appears as small lateral suckers or pits with adhesive glands.	ii. Prohaptor appears as oral sucker around mouth or it appears as two suckers openning in one cavity.
iii. Opisthaptor appears as simple or subdivided disc with 1 to 3 pairs of large hooks and 2 to 16 hooklets.	iii. Opisthaptor may or may not be armed. It may bear seperate suckers.
iv. Eyes present.	iv. Eyes absent.

Suborder Monopisthocotylea have been divided in two super families as Gyrodactyloid and Capsaloid. A comparision of the two is an under.

Gyrodactyloid	Capsaloid
i. Prohaptor made up of glands without a head organ.	i. Prohaptor made up of glands with head organ.
ii. Opisthaptor armed with one or	ii. Opisthaptor appears as a large muscular

two pairs of anchors. *eg.Gyrodactylus*	disc with or without hooks. eg.*Monocotyle*

Suborder Polyopisthocotylea have been divided in two super families as Polystomoid and Diclidophoroid. A comparision of the two is an under.

Polystomoid	Diclidophoroid
i. Oral sucker present around mouth.	i. Oral suckers represented by two small anterior suckers in oral cavity.
ii. Opisthaptor with 6 armed suckers eg.*Polystoma*	ii. Opisthaptorreprensented by two rows of suckers or sucker like projections supported by complicated network of cuticularized pieces eg.*Diplozoon*

SAQ-1

- Tremetoda are .... showing the absense of epidermis and cilia.
- Tremetoda body remains covered with thin or thick cuticle resting on ....
- Trematodes are generally .... showing well developed reproductive system.
- Trematoda have been divided in two orders ....
- Monogenea possess many testes located in posterior region and ....

Digenea : They are endoparasitc in the varied parts of the body of fishes, Amphibia, Reptilia, Birds and Mammals.

They have been divided in a number of families out of which the taxonomic status of some families is still Controversial. Leaving such families the important families are as under.

1) **Bucephalidae:** The members possess mouth in the middle region of the body which leads to a small sac like intestine. They shaw absence of acetabulum and presence of genital pore in the posterior region of the body. Their miracidia posses cilia on projecting rods and the cercaria possessa pair of long tails. They

encyst under scales of small fishes. eg*Bucephalus*

2) **Paramphistomidae:** The members possess a very large acetabulum in posterior part of the body. The pharynx is very muscular with two pouches. Thes gonopore lies in the anterior half of the body. Miracidium contains fully formed cercaria which are of amphistome type. eg.*Cotylophoron*

3) **Zoogonidae:** The members possess spiny cuticle. Their intestinal crura are short and their yolk glands are reduced to two small masses. Their eggs lack a proper shell. Miracidium penetrates marine snails. Cercariae are of cercariaeum type, without scales. They are produced by sporocysts eg.*Zoogonus*

4) **Azygiidae :** The members possess opaque, muscular body. The miracidium remains unciliated. It is eaten up directly by snails. It shows 4 anterior bristles for penetrating the intestinal wall of the snail. Cercariae. are of cystocercous type which are eaten directly by definitive host. eg.*Azygia*

5) **Hemiuridae :** The members show slender and cylindrical shape. The anterior part of their body shows thick ringed cuticle while the posterior part remains thin walled which helps in respiration. Their miracidia are non ciliated while the cercariae are of cystophorous type.eg.*Hemiurus*

6) **Didymozoonidae :** The adultmembers live in pairs in cyst on the surface, gills, operculum, oral cavity and pharynx of marine fishes. Their anterior region is slender and spoon like while posterior region is cylindrical or round. They show absence of acetabulum. Their miracidium lacks cilia. It is armed with anterior crown of thorns.eg.*Didymozoon*

7) **Gorgoderidae:** The members are parasitic in ureter and urinary bladder of fish, amphibia and reptilia. The egg contains miracidium. which infests snails. Cercaria develops directly from sporocyst. They are of macrocercous type.eg.*Gorgoderina*

8) **Plagiorchidae:** The members are parasitic in oral cavity, Oesophagus, intestine and respiratory tract of amphibia and reptilia. They show spiny cuticle, Y shaped urinary bladder and anterior or lateral gonopore. Egg contains fully developed miracidium which hatches only after ingestion of a snail. Cercariac are of stylet type.eg.*Plagiorchis*

9) **Dicrocoelidae:** The members are parasitic on liver and gall bladder of reptiles, birds and mammals. They show elongated and flattened shape, tubular excretory bladder and testis being anterior to ovary. The egg hatches only after

ingestion by a land snail. Miracidium passes through two generations of sporocyst. Cercariae pass out through pulmonary sac in mantle cavity of snail and form adhesive cyst. The cysts stick together to form balls containing hundreds of metacercaria. After ingestion by definitive host metacereariae hatch in intestine. They pass to portal system and finally to liver.eg*Dicrocoelium*

10 Opisthorchidae: The members show flat and semitransparent body with small suckers. They are parasitic in bile passage of fish eating reptiles, birds and mammals. They show Y shaped excretory bladder and posterior testes. Gononopore lies in front of acetabulum. Small eggs enclose complete miracidium which hatches only after ingestion by an operculate snail. The cercariae are of pleurolophocercous type. They encyst under skin of fresh water fish to be eaten by the definitive host. eg.*Opisthorchis*

11. **Heterophyidae:** The members are parasitic in intestine of aquatic, fish eating birds and mammals including, dogs, cats and human beings. They show oval and pyriform shape with motile and contractile anterior region showing spiny and scaly cuticle. They show absence of cirrus. Their acetabulum is reduced and incorporated in genital antrum. Eggs are eaten by operculate snails in which one generation of sporocyst and one or two generations of redia develop which form pleurolophocercous cercariae, with anterior spiny armature. They encyst under fish. eg.*Heterophyes*

12. **Microphallidae:** The members are parasitic in intestine of fishes and shore birds. They possess short intestinal crura and presence of genital papilla. Eggs containing miracidia are eaten by littoral snails in which sporocyst and rediae occur. The cercariae are of monostome type which encyst on crustaceans like amphipod, barnacles and crabs. eg.*Microphallus*

13. **Troglotrematidae:** The members are parasitic in lungs of mammals including human beings. The members show short oval form with scaly cuticle. They live two or more in cysts.With in each cyst out of two worms one is larger (female) and the other smaller (male). Their eggs are released out in sputum. The miracidium develops in 3 weeks in moist conditions. It penetrates operculate snail in which appears mother sporocyst and two generations of redia. The cercaria are of microcerous type. They crawl in leech like fashion and encyst on cray fish or crabs, After ingestion by final host the young fluke bores through intestinal wall in abdominal cavity.eg.*Paragonimus*

14. **Fasciolidae:** The members are parasitic in liver and bile passage of ruminants. The capsule at laying contains an uncleaved egg. It forms miracidium in some weeks. The miracidium penetrates pulmonate snails. The sporocyst produces two generations of redia which produce long tailed cercaria which encyst on grasses or aquatic plants. The definitive host ingest the cysts which hatch in young flukes which bore through intestinal wall in peritoneal cavity and finally in liver. eg.*Fasciola*

15. **Cyclocoelidae:** The members are parasitic in coelom, trachea, lungs, air sacs, and nasal cavity of aquatic birds. They show muscular body with reduced or no oral sucker. The intestinal crura fuse with each other in posterior region. Miracidium contains fully formed redia which are released in snail body. The redia produce cercariacum type of cercaria which encyst on the same snail. Definitive hosts get the infection upon eating such snails. eg.*Cyclocoelum*

16. **Clinostomatidae:** The members are parasitic in oral cavity, throat, and oesophagus of fish eating birds. They show small oral sucker, large anteriorly placed acetabulum and slightly coiled uterus. The capsules drop from the mouth of bird host. The miracidium penetrates snails of genus *Helisoma*. Sporocyst produce two generations of redia and lophocercous cercariae with forked tail. They encyst in muscles of fish and coelomic lining of frogs as yellow grubs. eg.*Clinostomum*

17. **Notocotylidae:** The members are parasitic in intestine of aquatic birds. They infest the eversible pouches of intestine in which glands open. The miracidium forms sporocyst in snail body which forms two generations of redia. The cercariae are tailed. They encyst on vegetation to be ingested by definitive host. eg.*Notocotylus*

18. **Echinostomatidae:** The members are parasitic in intestine of birds and mammals. They show slender and elongated form with spiny or scaly cuticle, large acetabulum behind small oval sucker. Their peculiarity is the presence of collar of spines which is very specific for the family. The capsule shows uncleaved egg which forms miracidium in a few weeks. The miracidium infests the snail and forms sporocyst which generates two generations of redia which form cercaria which encyst on other snails, tadpoles and fish as metacercaria. The cercaria and metacercaria also show the Collar of spines.eg.*Echinostoma*

19. **Strigidae :** The members are parasitic in intestine of birds and mammals. Their

body is divided in a forebody and a hind by a constriction, fore body is flattened, concave and spoon like, while hind body is cylindrical. Fore body shows a small oral sucker and an acetabulum and an accessory adhesive organ called as holdfast. It contains gland cells, whose secretion performs corroding effect on host tissue. Hind body shows reproductive system, Miracidia develop after laying of capsules. They penetrate lymnoid snails and form two generations of sporocysts. The cercariae are of pharyngatefurcocercous type. They penetrate aquatic animals and form metacercariae which may be naked or enclosed in gelatinous cyst. eg*Alaria*

20. **Brachylaimidae:** The members are parasitic in intestine of birds and mammals, rarely in amphibia and reptilia. They possess well developed suckers, posterior gonopore and a marked seminal vesicle free from cirrus sac. The capsules are dropped by birds on vegetation. They are eaten by snails chiefly *Succinia*. After hatching the miracidia penetrate the snail tissue. They form two generations of highly branched sporocysts. The branches enter the snail head and tentacles and get enlarged forming swollen sacs undergoing pulsations. The swollen snail skin ruptures releasing the pulsating sacs which contain encysted cercaria. The passerine birds peck the sacs and swollow them to get infected. eg.*Brachylaima*

21. **Sanguinicolidae:** The members are blood parasites of vertebrates. They possess slender shape with weak or degenerate suckers. Their protrusible anterior tip contains mouth armed with three hooks followed by poorly developed pharynx and small lobed sac likeintestine. They possess numerous testes in central area and a bilobed ovary.Uterus remains absent. Triangular capsules are laid singly in blood stream which takes them to gills. They possess miracidia which hatch in the blood vesseles. They escape through gills and enter in snail to form sporocyst and cercariae which are furcocercous in nature penetrating the definitive host directly.eg.*Sanguinicola*

22. **Spirorchidae**: The members are blood parasites of turtles occupying heart and large arteries. They possess an anterior mouth with oral sucker followed by long oesophagus and intestine divided in two crura which may be absent. Capsules are discharged inhost issue from which they pass out through digestive tract. Miracidia hatch after some days. They penetrate lymnaeid snails in which they form two generations of sporocysts. Cercaria are apharyngeal and furcocercous types. They penetrate directly in definitive host. eg.*Spirorchis*

23. **Schistosomatidae:** The members are parasitic in hepatic portal system and

pelvic veins of birds and mammals. They show sexual dimorphism, the female being slender and thread like. The ventral surface of the male remains incurved to form the gynecophoric canal in which the female remains lodged. Bolh suckers may be present or absent, acetabulum better developed. Pharynx remains absent.Long gesophagus leads to intestinal crura which get fused posteriorly to form single stem. Male shows several testes, female shows long tubular ovary and straight uterus with a few eggs. The female leaves the gynacophoric canal and deposits the capsules in a small blood vessel from where they pass out through intestine or urinary bladder. The egg by now forms miracidium which hatches in water, penetrates, pulmonate snail and forms two generations of sporocyst and many cercariae which are of apharyngealfurcocereous type. They penetrate directly in skin of definitive host. Thay do not form metacercaria.eg.*Schistosoma*

24. **Heronimidae:** The members are peculiar in the presence of nephridiopore on dorsal surface of anterior region and the uterus forms four coils in the body length. They are parasitic in lungs of turtle. eg.*Hevonimus*

Order Aspidobothria

Apart from Monogenea and Digenea class Trematoda also includes the order Aspidobothria,which is represented by family Aspidogastridae and Stichocotylidae. The former is represented by genus *Aspidogaster* and *Lophotaspis* while the latter by genus *Stigocotyle*.

These genera show a combination of following monogenetic and digenetic characters.

Monogenetic characters:

(i) Aspidogaster shows very large circular opisthaptor on ventral surface.

(ii) Its life cycle passes through one host only.

Digenetic Characters :

(i) *Aspidogaster* shows reproductive system similar to that of digenea.

(ii) *Lophostaspis* passes its life cycle through two hosts, snail and turtle.

(iii) *Stichocotyle* also passes its life cycle through two hosts. Thus this order can be considered as a connecting link between Monogenea and Digenea.

4.4 Primary and secondary hosts of Trematodes

A trematode parasite totally depends upon its host for food and shelter. Hosts of trematdoes are of two kinds one being primary (definitive) and the other being secondary (intermediate). Generally vertebrates serve as primary host and the invertebrates as secondary host. Primary host harbours the adult parasite while the secondary host harbours the larval parasites. In primary host the adult prarasite undergoes sexual reproduction while in secondary host the larval parasite undergoes asexual reproduction.

Adult trematodes are genetically and physiologically adapted to choose their primary host in two ways. In some cases a trematode species is very specific in selecting its primary host, while in other cases the species has adopted itself to harbour in the body of closely related species primary hosts, still others show the ability to infect unrelated species of primary host.

The monogenean trematodes pass their life cycle only through the primary host, the secondary host does not play any role. These trematodes are ectoparasitic on gills and skin of fresh water and marine fishes, a few on cephalopod molluscs or crustaceans. Some Monogenea show a tendency to become endoparasite harbouring the body structures that open to the exterior as nasal cavity, pharyngeal cavity, urinary bladder and ureter of fish, amphibians and reptiles. Only one species has gone endoparasite in the coelom of ray fishes (eg.<u>Dictyocotyle)</u>

Digenetic trematodes of a number of families have shown specificity in the selection of their primary host for example in family. Paramphistomidae genus *Gastrodiscus*selects horse, Nilocotyle selects hippopotamus, Brumptia selects elephants. In family Troglotrematidae the genus *Troglotreama*selects dogs. Genus *Spirorchis* of family Spirorchidae select turtlesas its primary host.

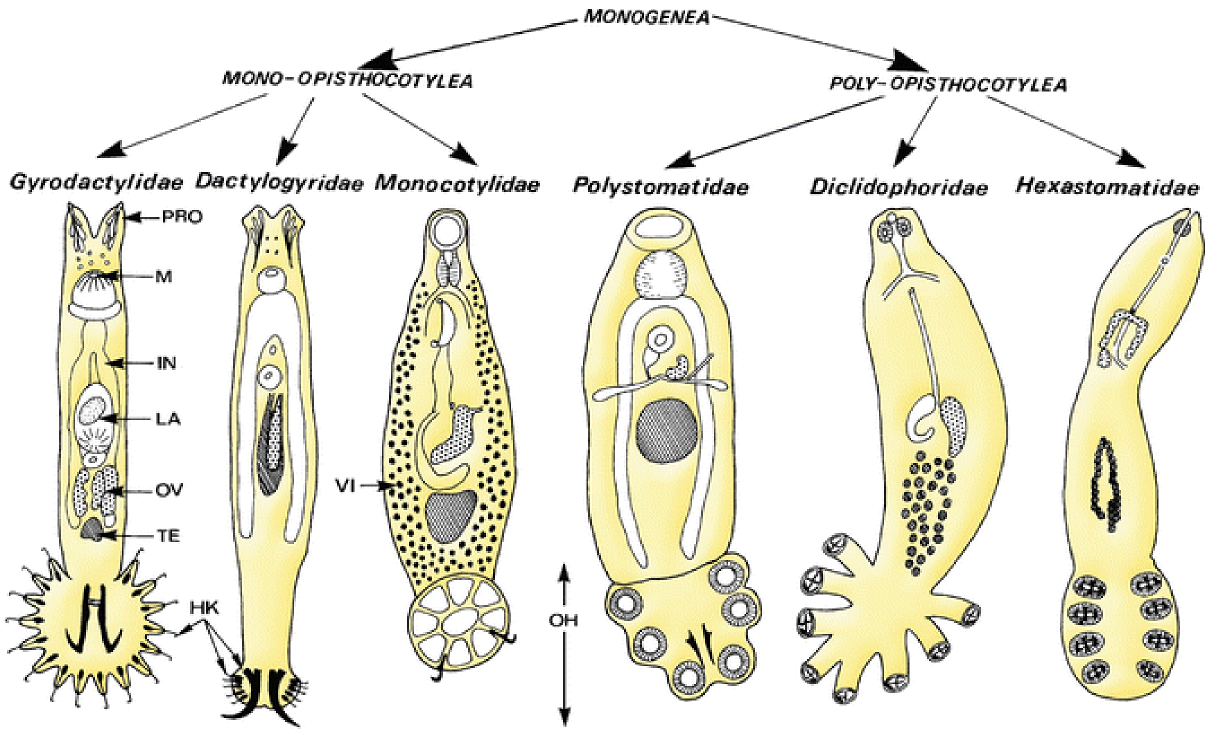
Some digenetictremotodes show the ability to attack closely related vertebrates for example genus *Paramphistomum* of family Paramphistomidae shows the ability to infect cattle, sheep, goat, deer and antelopes. Genus <u>Helipagus</u> of family Hemuridae infects frogs and salamanders.

Some digenetic trematodes show the ability to infect distantly related vertebrates for example genus <u>Plagiorchis</u> of the family Plagirochidae selects musk rats, aquatic birds and human beings.

In almost all digenetic trematodes the egg upon hatching gives rise to a free swimming larva known as miracidium which proceeds to complete the life cycle by infecting an invertebrates which serves as the secondary or intermediate host. The intermediate host may be a mdeusa or a fresh water or marine snail or a fresh water or marine bivalve or an aquatic insect larva, cray fish or a tadpole. The miracidium infects such secondary hosts only when it reaches an aquatic body which is possible by chance only. The miracidium is able to penetrate and enter the body of any one of the intermediate hosts within which it converts itself to a sac like elongated larva known as sporocyst containing a number of germ balls each of which produce a redia with similar germ balls which produce secondary redia which give rise to cercaria larva. The crecaria comes out of the body of intermediate host, swims freely in water and normally settles on an aquatic vegetation or an aquatic invertebrate as ametacercaria larva on which the definitive host feeds and gets the infection to complete the life cycle as the adult.

In some trematodes the life cycle passes through two intermediate hosts for example in the genus Spetotrema of family Microphallidae whose primary host is shore bird the first intermediate host is a littoral snail in which the miracidium passes through sporocyst, redia and cercaria which settles as a metaceraria on the body of a crustacean like an isopod or and amphipod or a barnacle or a crab which when eaten by a shore bird completes the life cycle.

Some tremodotes pass through three intermediate hosts as in the genus Alaria of the family Strigidae in which primary host is a dog or a cat. In its life cycle the first intermediate host is a snail, second intermediate host may be a snail, fish, leech or a tadpole, in which the cercaria settle as mesocercaria which is devoured by the third intermediate host which may be a small mammal in which mesocercaria forms the metacercaria which finds entry in the body of a dog or cat completing the life cycle.



Life Cycle variations in Monogenea and Digenea

Class Trematoda has been divided in three orders. They are Monogenea, Aspidobothria and Digenea. Aspidobothria are considered to coordinate with Monogenea and Digenea.

Monogenea can be represented by Polystomumintegerrinum which is parasitic in urinary bladder of frogs and toads while Digenea can be represented by Fasciola hepatica which is parasitic in liver and bile duct of sheep.

For analyzing the variations between the life cycle of the two orders the life cycles of the typical forms of the two orders should be taken into consideration.

Life cycle of *Polystomun in tegerrimum*

The species breeds in spring. As the result of copulation and fertilization the eggs are formed which are released in urinary bladder. Thefusiform eggs show filaments at one or both ends for attachment to the wall of bladder. Lateron they are released out in surrounding water in which the frog lives. The zygote undergoes unequal cleavage. The micromeres enclose the megameres showing epibody. The micromers flatten to form epidermis which lateron develops cilia. Within the megamere mass appears a cavity by disintegration of cells. The cavity develops an opening at the porterior end. It lateron fomes the gut. During this process in the mid ventral region of the developing gut appers a ball of cells which forms the pharynx which develops a connection with the ventral surface forming the mouth. Cells in contact with pharynx form cerebral ganglia. The remaining cells form mesenchyme, murcles and glands. Latron these cells form reproductive system. At the posterior end of the developing embryo develops an opisthaptor in the form of a disc armed with 10 hooklets in a circle. Each hooklet develops from a secreation between two cells.

In 4 or more weeks finally a larva is formed. It is termed as onchomeracidium. It shows 4 eyes, 2 protonephridia, cilia in transverse bands and an opisthaptor at the posterior end. After its release in water the larva gets attached to the gills of a tadpole of frog which has been formed as the result of sexual reproduction of the frog. The attachment of larva to the gills is done by the opisthaptor. The cilia and eyes are lost.

During the metamorphosis of the frog tadpole larva moves in alimentary canal and finally settles in urinary bladder as adult fluke in three years.

The life cycle of the parasite corresponds with the life cycle of the frog host.

The life cycle passes through only one host, intermediate host remians absent.

Life cycle of *Fasciola hepatica*

As the result of copulation and fertilization the eggs are released through the female gonopore of the parasite in the bile capillary from where they find entry in the intestinal cavity of the host (sheep). They are released out along with its faecal matter.

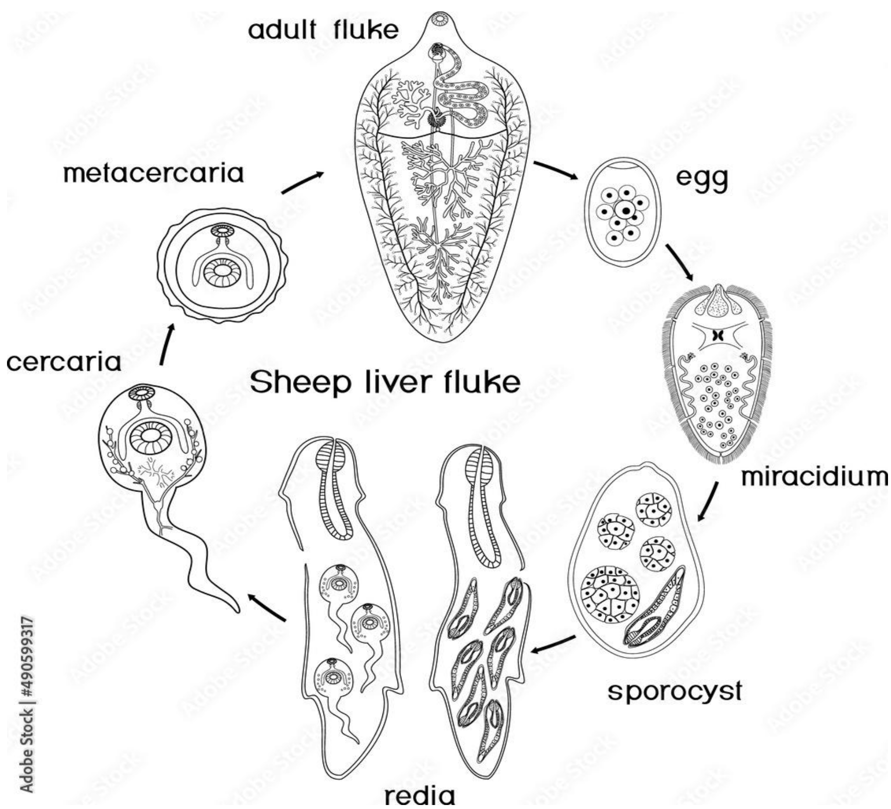
The egg appears an oval body having a zygote within a shell. It is provided with an operculum. The zygote starts cleavage while the egg remains present in the uterus of the parasite. The cleavage is hoboblastic and unequal. The first cleavage results in the formation of a propogatory blastomere and larger somatic blastomere. The somatic blastomere divides to a ball of unequal sized cells. Some of these cells move to periphery forming a vitelline membrane. The propagatory blastomere divides repeatedly. In each division one daughter cell shows propagatory nature while the other as somatic cell. As the result of cleavage of somatic cell the ball of cells so formed elongates to form the first larva as miracidium. The propagatory cell moves to the posterior region of embryonik miracidium and remains dormant.

Release of the miracidium occurs when the shelled egg containing it reaches a water body. At this stage the release of miracidium occurs upon the opening of the operculum of the egg. Miracdium is a minute oval body showing 21 ciliated cells in 5 tiers, a sac like apical gland opening at the tip of apical papilla, two penetration glands opening near apical papilla, two pigmented eye spots in medial region of anterior half, two flame cells, each continues as a ductule which opens by an excretory pore on lateral side of posterior half, single cerebral ganglia below the second tier of epidermal cell and the propagatory cell in posterior region.

The miracidium swims freely in search of suitable snail host. On meeting the snail it enters its body during which it looses it cilia, eyespots and penetration glands. Within the snail body it gets converted in the form of an elongated sac known as sporocyst which shows cuticular lining, two flame cells and a number of germballs formed from the propagatory cell. Each germs ball forms a redia, all such redia are released in the snail tissue upon the bursting of the sporocyst.

The redia appears as an elongated sac with a pair of lappets near posterior end, an anterior mouth opening, a sac like gut, a few flame cells a birth pore and many germ balls, each germ ball develops as secondary redia or cercaria which are released out through the birth pore in snail tissue.

The cercaria larva shows an oval body and a tail. It shows an oral sucker around anterior mouth, an acetabulum, many flame cells and an alimentary canal similar to that of the adult. The cercaria larva emerges out of snail tissue swims freely in water and finally settles an aquatic vegetation, leaves its tail, develops a cyst wall and forms the metacercaria which waits for an opportunity when the primary host, sheep eats the vegetation. It thus reaches the intestine of the sheep, discards the cyst, penetrates through the intestinal wall to reach coelomic cavity from where it enters liver to form the adult fluke.



Sources:https://www.google.com/search?sca_esv=f712e055a0066755&rlz=1C1JJTC_enIN1089IN1110&q=life+cycle+of+fasciola+hepatica+image&udm=2&source

A comparison of the two life cycles shows following variations.

(i) The life cycle of Monogenea is simple passing through a single definitive host, any intermediate host being absent while in Digenea the life cycle is complicated passing through a definitive host and 2 or 3 of intermediate hosts.

(ii) The Monogenea shows the appearance of a single larva, onchomiracidium while the Digenea shows the formation of miracidium sporocyst, primary redia, secondary redia, cercaria and metacereania in their life cycle.

(iii) The orchomiracidium does not perform swimming while the miracidium and cerearia larvae swim actively in water thus they perform dispersal of the species which is helpful in its survival.

(iv) The onchomiracidium does not reproduce while the digenetic larvae except cercaria and metacercaria undergo asexual reproduction hence the population of the members of the species shows tremendous increase which is helpful in covering the risk of not availability of a specific host at a specific time. Thus the chancees of survival of digenetic life cycle become better.

SAQ-2

- **Monogenea :** They are ectoparasite on ....of fresh water and marine fishes,
- ....are present two round testes located one on each side or one behind the other and single round ovary which may be lobed or branched.
- **....................**They are endoparasitc in the varied parts of the body of fishes, Amphibia, Reptilia, Birds and Mammals.
- Primary host harbours the .... while the secondary host harbours the ....
- Secondary host the larval parasite undergoes ....

4.5 Summary

- Tremetoda are ecto and endoparasites showing the absense of epidermis and cilia.
- Their body remains covered with thin or thick cuticle resting on mesenchyme.
- Trematodes are generally hermaphrodite showing well developed reproductive system.
- Trematoda have been divided in two orders Monogenea and Digenea.
- Monogenea possess many testes located in posterior region and single elongated and coiled ovary.
- **Monogenea :** They are ectoparasite on gills and skin of fresh water and marine fishes,
- Digenea are present two round testes located one on each side or one behind the other and single round ovary which may be lobed or branched.
- **Digenea :**They are endoparasitc in the varied parts of the body of fishes, Amphibia, Reptilia, Birds and Mammals.
- A trematode parasite totally depends upon its host for food and shelter. Hosts of trematdoes are of two kinds one being primary (definitive) and the other being secondary (intermediate). Generally vertebrates serve as primary host and the invertebrates as secondary host.
- Primary host harbours the adult parasite while the secondary host harbours the

larval parasites. In primary host the adult prarasite undergoes sexual reproduction.

- Secondary host the larval parasite undergoes asexual reproduction.

4.6 Terminal Questions

Question-1 Describe in details morphology of Trematoda.

Question-2 Describe in details classification and morphology of Trematoda

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Question-3 Describe in details primary and secondary hosts of Trematoda.

Question-4 Explain life cycle of *Faciolahepatica*.

Question-5 Explain life cycle of *Polystomumintegerrium*.

Question-6 ExplainPolystomum.

Question-7 ExplainHeterophyidae

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Question-8 ExplainMicrophallidae.

Question-9 ExplainCyclocoelidae.

4.7 Answers

SAQ-1

- ecto and endoparasites
- mesenchyme.
- hermaphrodite
- Monogenea and Digenea.
- single elongated and coiled ovary.

SAQ-2

- gills and skin
- Digenea
- Digenea

- adult parasite, larval parasites.
- asexual reproduction.

Unit-5 Parasitic Platyhelminthes-II

Structure

5.1 Introduction

Objectives

5.2 General Account of Cestoda

5.3 Classification of class Cestodsa

5.4 Primary and Secondary Hosts of Cestoda

5.5 Classification, Life and pathology of *Diphyllobothrium latum*

5.6 Life cycle of *Echinococcus granulosus*

5.7 Summary

5.8 Terminal Questions

5.9 Answers

5.1 Introduction

This unit deals with the general account of Cestoda followed by classification of upto order level with the popular examples; Primary and secondary hosts of Cestoda. It includes the Classification and life cycle of *Diphyllobothrium latum*. It also includes the classification and life cycle of *Echinococcus granulosus*

Objectives

After studying this unit you will able to

- Know about the Cestoda.
- Primary and secondary hosts of Cestoda
- Classification and life cycle of *Diphyllobothrium latum.*
- Classification and life cycle of *Echinococcus granulosus*.

5.2 General Account of Cestoda

Adult cestodes are parasitic in intestine of vertebrates showing one or twointermediate hosts which may be an invertebrate or a vertebrate. Adult cestodeshows a knob like or clavate scolex followed by a short undivided neck whichcontinually proliferates backwards formingimmature proglottids. The more the proliferating proglottids move posteriorly they developbothmale and female reproductive systems. They represent mature proglottids which undergo copulation andfertilization. Gradually as such proglottids move more backward they become fully filled up with uterus containing capsules.Such proglottids are called as gravid proglottids. The complete chain of immature, mature and gravid proglottids forms the strobila. The gravid proglottids either release their capsules through an opening or they get detatched from the strobila and pass out along with the faecal matter of the host.

The scolex is a solid mesenchymatous construction showing central part of nervous system, excretory system and organs of attachment like sucking depressions, hooks or a glandular area. The sucking depressions of scolex appear as bothria, bothridia or acetabula. The bothria are shallow depressions showing weak muscularity and inner bounding muscle layer. Their margins may be projecting or they form a tubular cavity, open at both ends.Bothridia are always four, broad, leaf like with thin and motile margins. They are more muscular than bothria. The acetabula are hemispherical depressions, always four in number with strong radial fibres.They may be unarmed or armed with hooks or spines. Apex of scolex may show additional attachment organs as a sucker, glandular area, a myzorhynchus or a motile rostellum armed with hooks.

Body wall shows absence of epidermis and presence of cuticle. All spacebetween internal parts getfilled up with mesenchyme which is a meshworkoffluid filled spaces. Below the mesenchyme is present three layeredmuscles. Outermost peripheral layer beneath the cuticle shows outer circular muscle fibres and inner longitudinal muscle fibers. The middlesubcuticular layer is not much developed. The inner mesenchymal layer remains strongly developed showing darsoventral, transverse and longitudinal muscles along with diagonal fibres.

Cestodes show total absence of digestive system and respiratory system. Living in the host intestine they absorb nutrients through their general body surface and undergo anaerobic mode of respiration.

Excretory system is represented by innumerable protonephridia with terminal flame bulbs. As flame bulbs are single celled they are also called as flame cells. which remains scattered in the mesenchyme. Each flame cell shows a nucleus, basal bodies from which arise flickering cilia in the capillary. These capillaries unite and reunite to form larger capillaries which ultimately terminate in a dorsal and a ventral protonephridial canal on each side, thelatter being wider than former. Ventral canals run the entire length of strobila

while the dorsal canals terminate in a median excretory bladder which opens by an excretory pore. When the last proglottid becomes gravid and is shed, the canals open directly. Ventral canals and sometimes the dorsal canals remaine connected at posterior part of each proglottid by transverse canals. In the scolex thelongitudinal canals continue and get connected by crossbranches or breakup in a plexus. In some cases the dorsal and ventral canals become confluent and reunite on each side.The flickering, cilia of the flame cells make the nitrogenous waste of the neighbouring cells move in it and pass through its capillary in the larger capillarieswhich finally reach the dorsal and ventral canals from where they are passed out at the posterior end. Nervous system is represented by two main lateral longitudinal nerves, one on each side throughout the length. Along with each lateral longitudinal nerve two accessory lateral nerves and a pair of dorsal and a pair of ventrallongitudinal nerves also run throughout the length. Thus ten longitudinal nerves run throughout the length. In each proglottid longitudinal nerves are connected by one ring commissure. In some case two or three ring commissures may also be present. At the junction of longitudinal nerve and ring commissure a ganglionic thickening may be present. From the longitudinal nerve and ring commissue numerous branches innervate the different parts of the proglottid. In the scolex the two main lateral longitudinal nerves swell in the form of a pair of ganglia connected transversely by a thick commissure. From this brain complexnerves pass anteriorly and laterally to different parts of scolex including suckers and rostellum. Anterior nerves may be 4 or 8 They get connected by a rostellar ring commissure. There may bea third ring commissure known as apical ring.

Sense organs are absent. Scolex and body surface are richly supplied with sensory nerve endings. Apart from them in some cases tangoreceptors with bristle endings may be seen in subcuticular nerve plexus.

Each proglottid of a cestode acts as a reproductive unit. It is generally hermaphrodite, rarely may be unisexual.In some case it contains two set ofbisexual reproductive systems thus one can imagine that cestodes showtremendous potential of reproduction.

Male reproductive system is represented by testes, sperm ductule, cirrus sac, seminal vesicle, cirrus and prostatic glands. Testes may be few (1 or 3) to several hundred. They may be large to small, located in central mesenchyme, may be grouped in two lateral fieldsextending upto ventral excretory canals or beyond them. They are generally anterior to ovary orsometimes beyond it.From each testis arises a ductule called as vasefferens. All vasaefferentia unite to form a large and coiled sperm duct known as vas deferens which enters a cirrus sac which is a highly muscularstructure. It shows non-eversible proximal portion of vas deferens calledas ejaculatory duct which continues as an enlarged sac known as seminalvesicle. The distal portion of seminal vesicle forms an eversible cirrus whichmay be armed with spines, bristles or hooks or it may be unarmed. The eversible cirrus shows the terminal opening.It performs copulation.Prostatic glands open in the sperm duct, sometimes within the cirrus sac.

Female reproductive system is representedby ovary, vitelline gland, oviduct, vitelline duct, vagina, seminal recepticle, ootype, shell glands, and uterus. The ovary is generally single, (exceptin case where doublereproductive system is present),ventral and posterior, located in central mesenchyme. The ovary is generally two lobed, each lobed may be forked darsoventrally or may be divided insubsidiary lobes. The vitellineglandmay be single present behind the ovary or it is represented by numerous small follicles in lateral bands. Rarely it may be absent. Oviduct singlearises from the bridge between two lobes. Single vitelline gland forms a vitellineduct which runs anteriorly towards oviduct. If vitelline glands are follicular,aductule arises from each follicle to form a main duct on each side whichruns transversly towards median line to form a common vitelline duct whichforms a reservoir before joining the oviduct. At the junction of oviduct and vitelline duct theootype is formed which remanis surrounded by shellglands. From the ootypeoriginate two ducts, one being vagina and the other as uterus. Vagina runs in straight or sinuous manner upto antrum. In it’s way itgets enlarged to form seminal recepticle which stores sperms received during copulation. Uterus appears as a sac or lobed tube from ootype. Initially it appears as a medium tube which forms lateral branches during storage of more and more capsules till itfully occupies the complete gravid proglottid.

In some cases the uterus opens on mid ventral or mid dorsal line of theproglottid from which the capsules are released. In cases where no opening exists the gravid proglottid gets detatched and is passed out with the capsulesalong with the faecal matter.

In some cases the uterus breaks up in many small uterine capsules each enclosing one to several embryos. In other casesit forms many tough fibrous sacs known as paruterine organs which receive and retain theembryos.

In many cestodes the cirrus sac and the vagina open in a common genital atrium which appears as a hemispherical depression.Itlies in the lateral margin of the proglottid, may be in the centre or towards anterior or posterior half. It may lie in the same side of strobila or may be regularly or irregularly alternating. In some cases the genital atrium lies on ventral or dorsal surface of the proglottid. Thus the genital atrium receives both male and femalegonopore. In most of the cestodes cirrus sac and sperm duct lie anterior to vagina thus male gonopore lies anterior to female gonopore in genital atrium. In some cases the terminal portions of sex ducts cross each other. When genital atrium is midventral female gonopore is posterior to malegonopore.The genital atrium opens to outside by a commongonopore.

During copulation both self fertilization and cross fertilization may occure. During self fertilization the cirrus is everted in the vagina of the same proglottid. It is most common method. Copulation between different proglottids of the same strobila or different strobila is also common. Veryrarely in some cases where vaginal opening is absent, the cirrus armed with hooks is thrust anywhere in the mesenchyme and released sperms perform their duty.

5.3 Classification of Class Cestoda

The Class Cestoda has been divided in two subclasses as under

Cestodaria	Eucestoda
1. Body unsegmented 2. Larva shows 10 hooks	1. Body segmented 2. Larva show 6 hooks

The subdassCestodaria has been divided in two orders as under

Amphilinidea	Gyrocotylidea
Scolex absent. It is represented by a protrusible proboscis with cluster of frontal glands. eg.*Amphilina*	Scolex absent. It is represented by a rosette with one end surrounding a funnel shaped depression. Anterior end pointed with a large opening having protrusible proboscis. eg.*Gyrocotyle*

The subclassEucestoda has been divided in following orders.

1. Order:Tetraphyllidea

(a) Scolex with 4 bothridia which may be sessile or stalked.

(b) Proglottids begin directly behind scolex.

(c) Proglottids often shed during immaturity. They mature during their stay in host intestine. Such proglottids change their anterior end to a round scolex like form.

(d) Uterus opens on midventral line byseveral openings.

(e) Capsules thin walled without operculum.eg.*Anthobothrium*

2. Order:Lecanicephaloidea

(a) Scolex divided in 2 portions; the lower is globose with 4 acetabula, upper being disc like or divided in tentacles or provided with a myzorhynchus or a glandular cluster.

eg.*Lecanicephalum*

3. Order: Proteocephaloidea

(a) Scolex globose with 4 motile acetabula. Apex of scolex shows an apical organ as a sucker, muscular or glandular mass.

(b) Mature proglottids show a gonoporeon the lateral margin.

(c) Uterus appears as a median tube with lateral diverticula. It shows one or more median ventral opening.

eg.*Proteocephalus*

4. Order:Diphyllidea

(a) Scolex large with powerful muscular rostellum armed with dorsal and ventral large hooks and several rows of small hooks. It is provided with 4bothria fused in pairs and a longhead stalk with 8 longitudinal row of T-shaped hooks.

(b) Gonopore lies in midventral line in posterior part of proglottid.

eg.*Echinobothrium*

5. Order:Trypanorhyncha (Tetrarhynchoidea)

(a) Scolex elongated showing a bothrial part and a long head stalk. Bothrialpart shows 2-4 shallow bothridiawhich get fused in pairs when theynumber four. Head stalk encloses a proboscis apperatus showing a longsinuous proboscis sheath whichterminates at the base as proboscis bulb.Proboscis is armed with hooks and spines and is eversible. Thesestructures perform locomotion than attachment.*Grillotia*

6. Order: Pseudophyllidea

(a) Scolex shows two shallow and elongated bothria, one dorsal and other ventral. They show various modifications as presence of an apical organ or a group of glands.

(b) Gonopore or gonopores lie in or near lateral margin or on ventral or dorsal surface.

eg.*Diphyllobothrium*

7. Order: Nippotaenioidea

(a) Anterior end bears single apical acetabulum.

(b) Reproductive system single.

(c) Gonopore lateral.

(d) Uterus with lateral sacculations but no openings.

eg.*Nippotaenia*

8.Order: Taenioidea (Cyclophyllidea)

(a) Scolex round pyriform, or clavate with 4 deep acetabula placed symmetrically.

(b) Apex of scolex with mobile, muscular rostellum armed with hooks in oneor more circles. Sometimes rostellum is withdrawable in a cavity knownas rostellar receptacle which may be absent in some cases.

(c) Uterus tube like with lateral branches, may form a partial or complete ring, or a reticulum or a large sac or it may break up in uterine capsules orparuterineorgans.

eg.*Taenia*

9. Order: Aporidea

(a) Scolex with 4 acetabula and a large buldging rostellum armed with tiny hooks arranged in 8 rows.

(b) Summit of rostellum shows a muscular structure as an acetabulum or muscle layer or a glandular mass.

(c) Testicular mass runs in the whole body length, on one side towards groove and encircles on other side by ovarian follicles. It form a germovitellaria.

(d) Sex ducts and gonopore absent.

eg.*Gastrodaenia*

SAQ-1

- Each proglottid of a cestode acts as a...................... It is generally hermaphrodite, rarely may be unisexual.
- In some case it contains two set of .... thus one can imagine that cestodes show tremendous potential of reproduction.
- The Class Cestoda has been divided in two subclasses as ....
- The subdassCestodaria has been divided in two orders as ....

5.4 Primary and Secondary Hosts of Cestoda

Generally the life cycle of a cestodes also passes through two hosts. The primary host is one in which the adult stage of a cestode lives andundergoes sexual reproduction. The secondary host (intermediate host) isone in which the larval stage of a cestode lives and completes the life cycle.

Class Cestoda has been divided in two subclasses, the Cestodaria and

Eucestoda. The Cestodaria showing unsegmented body are represented by two orders, the Amphilinidea and Gyrocotylidea.*Amphilinafoliacea*represents the type species of order Amphilinidea. Its life cycle has been well studied. Its adult lives in the coelom of sturgean fish ***Acipencersp***. While itslarva (lycophore) infests amphipod crustacean in which it gets converted in aprocercoid and lateron in a pleurocercoid larva. When the infectedcrustaceanis eaten by the primary host the pleurocercoid enters its coelom to form theadult, The type species of Gyrocotylideaisrepresented by*Gyrocotyleurna*.Although it devlopsalycophore larva but it does not pass through thesecondary host.

The Eucestoda are represented by following orders. The orderTetraphyllidea is represented by the type species as *Acanthobothrium*sp. It's life cycle passes through the primary host in the form of anelasmobranch fish. Itinvolves two intermediate host first being a copepodand the second as a marine fish. The order Lecanicephaloidea is representedby the type species *Tylocephalum* sp. It's primary host is an elasmobranch fishwhile its secondaryhost is represented by a pearl oyster or any other bivalve.The order Proteocephaloidea is represented by the type species as*Proteocephalus* sp. Its primary host may be a fresh water fish,an amphibian ora reptile. In some cases the firstseconday host may be a *Cyclops* andasmall fish or a tadpole may serve as second secondary host.

The order Diphyllidea isrepresented by the type species asEchinobothriumsp. It's primary host is an elasmobranch fish while the secondary host is amarine mollusc or a crustacean.The order Trypanorhyncha is represented by the type species *Haplobothriumglobuliforme* sp. Its primary host is the ganoid fish *Amiacalva* while itsecondary host may be a marine medusa, snail, bivalve, cephalopod, crustacea, holothurians.A teleost fish Ameirus sp. serves as thesecond secondary host. The order Pseudophyllidea is represented by the type species*Diphyllobothriumlatum* whose primary host may be fish eating vertebrateincluding human being. If first intermediate host is a copepod as *Cyclops*while the second intermediate host is always a fish, frog, toad and snakes.

The order Taenioidea is represented by cestodes of birds and mammals,rarely of amphibia and reptilia. Their invertebrate secondary hosts areoligochaetes, leeches, mollusks, crustaceans, fleas, lice, fly, beetles,butterflies, dragonflies, ants, centipede and millipede. Some mammals likepigs, cattle, sheep, goat, mice rats, rabbits, dogscats may also act assecondary hosts.

The primary and secondary hosts of it'sdifferent families are asunder.

The members of Tetrabothriidae attack dolphins, whales, seals and someoceanie birds as their primary host. As their life cycle has not been worked out no account of their secondary host can be given.

Some members of Davaineidae show varied conditions of their hosts. The genus *Davania* attacks, ostriches, emus, cassovary and fowl like birds. The secondary host may be slug or terrestrial snails. The primary hosts ofthe genus *Raillietina* are birds and small mammals, while their secondaryhosts are antsand beetles.

Genus *Prototaenia*, *Anoplocephala* and *Monizia* are some significantcestodes of the family Anoplocephalidae. The primary hosts of prototaeniaare mammals of the order Marsupialia and Insectivora while those ofAnoplocephala and Monizia are rodents and cattle. Their secondary hosts are free living mites.

Genus *Dipylidium*, *Choanotaenia* and *Amoebotaeniaare* representativecestodes of the family Dilepididae. The primary hosts of Dipylidium are catsand dogs. Itsseocondary hosts are dog flea, doglouse and *Pulexirritance*.The primary hosts of *Choanotaenia* are sparrow, chicken and birds. Its secondary hosts are beetles and house fly. *Amoebotaenia* infests domasticfowl as primary host, its secondary host is earthworm.

Representative species of family Hymenolepididae are *Hymenolepisnana* and *Hymenolepislanceolata*.The primary host of *Hymenolepisnana* are human children. It has no secondary host. The primary hosts of *Hymenolepislanceolata* are ducks and other aquatic birds. Its secondary host is*Cyclops*.

Family Taeniidae is represented by important type species as *Taeniasolium*whose primary host is human being and the secondary host is pig. The other species is *Taeniasaginata* whose primary host is also human being but itssecondary host is beef, Another important species is*Echinococcusgranulosus* whose primary host is dog and secondary host is human being.

5.5 Life cycle of *Diphyllobothrium latum and Taenia solium*

The primary host of this cestode is humen being which harbours it in its*intestinal cavity. It shows a scolex embedded in the intestinal wall, a neck*followed by a strobila having 3000 to 4000 proglottids in a chain. Many of the posterior proglottids become gravid which remain filled up with eggs. The eggs are released through the uterine porein the intestinal cavity of the host and are passed out along with the faecal matter. Each egg is oval with egg shell, an operculum and a zygote. The zygote undergoes cleavage, blastulation andgastrulation in 1 to 2 weeks and forms a larva known ascoracidiumwhichis released in water by the opening of operculum.

The coracidium larva is oval in shape with marginal cilia and a hexacanth with 6 hooks. It swims freely in water and gets ingested by *Cyclops*.Within the intestine of *Cyclops* the Coracidiumlooses its marginal cilia and supporting cells. It penetrates the intestinal wall with the help of 6 hooks and reaches the body cavity of *Cyclops* where it forms a procercoid larva in about 3 weeks.

At this stage the *Cyclops* with procercoid larva is eaten up by a fish. Theprocercoid penetrates through the gut wall of fish and settles in its liver andmuscles or fatty tissue.

It next 1 to 3 weeks the procercoid larva gets changed into a pleurocercoidlarva (Sparganum) by undergoing the loss of caudal appendage. Itivaginates its anterior end to form an inverted scolex. The pleurocercoid larva living in fish flesh reaches human gut when the human host eats poorly cooked infected fish. The pleurocercoidpasses through the stomach cavity to reach its intestinal cavity in which it everts out itsinvaginated scolex to attach in intestinal wall and develop as the adult worm in 5 to 6 weeks.

Life cycle of *Taenia solium*

The primary host of this cestode is human being which harbours it in its intestinal cavity. It shows a scolex embedded in the intestinal wall, a neck and a chain of proglottids forming the strobila. Many of the posterior proglottidsappear as gravid proglottids in which the uterus forms 7-13 lateralbranches. The uterus remains filled with eggs.

The posterior gravid proglottids get detachad from the strobila in the intestinal cavity of the host from where they pass out along with the faecal matter.Within the uterus each egg appears as an oval body having an egg shell, operculum and a zygote.

With in the uterus the zygote of the egg undergoes cleavage to form a

morula which develops 6 chitinous hooks, a pair of penetration glands and two membranes all around to form the onchosphere. The released gravid proglottidscontain onchospheres in the uterus. Outside the body of human host, on ground the gravid proglottids degenerate and theonchospheres are set free.

Pigs serve as the intermediate host of the parasite. They habitually feedupon human faecal matter which may be infected with gravid proglottids or onchospheres.Within the stomach of the pig onchosphereloosesit'sembryophore by the action of gastric juice and thus thehexacanth is released in the intestinal cavity. It bores through the mucosal epithelium to reach a submucosal blood vessel. Within the blood circulation the hexacanth loosesits hooks and reaches the liver through hepatic portal vein, from liver through heart it may enter arterial circulation to reach striated muscles of tongue, shoulder, neck and thigh of the pig where it forms a cysticercous larva. In the formation of cysticercouslarva the hexacanth, loosesits hooks, grows and develops a central cavity. Its wall gets invaginated forming four equatorial suckers, a rostellum and rostellar hooks.

In the striated muscles of the pig the cysticercous remains inactive and viable for many years.

Human beings get the infection by eating.uncooked or poorly cooked infected meat of the big.Within human intestine it everts out its scolex and gets attached to the subintestinallining as a bladder worm. Lateron the bladder gets cut off leaving only the embedded scolex with the neck which undergoes proliferation to form a chain of proglottids thus forming the adult.

Life cycle of *Taenia saginata* is similar to that of *Taenia solium* but its intermediate host is beef eg. cows and buffalows. It is believed that *Taenia solium* infests mostly the Hindu population which eats pigs while *Taenia saginata* infests Muslim population which eats beef. It is because of a religeous belief of Hindus who worship beef and that of Muslims who considers pigs as auspicious animal.

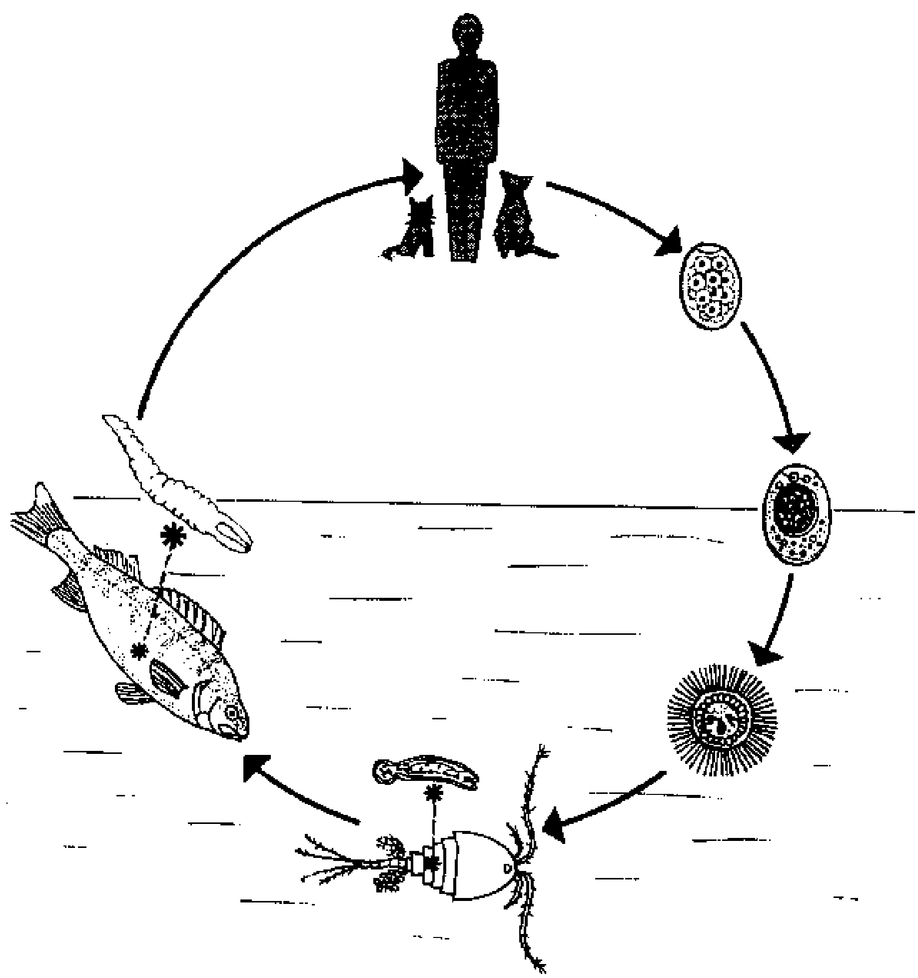

Fig.5.1: Life cycle of *Diphyllobothriumlatatum*

Source: https://www.google.com/search?q=Life+cycle+of+Echinococcus+granulosus+image&sca_

5.6 Life cycle of *Echinococcus granulosus*

The primary host of *Echinococcus granulosus*is dog. It lives in the intestine of dog. It shows normal scolex followed by a neck behind which occurs a strobila with three proglottids, the first being immature, second mature and third as the gravid proglottid having uterus filled up with eggs. The gravid proglottid is cut off from the strobila and is passed out of intestine of dog. By this time the immature proglottid becomes mature and undergoes reproduction to become the next gravid proglottid. The neck by now forms a new immature proglottid. It is a chain of events which continues for a long time.

On the ground the faecal matter of dog along with the released gravid proglottid degenerates leaving the eggs free.

Human beings or cattle serve as the intermediate host which get the contamination through its foodor drinks. Within the stomach of human being or cattlethe hexacanth is released. It enters the intestine, penetrates the mucosal lining to reach hepatic portal system where it looses its hooks and becomes onchosphere. Through blood circulation it reaches the liver or lungs or bone marrow in which it grows in size and develops acentral cavity to form a round hydatid cyst. Its lining shows outer fibrous pericyst below which liesectocyst followed by a germinal lining of endocyst. The central cavilyremanis filled up with cystic fluid, endocyst now produces many external and internal buds known asbrood capsules. Each brood capsule now formsmany buds internally. They are called as scolex capsules. Each scolex capsule shows an invaginated scolex with 4 suckers and a rostellum. Such scolex capsules are set freein liver, liver, lungs or bone marrow.

When so ever a dog eats infected meat of cattle it receives the scolex capsules. Throughstomach these capsules pass to its intestine in which the scolex get evaginated andgets attached to its intestinal wall to become an adult parasite which starts its normal life

Human beings get the infection during caring the pet dogs. In human beings the infection causes Hydatid disease.

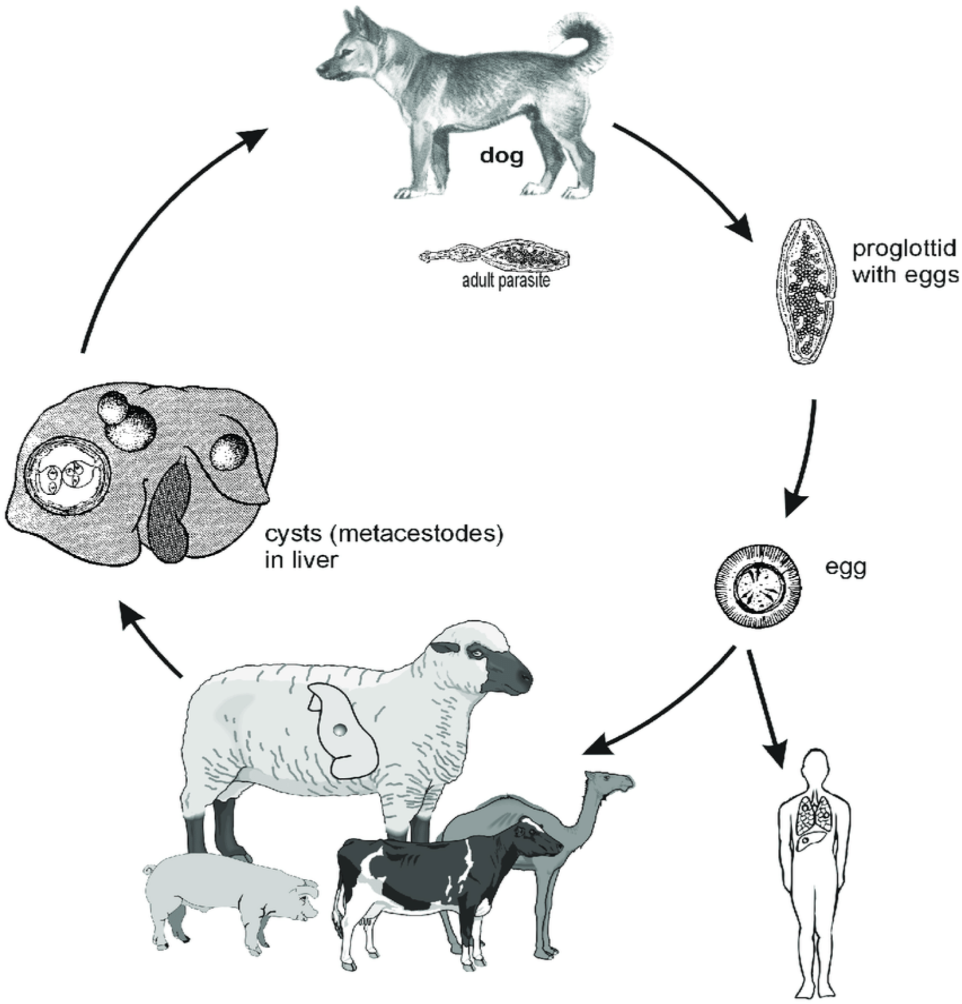

Fig.5.2: Life cycle of *Echinococcus granulosus*

Source: https://www.google.com/search?q=Life+cycle+of+Echinococcus+granulosus+image&sca_

SAQ-2

- The example of order Diphyllidea is ....
- The example of order Pseudophyllidea is ....
- The example of order Taenioidea is ....
- The primary host of *Echinococcus granulosus*is .... It lives in the intestine of ....

5.7 Summary

- Cestodes show total absence of digestive system and respiratory system. Living in the host intestine they absorb nutrients through their general body surface and undergo anaerobic mode of respiration.

- Excretory system is represented by innumerable protonephridia with terminal flame bulbs. As flame bulbs are single celled they are also called as flame cells.
- Each proglottid of a cestode acts as a reproductive unit. It is generally hermaphrodite, rarely may be unisexual.
- In some case it contains two set ofbisexual reproductive systems thus one can imagine that cestodes showtremendous potential of reproduction.
- The Class Cestoda has been divided in two subclasses as Cestodaria and Eucestoda
- The subdassCestodaria has been divided in two orders as Amphilinidea and Gyrocotylidea
- The example of order Diphyllidea is *Echinobothrium*
- The example of order Pseudophyllidea is *Diphyllobothrium*
- The example of order Taenioidea is *Taenia*
- Family Taeniidae is represented by important type species as *Taeniasolium*whose primary host is human being and the secondary host is pig.
- The coracidium larva is oval in shape with marginal cilia and a hexacanth with 6 hooks.
- The primary host of *Echinococcus granulosus*is dog.It lives in the intestine of dog.

5.8 Terminal Questions

Question-1 Describe in details general account and classification of Cestoda?

Question-2 Describe in details general account and classification of *Diphyllobothriumlatum*?

Question-3 Describe in details general account and classification of

***Taeniasolium*?**

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Question-4 Describe in details general account and classification of *Echinococcusgranulosus*?

--

Question-5 Describe in details general accounts of primary and secondary host of Cestoda?

--

5.9 Answers

SAQ-1

- reproductive unit
- bisexual reproductive systems
- Cestodaria and Eucestoda
- Amphilinidea and Gyrocotylidea

SAQ-2

- *Echinobothrium*
- *Diphyllobothrium*
- *Taenia*
- Dog

Unit-6 Classification and Life cycle of *Fasciolopsis buski, Schistosoma haematobium*

Structure

6.1 Introduction

Objectives

6.2 Classification and Life cycle of *Fasciolopsis buski*

6.3 Pathogenicity, treatment and prophyaxis of *Fasciolopsis buski*

6.4 Classification and Life cycle of *Schistosoma*

6.5 Pathogenicity, treatment and prophyaxis of *Schistosoma*

6.6 Summary

6.7 Terminal Questions

6.8 Answers

6.1 Introduction

This unit deals with classification cation morphology life cycle, pathogenicity treatment and prophylaxis of Fasciolopsis buski and schistosoma haematobium. *Fasciolopsis busk*i oval large thick set fluke without shoulders. It is slightly broader posteriorly than anteriorly. The body shows an oral sucker around the mouth at anterior end and a ventral sucker (acetabulum) on midventral line near anterior end. Acetabulum is markedly larger than oral sucker. The body surface shows cuticle beset with spines which may be lost. *Schistosoma* is darsoventrally flattened body of male is elongated with tapering ends. The female is more cylindrical. Both sexes possess an oral sucker at the anterior end and a ventral sucker, acetabulum near the anterior end.

Objectives

After studying this unit you should be able to know-

- Classification and Life cycle of *Fasciolopsis* buski
- Pathogenicity, treatment and prophyaxis of *Fasciolopsis buski*
- Classification and Life cycle of Schistosoma
- Pathogenicity, treatment and prophyaxis of Schistosoma

6.2 Classification and Life cycle of *Fasciolopsis* buski

Classification

Phylum : Platyhelminthes

Class : Trematoda

Order : Digenea

Family: Fasciolidae

Genus :Fasciolopsis

Species :*Fasciolopsis* buski

Habit : It is Parasite

Primary Host : Human being and Pig

Intermediate host: snails (Planorbissp and Segmentina sp.)

Habitat: Small intestine of primary host.

Geographical distribution: South eastern parts of Asia, particularly China

Morphology:

It is elongate oval large thick set fluke without shoulders. It measures 30-75 mm × 8-20mm. It is slightly broader posteriorly than anteriorly. The body shows an oral sucker around the mouth at anterior end and a ventral sucker (acetabulum) on midventral line near anterior end. Acetabulum is markedly larger than oral sucker. The body surface shows cuticle beset with spines which may be lost.

Alimentary canal shows a mouth opening at the anterior end. It continues posteriorly as apharynx and a short oesophagus which continues as an unbranched, blind intestinal caecum on each side showing twistings on its way and reaching almost upto the middle region of posterior end. The anus remains absent.

Excretory system is represented by innumerable flame cells scattered in the mesenchyme. Each flame cell shows irregular shape with a nucleus and a few bleferoplast and a central cavity which continuous as a ductule. From each bleferoplast arises a flickering cilia. The ductules join each other to form an excretory duct. All such ducts join to form a median excretory canal opening on middle of posterior end.

Reproductive system shows hermaphroditic condition showing both male and female organs. Male reproductive system shows two highly branched tandem testes present in middle region of posterior half of the body. From each testis arises a duct called as vas deferens. The two vasa differentia run anteriorly to join each other forming a common vas deferens which enters a cirrus pouch, which is long and tubular. It opens by a male gonopore anterior to acetabulum. Ovary single, branched located on right side of midline almost in the middle region of the body. Vitellaria innumerable, dot like filling almost the complete outer region of each intestinal caecum. Ovary leads to an oviduct running medially. On each side is seen a common vitelline duct formed by fusion of fine vitelline ductules of that side. The common vitelline duct of each side and the oviduct join medially to form an ootype from which arises a coiled wide uterus running anteriorly to open by female gonopore anterior to acetabulum in a common genital atrium.

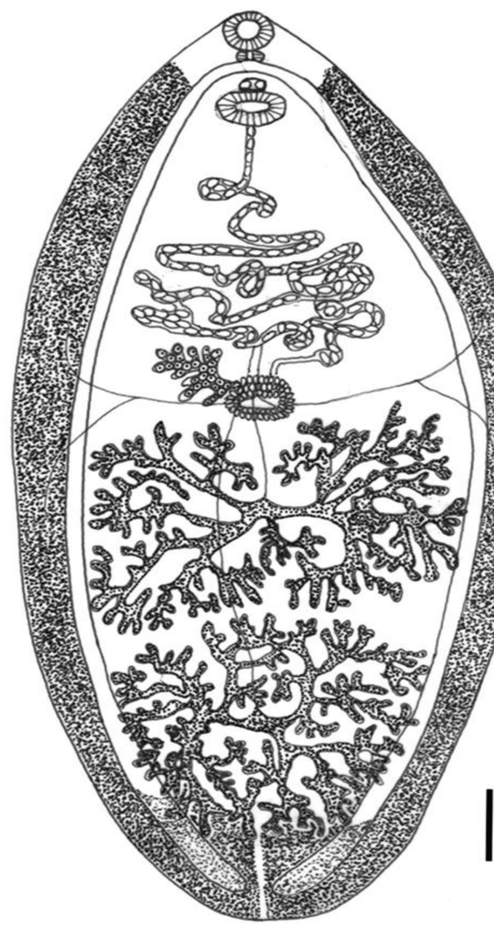

Fig. 6.1: *Fasciola*

Generally cross fertilization occurs failing which the self fertilization takes place. The eggs thus produced remain stored in the uterus.

Life cycle:

The oval and operculate eggs are passed in the faeces of host. Under favourable conditions of moisture and warmth within each egg develops a miracidium larva.

Upon the hatching of the eggs the miracidia are released in the surrounding water. The miracidium is roughly triangular is shape, anterior end being broader. It is covered with ciliated epilthelium. At the anterior end it bears a spine. It swims freely in water in search of a suitable snail host.

Spiral shelled snails of genus *Planorbis* and *Segmentina* serve as the intermediate host. They feed on certain plants as water calthrop, *Trapa natans, Trapa bicornis* and water chestnut *Eliocharis tuberose*.These plants are cultivated in fresh water bodies for food and are fertilized with human night soil especially in China.

The miracidium finds entry in the body of the snail. If suitable and specific snail is not available it dies. Within the body of snail itlooses its cilia and the spine and gets converted in an elongated sac like sporocyst, containing many germ balls in its interior. It leads a parasite life in the snail tissue.

The germ balls within the sporocyst develops as primary redia which are released upon the bursting of sporocyst. The primary redia appears as an elongated body showing a mouth without oral sucker at anterior end leading internally to a pharynx, a sac like intestine, an excretory system and a birth pore. It shows many germ balls within its interior. It leads a parasitic life during which each of its germ ball forms a daughter redia. All daughter radia gradually come out through the birth pore in the snail tissue and lead a prarasitic life. The daughter redia is similar in structure to primary redia. Its germ ball develop in the form of next larval stage known as cercaria. The cercariae thus produced are released through the birth pore in snail tissue.

Each cercaria larva shows an oval body and a tail. It has suckers and alimentary canal like that of adult, excretory and nervous system, special glands and an anterior spine. It penetrates through the snail tissue to reach the surrounding water in which it swims freely by the lashing movements of its tail in search of an aquatic plant and settles on it, releases its tail and develops a cyst wall by the secretion of its cystogenous glands and thus gets converted in the form of a resting larva known as metacercaria.

When encysted metacercaria is swallowed by a suitable host, human being or pig, it release its cyst in the intestinal cavity of the host where it settles as the adult parasite.

In China the matacercariae settle on tubers or nuts of water calthrop and water chest nut which are cultivated for food. Normally the chinease people eat these plants in raw state and thus get the infection.

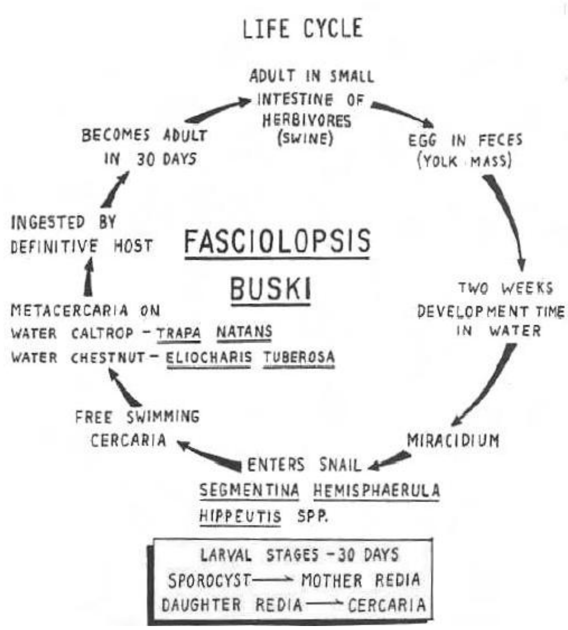

Fig 6.2: Life cycle of *Fasciolopsis* buski

Source: https://armymedical.tpub.com/MD0842/Life-cycle-of-Fasciolopsis-buski-Parasitology

6.3 Pathogenicity, treatment and prophyaxis of *Fasciolopsis buski*

Pathogenicity:

The adult parasite attaches itself to the intestinal mucosa of the host. It causes local inflammation and severe deep ulcerative leisons in heavy infection producing abdominal pain, diarrhoea, oedema and ascites.

Treatment:

In such a condition following drugs are used.

(i) Carbon tetrachloride, 0.3ml per kg. is administered through stomach tube.

(ii) Hexylresorcinol

(iii) Tetrachlorethylene.

Prophylaxis:

- Hygenic disposal of human night soil and faeces of pigs should be done.
- Tubers and nuts of plants must be properly boiled before eating.

6.4 Classification and Life cycle of Schistosoma

Classification

Phylum : Platyhelminthes

Class : Trematoda

Order : Digenea

Family: Schistosomatidae

Genus :Schistosoma

Species :*Schistosoma haematobium*

Habit : It is Parasitic

Primary Host : Human being

Intermediate host: snails (Katayama sp, Oncomelaniasp)

Habitat: Ciculatory system of human being.

Nature: Sexes separate; female lives in the gynacophoral canal of male formed by infolding of ventral surface.

Morphology:

The darsoventrally flattened body of male is elongated with tapering ends. The female is more cylindrical. Both sexes possess an oral sucker at the anterior end and a ventral sucker, acetabulum near the anterior end.

Nutrition:

The animal feeds upon the blood of human being. It shows a digestive system with a mouth opening at the anterior end surrounded by the oral sucker. The mouth leads to a short tube like oesophagus surrounded by glands. The oesophagus gets dilated anterior to acetabulum and bifurcates to form two intestinal caeca one on each side of acetabulum, the caeca run posteriorly up to about 2/3rd level where they join each other to form a common caecum which runs medially upto the posterior end. It terminates blindly as the anus is absent.

SAQ-1

- *Fasciolopsis buski* oval large thick set ………… without shoulders.
- *Fasciolopsis buski* excretory system is represented by innumerable …………scattered in the mesenchyme.
- Each flame cell shows irregular shape with a nucleus and a few ………… and a central cavity which continuous as a ductule.

- ……….. darsoventrally flattened body of male is elongated with tapering ends.
- *In Schistosoma* the female is more cylindrical. Both sexes possess an oral sucker at the anterior end and a ventral sucker, ……….. near the anterior end.

Reproduction and Life Cycle:

Male reproductive system shows 7, oval to round testes in a single column near the middle region of the body. Fine ductules arising from the testes are known as vasaeflerentia. They join to form a single common duct known as vas deferens which runs anteriorly.Slightly behind acetabulum it swells up to form a seminal vesicle which continues as a ductule to open by male gonopore located on midvenral line behind acetabulum.

Female reproductive system shows a single oval to elongated ovary in front of the posterior union of the two intestinal caeca. An oviduct runs from the posterior end of ovary towards the anterior side to open in a region known as ootype which remains surrounded by mehlis glands. Near its origin the oviduct forms a small duct ending in a sac known as receptaculumseminis. Five to seven pairs of oval to round vitelline glands are present in posterior $1/4^{th}$ region of body. All vitelline glands open through their ductules in a common vitelline duct which runs anteriorly to open in the ootype. Single tubular convoluted uterus arising from the ootype runs anteriorly to open by female gonopore located on mid ventral line behind acetabulum.

Sperms produced by testes are stored in seminal vesicle of male. During copulation they are released through female gonopore in uterus from where they travel downwards to be stored in receptaculumseminis of female. Seat of fertlization is the ootype. Secretions of vitelline glands and mehlis glands are helpful in the formation of the egg shell around the zygote which are stored in the uterus as eggs.

Life cycle of *Schistosoma* shows following stages and changes:

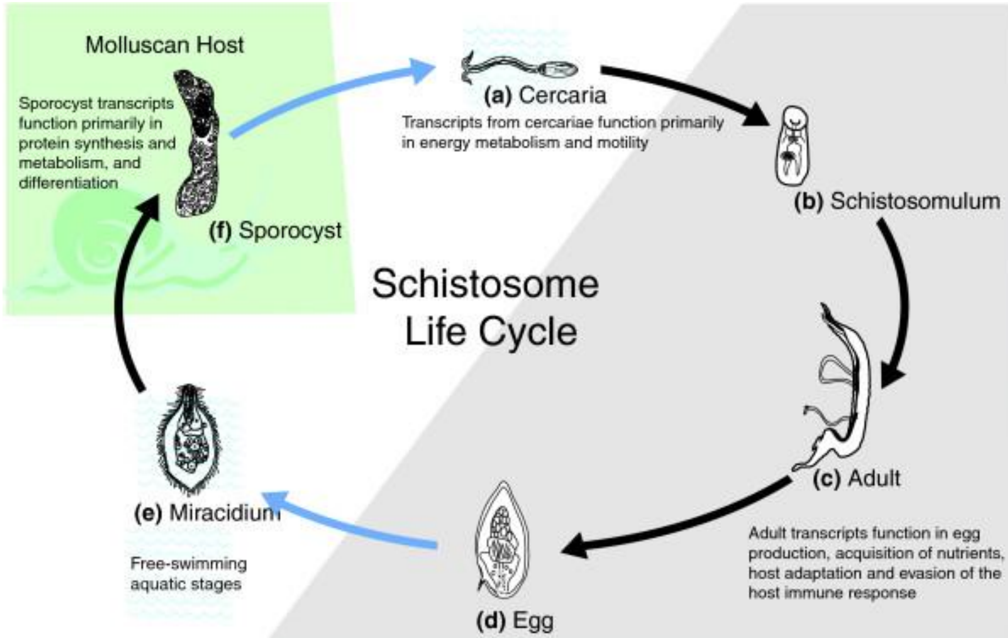

Fig.6.3: Life cycle of Schistosome

Source: https://www.researchgate.net/profile/Emmitt- The-schistosome-life-cycle-is-complex-with-morphologically-distinct-stages-occupying.png

1. **Eggs:** They are oval uninucleate bodies enclosed in a shell showing a curved spine.
2. **Egg laying:** The eggs are laid by the female through the genital opening in the small venules of submucosa of host intestine. They puncture the mucosa and reach intestinal cavity from where they pass out along with the faecal matter of the host.
3. **Formation and Release of miracidium larva:** The zygote undergoes cleavage, blastulation gastrulation and organogenesis to form a larva known as miracidium within the egg shell. Upon reaching water the egg shell splits liberating the miracidium.
4. **Miracidium:** It shows thin leaf like body with an anterior cone. It remains covered with 22 epidermal cells in 4 tiers. The tiers show 6,9,4,3 cells from anterior to posterior side. The body shows marginal cilia, a pair of eyespot in the medial region of anterior 1/3rd area and a few flame cells which open through their ductules by an excretory pore on each side.
5. **Fate of miracidium:** It swims freely for 24-32 hours undergoing dispersal. On coming in contact of a particular species of snail it penetrates in the body of the snail. Within the body of snail it looses its marginal cilia and eyespots and gets transformed in a sporocyst.

6. **Primary sporocyst:** It is an irregular sac with a few flame cells, two excretory openings, one on each side and a few germ balls in the interior.
7. **Fate of primary sporocyst:** Each germ balls develops in a secondary sporocyst. The primary sporocyst bursts releasing the secondary sporocysts in the snail tissue.
8. **Secondary sporocyst:** It is similar to primary sporocyst in shape and structure.
9. **Fate of secondary sporocyst:**Each germ ball forms a cercaria larva. Upon the bursting of the secondary sporocyst the cercaria larvae are released in the tissues of snail. They escape out from the body of snail in surrounding water.
10. **Furcocercous Cercaria:** It shows an elongated body and a tail which remains bifurcated at the free end. The body shows an stylet at the anterior end, a sac like gut, 4-5 paris of penetration glands opening at anterior end, an acetabulum near the middle region and a few flame cells which open by single excretory pore which open by single excretory pore present at the junction of body and tail. The margin of body shows minute spines.
11. **Fate of furcocercouscercaria:** It swims freely in water performing dispersal by the lashing movements of it tail. On coming in contact with a human being it punctures the skin with the help of its stylet. During this process it discards its tail. It finds entry in blood capillaries and lymph nodes of human host. It develops in an adult in mesenteric arteries or portal veins of human host.

Epidemiology

When a person bathes in infected water or drinks such water containing cercarial he becomes infected. The washerman and farmers get periodically infected.

6.5 Pathogenicity, treatment and prophyaxis of Schistosoma

Pathogenesis:

Penetration of cercaria of non-human schistosome in the skin of human beings causes schistosome dermatitis or swimmers itch. It produces mild erythema and odema. In gross infection passage of crcaria through lungs causes pneumonia. In early stage of the disease abdominal organs like liver get congested due to arrival of immature worms in intra hepatic portal blood vessels. Adult parasites causes severe damage during egg laying. The masses of eggs get surrounded by inflamed area. Such infiltration of leucocytes gives rise to abscess formation. Sometimes such abscesses burst discharging their contents in the gut followed by healing leading to scar formation. In liver such abscesses get encapsulated and calcified thus causing cirrhosis. During this state spleen and mesenteric lymph glands get congested showing increase of fibrous tissue.

Treatment:

Schistosamisis can be treated by the use of antinomy compound like tartar emetic, fuadin and anthiomaline.

Prophylaxis

(1) Human excreta should be properly treated before being used as fertilizer.

(2) Night soil should be fermented. It kills the eggs.

(3) Contaminated water should be sprinkled by copper sulphate or copper carbonate.

6.6 Summary

- *Fasciolopsis buski* oval large thick set fluke without shoulders.
- It is slightly broader posteriorly than anteriorly. The body shows an oral sucker around the mouth at anterior end and a ventral sucker (acetabulum) on midventral line near anterior end.
- Acetabulum is markedly larger than oral sucker. The body surface shows cuticle beset with spines which may be lost.
- Alimentary canal shows a mouth opening at the anterior end. It continues posteriorly as a pharynx and a short oesophagus which continues as an unbranched, blind intestinal caecum.
- The anus remains absent.
- Excretory system is represented by innumerable flame cells scattered in the mesenchyme.
- Each flame cell shows irregular shape with a nucleus and a few bleferoplast and a central cavity which continuous as a ductule. From each bleferoplast arises a flickering cilia.
- *Schistosoma* darsoventrally flattened body of male is elongated with tapering

ends. The female is more cylindrical. Both sexes possess an oral sucker at the anterior end and a ventral sucker, acetabulum near the anterior end.

- The animal feeds upon the blood of human being. It shows a digestive system with a mouth opening at the anterior end surrounded by the oral sucker.
- The mouth leads to a short tube like oesophagus surrounded by glands. The oesophagus gets dilated anterior to acetabulum and bifurcates to form two intestinal caeca one on each side of acetabulum.
- The caeca run posteriorly up to about $2/3^{rd}$ level where they join each other to form a common caecum which runs medially upto the posterior end. It terminates blindly as the anus is absent.

6.7 Terminal Questions

Q. 1 Write an essay on classification and life cycle of *Fasciolopsis buski*.

Q. 2 Write an essay on classification and life cycle of *Schistosoma.*

Q. 3 Write an essay on Pathogenicity, treatment and prophyaxis of *Fasciolopsis buski.*

Q. 4 Describe in details Pathogenicity, treatment and prophyaxis of Schistosoma.

6.8 Answers

SAQ

- fluke
- flame cells
- bleferoplast
- *Schistosoma*
- *acetabulum*

Block-2 – Pathogen and Transmission of Parasitse-II

In block-I; you have studied about pathogen and transmission of parasite-I. In this block we will discuss about the pathogen and transmission of parasite-II. This block is divided into six (06) units (7 to 12).

Unit-7: This unit deals with of general account of phylum Nematoda and its classification, It covers classification morphology life cycle, pathology, treatment and prophylaxis of *Ascaris*, *Ancylostoma, Wuchereia* and *Dracunculus*.

Unit-8: This unit deals with the concept of plant diseases, host parasites relationship in nematode infection. Effect of abiotic factors in nematode multiplication. Mechanism involved in injury histopathology of infected tissue.

Unit-9: This unit deals with the importance biology and control of Ticks, which are significant parasites mainly of mammals. It covers the classification, habit, hosts, distribution morphology life cycle zoonosis and prevention and control of Hard tick and soft tick, Mite (*Sarcoptes*) and Insect parasites like (*Pediculins humanus*), flea (*xenopsylla chepis*), bed bug (*cimex lectularis*).

Unit-10: This unit deals with the Cookicutter Shark, Hood Mocking bird, Vampire bats and their parasitic behavior and effect on host.

Unit-11: It deals with the micro and macro environment of parasites, autecology and synecology of parasitic helminthes.

Unit- 12: This unit deals with the host parasite interactions Physiology of host parasite interactions, immunological control of vector borne and nonvector borne diseases. Population dynamics of helminthes, Bio-invasion and helminthes.

Objectives:

After studying this block you should be able to know-

- Parasitic Nematoda, Host parasites relationship in nematode
- Parasitic Arthropods, Parasite Vertebrates
- Micro and Macro environment of parasites, host parasite interactions

Unit-7 Parasitic Nematoda

Structure

7.1 Introduction

Objectives

7.2 General Account of Phylum Nematoda

7.3 Classification of Phylum Nematoda

7.4 Classification, Life cycle of *Ascaris*

7.5 Classification, Life cycle of *Ancyclostoma*

7.6 Classification, Life cycle of *Wuchereria*

7.7 Classification, Life cycle of *Dracunculus*

7.8 Summary

7.9 Terminal Questions

7.10 Answers

7.1 Introduction

This unit deals with of general account of phylum Nematoda and its classification, It covers classification, morphology life cycle, pathology, treatment and prophylaxis of *Ascaris*, *Ancylostoma,Wuchereia* and *Dracunculus*. Nematoda represents the largest phylum of Pseudocoelomate group including 15000 or more species. They show wide distribution in soil, fresh water and sea water. Apart form them they are found as plant and animal parasites. They possess an unsegmented body of varied shape. They may show fusiform shape, widest in middle and tapering at both ends or filiform shape being threat like showing uniform diameter.

Objectives

After studying this unit you should be able to know-

- Classification of Phylum Nematoda
- Classification, Life cycle of *Ascaris*
- Classification, Life cycle of *Ancyclostoma*
- Classification, Life cycle of *Wuchereria*

- Classification, Life cycle of *Dracunculus*

7.2 General Account of Phylum Nematoda

Nematoda represents the largest phylum of Pseudocoelomate group including 15000 or more species. They show wide distribution in soil, fresh water and sea water. Apart form them they are found as plant and animal parasites.

They possess an unsegemented body of varied shape. They may show fusiform shape, widest in middle and tapering at both ends or filiform shape being thread like showing uniform diameter. They are circular in cross section hence commonly called as roundworm. The region of their body behind gonopore represents the tail. Their general body surface is smooth in parasitic forms but in freeliving forms it shows striations bristles, spines, warts and papillae.

Body wall

Their body wall shows three layers as under-

(i) **Cuticle:** It forms the outermost covering, showing three layers as outermost dense keratinized cortex, below, which lies a spongy layer known as matrix containing matricin. The inner most layer is made up of dense connective tissue called as fibre layer. It is bound internally by a basement membrane.

(ii) **Epidermis or Hypodermis or Subeutis:**It may be cellular or syncitial. It bulges internally on mid dorsal, mid ventral and the two lateral lines as longitudinal cords.

(iii) **Muscle layer:** It is represented by four bands of longitudinal muscles interspread by the longitudinal cords of epidermis. Each band shows specific number of muscles. Each muscle cell shows a fibrillar zone one having longitudinal bands of contractile substance alternating with noncontractile supporting fibrils. These muscles show a platymyarian condition in which they remain parallel to epidermis or coelomyarian condition in which the protoplasmic zone of the muscle budges in the pseudocoel. This zone shows a nucleus and a bleferoplast from which arises a neuromuscular fibril. All fibriles of dorsal half join the dorsal longitudinal nerve while those of ventral half join the vental longitudinal nerve.

Pseudocoel (Pericentric Space):

It is the space between body wall and alimentary canal. It contains fibrous tissues and fixed number of cells. In parasitic forms single large cell is present in this space dorsally to the pharynx. These cells known as pseudocoelocytes (stellate cells) show a large intracellular space containing pericentric fluid. They show numerous processes ending in terminal knobs. They are phagocytic.

Digestive System

It shows following parts.

(i) Mouth: It is anterior terminal surrounded by three lips, one dorsal and two ventrolateral, each with sensory papillae. In some cases only two lips are present ,each with three papillae.In parasitic forms a pair of depressions are present on each side of anterior end laterally or postero laterally. They are amphids which act as chemoreceptors.

(ii) Buccal Capsule: It is present behind the mouth. This portion is cylindrical or prismatic lined with heavily sclerotized cuticle.

(iii) Pharynx (Oesophagus): It is present behind buccal capsule. It shows cylindrical shape with triradiate lumen. Its wall contains three oesophageal glands, one in each sector. The dorsal gland opens in mouth, other two in the cavity. These glands secrete digestive enzymes. In its way the pharynx shows one or more swellings known as pharyngeal bulbs.

(iv) Intestine (Midgut): It is simple straight tube with one layered cellular epithelium having cuboidal or columnar cells.

(v) Rectum: It is a short flattened tube lined with cuticle. It shows three rectal glands in females and six in males, in males it serves as cloaca with a spicule pouch containing copulatory spicules.

(vi) Anus: In females the rectum opens to outside by a midventral anus which is a transverse opening with thick lips. In males the rectum serves as cloaca which opens to outside by cloacal opening.

Excretory System:

It is represented by two unbranched longitudinal canals embedded in the two lateral epidermal ridges. In many forms the two canals join each other by a tranverse canal behind the perioesophageal nerve forming a ‘H’ system. In some cases instead of a transverse canal a network of fine canals joins the two longitudinal canals. The ‘H’ system may show single or many nuclei. Sometimes the anterior limbs of ‘H’ system get lost thus the 'H' system get converted in an inverted 'U' system, from one end of the junction of transverse canal with longitudinal canals arises a canal which runs anteriorly to open by an excretory pore which is situated ventrally behind anterior extremity. In some cases this system remains absent.

Nervous System:

It shows a circumentric nerve ring around pharynx. It is made of nerve fibres with a few ganglia which are as under:

(i) Single or paired ventral ganglia

(ii) Paired lateral ganglia

(iii) Single small dorsalganglion

(iv) A pair of subdorsal ganglia

(v) A pair of post lateral ganglia behind lateral ganglia

(vi) A pair of post ventral ganglia behind ventral ganglia.

Anterior nerves arising from the nerve ring are

(i) Two darsolateral nerves

(ii) Two lateral nerves

(iii) Two ventrolateral nerves

They innervate the anterior sense organs. Apart from them free nerve endings are abundant in anterior region of parasitic forms.

Posterior nerves arising from nerve ring are as under-

(i) A middorsal nerve

(ii) One to three pairs of lateral nerves

(iii) A midventral nerve which is the main body nerve showing ganglia.

Many ventrolateral connectionsexists between ventral and lateral nerves. Tail region is supplied by nerves from anal and lumber ganglia. They innervate the phasmids

Sense organ

Anterior sense organs are as under:

(i) 6 outer labial papillae

(ii) 4 cephalic papillae

(iii) Cervical papillae

(iv) Amphids

The labial and cephalic papilla show thin cuticle with a circle groove. The cervical papillae show an ascending nerve fibre provided with a supporting and accompanying cell. The amphids are two present on lateral lines. They are cuticular elevations of varied shapes with a cluster of nerve endings of amphidial nerve. In parasitic forms the amphids are reduced.

Posterior sense organs are

(i) Genital papillae

(ii) Phasmids

Genial papillae are wart like elevations with thin cutical. They show central circular opening. The phasmids are a pair of unicellular glands that open by a canal and a pore on each side of tail. They are glandulosecretory in nature. They are well developed in parasitic forms.

Reproductive System:

Sexes are separate. They show sexual dimorphism as the males are smaller than females. The male possesses a curved posterior end with copulatory spicules projecting out of cloacal opening.

Male Reproductive System

It shows following parts

(i) Testes: They are one or two, long thread like and coiled lying in the pseudocoel. It shows a central axis around which the developing sperms are clustered. The sperms are amoeboid.

(ii) Vas deferens (sperm duct): It arises from the proximalend of testis and runs posteriorly

(iii) Seminal vesicle: It is a wide muscular tube in continuaton with vas deferens. It occupies the posterior one third region of the body. It stores mature sperms.

(iv) Ejaculatory duct: The seminal vesicle continues as a short narrow musculo glandular duct. It opens in rectum forming a cloaca. Distally it is lined by prostatic glands. At its junction with rectum if forms a sphincter.

(v) Cloaca: It is the common chamber in which both digestive and reproductive ducts open. It opens to outside by cloacal opening on midventral line.

(vi) Spicule pouch and copulatory spicules: The dorsal wall of cloaca forms a pouch like structure in which one or two copulatory spicules remain lodged. The copulatory spicules (Pineal spicules) are made up of hard cuticle with cytoplasmic core. They show varied shapes. When two they may be similar or dissimilar, the left being longer than right. In some cases the dorsal wall of spicule pouch gets sclerotized forming gubernaculum. It guides the spicules to enter the female gonopore during copulation.

Female Reproductive System:

It shows following parts-

(i) Ovaries: They number one or two or upto 10 or 11. They are thread like, straight or sinuous. The central part shows cytoplasmic rachis. The young ova are clustered around the rachis.

(ii) Oviduct: From the posterior end of ovary arises the oviduct which is slightly broader.

(iii) Seminal Recepticle: It is present in continuation with oviduct. It stores sperms after copulation and acts as a seat of fertilization.

(iv) Uterus: Each oviduct leads to a uterus. It is long, wide, straight and muscular. It stores the fertilized eggs.

(v) Vagina: The uteri run anteriorly and unite to form a short median thick walled vagina lined internally by cuticle.

(vi) Vulva: It is the opening of vegina located ventrally near the anterior end.

In parasitic forms the growth zone of ovary and uteri are greatly elongated as these forms are very prolific producing thousands of eggs per day.

Development:

(1) The egg undergoes normal cleavage leading to the formation of a morula which forms an embryo which shows a broad anterior end.

(2) Fully formed larva shows 4 moults during which the whole cuticle is shed and replaced by a new cuticle.

(3) Between two moults 2 phases appear. In first phase the larva feeds and grows. During second phase it becomes inactive showing changes for next moult.

(4) After secondmoult the larva becomes infective for final host.

(5) The life cycles are of two kinds as under

(i) In cases where no intermediate host exists the eggs hatch in open and larve remains free living for sometime the infective larva enters the host through mouth during feeding or it penetrates the host skin or eggs develop in open but do not hatch. Such unhatched eggs enter in the host through mouth during feeding.

(ii) In cases where an intermediate host exist.

The viviparous larvae enters the intermediate host after a short existence or the eggs do not hatch but are ingested by intermediate host which is eaten by the definitive host.

After entering the definitive host many nematodes migrate within the host body before settling in normal habitat. In this process they do a lot of damage to the host organs.

7.3 Classification of Phylum Nematoda

The phylum Nematoda is characterized by their cylindrical shape, four internal longitudinal epidermal chords, three angled pharynx, circumentric nerve ring, copulatory spicules, one or two tubular gonads, opening independently in female but in rectum in males.

The phylum is divided in two classes as under:

Class Aphasmida	Class Phasmida
1. Phasmids absent	1. Phasmids present
2. Amphids spiral or discoidal	2. Amphids pore like
3. Excretory canal absent	3. Excretory canal present
4. Pseudocoelomocyteswell developed	4. Pseudocoelomocytes 4 to 6
5. Mesenterial tissue well developed	5. Mesenterial tissue reduced

6. Caudal adhesive glands present	6. Caudal adhesive glands absent

Class Aphasmida is divided in two orders s under.

Order Enoploidae	Order Dorilaimoidea
(1) Cuticle with bristles	(1) Cuticle without bristles
(2) Anteriorend with 6 labial lapilla in one circle	(2) Anterior end with 6-10 papillae in two circles
(3) Habitat free living and marine	(3) Habitat soil and fresh water
eg.*Anticoma*	eg.*Dorylaimus*

Class Phasmida is divided in following orders as under:

(1) Order Mermithodea

i. Body shape filiform

ii. Juvenile is parasite in insects, adult is free living in soil or water.

iii. Buccal capsule absent

iv. Pharynx very long. It does not open in intestine.

v. Stichocytes attached to posterior region of pharynx.

vi. Intestine changed to trophosome with enlarged cells having food reserve.

eg.*Tetradonema*

(2) Order Chromadoroidea

i. Habitat marine

ii. Amphids spiral

iii. Buccal capsule armed

iv. Pharynx with a posterior bulb.

eg.*Desmodora*

(3) Order Araeolaimoidea

i. Presence of 4 cephalic bristles with papillae.

ii. Amphids spiral or loop like
iii. Cuticular ornamentation absent
iv. Absence of preanal copulatory aids

eg.*Wilsonema*

(4) Order Monohysteroidea

i. Amphids circular
ii. Aquatic teristrial marine
iii. Cuticle smooth or slightly ringed
iv. Ovaries single or double
v. Preanal papillae present.

eg.*Theristus.*

(5) Order: Desmoscolecoidea

i. Marine habitat
ii. Head set off from the body
iii. Body surface bristly or heavily ringed
iv. Amphids hemispherical
v. Buccal capsule absent.

eg.*Desmoscolex*

(6) Order Rhabditoidea

i. Free living in decomposing material or aquatic.
ii. Amphids small, pocket like
iii. Pharynx with one volvular and other pseudobulb
iv. Phasmids present
v. Copulatory spicules equal and similar
vi. Gubernaculum present.

eg.*Heterodera*

(7) Order: Rhabdiasoidea

i. Similar to Rhabditoidea

ii. Parasitic in vertebrates

eg.*Rhabdias*

(8) Order :Oxyuroidea

i. Obligatory parasites of vertebrates

ii. Shape fusiform

iii. Head organs papillae like, present in circle of 8 or 10.

iv. Amphids tubular pocket like

v. Lips 3 to 6.

vi. Buccal capsule small

vii. Pharynx with volvulated end bulb.

viii. Tail of female long, slender and pointed

ix. Pineal spicules one or two equal

x. Candal alae present.

eg.*Leidynema*

(9) Order: Ascaroidea

i. Obligatory parasites of vertebrate intestine

ii. Three prominent lips present

iii. Amphids present

iv. Buccal capsule absent

v. Phanynx simple without bulb

vi. Caudal alae absent

vii. Copulatory spicules equal

viii. Gubernaculun absent.

ix. Excretory system ‘H’ shaped.

eg.*Ascaris*

(10) Order: Strongyloidea

i. Obligarony parasites of mammals

ii. Lips not prominent

iii. Pharynx cylindrical without bulb

iv. Male with marked expanded bursa with 2 large lateral lobes each supported by 6 muscle rays and a small median lobe with one ray.

v. Female with two uteri with muscular ovijector.

eg.*Necator.*

(11) Order Spiruroidea

i. Lateral lips two unlobed or trilobed

ii. With inner labial circlet of 6 papillae and external circlet of 4 double or 8 papillae.

iii. Pineal spicules 2, unequal and dissimilar.

iv. Vulva anterior on body midline

v. Ovijector present.

vi. Renette cells absent, Excretory system inverted 'U' shaped.

eg.*Rictularia*

(12) Order: Dracunculoidea

i. Parasitic in connective tissue and coelom of vertebrate; copepods act as intermediate host.

ii. Shape filiform

iii. Lips absent

iv. Labial papillae 6; external circlet of 8 separate or 4 double papillae

v. Pharynx divided in anterior narrow muscular and posterior broader glandular portion.

vi. Copulatory spicules filiform

vii. Gubernaculum present

viii. Uteri double and opposed

ix. Vulva near middle of body

x. Viviparous

eg.*Dracunculus*

(13) Order: Filarioidea

i. Parasitic in circulatory system, coelom, muscles and connective tissue of vertebrates

ii. Shape filiform

iii. Lips and Buccal capsule absent

iv. Phanynx divided in anterior muscular and posterior glandular portion.

v. Copulatory spicules unequal and dissimilar.

vi. Vulva present in pharyngeal region.

eg.*Filaria*

(14) Order: Trichuroidea

i. Parasitic in alimentary canal of birds and mammals

ii. Anterior region slender than posterior region

iii. Mouth simple without lips

iv. Pharynx slender, delicate, embedded in stichosome made up of large cells

v. Copulatory spicules absent , eversible spicule sheath may be present.

vi. Female system single

vii. Vulva variously placed.

eg.*Trichuris*

(15) Order: Dioctophymoidea

i. Parasitic in birds and mammals; fish acts as intermediate host.

ii. Mouth encircled by one or two circlets of 6, 12 or 18 papillae.

iii. Lips absent

iv. Pharynx elongate without bulb

v. Male with bell shaped muscular bursa without rays

vi. Female with single reproductive system.

vii. Male with one copulatory spicule

eg.*Dioctophyme*

7.4 Classification, Life cycle of *Ascaris*

Classification

Phylum : Nematoda

Class :Phasmidia

Order :Ascaroidea

Family: Ascaridae

Genus :*Ascaris*

Species :*Ascaris lumbricoides*

Habit :Parasitic

Host : Human being or Pig (Intermediate host absent)

Habitat: mainly duodenum region of intestine.

Morphology:

The cylindrical body is tapering at both ends. It shows sexual dimorphism; the female being larger than male. The posterior end of female is straight with a subterminal ventral anus while the posterior end of the male is ventrally curved showing two copulatory spicules arising from thecloacal opening. The anterior end of both sexes is similar showing a terminal mouth surrounded by a dorsal lip and two ventrolateral lips. The dorsal lip shows a pair of labial papillae while each ventrolateral lip shows a labial papilla and an amphid.

The body wall shows 3 layers as under

(i) Cuticle: it is the outer most transparent proteinaceous layer.

(ii) Ectoderm: It is present below the cuticle showing syncitial nature (without cell walls) and 4 internal longitudinal ridges on middorsal, midventral and two lateral lines.

(iii) Muscle layers: They are represented by longitudinal muscles only.They are arranged in 4 sectors (two darsolateral and two ventrolateral). Each sector contains-40-60 muscles. Each muscle shows a fibrillar zone having longitudinal muscle fibrils and supporting fibrils, a cytoplasmic bladder extended inwards in pseudocoel and a neuromuscular fibril arising from a bleferoplast. All neuromuscular fibrils of dorsal half join the dorsal longitudinal nerve while these of ventral half join the ventral longitudinal nerve.

Nutrition:

The animal feeds upon blood and fully or partly digested food present in the alimentary canal of host. It is sucked up by the pharynx. The alimentary canal shows an anterior terminal mouth surrounded by a dorsal and two ventrolateral lips. It leads internally to a thin and small tube like buccal cavity behind which lies the musculoglandular suctorial pharynx having a triradial cavity lined with cuticle. Pharynx is followed by intestine which is a darsoventrally flattened syncitial tube lined internally by microvilli. Behind the intestine is present a darsoventrally flattened rectum lined internally by cuticle. In females the rectum opens by a transverse subterminal slit like anus which is surrounded by sphincter muscles. In males the rectum opens by anus in a cloaca which opens to outside on midventral line near the posterior end.

Extracellular digestion occurs in the cavity of intestine by the action of proteases, amylases and lipases secreated by the intestinal lining which performs absorption of food. The food is stored in the form of glycogen and fat in ectoderm and muscle cells.

Reproduction:

Male reproductive system shows following parts:

1. Testis: It is single long, thread like and highly coiled, present within the pseudocoel.
2. Vas deferens: It is a narrow, short duct arising from the proximal end of testis.
3. Seminal vesicle: It is an elongated sac in continuation with vas deferens. It runs anteriorly.
4. Ejaculatory duct: It is thick muscular duct arising from distal end of seminal vesicle, running posteriorly to open in cloaca.
5. Cloaca: It is a common chamber in which both rectum and ejaculatory duch opens. It opens on mid ventral line near posterior end.
6. Spicule pouch and Pineal Spicules: On the dorsal wall of cloaca is present a pouch in which two curved and chitinous spicules are present. During copulation they protrude out through cloaca opening.

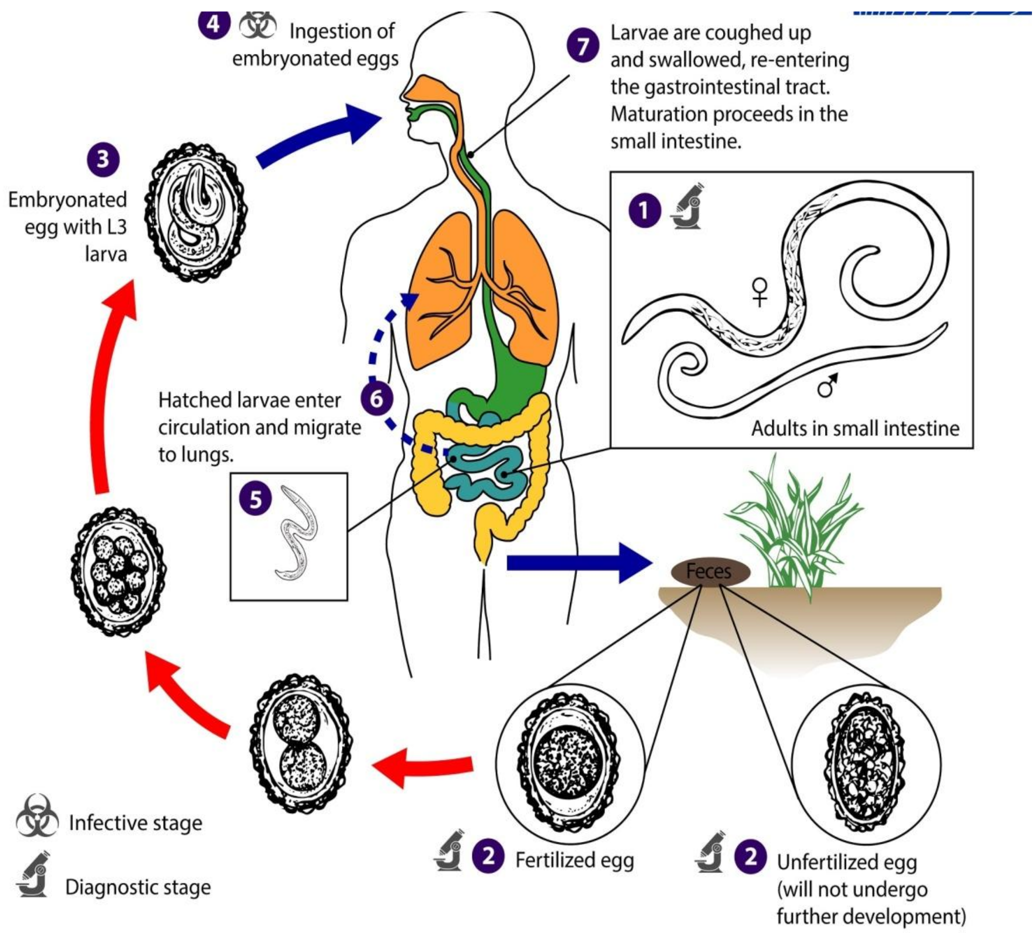

Fig.7.1: Life cycle of Ascaris

Source: https://www.google.com/search?q=image++Life+cycle+of+Ascaris

Female Reproductive System shows following parts:

(i) Ovaries: They are two long, thread like and highly coiled bodies present in the pseudocoel.

(ii) Oviducts: They are two shorts ducts, one arising from distal end of each ovary.

(iii) Receptaculumseminis: They are two small sacs one in continuation with each oviduct. They store sperms.

(iv) Uterus: They are two elongated sacs one arising from each receptaculumseminis. They run anteriorly parallel to each other and join at about 1/3rd level from the anterior end.

(v) Vagina: It is single muscular duct arising from the junction of the two uteri.

(vi) Female Gonopore: It is single opening at the free end of vagina. It is located near the anterior end on midventral line.

During copulation the protruded pineal spicules of male find entry in the female gonopore. The amoeboid sperms travel over them to enter the vegina. They pass through the uteri to reach receptaculumsemimis where fertilization of ovum occurs. The fertilized eggs are stored in the two uteri.

Life Cycle - Structure of egg: Each egg is an oval body showing a zygole enclosed in a thick resistant covering known as mammilated coat. It shows an inner lipoid layer, middle proteinaceous layer and outer chitinous and warty layer.

Development of egg**:**Within the uterus the zygote of the egg urdergoes holoblastic, spiral and determinate cleavage leading to the formation of a morula, blastula and gastrula which undergoes organogenesis to form a larva known as Rhabdiform larva. The egg containing the larva is called as embryonated egg.

Release of eggs: The embryonated eggs are released, through the female gonopore in the intestinal cavity of human being or pig, from where they go out along with the faecal matter of the host. They remain present in the soil.

Transmission and fate of eggs**:** Transmission occurs into the body of a new host by the contamination of its food and drinks. In case of human beings housefly plays important role. Within the stomach of the host the mammilated coat gets dissolved by the action of gastric juice and the juvenile is set free.

Structure and fate of Juvenile: The juvenile shows a tapering body whose anterior end remains covered by a hyaline cap. It shows a rudimentary alimentary canal, an excretory pore and a nerve ring.The juvenile enters the cavity of duodenum. It enters the duodenal lining to reach the hepatic portal system through which it performs following journeywithin the body of host.

Oesophagus, stomach, duodenum, hepatic portal system, liver, post canval heart

During the course of its journey it undergoes 4 moulths. First moult occurs in the egg on 10^{th} day, second moult occurs in lungs on 15^{th} day, third moult occurs in lungs on 21^{st} day and fourth moult in duodenum of the host in 60 to 75 days. Upon reaching back to duodenum it gets transformed in the adult as the result of fourth moult.

Most important event during its journey is the damage of alveolar lining of the host. In human beings may it lead to the occurrance of pheumonia.

Pathology

The disease caused by the infected of *Ascaris* is known as Ascariasis. During the life cycle the second stage larvae damage the intestinal lining to cause internal bleeding, fever, anamia and muscular spasms. The larvae damage the capillaries of lungs causing conditions of eosinophilia and pneumoinia. Sometimes the larvae damage the kidneys, brain, spinal cord causing serious leisons. The Adults living in the intestine cause irritation, indigestion colie pain, diarrhoea and vomiting, Heavy infestation may cause blockage of intestine and bile duct. It may lead even to death of the patient.

Prophylaxis:

- One should avoid eating raw vegetables and fruits. They should be thoroughly washed and properly cooked before consumption.
- Proper hygenic conditions should be maintained. Sanitary education should be given to people especially the children in the family. Such education includes washing of hands before every meal and regular cutting of nails. Human faeces should be disposed off by an underground sewer system.

Treatment:

Common drugs used irradicate the worms are, santomin, hetrozan, piperazine hydrate, tetramisole and hexyresorcinol

SAQ-1

- Nematoda represents the largest phylum of …………………………group.
- Nematoda wide distribution in soil, fresh water and sea water. Apart form them they are found as …………………………and …………………………..
- Nematoda possess an …………………………body of varied shape.
- Nematoda structure fusiform shape, widest in middle and …………………………or filiform shape being threat like showing uniform diameter.

7.5 Classification, Life cycle of *Ancylostoma*

Classification

Phylum : Nematoda

Class :Phasmidia

Order :Strongyloidea

Genus :*Ancylostoma*

Species :*Ancylostomaduodenal*

Habit : Parasitic

Primary Host : Human being (Intermediate host absent)

Habitat: The parasite lives in small intestine mainly in jejunum, sometimes in duodenum and rarely in ileum.

Morphology:

The cylindrical body shows sexual dimorphism; the female being larger than male. The posterior end of the male forms a copulatory bursa provided with six pairs of bursa provided six pairs of lateral rays and one dorsal ray. The copulatory bursa is absent in a female which shows a posterior caudal spine. The anterior end of both sexes is similar. It is slightly bent dorsally. It shows cervical papillae on lateral side. It lack the lips.

Nutrition:

The animal feeds upon blood, lymph and pieces of intestinal mucosa of the host intestine. The alimentary canal shows an anterior buccal capsule lined with cuticle. At the base of buccal capsule lies the mouth opening guarded by two ventrolatral cutting plates and a dorsal plate. Each ventrolateral plate possesses two teeth and the dorsal plate shows one tooth. At the base of capsule are present a pair of small teeth. Laterally the capsule shows the opening of the ducts of cephalic glands. The secretion of cephalic glands dissolves the mucosa of host intestine and the teeth puncture the submucosa for the release of blood on which the animal feeds. The moult leads internally to muscular pharynx showing triradiate lumen lined with cuticle.The pharyngeal wall shows radial muscles and gland cells secreting anticoagulants and digestive enzymes. Behind the pharynx lies the intestine which is a wide tube with secretory and absorptive epithelium. It leads internally to rectum which is a short tube lined with cuticle. In a female rectum open through anus on ventral side near the posterior end but in a male the anus opens in a cloaca which is a common chamber in which both digestive and reproductive ducts open. The cloaca opens on ventral side near middle of copulatory bursa on a small papilla called as genital cone.

The digestion of the food begins out side the animal body by enzymes produced by pharynqeal glands. It is called as extra corporealdigestion. It is followed by extra cellular digestion occuring in the intestinal cavity. The absorptior of food occurs mainly in middle or posterior region of intestine.

Reproduction

Male Reproductive system shows following parts

(i) Testis: It is simple thread like coiled around the intestine.

(ii) Vas deferens: It is fine ductule arising from testis. It is also coiled around the intestine.

(iii) Seminal vesicle: It is an elongated sac in continuation with the vas deferens.

(iv) Ejaculatory duct: It arises from the posterior end of seminal vesicle and runs backwards. It is surrounded by two large muticellular cement glands. The secretion of these glands helps attachment of bursa of male to the body of female during copulation.

(v) Cloaca: It is the common chamber in which both digestive and reproductive ducts open.

(vi) Pineal sac and Pineal spicules: On the dorsal wall of cloaca is present an elongated pineal sac which lodges two needle like protrusible pineal spicules.

(vii) Cloacal opening: It is present in the middle of copulatory bursa on midventral line on a small papilla called as genital cone.

(viii) Copulatory bursa: it is a large bilobed expansion of skin at the posterior end of body. The lobes are supported by muscular rays.

Female reproductive system: It shows following parts-

(i) Ovaries: They are two thread like bodies coiled around the intestine. One ovary lies anterior to vulva and the other posterior to it.

(ii) Oviducts: They are two fine ducts arising from each ovary.

(iii) Seminal receptacles: They are two wide and elongated sacs, one in continuation with each oviduct.

(iv) Uteri: They are two elongated sacs, one in continuation with each seminal receptacle. They join each other in the middle region of body.

(v) Vagnia: It is a short duct formed from the junction of the two uteri: It opens by the femalegonopore known as vulva. The opening of the two uteri in the vagina is provided with sphincter muscles.

(vi) Vulva: It is single opening on midventral line in the middle region of the body.

Life cycle:

Copulation occurs in the intestinal cavity of human beings. During this process the male holds the female with its copulatory bursa. Seat of fertilization is seminal receptacle. The eggs get stored in the uteri. They pass out through the vulva in the host intestine from where they are released out along with the faecal matter of the host.

Structure and fate of eggs:

Each egg contains a zygot enclosed in a 3 layeredshowing outer lipid membrane, middle chitinous layer and inner proteinaceous layers.

As the result of cleavage, blastulatiorn, gastrulation and organogenesis within 24 hours a rhabditiform larva is formed which is released in the soil upon the bursting of the egg. This larva is free living in soil feeding upon bacteria and organic debris. It undergoes first moult on second day to form strongyle form larva. It grows and undergoes second moult during fifth to eight day to form fileriform larva. It does not feed but remains active for a long time living in the upper layer of soil.

Infection human beings:

Living in the soil when the fileriform larva comes in contact with a bare footed person if bores into the skin of feet, legs or hand. In the dermis it penetrates the blood capillaries and enters blood circulation, from the heart it reaches lungs where it punctures alveolar lining to enter alveolar cavity from where it travels through bronchioles, bronchi, trachea and glottis to reach pharynx. It now enters gullet, oesophagus and stomach to reach intestine where it settles in between the villi where it undergoes third moult during third to fifth day of its entry in the host. It now enters intestinal cavity grows in size, develops buccal capsule and teeth and gets attached to mucosa. It now undergoes fourth moult to form the adult. The life cycle is completed in about six weeks. The life span of the parasite in human host is about of five years.

Pathology:

Prolonged infection causes anaemia, mental and physical deficiency and lowered immunity. The patient becomes sluggish. Penetration of larva in a small area of skin usually causes dermatitis. The damaged sites on the skin may show secondary infection by bacteria and fungi. Poor people moving bare footed are more prone to infection.

Prevention: Proper sanitary disposal of human faeces and use of shoes are important preventive measures.

7.6 Classification, Life cycle of *Wuchereria*

Classification

Phylum : Nematoda

Class :Phasmidia

Order :Filarioidea

Genus :*Wuchereria*

Species :*Wuchereriabankrofti*

Habit : Parasitic

Primary Host : Human being

Intermediate host: Female Culex

Habitat: In primary host the parasite lives in lymph vessels, lymph nodes, circulatory system, muscular system and connective tissues.

In intermediate host it lives in stomach cavity, haemocoel and thoracic wall.

Morphology:

The cylindrical body is tapering at both ends. It shows sexual dimorphism; the female shows narrow and straight posterior end with anal opening near posterior end. It shows a pyriform ovijector while the male shows ventrally curved posterior end showing a cloacal opening through which protrude two pineal spicules. The male shows caudal alae and numerous genital papillae.

The body wall shows 3 layers as under:

(i) Cuticle: It is outermost, transparent and proteinaceous layer.

(ii) Ectoderm: It is middle syncitial layer with 4 internal longitudinal ridges on middorsal midventral and two lateral lines.

(iii) Muscle Layer: It is represented by longitudinal muscles which are arranged in 4 sectors (two darsolateral and two ventrolateral). Each muscle shows a fibrillar zone, a cytoplasmic bladder extended inwards in the pesudocoel and a neuromuscular fibril arising from a bleferoplast. All fibrils of dorsal half join the dorsal longitudinal nerve while those of ventral half join the ventral longitudinal nerve.

Nutrition:

The animal feeds upon blood, lymph and tissue exudates of host which are sucked by the pharynx. The alimentary canal shows an anterior mouth followed by pharynx which shows anterior suctorial muscular zone and posterior glandular zone. It is followed by simple glandular intestine which performs digestion and absorption. Behind it is present a cuticle lined rectum which opens by anus on midvental line near the posterior end in females. In males the rectum opens through anus in the cloaca which is a common chamber for both digestive and reproductive openings. The cloaca opens to outside on midventral line near posterior end. It shows a dorsal spicule pouch with two protrusible pineal spicules.

Reproduction :

Male reproductive system shows following parts

(i) Testis: It is single, long, thread like highly coiled body present in pseudocoel.

(ii) Vas deferens: It is single duct arising from the proximal end of testis.

(iii) Seminal vesicle: It is an elongated sac in continuation with vas deferens. It runs posteriorly within the pseudocoel.

(iv) Ejaculatory duct. It is highly muscular duct in continuation with seminal vesicle.

(v) Cloaca: It is a common chamber in which both rectum and ejaculatory duct opens.

(vi) Spicule pouch and Pineal spicules: On the dorsal wall of cloaca is present a spicule pouch in which 2, unequal, curved and chitinous protrusible spicules are present. They move over a plate known as gubernaculum to protrude out of cloacal opening during copulation.

(vii) Cloacal opening: It is the opening of cloaca present on midventral line near the posterior end.

Female Reproductive System shows following parts

(i) Ovary: It is single long, thread like, highly coiled body present in the pseudocoel.

(ii) Oviduct: It is single duct arising from the proximal end of ovary. It runs posteriorly within the pseudocoel.

(iii) Receptaculumseminis: It is a swelling of the distal end of oviduct for the storage of sperms.

(iv) Uterus: It is single, elongated, broad tube in continuation with receptaculumseminis. It runs anteriorly. It acts as an organ of storage of eggs.

(v) Vagina: It is a muscular and cuticular duct arising from distal end of uterus.

(vi) Ovijector: It is the terminal portion of vagina showing a non muscular proximal region and muscular distal region. It performs expulsion of eggs.

(vii) Female gonopore: It is present at the terminal end of ovijector , located anteriorly on midventalline near the middle of pharyngeal region. It is provided with sphincter.

Life cycle:

During copulation the pineal spicules of male find entry in the female gonopore. The amoeboid sperms travel over the spicules into the vaginal tract. They pass uptoreceptaculumseminis through uterus. Fertilization is cross and internal occuring in receptaculumseminis. The zygotes pass into the uterus as eggs where they are stored.

Structure and fate of eggs: Each egg contains a zygote enclosed in a shell. As the result of cleavage, blastulation, gastrulation and organogenesis the zygote forms a larva known as microfilaria within the shell. Upon bursting of the egg shell the microfilaria are released in the lymph.

Structure of Microfilaria: Its cylindrical body is tapering posteriorly. It is 0.2-0.3 mm long. It shows a hyaline shealth at the anterior and posterior ends. The alimentary canal appears as a cytoplasmic column with fissure of a mouth at anterior end and a fissure of anus at the posterior end. It also shows single excretory pore, a band of nerve ring and a renettle cell.

Fate of microfilaria: The microfilaria circulates through lymph nodes, lymphatic tissue and blood. Within the blood circulation they show diurnal rhythm that is they come in peripheral circulation during 10PM and 4 AM. During this period the human being remain asleep and a female *Culex* finds an opportunity to suck the blood of the infected person.

Fate of Microfilaria within the body of female culex: The microfilaria gather in the stomach of the mosquito. They cast off their sheath and penetrate through the gut wall to reach the thoracic wall and wing muscles.They undergo two moults and get changed in a sausage shaped body. The first moult occurs in 3-7 days and the second moult in 10-11 days. By 14th day they migrate to proboscis and labium of the mosquito.

Transmission of microfilaria in the body of human being: During mosquito bite they are deposited in pairs on the skin near the bite wound. They penetrate in human body through the wound to reach blood stream. They finally settle in inguinal, scrotal and abdominal lymphatics where they as adults in 5-18 months.

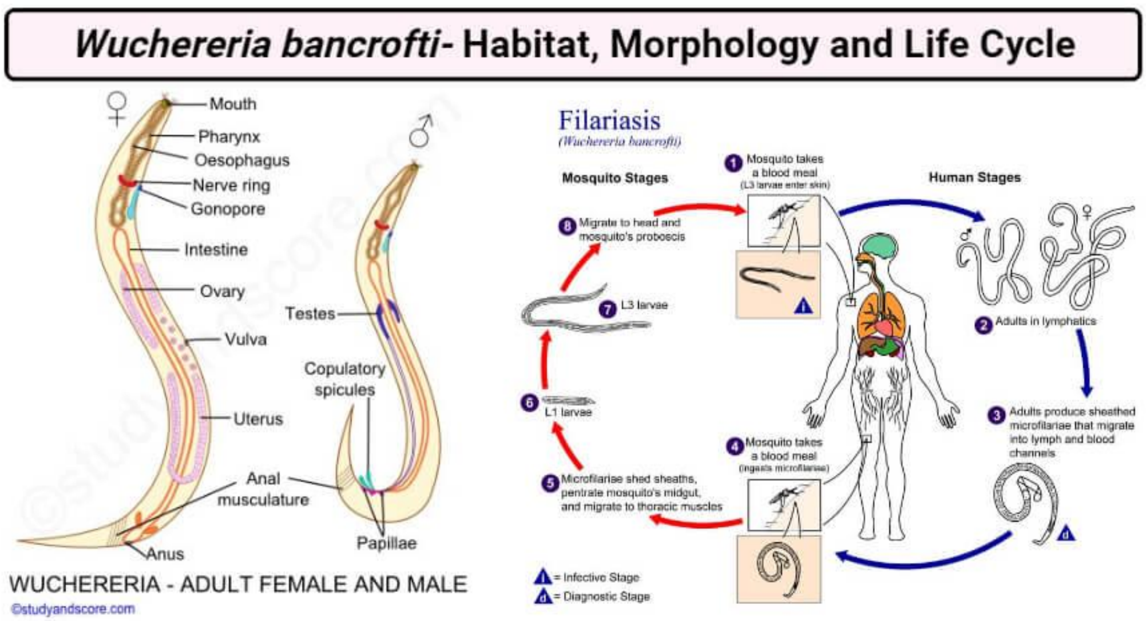

Fig. 7.2: Life cycle of *Wuchereria*

Source: https://microbenotes.com/wuchereria-bancrofti-habitat-morphology-and-life-cycle/

Pathology of infection:

The adult worms causes inflammatory reaction within the lymphatic system known as lymphagitis. It shows allergic manifestations like utricaria and fugitive swelling which show raised, painful tender red areas of skin and lymphoedema known as filariasiss or elephantiasis which is caused by mechanical irritation, liberation of metabolites, absorption of toxic products and bacterial infection.

Treatment includes use of arsenical preperations like Mel w for treating adult worms, heterazon for microfilariae and paramelaminyl- phenyl stibonate (MSB) for infective larvae.

Prophylaxis includes destruction of mosquitos treatment of carriers by heterazon and protection against mosquito bite.

SAQ-2

- The phylum Nematoda is characterized by their cylindrical shape, four internal longitudinal ………………………..
- Ancylostoma Prolonged infection causes ………………………., mental and physical deficiency and lowered immunity.
- Phylum nematode divided into two class ……………. and ………………
- Aphasmida is divided into two orders ……………. and …………….

7.7 Classification, Life cycle of *Dracunculus*

Classification

Phylum : Nematoda

Class :Phasmida

Order :Dracuncyloidea

Family :Dracunculidae

Genus :*Dracunculus*

Species :*Dracunculus medinensis*

Habit : Parasitic

Primary Host : Human being, horse, dog, cattle

Intermediate host: *Cyclops* sp. (water flea)

Habitat:

In primary host: Subcutaneous connective tissue of arms, shoulder and legs.

In intermediate host: Body cavity.

Morphology:

- Male are markedly smaller than females .
- Anterior end shows a mouth opening surrounded by an internal circlet of 6 labial papillae and an external circlet of 4 double papillae.
- Posterior end in males is conical curved and pointed; in females it is bluntly rounded. In males it bears 10 pairs of genital papillae. Out of them 4 pairs represent preanal and 6 pairs as post anal papillae. A part from them 2 fili form

copulatory spicules of equal size are present,gubernaculum,present.

- Digestive system shows a mouth followed by pharynx without a pharyngeal bulb. It shows narrow muscular anterior region and broad glandular posterior region. It is followed by intestine opening posteriorly by transverse anal present on midventral line.
- Reproductive system in male and female shows typical nemotoda pattern. A mature female shows two uteric forming a continuous tube anteriorly forming a muscular vagina which opens by female gonopore near anterior end on midventral line.
- Copulation occurs when both sexes are young. The male dies and disappears after copulation. In a mature female the uteri remain packed with young worms after about one year.
- Release of young ones: The mature female migrates to more superficial layers of skin mainly in those areas of the human host which frequently come in contact with water as fore and hind limbs. The head end produces a small blister in the epidermis by secreting a toxic substance. Gradually the blister breaks exposing the eulcerous area with a central opening. When the ulcer is douced with water by the host the female contracts convulsively releasing a milky fluid containing the motile larvae in the water. After discharging all juveniles the female shrivels and dies. The released larvae swim freely in water for many days.
- Role of intermediate host: *Cyclops* is a common in habitanl of accumulated fresh water in ponds, pools and ditches. It ingests the larvae released in water. According to some workers the larvae penetrate through the skin of *Cyclops* within the body cavity of *Cyclops* the larva undergoes two moults.
- Transmission of larvae in a primary host: Human beings get the infection of the larvae when they drink the water containing infected *Cyclops* or during mouth washing.
- Fate of larva in human body: The *Cyclops* present in water gets digested in the alimentary canal releasing the juveiles. They migrate to the specific location of deep sub-cutaneous tissue of arms and get established as adult. The route of their migration is not known.
- Zoonosis: The disease is known as Dracuntiasis or Dracunculiasis.

Important symptions: (i) Occurance of very painful state in the arms. (ii) vomiting, diarrhoea, dizziness, asthama and eosinophilia.

Prophylaxis: (i) Provision for safe drinking water. (ii) Educating public about the role of Cyclops in ponds and pools.

Treatment: (i) Drugs used are Niridazole, Mebendazole, Metronedazole (ii) Surgical removal of worm.

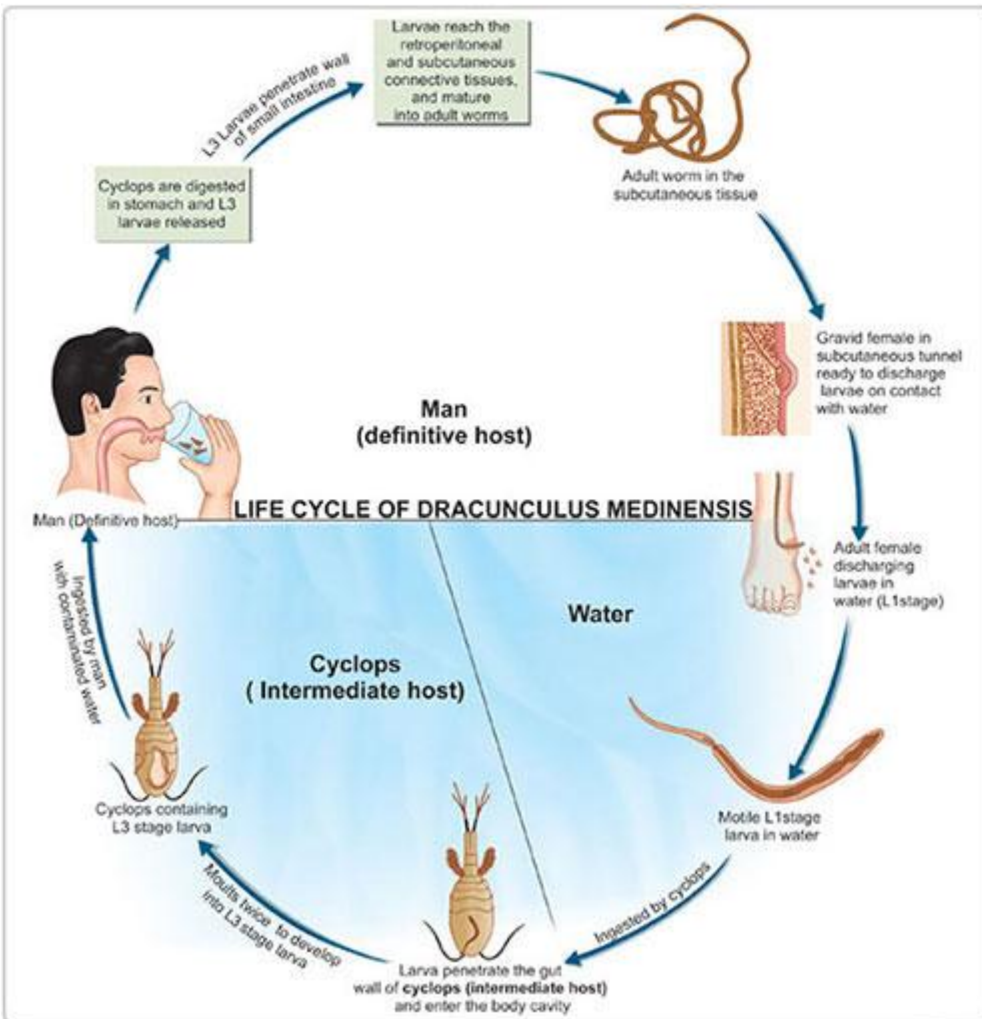

Fig. Classificationand life cycle of *Dracunculus*

Source:https://www.google.com/search?image+Classification+and+life+cycle+of+Dracunculus

7.8 Summary

- Nematoda represents the largest phylum of Pseudocoelomate group including 15000 or more species.

- They show wide distribution in soil, fresh water and sea water. Apart form them they are found as plant and animal parasites. They possess an unsegemented body of varied shape.
- They may show fusiform shape, widest in middle and tapering at both ends or filiform shape being threat like showing uniform diameter.
- The phylum Nematoda is characterized by their cylindrical shape, four internal longitudinal epidermal chords, three angled pharynx, circumentric nerve ring, copulatory spicules, one or two tubular gonads, opening independently in female but in rectum in males.
- The juvenile shows a tapering body whose anterior end remains covered by a hyaline cap. It shows a rudimentary alimentary canal, an excretory pore and a nerve ring.
- The juvenile enters the cavity of duodenum. It enters the duodenal lining to reach the hepatic portal system through which it performs following jourey within the body of host.
- Ancylostoma Prolonged infection causes anaemia, mental and physical deficiency and lowered immunity. The patient becomes sluggish. Penetration of larva in a small area of skin usually causes dermatitis. The damaged sites on the skin may show secondary infection by bacteria and fungi. Poor people moving bare footed are more prone to infection.

7.9 Terminal Questions

Q. 1 Write an essay ongeneral account of phylum nematoda.

Q. 2 Write an essay on classification of phylum nematoda.

Q. 3 Write an essay on classification, life cycle of *Ascaris.*

Q. 4Describe in details Classification, Life cycle of *Ancyclostoma.*

Q. 5Describe in details classification, life cycle of *Wuchereria.*

Q. 6Describe in details Classification, Life cycle of *Dracunculus.*

7.10 Answers

SAQ-1

- Pseudocoelomate
- plant and animal parasites
- unsegemented
- tapering at both ends

SAQ-2

- epidermal chords.
- anaemia

- aphasmida and phasmida
- Enoploidae and Dorilaimoidea

Unit-8 Host Parasites Relationship in Nematode

Structure

8.1 Introduction

Objectives

8.2 General Characteristics and Classification of Phytoparasitic Nematodes

8.3 Concept of Plant Diseases

8.4 Effect of Abiotic Factor in Nematode Multiplication

8.5 Host Parasites Relationship

8.6 Mechanism Involved in Injury Histopathology of Infected Tissue in Nematodes

8.7 Summary

8.8 Terminal Questions

8.9 Answers

8.1 Introduction

The plant parasitic nematodes often cause severe damage to cultivated crops, but their role as a limiting factore in agricultural production has not yet been established. These organisms are also called thread worms, eelworms, roundworms etc. These mostly inhabit the soil in association with the roots of plants. A few species feed on the aerial parts of plants as well.

Unlike insects and other disease-causing agents like bacteria, fungi and viruses, nematode populations increase rather slowly, and the diseases caused by them are not of sudden epidemic type resulting in obvious destruction of the crop over vast areas in a matter of days, but cause slow decline in yields spreading over years. Symptoms of nematode diseases are not easy to detect.

The life cycle of a plant-parasitic nematode has six stages: egg, four juvenile stages and adult. Male and female nematodes occur in most species, but reproduction without males is common, and some species are hermaphroditic. Egg production by the individual completes the cycle. Most species produce between 50 and 500 eggs per female, depending on the nematode species and their environment, but some can produce more than 1,000 eggs. The length of the life cycle varies considerably, depending on nematode species, host plant, and the temperature of the habitat. During summer months when soil temperatures are 80 to 90°F, many plant nematodes complete their life cycle in about four weeks.

Objectives

After studying this unit you should be able to know-

- Concept of plant diseases.
- Host parasites relationship in nematode
- Injury histopathology of infected tissue in nematodes

8.2 General Characteristics and Classification of Phytoparasitic Nematodes

The distribution of nematodes within any site is **very irregular,** so the shape, size and distribution of areas with the most severe effects of nematodes will be erratic within the field. Nematodes move very few feet per year on their own. In the undisturbed soil of groves, turf and pastures, visible symptoms of nematode injury normally appear as **round, oval or irregular** areas that gradually increase in size year by year.

In cultivated land, nematode-injured spots are often **elongated in the direction of cultivation** because nematodes are moved by machinery. Erosion, land leveling, and any other force that moves masses of soil or plant parts can also spread a nematode infestation much more rapidly than it will go by itself. Nematode damage is often **seen first** and most pronounced **in areas under special stresses** , such as heavy traffic, excessive drainage because of slope or soil and dry areas outside regular irrigation patterns.

General Characteristics of Phytoparasitic Nematodes

- Mostly parasitic, elongated worms measuring 0-3 mm to 5-0 mm. Anterior end is provided with oval aperture bounded by lips and a stylet or spear like a sharp pointed tube.
- These are obligate parasites and feed only on the living plants. In the male, the anus serves as a reproductiive aperture. The female reproductive apearture is distinct and ventral in position.
- The development of phytoparasitic nematodes is of simple type. They undergo a series of divisions to form first stage larvae, moult within the eggs and the second stage larvae emerge out from the eggs.

The second stage larvae resemble the adults except for their samaller body size. The second stage larva starts feeding on living plants, undergoes three moults and attains mature adult stage.

Classification of Phytoparasitic Nematodes

The nematode parasites of plants can be classified as follows-

- **Ectoparasites**

These are external feeders and do not enter the plant tissue. They feed on the cells of small roots near the root cap and may cause death of cells resulting in collapse of tissues.

Examples: Spiral nematodes (*Helicotylenchus*), lance nematodes (*Hoplo-laimus*), rind nematodes (*Criconemoides*) and stunt nematodes (*Tylenchor- hynchus*).

Some ectoparasites cause small galls on the roots, eg. sheath nematodes (*Hemicycliophora*) and dagger nematodes (*Xiphinema*).

Some parasitic nematodes feed on the leaves and flower buds.

- **Semi Endoparasites**

The citrus nematode (*Tylenchulussemipenetrans*) and the reniform nematode (*Rotylenchulusreniformis*) are the examples of this category. Both these nematodes are widely distributed in India and cause lot of damage to the host plants. While the citrus nematode is specific to citrus, the reniform nematode infests a variety of crops like millets, pulses, cotton, castor, vegetables, chillies, potato etc.

- **Endoparasites**

These are internal parasites and cause some of the most destructive crop pests known. These belong to the order Tylenchida. This order is characterised by the presence of a head composed of six fused lips, incospicuous amphids, a well developed oesophageal bulb, annulated cuticle and an excretory pore.

SAQ-1

- The life cycle of a plant-parasitic nematode has ………….. egg, four juvenile stages and adult.
- Male and female nematodes occur in most species, but reproduction without males is common, and some species are …………...
- Plant nematodes are tiny worms usually 0.25 mm to 3 mm long and ……………, …..the head and tail.
- Females of a few species lose their worm shape as they mature, becoming pear-,

……………….. shaped.

- Plant parasitic nematodes possess all of the major organ systems of higher animals except ………….. and ………….. systems.

8.3 Concept of Plant Diseases

The characteristics of the important genera are--

(i) **Root-knotnematodes** ***(Meloidogyne sp***.)-These show marked sexual dimorphism. Veroniform males have a well-developed oesophagus but no bursa. The females are swollen and flask-shaped, with two ovaries and an anus. The eggs are deposited in a mass within the root galls.

The first stage larva which is found inside the egg-shell, and the second stage larvae are the infective stages. On entering a young root, the larva begins to feed and grow, hardly showing any movement, except that of the head while feeding. During its development, the larva becomes swollen, It first becomes flask-shaped and after several moults develops into an adult

The nematodes produce galls on roots which block the flow of water and food through the roots and the plants show symptons of starvation. These cause considerable damage to crops like tomato, brinjal, bhindi, cucurbits, banana, citrus etc

(ii) **Cyst forming nematodes (*Heterodera spp*.)-** These resemble Meloidgyne in morphology These form pear-shaped cyst containing embryonated eggs. The cysts may remain dormant in the soil for several years. The second stage larva constitutes the motile infective stage and the subsequent development takes place within the roots of the host plant

Because of their attack, the roots proliferate into a shallow bushy system with circular or oval patches, the plants exhibiting poor growth. These patches increase year after year, if cropping is continued. These nematodes cause intensive damage to potatoes, pulses, maize, etc

(iii) **Root lesion nematodes (*Pratylenchus spp*.)-** These are internal toot parasites whose adults are migratory in habit and move about through the cortical tissues of the root. These cause extensive injuries in the form ol root lesions, browning and necrosis. Host plants include important cultivated crops such as rice, vegetables, millets, pulses, cotton, sugarcane bananas, citrus, coffee, etc

(IV) **Seed-gall nematodes (*Flower and Seed parasites*)-**These are white tip nematodes of rice, Aphelenchoidesbesseyi. It is a seed-transmitted nematode causing distortion and chaffiness in rice grains. Anguina tritici produces galls in the flowering parts of the host plant. The hard round galls containing nematode larvae replace the seed in the ears These two species cause wide-spread damage to rice and wheat respectively

(v) **Foliarnematodes (*Aphelenchoides spp*.)-**These line as internal parasites of buds and foliage of plants like chrysathemum, strawberry, etc., and cause distortion and crinkling of foliage and leaf spots.

1. Lance Nematode (*Hoplolaimus indicus*)

Distribution and Life Cycle

This parasite has wide spread distribution on a variety of crops like citrus orchards, tomato, brinjal, sugarcane, etc. in Punjab.

The female nematode deposits eggs measuring 72-75µ in length and 30 µ in width. Further development of the egg continues inside the egg. The first stage larva is visible in about 13 days after the deposition of eggs. The larva emerges from the egg when it is in the second stage and starts feeding soon after emergence. To attain full growth, the larva passes through five stages. The life-cycle is completed within 6-15 weeks. The optimum temperature for egg-laying and for the survival of various stages is 30°C. The optimum soil moisture is about 16 percent. Sandy loam soils are more suitable for reproduction.

Damage and Control

The maximum population occurs upto a depth of 15 cm. from the surface. It feeds on root tissues for a short time and then retreats into the soil. The nematode has a high population in tomato fields. It causes stunted growth of plants, yellowing of leaves, disclouration and bunchy appearance of roots, and reduction in yield.

- Rotation with non-host crops.
- Deep ploughing and summer fallow help in reducing nematode population.

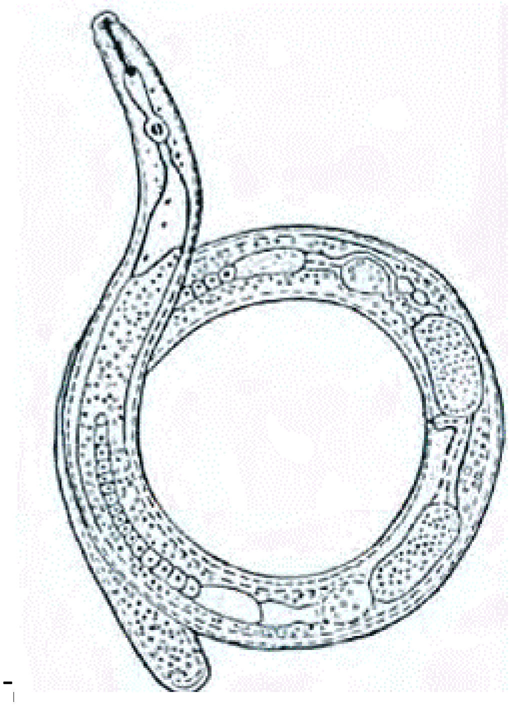

Fig.8.1: Lance Nematode (*Hoplolaimus indicus*)

Source: https://www.google.com/search?q=image+of+Lance+Nematode

2. Potato Cyst Nematode *(Heterodera rostochienensis)*

This is a dreaded pest of Potato but is also found infesting tomato, brinjal and chillies. It is confined to Nilgiri Hills in South and Himachal Pradesh in North. The nematode is an endoparasite.

The infested plants when pulled out show clusters of white and golden spherical bodies attached to the roots and tubers about the size of a sand grain. These are the cysts of mature female bodies. These appear when the crop is 2-3 months old. The cyst contains 200-500 eggs.

Life-cycle

The eggs remain dormont in the cyst. In the presence of the suitable crop, the eggs hatch within the cysts. The young larvae remain within the cysts and moult again before they are set free. By wriggling movements, these reach the roots of the host plant and bore into them near the tip. Here they moult thrice. When full-fed, the males measure about I mm. in length. At this stage, they leave the roots and move around in search of female. The female adults remain attached to roots in the form of white glistening bodies which turn into brown cysts later, each cyst containing 200-500 eggs. The cysts can survive for several years without losing infectivity

Damage and Control

Larvae feed on the juice sucked from the roots. The infestation appears in small patches of prooly growing plants, wilting during hot parts of the day. Heavily attacked piants remain stunted, with dull and unhealthy foliage, poor development of root system and reduced size and fewer tubers.

- The nematode is highly host-specific and, therefore, cultivation of potato, brinjal and chillies should be rotated with a gap of four years with other crops. This keeps the population build up of the nematode to the minimum.
- Vegetable nurseries and other plants meant for transplantation should not be raised in infested land.
- Application of Fensulfothion or Aldicarb at 10-15 kg/ha and 2-4kg/ha

respectively, just before planting is effective in controlling the pest.

Fig.8.2: Potato Cyst Nematode *(Heterodera rostochienensis)*

Source: https://www.google.com/search?q=image+of+Heterodera+rostochiensis+nematode

3. The Root-knot Nematode (*Meloidogyne incognita*)

The root-knot nematode is distributed throughout India. It is a serious pest of brinjal, tomato and lady's finger.

The root-knot nematode feeds on the roots of the host plants and forms galls. The infested plants remain stunted and show symptoms of yellowing and small ring of leaves and the flowering is delayed.

Life-cycle

The gravid females die inside the galls after laying the eggs there. The eggs are found in clusters of yellowish colour. A single female may lay as many as 700 eggs.

The optimum temperature for the hatching of eggs is 20-30°C. There is no hatching during winter months. In February-March, the larvae are released in the soil on disintegration of root knots. On reaching the host roots, they feed on entering the cortex. The larval stage is completed in 3 weeks and the females reach maturity in 30-33 days. During active period, many overlapping generations are completed on one crop.

Damage and Control

At the site of feeding, the internal tissues of the roots become modified to form galls. Sometimes, the galls also appear on other parts of the plant, which are above the ground. The typical symptoms of the disease caused by this nematode include the discoloration and smalling of the leaves, the stunting of plants and, occasionally, their death. The diseased plants in a field can be spotted quite easily

In general, vegetable crops are highly susceptible to this nematode and suffer maximum damage in all parts of the country, often with complete loss in yield.

- Rotation with non-host crops especailly with cereals.
- Fallowing and deep ploughing 2-3 times in summer months.
- Treatment of nursery beds with nematicides so as to raise nematode-free seeding.

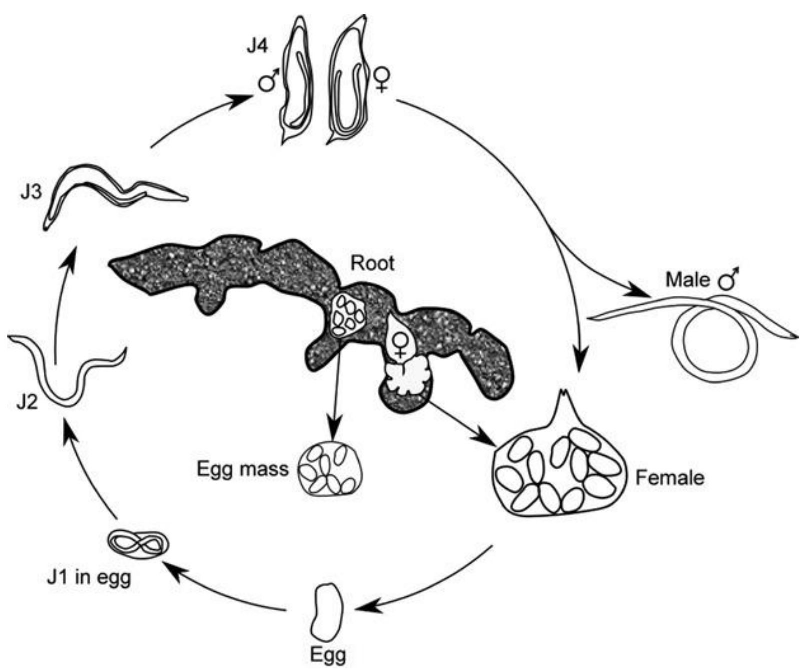

Fig.8.3: Associated bacteria of different life stages of Meloidogyne incognita

Source:https://www.google.com/search?q=image+of+Meloidogyne+incognita+nematode&sca_

8.4 Effect of A Biotic Factor in Nematode Multiplication

The main effect of a biotic factors are -

- **Physical method-**The most commonly used physical methods of nematode control are steam sterilization of soil and hot water treatment of planting material. Hot water treatment is widely used for transplanted crops. Effective time and temperature vary from 240 minutes at 43-3°C to 1 minute at 54-4°C. Usually dormant bulb material like Narcissus, Iris, chrysanthemum, Easter lily and root stocks like citrus, peach etc. are treated against nematode parasites by this method. Hot water treatment of rice seed at 52-55°C for 10-15 mnts is a very effective method to control the white tip nematode.

- **Chemical treatment-**This is by far the most effective method to control plant parasitic nematodes. The most successful nematicides are soil fumigants. The soil should be fumigated at least 2-3 weeks before planting. A mixture of granular type of fumigants and fertilizer should be applied to the field with ploughs. The chemicals which are in liquid form can be incorporated itno the soil with the aid of injectors. The rate of application and amount of chemicals are variable depending upon the degree of infestation and nature of the chemical. The important chemicals used include Dowfume MC-2 (98% Methyl bromide and 2% Chloropicrin), Dorlone (Telone 75-2% and Dowfume W 85-24% by weight).Picfume (Technical Chloropicrin), Nemagon (1, 2-dibromo 3-Chloropane) and D.D. (Dichloropropane-dichloropropene).

- **Biological control-**Plant parasitic nematodes are attacked by a number of parasites and predators. These include the groups of organisms like fungi, protozoa, insects, oligochaetes and nematodes. Certain plants have also been found to be killer of plant parasitic nematodes. For example, the larvae of root-knot nematodes can be controlled by the roots of marigold. But, to date, such control measures remain of academic interest only as very little progress has been made in this direction.

- **Crop rotation-**It is one of the recognised methods of keeping nematode populations under check. la this method, susceptible crops are grown only once in a few years, rotating them with highly resistant varieties of non-host crops. Vegetable crops should not be grown repeatedly in the same field, but she eld be rotated with cereal crops in order to reduce infestation by to nematodes.

- **Summer fallow and ploughing-**Hot dry summer conditions pen inIndia could be made use of for nematode control with very satisfactry results Nematodes are very sensitive to heat and the drying action of the sun and wind Keeping the land fallow during summer months and ploughing the soil deep 2-3 times at intervals of 10-15 days is an excellent method to reduce root-knotnematodes & others to the minimum.

- **Trap Crop-**This method is commonly used to control the infestation due to Heterodera and Meloidogyne spp. The trap crop is planted between two successive host crops. When the trap crop is attacked by maximum number of parasites, the trap crop is removed from the field before the parasite matures and produces eggs for the next generation. In this way, the soil becomes free from parasites.
- **Seed handling-**The nematode galls of wheat get mixed with seed grains. The mixed galls are poured into brine solution and the floating galls are removed with a sieve by repeated stirring of the seeds.
- **Use of resistant and tolerant varieties-**This is one of the most economical and practical methods of controlling nematodes. A number of resistant varities of plants have been evolved in different parts of the world. These include barley varieties (Morocco and Moroccaine), potato varieties (Antinema, Cobra, Ulster, Glade), cowpea varieties (Iron, Clay, Grand), capsicum varieties (Red chilli, mississipi, Nemaheart), tomato varieties, etc.

8.5 Host Parasites Relationship

- When a parasite gains access to a host, the host has to compromise, and the parasite has to adopt itself in host environment. In this way host and parasite establish a sort of relationship which effects each others growth, metabolism, etc.
- In general the series of events that constitutes the relation of host and parasite may be considered as beginning with the transmission of parasite from one host to another, then follows the distribution and localization of parasite on or within the host, then growth or multiplication of parasite, the resistance of host to the parasite and the parasite to the host.
- The method of attack of parasite, changes in host brought about by parasite and those in parasite due to residence in host. Host parasite adjustments during the infection, the escape of infective stages of the parasite from the host and then

the recovery or death of host.

In the host-parasite relationship, we can identify two categories of bio-physiological function. These are:

(a) Parasite invasiveness which is aimed to obtain entry into the host and continue its life within the host, and

(b) Host resistance which tends to prevent the invasion of parasite and its colonization.

In a host-parasite relation we can see that both these functions counter each other thereby acting as a check to maintain balance in the host parasite relationship.

SAQ-2

- Ectoparasitic nematodes feed on ……………….. from outside the plant
- Endoparasitic nematodes feed ………………...
- Ectoparasitic nematodes, which never enter roots, may be recovered only from ………………..
- Foliar nematodes (*Aphelenchoides* spp.) are ……………….. nematodes that feed on or inside the leaves and buds of ferns.
- Some nematodes that attack plants above ground, but are not common in Florida, cause leaf or ………………...

8.6 Mechanism Involved in Injury Histopathology of Infected Tissue in Nematodes

- Histopathological studies of nematode-infected tissues reveal a complex interplay of cellular and molecular mechanisms. Nematodes are parasitic organisms that invade various tissues of plants and animals, causing a range of structural and functional changes.
- The pathogenesis involves direct mechanical damage, immune responses, and biochemical alterations in the host tissue.
- Nematodes often cause mechanical damage to tissues as they penetrate, migrate, and establish themselves in the host. This process involves:
- Parasitic nematodes use their stylets (in plant-parasitic nematodes) or specialized buccal structures (in animal-parasitic nematodes) to penetrate host

tissues.

- In plants, root-knot nematodes (Meloidogyne spp.) and cyst nematodes (Heterodera spp.) pierce cell walls, leading to cell rupture and necrosis. The destruction creates pathways for secondary infections by fungi or bacteria.
- In animals, hookworms (Ancylostoma spp. and Necator spp.) penetrate the intestinal mucosa, causing local bleeding and ulceration.
- Nematodes feed on host cells, often killing them in the process. This direct cell destruction contributes to tissue injury.
- For example, in plants, giant cells or syncytia form at nematode feeding sites, disrupting normal cellular architecture and nutrient transport.
- Migration of nematodes through host tissues leads to structural disruption, including tearing of fibers, loss of tissue integrity, and hemorrhages in animal hosts.
- The immune response plays a significant role in tissue injury during nematode infections. While these responses aim to control the infection, they often lead to collateral damage to host tissues.
- Inflammatory cells, such as neutrophils, macrophages, and eosinophils, are recruited to the site of infection.
- Inflammatory mediators (e.g., cytokines, chemokines, and reactive oxygen species) released during this process can cause oxidative damage to surrounding tissues.
- In the case of filarial nematodes, granulomatous reactions around dead or dying worms result in fibrosis and tissue scarring, as seen in lymphatic filariasis.
- In some cases, nematode infections trigger hypersensitivity reactions, particularly in response to secretory or excretory antigens.
- For example, allergic-type reactions involving mast cells and IgE antibodies occur in ascariasis, leading to localized swelling and pruritus.
- Nematode-secreted products can induce apoptosis in host cells, contributing to tissue damage. This mechanism is observed in both plant and animal hosts, where the nematode manipulates cell death pathways for its benefit.
- In plants, nematodes such as Meloidogyne spp. induce hypertrophy and

hyperplasia in root cells to form giant cells or galls. These abnormal growths disrupt normal root function.

- In animals, similar cellular responses occur, leading to organomegaly (e.g., hepatomegaly in Toxocara infections).
- Chronic infections often lead to fibrosis, where excessive deposition of collagen replaces normal tissue. For example, in humans, Onchocerca volvulus infection results in de…
- Bacteria and fungi can infect nematodes, causing diseases or manipulating their behavior. These infections often occur in natural ecosystems, agricultural settings, or laboratory conditions. Here are examples of bacterial and fungal infections in nematodes:
- This bacterium is symbiotic with entomopathogenic nematodes like Heterorhabditis bacteriophora. It infects and kills insect larvae after being introduced by the nematode. Occasionally, it can also affect the nematode itself, disrupting its life cycle.
- Bt produces crystal proteins toxic to many nematodes, including Meloidogyne incognita (root-knot nematode). It infects nematodes in agricultural environments as part of biocontrol strategies.
- This nematophagous fungus captures nematodes, such as Caenorhabditis elegans, using adhesive hyphal traps or constricting rings. It infects and digests nematodes as part of its nutrient acquisition.
- This endoparasitic fungus targets plant-parasitic nematodes like Heterodera glycines (soybean cyst nematode). It penetrates the nematode's cuticle, grows inside, and ultimately kills the host.
- These interactions are often studied for their ecological importance and potential use in biological pest control

8.7 Summary

- The life cycle of a plant-parasitic nematode has six stages: egg, four juvenile stages and adult. Male and female nematodes occur in most species, but reproduction without males is common, and some species are hermaphroditic.
- Egg production by the individual completes the cycle. Most species produce between 50 and 500 eggs per female, depending on the nematode species and

their environment, but some can produce more than 1,000 eggs.

- The length of the life cycle varies considerably, depending on nematode species, host plant, and the temperature of the habitat. During summer months when soil temperatures are 80 to 90°F, many plant nematodes complete their life cycle in about four weeks.
- Plant nematodes are tiny worms usually 0.25 mm to 3 mm long (1 / 100 " to 1 / 8 ") and cylindrical, tapering toward the head and tail. Females of a few species lose their worm shape as they mature, becoming pear-, lemon- or kidney-shaped.
- Plant parasitic nematodes possess all of the major organ systems of higher animals except respiratory and circulatory systems. The body is covered by a transparent cuticle, which bears surface marks helpful for identifying nematode species.
- Ectoparasitic nematodes feed on plant tissues from outside the plant; endoparasitic nematodes feed inside the tissues.
- The feeding/living relationships that nematodes have with their hosts affect sampling methods and the success of management practices.
- Ectoparasitic nematodes, which never enter roots, may be recovered only from soil samples.
- Endoparasitic nematodes often are detected most easily in samples of the tissues in which they feed and live (burrowing and lesion nematodes), but some occur more commonly as migratory stages in the soil (root-knot and reinform nematodes).
- Endoparasitic nematodes inside root tissues may be protected from those kinds of pesticides that do not penetrate into roots. Root tissues may also shield them from many microorganisms that attack nematodes in the soil. Ectoparasites are more exposed to pesticides and natural control agents in the soil.
- Foliar nematodes (*Aphelenchoides* spp.) are migratory nematodes that feed on or inside the leaves and buds of ferns, strawberries, chrysanthemums and many other ornamentals. They cause distortion or death of buds, leaf distortion, or yellow to dark-brown lesions between major veins of leaves.
- Other nematodes that attack plants above ground, but are not common in

Florida, cause leaf or seed galls. Still others cause deterioration of the bulbs and necks of onions and their relatives.

8.8 Terminal

Q. 1 Write an essay on nematode parasites of plants and their control.

Q. 2 Write an essay on host parasite relationship in nematode.

Q. 3 Write an essay on effect of abiotic factors in nematode.

Q. 4 Describe in details Mechanism Involved in Injury Histopathology of Infected Tissue in Nematodes.

Q. 5 Describe in details general characteristics features of nematode.

8.9 Answers

SAQ-1

- six stages
- hermaphroditic
- cylindrical, tapering toward
- lemon- or kidney
- respiratory and circulatory

SAQ-2

- plant tissues
- inside the tissues
- soil samples
- migratory
- seed galls

Unit-9 Parasitic Arthropods

Structure

9.1 Introduction

Objectives

9.2 Importance, Biology and control of Ticks

9.3 Classification of *Dermacentor variabilis* (Cattle tick or Hard tick)

9.4 Classification of *Ornithodoros moubata* (Soft Tick)

9.5 Classification of *Sarcoptes scabiei* (Mite)

9.6 Classification of *Pediculus humanus* (Lice)

9.7 Classification of *Xenopsyllacheopis* (Flea)

9.8 Classification of *Cimex lectularis* (Bed bug)

9.9 Summary

9.10 Terminal Questions

9.11 Answers

9.1 Introduction

This unit deals with the importance biology and control of Ticks which are significant parasites mainly of mammals. Ticks are members of family Ixodidae of the order Acarina of subclass Euarachnida of the order Arachnida belonging to phylum Arthropoda. They show indistinct segmentation in which first six segments form prosoma and vest pegments as opisthosoma. A hard chitinous shield (scutum) covers the whole dorsal surface in males but only a small portion behind head in larva, nymph and females. They posses one pair of spiracles which perform air breathing. This unit also covers the classification, habit, hosts, distribution morphology like cycle zoonosis and prevention and control of Arachnid parasites like Hard tick (*Dermacentor variailis*) soft tick (*ornithodoros moubatala*), Mite (*Sarcoptes scabies*) and Insect parasites like (*Pediculus humanus*), flea (*xenopsylla cheopis*), bed bug (*cimex lectularis*).

Objectives

After studying this unit you should be able to know-

- Classification of *Dermacentor variabilis* (Cattle tick or Hard tick)
- Classification of *Ornithodoros moubata* (Soft Tick)
- Classification of *Sarcoptes scabiei* (Mite)
- Classification of *Pediculus humanus* (Lice)
- Classification of *Xenopsylla cheopis* (Flea)
- Classification of *Cimex lectularis* (Bed bug)

9.2 Importance, Biology and control of Ticks

Ticks are members of family Ixodidae of the order Acarina of subclass Euarachnida of the order Arachnida belonging to phylum Arthropoda. They show indistinct segmentation in which first six segments form prosoma and vest pegments as opisthosoma. A hard chitinous shield (scutum) covers the whole dorsal surface in males but only a small portion behind head in larva, nymph and females. They posses one pair of spiracles which perform air breathing. The first pair of afterdays is known as chelicerae while the second pair as pedipali. The one pair of eyes lies on lateral margin of scutum. The female undergoes egg laying in sheltered spots giving birth to a large number of eggs in one batch. The egg forms a larva with 6 legs. The larva mouths to form a nymph which is similar to the adult but with smaller size and rudimentary reproductive system. Instar undergoes three mouths during which it sheds the exoskeleton which is replaced by a new one in the next instar.

Ticks are ectoparasitic on mammals including human beings. They are of 3 kinds as under.

(i) One host tick shows all its 3 instars engorge on the same host.

(ii) Two host tick: In such a case the larva engorges and mouths on a host. The nymph drops and moulths on the ground. The imago so formed seeks a new host.

(iii) Three host tick: In such a case every instar requires a different host, every time drop on the ground and moult.

On the basis of seutum the ticks are of two kinds.

(i) Hard tick which possesses a marked seutum.

(ii) Soft tick which lacks a scutum.

During feeding they bury their mouth parts deeply in the host tissue and remain attached until fully fed. They such the blood and lymph of the host.

Important genera of ticks are *Ixodes, Boopphilus, Margoropas, Dermacentor* and *Hyalomma.*

Ticks are harmful to their hosts in following ways.

(i) Their bite injury may predispose the host by the attack of blow flies, screw worm flies and lriting flies.

(ii) They transmit virus, bacteria and protozoa on to the host.

(iii) As they such the blood, the host bears a marked loss of blood. As single adult female sucks 0.5 to 2.0 ml. of host blood, infection of several thousands ticks leads to huge loss of blood which may lead to the death of the host.

(iv) Infection of a few hundred ticks causes “Tick worry” to the host including irritation by bite, skin infection, blood loss and secondary attach by flies.

(v) Infection in sever state causes “Tick paralysis” which is due to the injection of toxins by certain developmental stages of ticks. It is a motor paralysis which bynis from hind limbs and spreads to whole body. Such a toxic is produce by a particular glandular acinus of salivary gland of female tick which has fed for several days. This toxin is similar to snake poison. The toxic leads to diversative changes in medulla and spinal cord leading to ultimate death of the host.

The control measures of tick infection are directed against the diseases of which the ticks are vectors. Hence they are based on habits of the ticks. As the ticks get attached to the whole body of the host it is made to dip in a suitable tank containing aqueous solution, suspension or emulsion. As various stages of ticks stay on their host for only a few days the dipping should be planned with the knowledge of the biology of the tick species. The dipping can also be replaced by spraying.

For the purpose of control one should know if the species passes its life cycle in one host or two hosts or three hosts. One host tick is easier to control. For controlling the tick infection.Acaricides like BHC and Toxaphane are commonly used. During this process one should know if the a caricide is effective on to which stage of life history of tick for example the adults of *Buphilus decoloratus* show resistance to Toxaphane but on its larvae this Acaricide is very effective. Organophorus and carbamate innecticides are also commonly used.

Two or three host ticks spend a long period of their life cycle on pastures. For controlling such ticks following measures are commonly used:

(i) Burning of pastures kill a large number of larvae and nymphs of the tick species whom they are off their host.

(ii) When the pasture is exposed to bright sunnlyt or deep ploughing is done the eggs of the tick species due.

(iii) Use of repellents like Indalone, Dimethyl phythalate and Rutgers 62 is effective in the control.

(iv) Use of natural enemies like *Ixodiphagus* sp. and *Hunterellus* sp. belonging to insect order.

(v) Hymenoptera are parasitic on tick nymphs.

(vi) Through fumigation of infected buildings with cyacide is very effective for ticks.

SAQ-1

- Ticks are members of family ………… of the order ………… of subclass Euarachnida of the order Arachnida belonging to phylum Arthropoda.
- Ticks are ………… on mammals including human beings.
- On the basis of seutum the ticks are of two kinds. ………… tick and ………… tick.
- The control measures of tick infection are directed against the diseases of which the ticks are ………….

9.3 Classification of *Dermacentor variabilis* (Cattle tick or Hard tick)

Classification

Phylum : Arthropoda

Class : Arachnida

Order :Acarina

Family : Ixodidae

Genus :*Dermacentor*

Species :*Dermacentor variablis*

Habit: It is parasitic

Host:Horse, Dog, Cattle, Sheep, Mice, cats, Rabbitand Humanbeings

Distribution: Commonly found in humid areas round the year, most abundant in spring and summer.

Shape: Chest nut like, with leathery covering.

Colour: Brown to blue gray.

Morphology:

- Head, thorax and abdomen get fully fused. Thus the body appears unsegmented.
- Body is divisible in acapitulum, scutum and opisthoma.
- Capitulam shows a pair of chelicera, a pair of three segmented padipalpi and anterior mouth.
- Opisthoma shows, two eyes, one on each side in anterior region and 4 pair of jointed legs with bristles and anterior mouth. Mouth parts stick out infront of the body.
- Sexual dimorphism occurs. The males possess hard chitinous dorsal shield over opisthoma. In females this shield is absent and thus the opisthoma becomes soft.

Life Cycle:

- The female gets attached at one spot of the host for 5 to 13 days.
- The male visits on 4^{th} to 6^{th} day and performs copulation.
- The female feeds on blood of the host, releases her mouth parts and drops on the ground. It spends about 2 to 4 weeks in some protected place and releases 4000 to 6500 eggs and dies thereafter.
- The round and brownish eggs hatch in 1 to 2 months producing first nymph.
- The 1^{st} nymph is yellow to grey, measuring about 1/40 inches. It shows 3 pairs of legs. It climbs upto the end of grass blade in its viscinity.
- On getting an opportunity it gets attached to some passer by animal and feeds on it blood for 3 to 12 days. When fully fed it drops on the ground.
- In next 1to 30 weeks it undergoes first moult to form the second nymph.

- The 2nd nymph is about 1/16 inches in length showing 4 pairs of legs. It lives in soil for 4 days to one year. It now climbs to the ends of near by grass blades.
- On getting an opportunity it gets attached to some passing animal and feeds on its blood during day time. When fully fed in 3 to 10 days it drops on the ground and undergoes second moult to form the adult which gets attached to a proper host on getting an opportunity.

- The life cycle is completed in 2 to 3 years.

Fig 9.1:. *Dermacentor*

Source: https://www.google.com/search?q=image%20of%20%20%20Dermacentor%20variabilis&udm

Zoonosis:

The ticks transmit following diseases in human beings:

(i) Rocky mountain spotted fever (Tick typhus)

(ii) Tularaemia

(iii) Viral Encephalitis

(iv) Colorado tick fever

(v) Viral haemorrhagic fever

(vi) Tick paralysis

(vii) Babesiosis

These disease are caused by bacterial or viral infection on the wound of human skin.

Prevention and control:

(i) Roaming of pet mammals in moist areas where grass in abundant should be avoided.

(ii) The body of such mammals especially the hair of head should be frequently examined and tick be removed.

(iii) Pet dogs should be treated with 4-5% rotenon dust to kill the ticks on their body. They should be washed with 4-5 ounses of rotenon powder with one ounce of soap and one gallon of water every 5^{th} day.

(iv) Tincture of iodine should be injected in the wound made by the tick.

(v) The blood of the crushed tick should not come in contact with eyes or scratches on the skin.

(vi) Spraying of DDT, Toxophane, Chlordane, Dieldrin or Diazinon should be sprayed 0.5@lb/acre in the field.

9.4 Classification of *Ornithodoros moubata* (Soft Tick)

Classification

Phylum : Arthropoda

Class : Arachnida

Order :Acarina

Family :Argasidae

Genus :*Ornithodoros*

Species :*Ornithodoros moubata*

Habit : It is Parasitic

Host : Tortoise, Birds, domestic and wild mammals (bats) and human beings.

Distribution: Commonly found in native huts and in sand under trees.

Shape: Chest nut like.

Morphology:

- Head, thorax and abdomen get fully fused hence body appears unsegmented.
- Body shows absence of scutum

- Mouth parts lie on underside of the body.
- Eyes are absent but in *ornithodoros savignvi* they are present.

Life cycle:

- The female lays batches of 100 eggs in the sand.
- The larvae moult in the eggs.
- The nymphs perform hatching; several nymphal instars are passed through.
- The nymphs and adults attach to their host for a short period for feeding on the blood. They normally bite during night.
- The nymphs and adults are very sensitive to climate changes which affect their life.

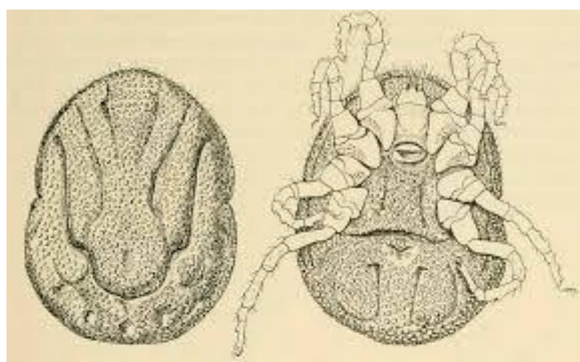

Fig.9.2: *Ornithodoros moubata*

Source:
https://www.google.com/search?q=image%20of%20%20%20Dermacentor%20variabilis&udm

Zoonosis:

- In south west Africa it feeds on sheep at their resting places.
- It is the only vector of *Borrelia duttoni* which causes African relapsing fever in human begins.
- It is the vector of Q fever, lyme disease and TBRF.

9.5 Classification of *Sarcoptes scabiei* (Mite)

Classification

Phylum : Arthropoda

Class : Arachnida

Order :Acarina

Family :Sarcoptidae

Genus :*Sarcoptes*

Species :*Sarcoptes scabiei*

Habit : It is Parasitic on skin making horizontal or tortuous burrow in hairy parts of legs.

Host : Horses, cattle, sheep, rabbit, squirrel, cat, fox and human being.

Location of attack: In between fingers, wrist, elbows, back of knee, ankle, toes and external genitalia.

Shap: Roughly circular.

Size: Males measure 200μ. to 240μ.$\times$ 140$\mu$to 200μ.

Females measure 330μ.to 600$\times$ 250μ. to 400μ.

Morphology:

- Head, thorax and abdomen remain fused forming a unsegmented body.
- Dorsal surface remains covered with fine folds and transverse grooves. It bears triangular seales, spines and cones. Ventral surface smooth with some bristles.
- In females on either side of midline three short spines and posteriorly six longer spines are present.
- Jointed legs present in four pairs; the third and fourth pair do not project beyond the margin of body.

Life Cycle:

- The female burrows in the skin and lays 40-50 eggs in the tunnel.
- The eggs hatch in 3 to 5 days to produce a six legged larva. Some larvae escape from the tunnel and move about in the skin, while others remain in the tunnel to continue the development as two successive nymphal stages.
- The nymphsposses four pairs of legs but no genital opening. They give rise to adult males and females in six to eight days.
- After copulation the male dies and the female begins egg laying after 4-5 days.

It lives for about 3-4 weeks.

- The mites are very susceptible to dryness. They can not live more than a few days without their host.

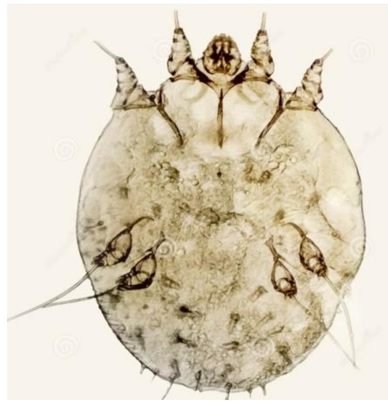

Fig. 9.3:*Sarcoptes scabiei*

Source: https://www.google.com/search?q=image%20of%20%20%20Dermacentor%20variabilis&udm

Zoonosis:

- These parasites pierce the skin of host to suck lymph and feed on epidermal cells. It produces marked irritation and intense sitching and scratching. The inflammation of skin leads to the release of an exudates which coagulates and forms crusts. It leads to excessive keratinization and proliferation of connective tiesue. Thus the skin becomes much thickened and wrinkled showing loss of hair. The disease in known as mange or scabies. The infection may spread to the whole body.
- The mange of horse may spread to human begins causing "cavalary man's itch."
- Sites of leisons: In human beings the infection is seen in hands, wrist, elbow, axillae, buttocks, lower abdomen, feet, ankle, palm in infants, breast in women and genitals.
- Modes of spread: The infection spreads by close contact of an infected person as sleeping on the same bed, playing together and nursing of the infected person and use of contaminated clothes.

Prevention and control:

(i) All members of the affected house must be treated with through washing with soap and hot water.

(ii) 25% Benzylebenzonate should be applied all over the body and should be allowed to dry. This application must be repeated after twelve hours after which a bath should be given. Only two such application per week are recommended.

(iii) 0.5% to 1.0% Lindane in coconut oil, vegetable oil and cream should be rubbed on affected part at interval of 2 to 3 days.

(iv) 5% solution of Tetmosol should be applied thrice a day.

(v) 2.5% to 10% sulphur ointment should to used for 4 days.

(vi) All infected premises should be cleaned out and disinfected by spraying BHC solution or lime sulphur dip and are left unused for 14 to 17 days.

SAQ-2

- Controlling the tick infection. Acaricides like ………… and ………… are commonly used.
- ………… are parasitic on tick nymphs.
- Through fumigation of infected buildings with ………… is very effective for ticks.
- Use of natural enemies like ………… sp. and *Hunterellus* sp. belonging to insect order.

9.6 Classification of *Pediculus humanus* (Lice)

Classification

Phylum : Arthropoda

Class :Insecta

Sub class :Pterygota

Order :Anopleura

Genus : *Pediculus*

Species :*Pediculus humanus*

Habit :Ectoparasitic on human beings.

Habitat : Present in head region and body, attached to the hair.

Morphology:

(i) Body is small, wingless and darsoventrally flattened.

(ii) It is divisible in a head, thorax and abdomen.

(iii) Head pointed anteriorly. It bears a pair of short 5 segmented antennae, 2 pigmented eyes and sucking type of mouth parts.

(iv) Thorax small with 3 fused segments. It bears 3 pairs of legs of the same size having slender claws in the tarsi. Hair of the host is held between the claw and a thumb like process on ventral apical angle of tibia known as tibal pad. It locks the grip of the hair.

(v) Abdomen relatively large with 7 of the 9 visible segments. Segments bear dark brown or black areas of thick chitin known as paratergal plates.

(vi) One pair of spiracle is present in mesothorox and 6 pairs present in abdominal region.

Life cycle:

(i) Single host (Human being) harbours the complete life cycle.

(ii) Eggs operculate; they remain cemanted with the hair of host.

(iii) Metamorphosis absent as the egg gives rise to first nymph which undergoes two successive moults forming second and third nymph which gives rise to the adult.

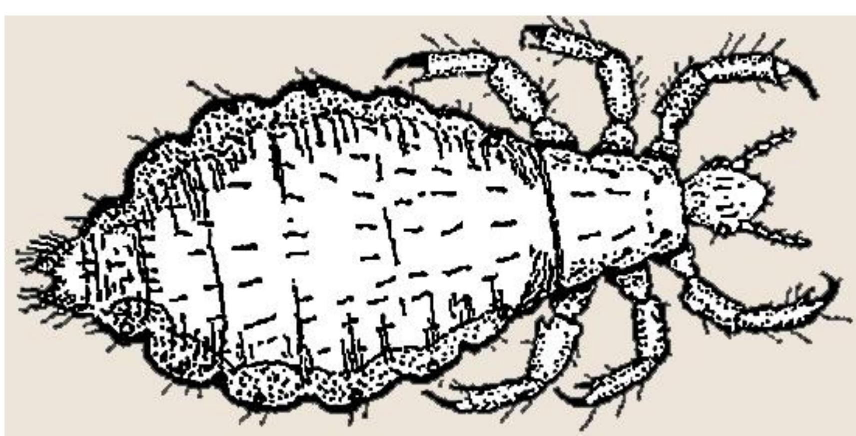

Fig.9.4: *Pediculus humanus*

Source:
https://www.google.com/search?q=image%20of%20%20%20Dermacentor%20variabi

Transmission:

The parasite gets transmitted from one host to the other by close contact.

Zoonosis:

- They cause irritation mainly during winter because of longer hair and lac of general vigour.
- Scratching may produce wounds or bruises.
- Sever irritation may cause matting of hair.

Control Measures:

1. For body louse use of 10% DDT powder is recommended.
2. For head louse a mixture of 68% Benzylebenzonate, 6% DDT, 12% Benzocaine and 14% Tween 80 is sponged on the head after which no bath should be taken for 24 hours.

9.7 Classification of *Xenopsylla cheopis* (Flea)

Classification

Phylum : Arthropoda

Sub Phylum :Mandibulata

Class :Insecta

Sub class :Pterygota

Order :Siphonoptera

Genus :*Xenopsylla*

Species :*Xenopsylla cheopis*

Habit: Note a permanent parasite, not very specific for its host, may attack other hosts for blood sucking and feeding on faeces and organic matter.

Morphology:

1. Body small, strongly compressed laterally.
2. Size 1.5-4mm in length.

3. Body covered with thick chitin of dark brown colour.
4. Body divided in head, thorax and abdomen.
5. Head very small with simple paired eyes and a pair of short clubbed antennae sunken in antennal grove on the side of head, it shows absence of pronotalctenidia (spines).
6. Thorax with 3 segments (pro, meso and metathorax). They are much wider than the first abdominal segment. It bears 3 pairs of long and strong legs adapted for leaping.
7. Abdomen shows 10 segments. In both male and female 9^{th} abdominal segment bears a dorsal plate known as sensitium or pygidium which shows sensroy setae. In males the tergum of this segment is modified to form claspers. The male copulatory organ (penis) is chitinous and coiled with complex structure. The last (10^{th}) abdominal segment shows two hooked processes, known as anal struts,for attachment.

Life cycle:

1. The female lays 20 eggs at a time producing 400-500 eggs in whole lifetime.
2. Eggs 0.5mm long, oval, white and round at poles. They are deposited on host body, dust or dirt. They are not sticky.
3. Hatching of eggs occurs in 2-16 days. It is done by a chitinous spine on the head of first larval instar, which breaks the egg shell.
4. Metamorphosis complete.
5. Larva elongate, slender, maggot like with three thoracic and 10 abdominal segments showing a few long hair. It is very active but avoids light.
6. Last instar spins a cocoon in which the pupa remains present. At one stage upon getting converted in adult it breaks open the cocoon to lead a normal life.
7. Development favours moderate temperature and high humidity.

Fig.9.5: *Xenopsylla cheopis*

Source:
https://www.google.com/search?q=image%20of%20%20%20Dermacentor%20variabilis&udm

Pathogenesis:

(1) It makes the infected host restless performing intense itching spoiling the hair coat.

(2) Bitten spot shows ischaemia surrounded by elevated red oedema which may persist for many days.

(3) Its saliva gets fixed on host skin and later becomes an antigen.

(4) It transmits Bubonic plague caused by the bacteria *Pasteurlella pastis*

(5) During feeding its chitinous teeth of proventriculus get blocked with blood and plague bacilli. Thus it remains unable to feed hence wanders from one host to the other, contaminating them with the plague bacilli.

Control:

1. It is done by the used of pyrethrum and rotenone which kill the flea present on the host.
2. DDT (5% dust) and bite (0.01% gamma isomer dust is used.
3. Use of malathion (4% dust or 2.5% spay) is used to eradicate the fleas.

9.8 Classification of *Cimex lectularis* (Bed bug)

Classification

Phylum : Arthropoda

Class :Insecta

Sub class :Pterygota

Order : Hemiptera

Genus : *Cimex*

Species : *Cimex lectularis*

Habit :Ectoparasitic and nocturnal

Habitat: Found in human dwelling mainly during damp season, commonly found in crevices of beds, chairs of cinema halls and other such places.

Behaviour: They like odour of human body and feed on human blood mainly during sleeping hours. They can survive without food for months.

Morphology:

- The body is oval and darsoventrally flattened. In remain covered with spinose bristles.
- It is divided in a head, thorax and abdomen.
- Head is short and broad. It shows a pair of 4 jointed antennae and a pair of compound eyes.
- Mouth parts are of piercing and sucking type. They consist of labrum, labium, paired mandibles and maxillae. Labium forms the rostrum is the form of a hollow tube bearing a needle like stylet having two channels. Through the vental channel the saliva is released and through the dorsal channel the blood is sucked when the needle is injected on human skin.Before its action the mandibular stylet punctures the skin and maxillary stylets are thrust in the wound.
- Thorax shows large prothorax and small mesothorax and metathorax. It shows 3 pairs of clawed legs. It shows ventral thoracic stink gland.
- Abdomen shows 8 visible segments. In females it is broad and round while in males it bears a curved hook like clasper. Abdomen shows dorsal abdominal gland. The thoracic and abdominal glands give peculiar odour.

Life History:

- After copulation female gives rise to above 200 eggs, laying 2 or 3 eggs per day in the crevices of chairs, beds an under mattresses

- Eggs one mm long creamy white, operculate with thick rim at one pole.
- Hatching occurs in about a week giving rise to very small nymph which feeds on blood present in body of older bugs in the absence of human host. Five successive nymphal stags one after the other. 5th nymph forms the adult.

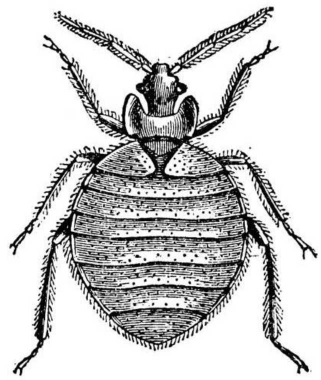

Fig.9.6: *Xenopsylla cheopis*

Source: https://www.google.com/search?q=image%20of%20%20%20Dermacentor%20variabilis&udm

Zoonosis:

- Bed bugs cause irritation during bite and blood sucking which result in sleeplessness of the affected human host.
- They serve as transmitting agents of kala Azar, Plague, Typhoid and Relapsing fever.

Control:

- Lindance, Chlordane and Dieldrin are used as powders, sprays and smokes to kill these insects.
- 5% emulsion or solution of DDT to base board crevices beds and mattresses is used to kill these insects.
- 0.5% to 1% malathion are Diazinon is used in the form of dust is used when the insects show more resistance.

9.9 Summary

- Ticks are members of family Ixodidae of the order Acarina of subclass Euarachnida of the order Arachnida belonging to phylum Arthropoda.

- Ticks are ectoparasitic on mammals including human beings
- On the basis of seutum the ticks are of two kinds. (1)Hard tick which possesses a marked seutum. (2)Soft tick which lacks a scutum.
- The control measures of tick infection are directed against the diseases of which the ticks are vectors.
- Controlling the tick infection. Acaricides like BHC and Toxaphane are commonly used.
- Hymenoptera are parasitic on tick nymphs.
- Through fumigation of infected buildings with cyacide is very effective for ticks.

9.10 Terminal Questions

Q. 1 Write an essay on Classification of *Dermacentor variabilis* (Cattle tick or Hard tick).

Q. 2 Write an essay on Classification of *Ornithodorosmoubata* (Soft Tick).

Q. 3 Write an essay on Classification of *Sarcoptes scabiei* (Mite).

Q. 4 Describe in details Classification of *Pediculus humanus* (Lice).

Q. 5 Describe in details Classification of *XenopsyllaCheopis* (Flea).

Q. 6 Describe in details Classification of *Cimexlectularis* (Bed bug).

9.11 Answers

SAQ-1

- Ixodidae, Acarina
- ectoparasitic
- Hard and Soft
- vectors.

SAQ-2

- BHC and Toxaphane
- Hymenoptera
- cyacide
- *Ixodiphagus*

UNIT 10 PARASITE VERTEBRATES

10.1 Introduction

Objective

10.2 Cookie cutter shark

10.3 Hood Mocking Bird

10.4 Vampire Bats and their parasitic behaviour and effect on host.

10.5 Summary

10.6 Terminal Questions

10.7 Answers

10.1 Introduction

Parasitic diversity is also observed in higher animals also. It starts from Pisces to Mammals. Although the majority of parasites in the world are invertebrates, it should be of no surprise that parasitism has arisen within the Vertebrates as well. Classic examples include the remora, which attach to sharks and rays, the jawless fishes (lamprey and hagfish) which prey upon other fish, vampire bats, and brood parasitism among birds. However, additional examples of parasitism within the Vertebrates exist. Some examples of parasitic chordates are remoras (which attach to sharks and rays); the jawless fishes (lampreys and hagfishes), which prey upon other fishes; some birds that practice brood parasitism; and vampire bats. The Superclass Agnatha has both extinct groups and extant species, including the "jawless" fish (lamprey and hagfish) that lack jaws, paired fins, and scales. The family Petromyzontidae (lampreys) includes about eight genera and forty-two species of lampreys; of these, about eighteen species (forty-three percent) are parasitic. Although most are free-living, the parasitic species attack fish, weakening or outright killing them. Their sucker-like mouth possesses rows of teeth, and the tongue is rasp-like, which helps it bore into the sides of fish and suck out blood, tissue fluid, and/or viscera. One of the most well-known lamprey species is the sea lamprey, *Petromyzon marinus*, native to the Northern Hemisphere. It is considered a major pest in the Great Lakes region. In Arkansas, there are two species of parasitic lampreys, the chestnut lamprey (*Ichthyomyzon castaneus*) and silver lamprey (*I. unicuspis*). The former is found in clear streams of the Arkansas, Buffalo, Caddo, Illinois, Little, Ouachita, Petit Jean, Saline, and White rivers, where they prey upon an abundance of large riverine fishes. Spawning adults can be found in medium creeks to large rivers, and larvae require clear streams with permanent flow, stable sand bars, silt, and organic matter. There are three genera and about eight species of parasitic remoras (Osteichthyes: Echeneidae) that occur in the Atlantic, Indian, and Pacific oceans. There are eight genera and thirty-six species of pearlfishes or cusk eels (Ophidiiformes: Carapidae) that live symbiotically within benthic (deep-water) invertebrates. The relationship of the fish to the host is quasi-parasitic; only in a few cases is the association considered overt parasitism. In most cases, the fish either consumes food that could be used by the host or simply takes up space. One representative species is the pearlfish (*Carapus acus*), that resides within the anus of holothurians (sea cucumbers) in the eastern Atlantic. About one percent of all birds (about 103 species) practice brood parasitism. This is a parasitic association where one bird (the parasitic species) lays its eggs within the nest of another bird (the host or foster bird species). The fostering bird then cares for the offspring of the invader. Some species of birds reject the eggs of a brood parasite, whereas others will accept the egg. A number of ducks (family Anatidae) found in Arkansas display various types of brood parasitism, both intra- and inter-specific. One of the most famous brood parasites is the brown-headed cowbird (*Molothrus ater*), which also occurs in the state. Brown-headed cowbirds tend to use neotropical migrant birds as hosts, and parasitism has been so successful that populations of some of these migrants are declining, with up to seventy percent of the nests of some hosts being parasitized. The female cowbird will lay an egg within a nest (usually just before sunrise) after the host has already laid two or more eggs but before incubation has begun. The female cowbird usually removes one or more of the host eggs by piercing the egg with her bill and carrying it away to be eaten. If the cowbird egg is too dissimilar to the host eggs, however, some birds will abandon their nest altogether or remove the cowbird eggs. Although none of the sixteen species of bats (class Mammalia, order Chiroptera) that occur in Arkansas are considered parasitic, the hairy-legged vampire bat (*Diphylla ecaudata*) ranges as far north as extreme southern Texas and does practice parasitism. It tends to be timid and feeds primarily on bird blood.

Objectives

The Study of this unit will help you to:

1- Understand the concept of Cookiecutter shark and their parasitic behaviour

2- Know the behaviour of Hood Mocking Bird

3- Vampire Bats and their parasitic behaviour and effect on host

10.2 Cookiecutter shark

Kingdom: Animalia
Phylum: Chordata
Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Squaliformes
Family: Dalatiidae
Genus: *Isistius*
Species: *brasiliensis*

The cookie cutter shark (*Isistius brasiliensis*), also called the cigar shark, is a species of small dogfish shark in the family Dalatiidae. This shark occurs in warm, oceanic waters worldwide, particularly near islands, and has been recorded from as deep as 3.7 km (2.3 mi). It migrates vertically up to 3 km (1.9 mi) every day, approaching the surface at dusk and descending with the dawn. Reaching only 42–56 cm (17–22 in) in length, the cookie cutter shark has a long, cylindrical body with a short, blunt snout, large eyes, two tiny spineless dorsal fins, and a large caudal fin. It is dark brown in color, with light-emitting photophores covering its underside except for a dark "collar" around its throat and gill slits. The name "cookie cutter shark" refers to its feeding habit of gouging round plugs, like a cookie cutter, out of larger animals. Marks made by cookie cutter sharks have been found on a wide variety of marine mammals and fishes, as well as on submarines, undersea cables, and even human bodies. It also consumes whole smaller prey such as squid. Cookie cutter sharks have adaptations for hovering in the water column and likely rely on stealth and subterfuge to capture more active prey. Its dark collar seems to mimic the silhouette of a small fish, while the rest of its body blends into the down welling light via its ventral photophores. When a would-be predator approaches the lure, the shark attaches itself using its suctorial lips and specialized pharynx and neatly excises a chunk of flesh using its bandsaw-like set of lower teeth. Though rarely encountered because of its oceanic habitat, a handful of documented attacks on humans were apparently caused by cookie cutter sharks. Nevertheless, this diminutive shark is not regarded as highly dangerous.

Taxonomy

French naturalists Jean René Constant Quoy and Joseph Paul Gaimard originally described the cookie cutter shark during the 1817–1820 exploratory voyage of the corvette Uranie, giving it the name *Scymnus brasiliensis* because the type specimen was caught off Brazil. In 1824, their account was published as part of Voyage autour du monde...sur les corvettes de S.M. l'Uranie et la Physicienne, Louis de Freycinet's 13-volume report on the voyage. In 1865, American ichthyologist Theodore Nicholas Gill coined the new genus Isistius for this species, after Isis, the Egyptian goddess of light.

One of the earliest accounts of the wounds left by the cookiecutter shark on various animals is in ancient Samoan legend, which held that atu (skipjack tuna) entering Palauli Bay would leave behind pieces of their flesh as a sacrifice to Tautunu, the community chief. In later centuries, various other explanations for the wounds were advanced, including lampreys, bacteria, and invertebrate parasites. In 1971, Everet Jones of the U.S. Bureau of Commercial Fisheries (a predecessor of the National Marine Fisheries Service) discovered the cigar shark, as it was then generally known, was responsible. Shark expert Stewart Springer thus popularized the name "cookie cutter shark" for this species (though he originally called them "demon whale-biters"). Other common names used for this shark include luminous shark, small tooth cookie cutter shark, and smooth cookie cutter shark.

Common Names: The cookie cutter shark is named after the cookie-shaped wounds that it leaves on the bodies of its prey items. English: Cookie-cutter shark, Cigar shark, luminous shark

Description

The cookie cutter shark has an elongated, cigar-shaped body with a short, bulbously rounded snout. The nostrils have a very short flap of skin in front. The large, oval, green eyes are placed forward on the head, though not such that there is extensive binocular vision. Behind the eyes are large spiracles, positioned on the upper surface of the head. The mouth is short, forming a nearly transverse line, and is surrounded by enlarged, fleshy, suctorial lips. There are 30–37 tooth rows in the upper jaw and 25–31 tooth rows in the lower jaw, increasing with body size. The upper and lower teeth are extremely different: the upper teeth are small, narrow, and upright, tapering to a single, smooth-edged cusp. The lower teeth are also smooth-edged, but much larger, broader, and knife-like, with their bases interlocking to form a single saw-like cutting edge. The five pairs of gill slits are small.

The pectoral fins are short and roughly trapezoidal in shape. Two spineless dorsal fins are placed far back on the body, the first originating just ahead of the pelvic fins and the second located just behind. The second dorsal fin is slightly larger than the first, and the pelvic fins are larger than either. The anal fin is absent. The caudal fin is broad, with the lower lobe almost as large as the upper, which has a prominent ventral notch. The dermal denticles are squarish and flattened, with a slight central concavity and raised corners. The cookie cutter shark is chocolate brown in color, becoming subtly lighter below, and there is a dark "collar" that wraps around the gill region. The fins have translucent margins, except for the caudal fin, which has a darker margin. Complex, light-producing organs called photophores densely cover the entire underside, except for the collar, and produce a vivid green glow. The maximum recorded length for this species is 42 cm (17 in) for males and 56 cm (22 in) for females.

Distribution and habitat

Inhabiting all of the world's major tropical and warm-temperate oceanic basins, the cookie cutter shark is most common between the latitudes of 20°N and 20°S, where the surface water temperature is 18–26 °C (64–79 °F). In the Atlantic, it has been reported from off the Bahamas and southern Brazil in the west, Cape Verde, Guinea to Sierra Leone, southern Angola, and South Africa in the east, and Ascension Island in the south. In the Indo-Pacific region, it has been caught from Mauritius to New Guinea, Australia, and New Zealand, including Tasmania and Lord Howe Island, as well as off Japan. In the central and eastern Pacific, it occurs from Fiji north to the Hawaiian Islands, and east to the Galápagos, Easter, and Guadalupe Islands. Fresh wounds observed on marine mammals suggest this shark may range as far as California in favorable, warm years. Based on catch records, the cookie cutter shark appears to conduct a diel vertical migration of up to 3 km (1.9 mi) each way. It spends the day at a depth of 1–3.7 km (0.62–2.3 mi), and at night it rises into the upper water column, usually remaining below 85 m (279 ft), but on rare occasions venturing to the surface. This species may be more tolerant of low dissolved oxygen levels than sharks in the related genera *Euprotomicrus* and *Squaliolus*. It is frequently found near islands, perhaps for reproductive purposes or because they hold congregations of large prey animals. In the north eastern Atlantic, most adults are found between 11°N and 16°N, with the smallest and largest individuals being found in lower and higher latitudes, respectively. There is no evidence of sexual segregation.

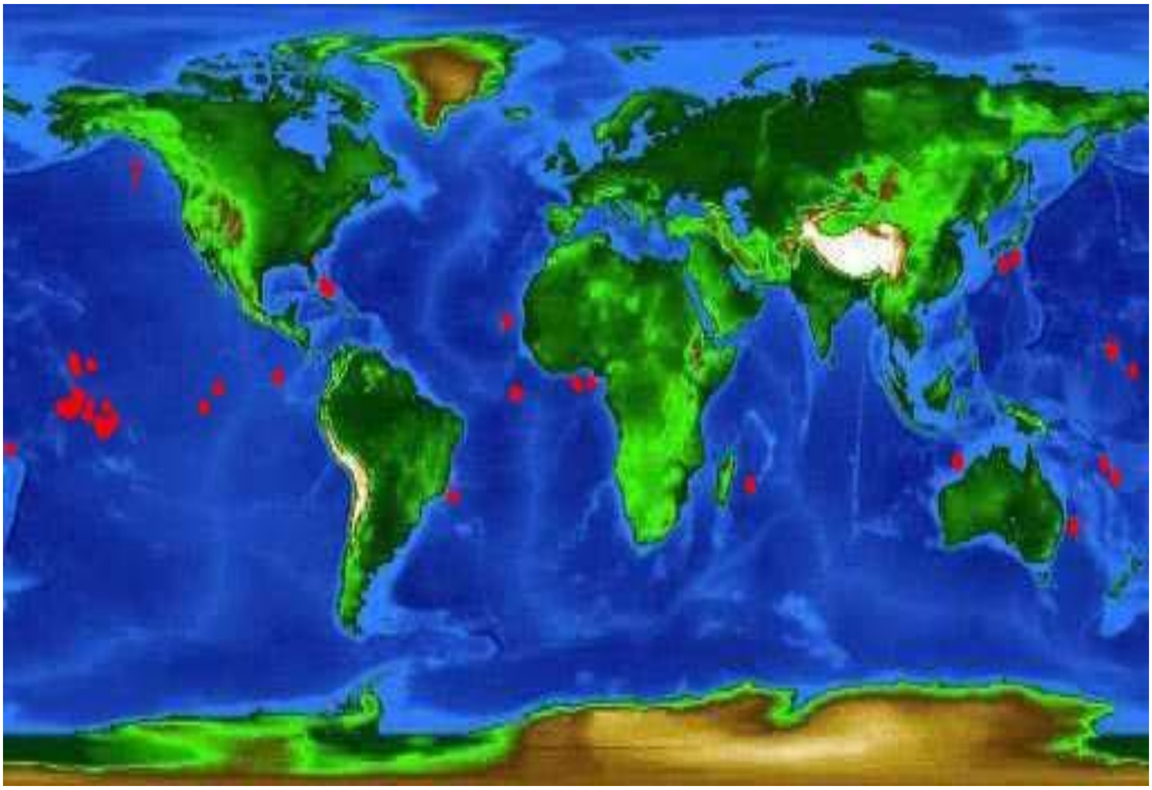

Fig.10. 1- World distribution map for the Cookie cutter shark

Biology and ecology:

Best known for biting neat round chunks of tissue from marine mammals and large fish, the cookie cutter shark is considered a facultative ectoparasite, as it also wholly ingests smaller prey. It has a wide gap and a very strong bite, by virtue of heavily calcified cranial and labial cartilages. With small fins and weak muscles, this ambush predator spends much of its time hovering in the water column. To maintain neutral buoyancy, its liver, which can comprise some 35% of its weight, is rich in low-density lipids. As this species has higher skeletal density than *Euprotomicrus* or *Squaliolus,* its body cavity and liver are proportionately much larger, and the oil content is much higher. Its large caudal fin allows for a quick burst of speed to catch larger, faster prey that come in range.

The cookiecutter shark regularly replaces its teeth like other sharks, but sheds its lower teeth in entire rows rather than one at a time. A cookie cutter shark 14 cm (5.5 in) long has been calculated to have shed 15 sets of lower teeth by the time it is 50 cm (20 in) long, totaling 435–465 teeth. This represents a significant investment of resources and is probably why the old sets of teeth are swallowed, so that the shark can recycle the calcium content. Unlike other sharks, the retina of the cookie cutter shark has ganglion cells concentrated in a concentric area rather than in a horizontal streak across the visual field; this may help to focus on prey in front of the shark. This shark has been known to travel in schools, which may increase the effectiveness of its lure (see below), as well as discourage counterattacks by much larger predators.

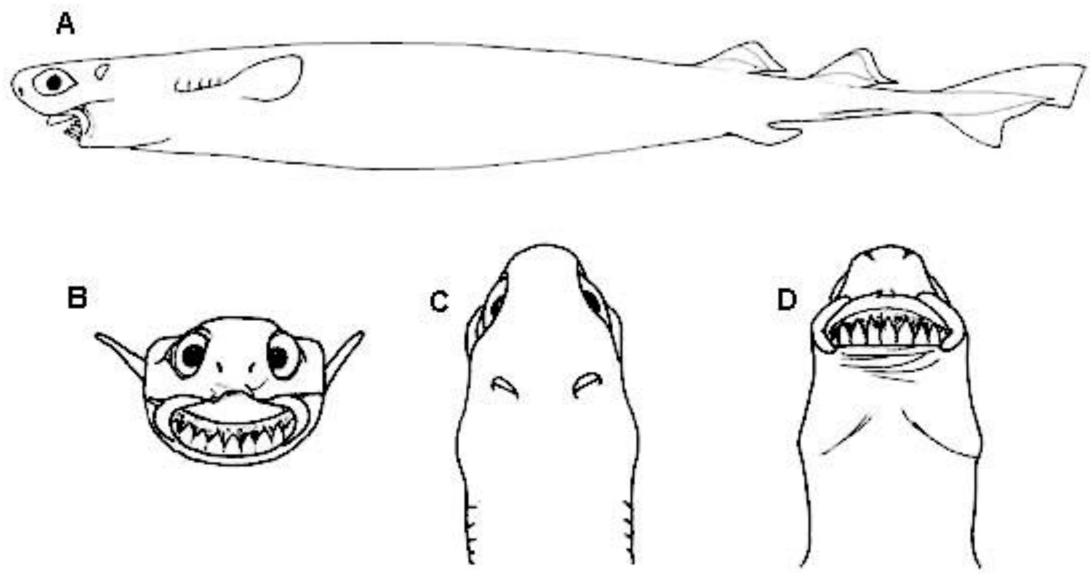

Fig.10. 2- Large tooth Cookie cutter shark *(Isistius plutodus*), A) Side view B) frontal view of the head, C) dorsal view of the head, D) ventral view of the head. (Source: Illustration courtesy FAO)

Distinctive Features: The cookie cutter shark has a small cigar-shaped body with a short conical snout and unique suctorial lips. The eyes are located toward the front of the head, but far enough back that the shark lacks much of a binocular field of vision (Klimley. 2013). There are two close-set spineless dorsal fins of equal size positioned toward the rear of the body. The pelvic fins are larger in size than the dorsal fins; the pectoral fins are subquadrate in shape. The caudal fin is large with a long ventral lobe. The anal fin is absent on this species.

Coloration

The dorsal portion of the cookiecutter shark is dark brown with a lighter ventral surface. There is a distinct dark brown collar around the gill region. The entire ventral surface of the cookiecutter shark with the exception of the dark collar contains a network of tiny light-producing organs called photophores (Klimley. 2013). Photophores produce an even greenish colored glow on the underside of this shark.

These photophores reportedly produce light for up to three hours after the death of the shark. The fins have pale margins with the exception of the caudal fin which has dark tips (Compagno. 2005).

Large tooth Cookiecutter shark *(Isistius plutodus*) dentition. Photo © George Burgess

Dentition

Cookie cutter sharks have 30-37 small, erect teeth in the upper jaw and 25-31 larger triangular teeth in the lower jaw with larger specimens having the larger numbers. The teeth are interconnected at the bases, allowing the entire row of teeth to move if one tooth is touched (Compagno. 2005). The teeth are lost as a complete unit rather than individual teeth common to most sharks. As the lower teeth are shed, they are ingested by the shark. This is thought to aid in maintaining the calcium levels in the body (Klimley. 2013). The denticles are roughly square-shaped with a depression in the middle and raised points at the corners (Compagno. 2005)

Food Habits and Predatory Behaviour:

Potential predators of the cookiecutter shark include large sharks and bony fish (Compagno. 2005).Prey items are attracted to the ventral surface of the cookiecutter shark due to the light given off by the glowing photophores (Compagno. 2005). The glowing area appears similar to a small fish from the depths, prompting larger fish to approach in search of their next meal. Just prior to biting the cookie cutter shark, the large fish is unexpectedly bitten by the shark. The cookie cutter shark attaches itself to its prey with its sucking lips and sharp pointy upper teeth. Once it is attached, the small shark spins its body removing a cookie-shaped plug from the flesh of its prey with its larger serrated bottom teeth. The prey is left with a perfectly round cookie cutter-shaped hole in the side of its body (Compagno. 2005). Common prey items include large fishes such as marlin, wahoo, dolphin, tuna, sharks, and stingrays as well as marine mammals including seals, whales, and dolphins. There are reports of this shark leaving crater marks on the sonar domes of nuclear submarines. The cookiecutter shark has also been reported to commonly feed on whole squid and crustaceans (Papastamatiou et al. 2010).Best known for biting neat round chunks of tissue from marine mammals and large fish, the cookiecutter shark is considered a facultative ectoparasite, as it also wholly ingests smaller prey. It has a wide gap and a very strong bite, by virtue of heavily calcified cranial and labial cartilages. With small fins and weak muscles, this ambush predator spends much of its time hovering in the water column. To maintain neutral buoyancy, its liver, which can comprise some 35% of its weight, is rich in low-density lipids. As this species has higher skeletal density than "Euprotomicrus" or "Squaliolus", its body cavity and liver are proportionately much larger, and the oil content is much higher. Its large caudal fin allows for a quick burst of speed to catch larger, faster prey that come in range.

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Parasitic attacks by the cookie cutter shark leave a round "crater wound", averaging 5 cm (2.0 in) across and 7 cm (2.8 in) deep. The prevalence of these attacks can be high; off Hawaii, nearly every adult spinner dolphin bears scars from this species. Diseased or otherwise weakened animals appear to be more susceptible; in the western Atlantic, there are records of emaciated beached melon-headed whales with dozens to hundreds of recent and healing cookie cutter shark wounds, while such wounds are rare on non emaciated beached whales. The impact of parasitism on prey species, in terms of resources diverted from growth or reproduction, is uncertain.

The cookie cutter shark exhibits a number of specializations to its mouth and pharynx for its parasitic lifestyle. The shark first secures itself to the body surface of its prey by closing its spiracles and retracting its basihyal (tongue) to create negative pressure; its suctorial lips ensure a tight seal. It then bites, using its narrow upper teeth as anchors while its lower teeth slices into the prey. Finally, the shark twists and rotates its body to complete a circular cut, quite possibly aided by the initial forward momentum and subsequent struggles of its prey. The action of the lower teeth may also be assisted by back-and-forth vibrations of the jaw, a mechanism akin to that of an electric carving knife. This shark's ability to create strong suction into its mouth is likely also of utility in capturing smaller prey such as squid.

Bioluminescence

The intrinsic green luminescence of the cookiecutter shark is the strongest known of any shark, and has been reported to persist for three hours after it has been taken out of water. The ventrally positioned photophores serve to disrupt its silhouette from below by matching the downwelling light, a strategy known as "counter illumination", that is common among bioluminescent organisms of the mesopelagic zone. The individual photophores are set around the denticles and are small enough that they cannot be discerned by the naked eye, suggesting they have evolved to fool animals with high visual acuity and/or at close distances. Set apart from the glowing underside, the darker, nonluminescent collar tapers at both sides of the throat, and has been hypothesized to serve as a lure by mimicking the silhouette of a small fish from below. The appeal of the lure would be multiplied in a school of sharks. If the collar does function in this way, the cookiecutter shark would be the only known case of bioluminescence in which the absence of light attracts prey, while its photophores serve to prevent premature detection by incoming would-be predators. As the shark can only match a limited range of light intensities, its vertical movements likely serve to preserve the effectiveness of its disguise across various times of day and weather conditions.

Human interactions

A cookie cutter shark is caught on a long line near Hawaii; large spiracles are located behind the eyes. Favouring offshore waters and thus seldom encountered by humans, the cookie cutter shark is not considered dangerous because of its small size. However, it has been implicated in a few attacks on humans; in one case, a school of 30-cm (12 in) long fish with blunt snouts attacked an underwater photographer on an open-ocean dive. Similar reports have come from shipwreck survivors, of suffering small, clean, deep bites during the night In March 2009, Maui resident Mike Spalding was bitten by a cookie cutter shark while swimming across Alenuihaha Channel. Swimmer Eric Schall was bitten by a cookiecutter shark March 31, 2019 while crossing the Kaiwi Channel, and suffered a large laceration to his stomach. A second cookiecutter attack occurred in the same spot three weeks later: Isaiah Mojica was attempting the channel swim on April 6, 2019 as part of the Oceans Seven challenge when he was bitten on the left shoulder. A third person attempting to complete the swim was bitten in nearly the same area of the channel: Adherbal Treidler de Oliveira was attempting the swim on July 29, 2019, when he was bitten on the stomach and on the left thigh.[28] Two of the three swimmers were using electrical shark deterrents, but they did not deter the sharks. In 2017, a seven-year-old boy, Jack Tolley, was bitten in the leg while wading in Alma Bay in North Queensland with his family. The shark caused a 7.3 cm wound that was nearly down to the bone. On February 9, 2022, a deep-water swimmer off Kailua-Kona, Hawaii was bitten on the right foot and calf. In March 2023, Andy Walberer was attacked by two cookie cutter sharks while swimming the Molokai channel. He was able to grab and throw both sharks before serious injury was inflicted.

There are several records of human bodies recovered from the water with post-mortem cookie cutter shark bites. During the 1970s, several U.S. Navy submarines were forced back to base to repair damage caused by cookie cutter shark bites to the neoprene boots of their AN/BQR-19 sonar domes, which caused the sound-transmitting oil inside to leak and impaired navigation. An unknown enemy weapon was initially feared, before this shark was identified as the culprit; the problem was solved by installing fiber glass covers around the domes. In the 1980s, some 30 U.S. Navy submarines were damaged by cookie cutter shark bites, mostly to the rubber-sheathed electric cable leading to the sounding probe used to ensure safety when surfacing in shipping zones. Again, the solution was to apply a fiber glass coating. Oceanographic equipment and telecommunications cables have also been damaged by this species.

The harm inflicted by cookie cutter sharks on fishing nets and economically important species may have a minor detrimental effect on commercial fisheries.[6][35] The shark itself is too small to be of value, and is only infrequently taken, as bycatch, on pelagic longlines and in midwater trawls and plankton nets. The lack of significant population threats, coupled with a worldwide distribution, has led the IUCN to assess the cookie cutter shark as of least concern. In June 2018 the New Zealand Department of Conservation classified the cookie cutter shark as "Not Threatened" with the qualifier "Secure Overseas" under the New Zealand Threat Classification System.

10.3: Hood mockingbird

Kingdom – Animalia

Phylum – Chordata

Subphylum – Vertebrata

Superclass – Gnathostomata

Class – Aves

Order – Passeriformes

Family – Mimidae

Genus –*Mimus*

Species –*macdonaldi*

The **Hood mockingbird** (***Mimus macdonaldi***), also known as the **Española mockingbird**, is a species of bird in the family Mimidae. It is endemic to Española Island in the Galápagos Islands, Ecuador, and it is one of four closely related mockingbird species endemic to the Galápagos archipelago. It is found in dry forests and is omnivorous, though it primarily is a carnivore or scavenger. The species has a highly territorial social structure and has no fear of humans. It is the only species of Galápagos mockingbird that Charles Darwin did not see or collect on the voyage of HMS *Beagle*.

Description

Similar to the other species of Galápagos mockingbirds, this species has a mottled gray and brown plumage with a white underbelly. A long tail and legs give the bird its distinctive appearance. The species has a long, thin beak, useful for tapping into the eggs of seabirds. The species has the largest bill of any of the Galápagos mockingbirds. The species, along with the other Galápagos mockingbirds, is most closely related to the Bahama mockingbird (*Mimus gundlachi*i), despite the closer geographical proximity of Ecuador's long-tailed mockingbird (*Mimus longicaudatus*).

Its natural habitats are subtropical or tropical dry forests and subtropical or tropical dry Shrubland. Found only on Española Island, the bird can be found throughout the dry scrub of the island.

The Hood Mockingbird (Mimus macdonaldi) is an iconic and endemic bird species found exclusively in the Galápagos Islands, a remote archipelagosituated in the Pacific Ocean, approximately 600 miles off he coast of Ecuador. Within the Galápagos, this species is specifically localized to the Hood Island (also known as Española Island), an area where it thrives in diverse habitats across the island's varied Landscape. These mockingbirds predominantly inhabit arid and semi-arid zones, favouring dry lowlands, coastal areas, and arid scrub habitats found on Hood Island. The availability of various vegetation types, including thorny shrubs, cacti, and scattered trees, provides the Hood Mockingbird with suitable nesting sites and foraging grounds. Their adaptability to this arid environment is remarkable, showcasing their ability to thrive in the harsh conditions typical of the Galápagos *Diet and Parasitic behaviour:*

The bird is extremely aggressive and curious, and has no fear of humans whatsoever. The bird will chase after tourists in search of food, drink, or any unusual object. In some cases, the species will attempt to obtain water from tourists by pecking at their water bottles. The birds have a strong social structure organized into family groups. Highly territorial, these groups will cooperatively hunt within their area as well as defend it against other groups. Lower-ranking members of the group will assist in caring for the young.

The Hood mockingbird has a more powerful bill than other members of the genus. They use their bill to predate the eggs of swallow-tailed gulls. Larger eggs of boobies and albatrosses are only attacked if already damaged

The species has an omnivorous diet, but is mainly a predator or scavenger. The species will eat the eggs of seabirds nesting on the island as well as eat from dead animals and kills made by other predators, such as the Galápagos hawk. Sometimes, just like a vampire finch, they will feed on blood of wounded seabirds. The eggs of seabirds nesting on the island. Dead animals and kills made by other predators, such as the Galápagos hawk. Insects, marine arthropods, small vertebrates Carrion from the carcasses of seabirds, lizards, and marine mammals.

Parasitic feeding behaviour on sea birds, sea lions, lizards:

Hood mockingbirds are opportunistic vampires and have been known to drink the blood of wounded sea birds, injured sea lions, sea lion placenta. It also feeds on decaying flesh and carcasses of seabirds, lizards and marine mammals. Its powerful bill enables it to consume damaged seabird eggs.

The Hood Mockingbird has developed some peculiar feeding behaviour, especially in dry season: it drinks blood from wounds on living sea lions, from sea lion placentas, on marine iguanas, and nestling birds by frequenting the hunting areas of the Galapagos Hawk. It sometimes removes the ticks and some pieces of dead skin from iguanas, sometimes involving the creation of small wounds from which it drinks the blood. This habit probably arose from a mutually beneficial arrangement between the bird and the various animals on the island. When it isn’t out for blood, the hood mockingbird will often land on ananimal’s back and pluck off ticks and other parasites. The blood-filled insects, and the wounds they left on the animal, were a gateway into vampirism. The Hood Mockingbird, with its distinctive black hood and striking white plumage, stands as an iconic avian species native to the arid and semi-arid regions of its habitat. Its remarkable adaptations for survival in harsh environments, agile flight patterns, and foraging strategies provide insights into the resilience and adaptability of avian species. The Hood Mockingbird's role in maintaining ecologicalalance,itsnesting behaviors, and its interactions within the unique ecosystem it in habits showcase the importance of preserving biodiversity and understanding the intricate relationships between species and their environments.

10.4 Vampire Bats and their parasitic behaviour and effect on host

Habitat

Common vampire bats are limited to warm climates. They can be found in both arid and humid parts of the tropics and subtropics. They occur up to 2400 meters in elevation. The distribution is thought to approximate the extent of the 10 degree minimal isotherm for January. The bats usually live in colonies ranging from 20 to 100 individuals although much larger colonies (up to 5,000) have been reported. *Desmodus rotundus* roosts in moderately lighted caves with deep fissures, and in tree hollows. Vampire bats can also be found in old wells, mine shafts, and abandoned buildings. Roosts often smell strongly of ammonia because of the digested blood that has collected in the crevices and on the floors of the roosts.

Physical Description

Desmodus rotundus has grayish-brown fur which is lighter on the ventral side. The muzzle is compact and looks swollen, and the ears are pointy. The wing span averages 350-400mm and the head and body length is usually 70-90mm. The common vampire bat has no tail and the membrane between the hind legs, called the uropatagium, is reduced. Females are usually larger than males.The common vampire bat is highly adapted for its specialized feeding behavior. The braincase is large and the rostrum is reduced to accomodate large razor-sharp incisors and canines. There are two lateral grooves in the tongue that expand and contract as the bat feeds. *Desmodus rotundus* has an acute sense of smell and large eyes.The limbs are also specialized. The thumb of the wing is long and well developed, and the hind legs are strong.

Reproduction

Males compete for space in roosting places containing females. When more than one male occupies a roost, each defends a small part of the roost from other males. Wilkinson observed resident males in tree roosts actively defending their territory from other wandering males. Defense often includes chasing, pushing, and fighting. Fighting consists of gesturing, striking with the wings, and biting. Mating behavior begins with a male climbing onto a female's back, grasping her folded wings with his wings, and holding the back of her neck in his mouth. Copulation lasts three to four minutes.

Mating System-

Desmodus rotundus is believed to be sexually active throughout the year. Although young may be born at any time during the year, peak times for births occurred during April and May and in October and November. A higher number of pregnant females were seen during the rainy season in Mexico and Costa Rica. Most females have one pregnancy per year, but it is possible to have more than one pregnancy in a year. The gestation period is about seven months. Usually only a single young is born, but occasionally there are twins. The newborns are well developed and weigh between five and seven grams at birth. For the first month, the young feed strictly on the mother's milk. Their weight doubles during this time. The young are introduced to blood meals by receiving regurgitated blood from the mother during the second month of life and they accompany their mothers on hunts when they are four months old. The rapid growth is complete in five months.

Behavior

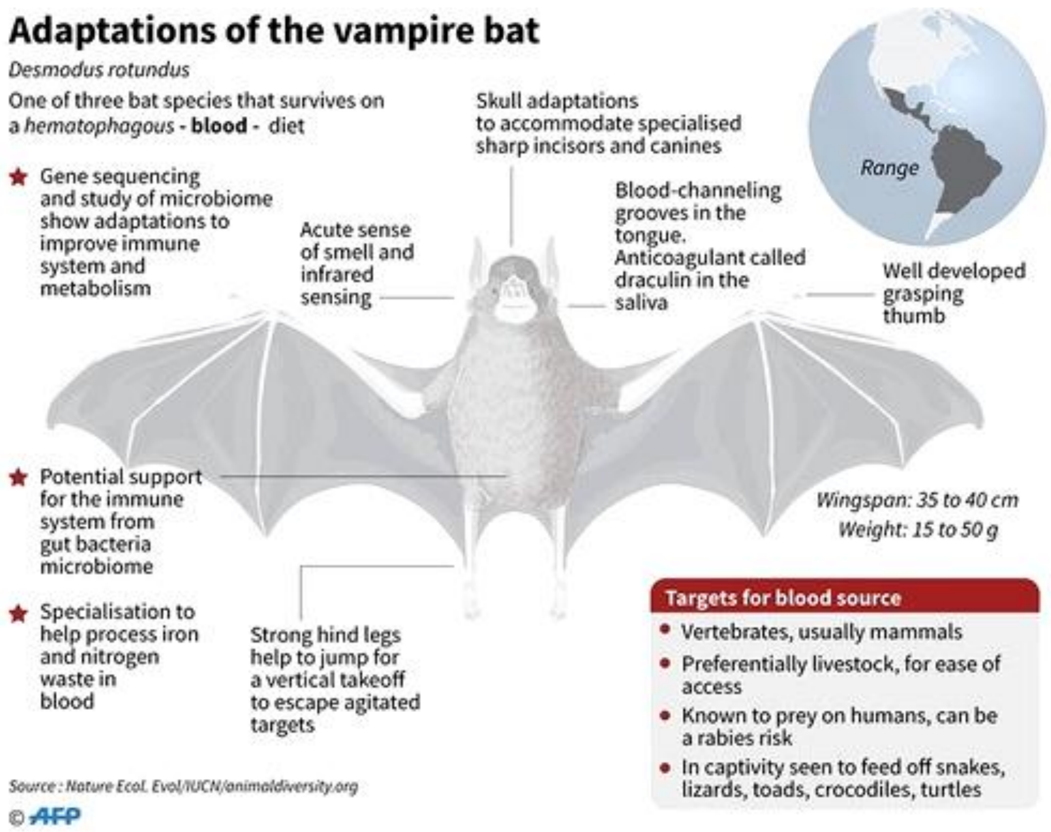
Much of the behavior exhibited by common vampire bats revolves around their methods of obtaining food. Terrestrial movement is a critical part of stalking and attacking prey. Unlike other bat species, *Desmodus rotundus* can walk, run, and hop quadrupedally along the ground. The weight of the bat is supported by the strong hind limbs and modified thumbs. When faster accelerations are necessary, hopping and jumping are preferred (see Altenbach, 1979 for detailed descriptions and pictures of locomotion).This species is agile and stealthy. Usually when a bat approaches its prey, it does not land directly on the animal, but rather, lands nearby and walks or hops up to the unsuspecting victim. It then climbs up the animal and finds a suitable meal site. *Desmodus rotundus* usually climbs backwards, or slightly sideways and is always highly alert while climbing. It is light on its feet and moves delicately to avoid detection. Once the site has been chosen the bat makes a 3mm incision in the skin and laps up the blood from the wound. The bite is relatively painless and rarely wakes a sleeping victim.

Quick reflexes and agile movement are important qualities when avoiding the unpredictible responses of large prey such as livestock. Jumping is one of the vampire bat's main avoidance techniques. It has the ability to jump forward, backward, and laterally. These movements provide quick escape routes from kicking hooves, swishing tails, and even other predators such as owls and snakes.Jumping is also used to initiate flight. Particularly after a large meal, a bat may not be able to take flight directly from the ground. Jumping allows *Desmodus rotundus* to get a heavy stomach off the ground at the end of a meal. It is the only species that can launch itself almost vertically into flight from a horizontal surface.

Desmodus rotundus is a social animal that hunts and lives in groups. The bats live in colonies consisting of both males and females. In captivity, dominance hierarchies based on access to food were observed, but there is little conclusive evidence of complex hierarchies in the wild.Curiously, most close associations are formed between several females or females and their offspring; adult males do not form close social ties in the roost. Females frequent more roost site than males, making associations in many different places. The associations between females are maintained over many years. Self-grooming occurs more often, social grooming is an important part of the vampire bat's behavior. Social grooming usually occurs between females and their offspring, but it is also significant between adult females. The adult females participating in grooming are usually closely related or roost mates. Social grooming has more to do with food sharing than with the removal of ectoparasites. In many instances, social grooming begins with one female approaching another and grooming her for as long as two minutes. The female being groomed then regurgitates part of her blood meal for the grooming female. It is also common to see females regurgitate food for their offspring.Young vampire bats do not exhibit aggressive behavior, although they play and wrestle with other juveniles. In order to avoid aggressive encounters with older bats in the roost, juveniles perform a gesture of appeasement where one folded wing is lifted and the body is bent to one side.

Communication and Perception

Vocalizations are most common between mother and offspring. Small contact cries have been heard from the offspring at 6-12kHz. These usually occur during food sharing. Contact calls are also given when the offspring is trying to find its mother. Chemical cues and touch are also likely to play an important role in communication.Vampire bats use echolocation and vision to navigate and find prey. They may also use olfaction and auditory cues to identify prey.



Food Habits

Desmodus rotundus feeds exclusively on the blood of other vertebrates. The species is an obligate parasite. In the wild, the bats feed preferentially on livestock because of their abundance, but also prey on wild animals and humans. In captivity, these bats have also been known to feed on snakes, lizards, toads, crocodiles, and turtles.

Feeding

A vampire bat feeding on a pig (taxidermy specimens)

Vampire bats hunt only when it is fully dark. Like fruit-eating bats, and unlike insectivorous and fish-eating bats, they emit only low-energy sound pulses. The common vampire bat feeds primarily on the blood of mammals (occasionally including humans), whereas both the hairy-legged vampire bat and white-winged vampire bat feed primarily on the blood of birds. Once the common vampire bat locates a host, such as a sleeping mammal, it lands and approaches it on the ground while on all fours. It then likely uses thermoception to identify a warm spot on the skin to bite. They then create a small incision with their teeth and lap up blood from the wound.Vampire bats, like snakes, have developed highly sensitive thermo sensation, with specialized systems for detecting infrared radiation. Snakes co-opt a non-heat-sensitive channel, vertebrate TRPA1 (transient receptor potential cation channel A1), to produce an infrared detector. However, vampire bats tune a channel that is already heat-sensitive, TRPV1, by lowering its thermal activation threshold to about 30 °C (86 °F), which allows them to sense the target. The most common species, the common vampire (*Desmodus*) is not fastidious and will attack any warm-blooded animal. The white-winged vampire (*Diaemus*) appears to have a special preference for birds and goats. In the laboratory it has not been possible to feed *Diaemus* on cattle blood. If there is fur on the skin of the host, the common vampire bat uses its canine and cheek teeth like a barber's blades to shave away the hairs. The bat's razor-sharp upper incisor teeth then make a 7 mm wide and 8 mm deep cut. The upper incisors lack enamel, which keeps them permanently razor sharp. Their teeth are so sharp, even handling their skulls in a museum can result in cuts.

The bat's saliva, left in the victim's resulting bite wound, has a key function in feeding from the wound. The saliva contains several compounds that prolong bleeding, such as anticoagulants that inhibit blood clotting, and compounds that prevent the constriction of blood vessels near the wound.

Digestion

A typical female vampire bat weighs 40 grams (1.4 oz) and can consume over 20 grams (1 fluid ounce) of blood in a 20-minute feed. This feeding behavior is facilitated by its anatomy and physiology for rapid processing and digestion of the blood to enable the animal to take flight soon after the feeding. The stomach and intestine rapidly absorb the water in the blood meal, which is quickly transported to the kidneys, and on to the bladder for excretion. A common vampire bat begins to expel urine within two minutes of feeding. While shedding much of the blood's liquid facilitates flight takeoff, the bat still has added almost 20–30% of its body weight in blood. To take off from the ground, the bat generates extra lift by crouching and flinging itself into the air. Typically, within two hours of setting out in search of food, the common vampire bat returns to its roost and settles down to spend the rest of the night digesting its meal. Digestion is aided by their microbiome, and their genome protects them against pathogens in the blood. Its stool is roughly the same as that from bats eating fruits or insects.

Relationship with humans

The highest occurrence of rabies in vampire bats occurs in the large populations found in South America. The danger is not so much to the human population, but rather to livestock. Joseph Lennox Pawan, a government bacteriologist in Trinidad, found the first infected vampire bat in March 1932. He soon proved various species of bat, including the common vampire bat, are capable of transmitting rabies for an extended period of time without artificial infection or external symptoms. Fruit bats of the genus *Artibeus* were later shown to demonstrate the same abilities. During this asymptomatic stage, the bats continue to behave normally and breed. At first, Pawan's finding that bats transmitted rabies to people and animals were thought fantastic and were ridiculed. Although most bats do not have rabies, those that do may be clumsy, disoriented, and unable to fly, which makes them more likely to come into contact with humans. There is evidence that it is possible for the rabies virus to infect a host purely through airborne transmission, without direct physical contact of the victim with the bat. Although one should not have an unreasonable fear of bats, one should avoid handling them or having them in one's living space, as with any wild animal. Medical attention should be given to any person who awakens to discover a vampire bat in their sleeping quarters. It is possible that young children may not fully awaken due to the presence of a bat (or its bite). The unique properties of the vampire bats' saliva have found some positive use in medicine. A genetically engineered drug called desmoteplase,which uses the anticoagulant properties of the saliva of *Desmodus rotundus*, has been shown to increase blood flow in stroke patients.

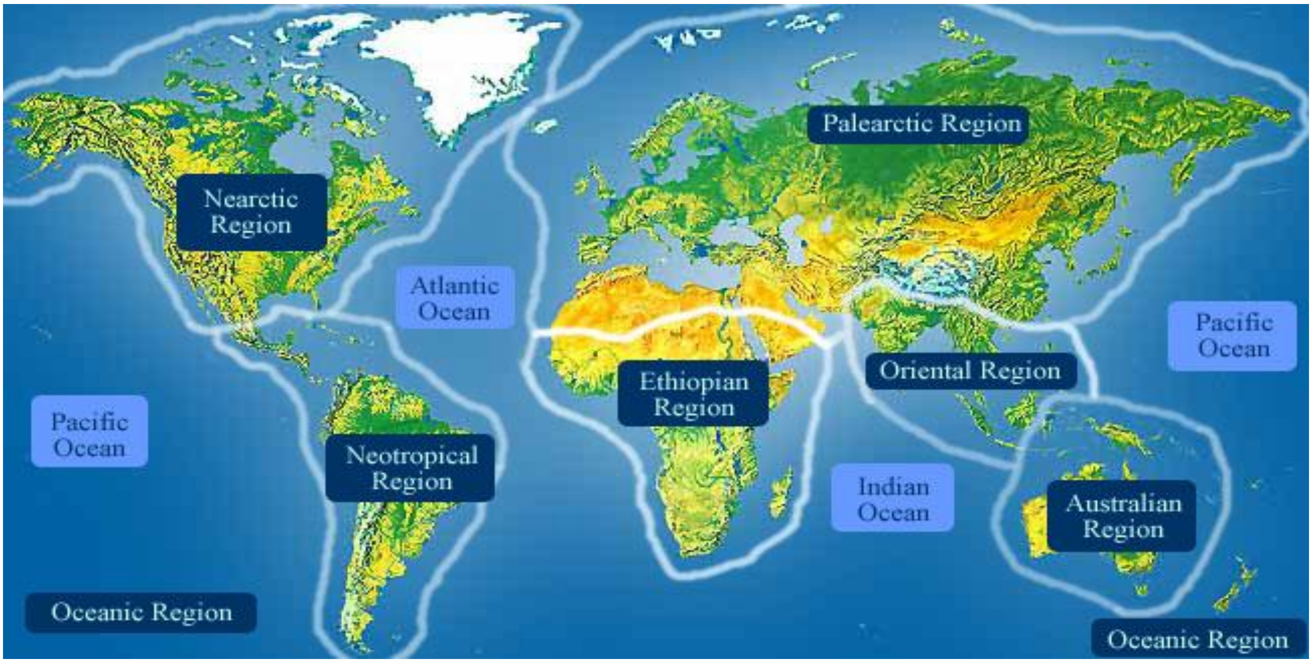
Economic Importance for Humans: Positive

Research on the anticoagulant agents in vampire bat saliva may improve medical treatment of some human injuries and diseases. Guano can be harvested and used as a fertilizer.

Economic Importance for Humans: Negative

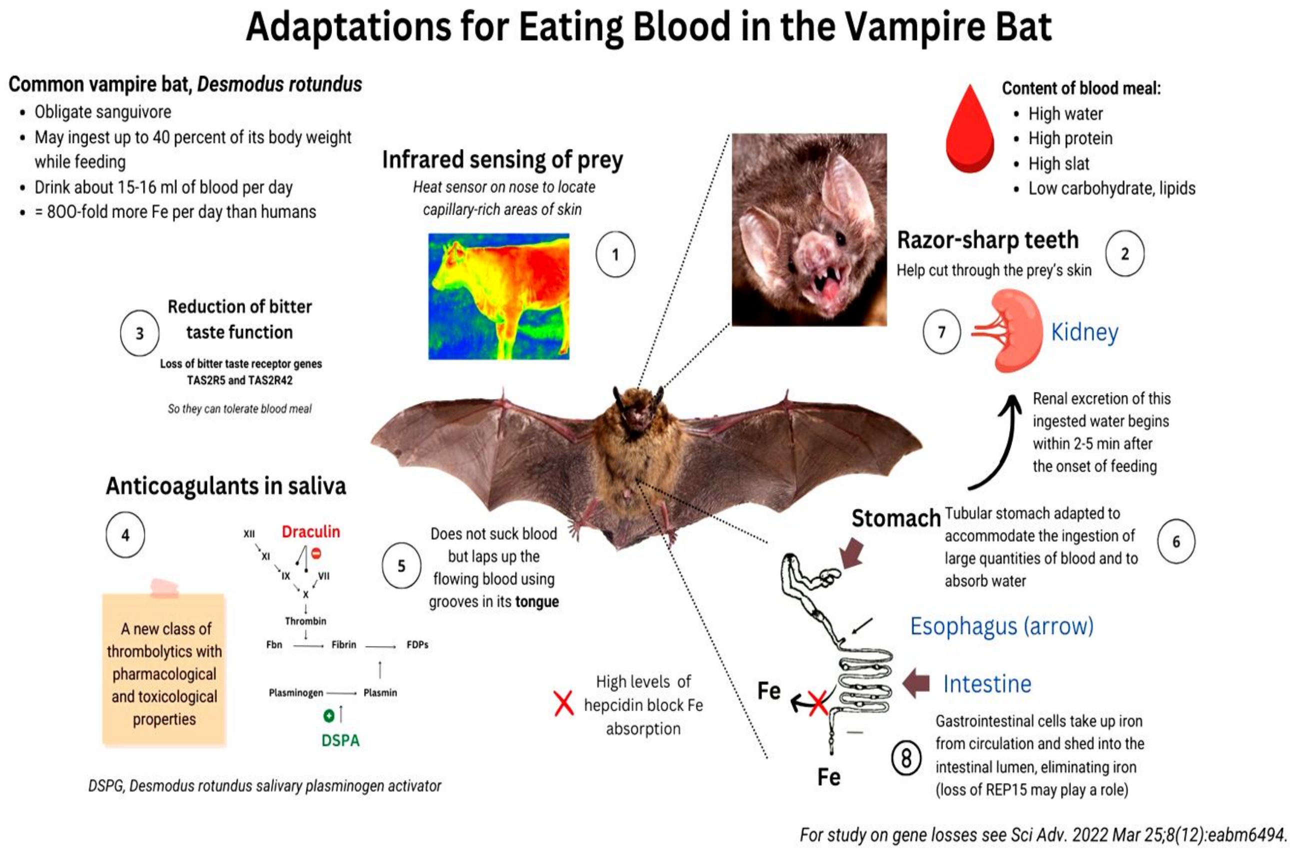
A bite from *Desmodus rotundus* can cause infections and transmit diseases carried by the bat. Infections can spread rapidly and cause death. The vampire bat transmits rabies to both humans and domestic livestock. Losses to the cattle industry in Latin America amount to many millions of dollars every year.

Researchers have isolated an anticoagulant called draculin in the saliva of vampire bats. The anticoagulant is a glycoprotein that stops wounds from clotting so that the bat can gain a full meal from its prey.Vampire bats have been the source of many myths and superstitions throughout the world. The Europeans have traditionally associated bats with the devil. In European pictures, the devil often has bat wings. The Persians and the Chinese, on the other hand, have chosen to depict the bat in a different light. The bat is a symbol of longevity and happiness in traditional stories and legends.



Parasitic Behaviour and effect on host -

Vampire bats are obligate sanguivores as adults; 30-40 g parasites that get all their nutrients from vertebrate blood. They are the only tetrapods that are obligate blood feeders, the only mammals that drink blood, and the only mammals that are parasites of other animals. But thehabit of blood-feeding has evolved many times in other species, so just as selection has pushedvampires away from the typical mammalian body plan, it has also caused convergence on otherblood-feeders, physiologically, anatomically, and behaviourally.



Locating host animals

Vampire bats appear to locate food over a range of distances through some combination of

olfaction, vision, echolocation, passive listening, and spatial memory. *Desmodus* can also hear low frequencies better than most bats and can recognize individual humans by the sound of their breathing which could help the bats find previous wounds for reopening on the same host. Vampire bats feed during the darkest part of the night, and as such can only see with their rods, having lost the colour vision present in their phyllostomid ancestors. Olfaction appears to help vampire bats to find and select their prey similar to other blood-feeding animals, including bedbugs ,ticks and mosquitoes. *Aedes* mosquitoes distinguish and prefer humans over other potential hosts. Ticks lack antennae, but have converged with other blood-feeders in this regard, having evolved chemosensory organs at the tips of their first pair of legs Feeding on the blood of a larger animal can be dangerous. For this reason, feeding *Desmodus* bring vibrissae on the nose leaf into contact with the skin of the host to give them a rapid means for detecting host movement and allowing a quick evasive jump if necessary.

Similar strategies to avoid host-induced injury are common among arthropod ectoparasites,

such as mosquitoes. Horseflies even improve their escape performance by feeding on the warmer locations of a host's skin, thereby increasing their own temperature dependent muscle performance. The need for rapid escape has resulted in a jumping ability and an overall terrestrial agility in *Desmodus* that exceed that known for any other bat giving them evasive abilities on par with a horsefly or deerfly. Another way to avoid a host's aggression is to feed on it while it sleeps. This strategy is wide spread among sanguivores, including bedbugs, mosquitoes, and vampire snails. *Diaemus* often avoid waking their hosts by feeding from a position adjacent to, but not directly on, the host's body, such as the underside of the branch upon which the bird is perched for the night. *Desmodus* and *Diphylla*, however, frequently feed from a position on the skin of the animal itself.

Another challenge imposed by the long feeding times of vampire bats is the risk a host will

wake up mid-feeding and run away. When this happens, *Desmodus* can use a running gait to chase after the animal without needing to take flight. The running gait of vampire bats is the only known running gait of a bat, and is the only known occurrence of a vertebrate lineage that has lost and then re-evolved the ability to run. The gait consists of a footfall sequence analogous to those seen in bounding squirrels, but with the roles of the forelimbs and hindlimbs reversed. The result is a gait that looks very much like "running push-ups," and is unique among tetrapods

Vampire bats do not suck blood, in contrast with other blood-feeders that attach to their hostsusing suction, such as lamprey and leeches. For those aquatic blood feeders, the primarypurpose of suction is to remain attached to the larger and faster-moving host, which in the caseof lamprey might even be a whale. Once applied, however, that suctionprovides the secondary benefit of a compressive force which allows the teeth to drive into the prey (Clark and Uyeno 2019). Vampire bats instead use the lower jaw to pinch the skin in orderto pierce it. The vampire bat bite itself can take several forms. The typical bite consists of a pinch betweenthe upper and lower jaw that excises a circular divot of flesh, with diameter and depth of ca. 5mm. A cut can also be made with a slashing slice of the upper incisors. In some instances, a"rasping" bite is made by rubbing the tongue against the skin similar to many hematophagous insects, including vampire moths and lice.

Venom effects on humans and other animals Feeding bites produced by vampire bats have characteristic shape and location. The large, sharp upper incisor teeth (Fig.) produce a crater-like, sharply circumscribed wound, with a diameter of approx. 4 mm. The bite is inflicted on the bare skin with the victim's hair being either combed or parted by the bat.

Skeleton of *D. rotundus* face showing the sharp upper incisors (Photograph by Antonio Sebben).

The blood is licked up by a piston-like motion of the tongue for about 30 min. The wound they produce not only freely bleeds when first inflicted, but also continues to bleed for several hours after the bat has ceased to eat *D. rotundus* feeds mainly on domesticated cattle, horses, goats, pigs and sheep. To a lesser extent they feed onpoultry, wild prey and humans. *D. ecaudata* feeds on birds, and *D. youngi* feeds on mammals but prefers birds. The prey is preferably asleep when attacked, minimizing the bat exposure to risks. The attack is slow and delicate in nature, with the bat avoiding any chance of being perceived by the prey. The bites are frequently described as painless, with the victim hardly waking up when being attacked. Besides the residual hemorrhaging, the vampire bat venom also elicits immune response on preys frequently fed upon.

Two distinct classes of anticoagulants are found in the saliva of vampire bats i.e. plasminogen activators and inhibitors of proteinases. Plasminogen activators act producing localized proteolysis in tissue remodeling, wound healing and neuronal plasticity. The tissue type

plasminogen activators (t-PA) are serine proteases that cleave the plasmin proenzyme to its active form, which in turn is responsible for degradation of blood clots. After long speculations and preliminary results, a plasminogen activator was identified in the saliva of The later cloning and expression of this activator revealed high similarity to t-PA.

It was also found that this activator is not a single protein, but a family of four *D. Rotundus* salivary plasminogen activators (DSPAs). This is not the case for the other vampire bats, which have only one t-PA in their genomes. The t-PA molecule has five domains: finger (F), epidermal growth factor (EGF), kringle 1 (K1), kringle 2 (K2) and serine protease (P). F and K2 domains are both involved in the competitive binding of fibrin as well as its inhibitor plasminogen inhibitor 1 and DD(E), a product of degraded cross-linked fibrin. PA shows activity as a single chain, but this activity is highly enhanced as a cleaved two chain form. With the exception of D. ecaudata PA, the plasminogen activators from vampire bats have smaller chains with domain deletions when compared to t-PA. *D. youngi* PA lacks K2 domain. The four variants of DSPAs (a1, a2, b, g) lack the K2 domain and a plasmin-sensitive activation site. DSPA-b additionally lacks F domain, while DSPA-g lacks F and EGF domains. These differences alter many binding properties of vampire bat PAs when compared to t-PA. The loss of K2 domain leads to decreased sensitivity to fibrinogen, plasminogen activator inhibitor, and DD(E). Absence of K2 domain also leads to strong fibrin specificity. The loss of plasmin-activation site allowed DSPAs to be active as single chains. Based on its extraordinary specificity for fibrin, DSPA-a1 became a candidate for thrombolytic therapy, being renamed as desmoteplase in medical literature. Glycosylation studies revealed two N-glycosylation sites (more than 30 different oligosaccharides linked to Asn117 and Asn362) and one Oglycosylation site (L-fucose linked to Thr61) in DSPA-a1. Despite equivalent to glycosylation sites in t-PA, there seem to be differences between the glycosydic structures linked to these sites, especially for Asn117. N-glycans in this position of DSPA-a1 are more processed during biosynthesis that the high-mannose counterpart in t-PA. This difference is pointed as a possible reason for the fourfold lowered clearance rate observed for DSPA-a1 when compared to t-PA.

The other anticoagulant found in the saliva of vampire bats (so far only studied in *D. rotundus*) is draculin, an inhibitor of activated factors X (fXa) and IX (fIXa). fXa is the only enzyme in the coagulation cascade to convert prothrombin into thrombin, the key enzyme in this process, and the activation of factor X is considered a common point between intrinsic and extrinsic pathways of blood coagulation.

Draculin is unique among compounds known to inhibit this enzyme, since it acts as a non competitive, tight-binding inhibitor of fXa. The biological activity of draculin is dependent on adequate N- and Oglycosylation and stress inflicted to the bat (e.g. frequent induced salivation) impairs this modification. The protein loses activity at rates proportional to the deglycosylation degree. It is suggested that native draculin is secreted as a mixture of glycoforms that modulate its final anticoagulant activity. The differential glycosylation associated to the noncompetitive inhibition of fXa are proposed to take part in the fIXa inhibition, a mechanism that is less understood.

The feeding bites of vampire bats are regarded as painless, different from their defensive bites. Although this might indicate an additional anesthetic in the saliva. Young bats learn

to inflict these bites, and that it seems to involve trial and error. No study on the putative anesthetic has been performedso far.

Biological and evolutionary aspects Vampire bats are highly specialized mammals, with

their entire physiology modified to use blood as their only source of food and water. They have a T-shaped gastroesophageal-duodenal junction with a tubular stomach, contrasting with regular mammalian gastrointestinal tracts. This allows the ingested blood to first enter the intestine and then overflow into the stomach. The stomach functions as a site for blood storage and water absorption. After ingesting 50% of its weight in blood, most of the water is eliminated by “instant diuresis”, and the highly nitrogenous remains of blood are then processed with very little water. For this, vampire bats have a high capacity for urea concentration in their urine, being considered physiologically equivalent to desert mammals.

They have reduced metabolism during digestion of the highly proteinaceous meal, upon which they depend entirely. Maltase and sucrase are absent in their gastrointestinal tracts, and dietary carbohydrates seem to be almost unused by these bats.

The vampire bats also lack storage fat tissue, requiring to daily feed on blood. To do so, the bats have modified sharp teeth, anticoagulants in their saliva and a specialized tongue. The blood is not sucked as normally depicted, but rather lapped up in a piston-like movement of the tongue.For this method to work, the blood must be liquid and flowing. The evolution of anticoagulants in the saliva of the three different vampire bat species reveals transitions in their preferred preys. Gene duplication, domain loss and sequence evolution altered the fibrin specificity and susceptibility to plasminogen activator inhibitor 1. The monophyletic Phillostomidae family, where Desmodontinae is included, holds the greatest diversity in feeding habits of all mammalian families, including frugivory, carnivory and hematophagy, the latter being derived from insectivory. In the subfamily, *D. ecaudata* has a single copy of plasminogen activator similar to those in other mammals. This vampire bat feeds only upon birds. The more generalist D. youngi, which feeds upon birds and mammals, lost the K2 domain, increasing fibrin specificity. In D. rotundus rounds of gene duplication and domain loss led to an active form of plasminogen activator with decreased sensitivity to plasminogen activator inhibitor 1, enhancing the ability to feed solely on mammalian blood.

It is interesting to point out that vampire bats are still considered pests, especially for cattle.

Since they can carry rabies viruses and also transmit equine trypanosomiasis,vampire bats have been exterminated by many methods, including shooting, gassing, poisoning, netting, trapping and dynamiting. There is now great awareness about controlling the vampire bat population while minimizing the impact on other species, including nonhematophagous bats that share the same habitats.

10.5 Summary

Parasitic diversity is also observed in higher animals also. It starts from Pisces to Mammals.

- The name "cookie cutter shark" refers to its feeding habit of gouging round plugs, like a cookie cutter, out of larger animals. Marks made by cookie cutter sharks have been found on a wide variety of marine mammals and fishes, as well as on submarines, undersea cables, and even human bodies. It also consumes whole smaller prey such as squid.
- The Hood mockingbird (*Mimus macdonaldi*), also known as the Española mockingbird, is a species of bird in the family Mimidae.
- Hood mockingbirds are opportunistic vampires and have been known to drink the blood of wounded sea birds, injured sea lions, sea lion placenta. It also feeds on decaying flesh and carcasses of seabirds, lizards and marine mammals. Its

powerful bill enables it to consume damaged seabird The eggs. Hood Mockingbird has developed some peculiar feeding behaviour,especi ally in dry season: it drinks blood from wounds on living sea lions, from sea lion placentas, on marine iguanas, and nestling birds by frequenting the hunting areas of the Galapagos Hawk.

- Common vampire bats are limited to warm climates. They can be found in both arid and humid parts of the tropics and subtropics.
- Vampire bats are obligate sanguivores as adults; 30-40 g parasites that get all their nutrients from vertebrate blood. They are the only tetrapods that are obligate blood feeders, the only mammals that drink blood, and the only mammals that are parasites of other animals. But the habit of blood-feeding has evolved many times in other species, so just as selection has pushed vampires away from the typical mammalian body plan, it has also caused convergence on other blood-feeders, physiologically, anatomically, and behaviourally.

10.6 Terminal Questions

1- Elaborate Parasitic Behaviour of Cookicutter Shark.

2- Write a brief note on Hood Mocking Bird.

3- Describe Feeding Behaviour of Vampire Bats.

Q 4 Write Shorts notes

A- Vampire bats

B- Parasitic feeding behaviour of Hood mockingbirds

SQ5- The cookie cutter shark is named because that it leaves ______wounds on the bodies of its prey

SQ6- Hood mockingbird are drink the blood of wounded-------------

SQ7- ____is only mammals known as obligate blood feeders

10.7 Answers

SQ5 cookie-shaped

SQ6 sea birds, injured sea lions, sea lion placenta

SQ7 Vampire bats

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UNIT 11- MICRO AND MACRO ENVIRONMENT OF PARASITES

11.1 Introduction

Objective:

11.2 Micro and Macro Environment of Parasites

11.3 Autecology and Synecology of Parasitic Helminthes

11.4 Summary

11.5 Terminal Questions

11.6 Answers

11.1 Introduction

Parasitism is a ubiquitous phenomenon that is probably as old as heterotrophic organisms themselves. It is one of the major types of symbiotic relationship between organisms of different species. The development of the biological sciences brought about a broader definition of parasitism. By the end of the nineteenth century, it was known that parasites thrive at the expense of their hosts and use the host as their dwellings. The definition of parasitism emphasized the damage parasites inflicted on hosts, the metabolic dependence of parasites on hosts, and ecological interactions between populations of these two species of living organisms. It is also known that parasites can lower the fitness of hosts by exploiting nutritional resources, habitats, and dispersal. Parasites can also modify host behavior and lead to their castration Parasites can have varied impacts on hosts. The attachment organs of the parasites can cause mechanical damage to host tissues. Acanthocephalan spikes and cestode hooks and suckers can cause intestinal pathology, while monogenean hooks and clamps can damage the structures of fish gill filaments. Large internal parasites or those occurring in great numbers can block digestive tracts. Host tissues can sustain mechanical damage as parasites migrate or pass from one developmental stage to the next. While migrating into the host body cavity, roundworm larvae from the family Anisakidae break through stomach walls or pyloric caecae of the fish, which are the intermediate host. Tapeworm larvae of the genus *Ligula*, which settle in the body cavity, exert pressure on the fish gonads causing castration. They feed either on as yet undigested food or the components of food that has been broken down by enzymes; thus depleting hosts of protein, lipids, carbohydrates, vitamins, and enzymes. The parasites themselves produce enzymes that damage host cells and inhibit physiological processes. Parasitic metabolic products can be toxic to hosts; some parasites produce substances that impede blood clotting (leeches), destroy epithelial cells (cercariae Digenea), which creates the conditions necessary for secondary infection.

Objective:

The study of this unit will help you to:

1- Understand the concept of Different types of environment of parasite
2- Fundamentals of ecology of Plathyhelminthes
3- Basic concept of **Autecology** and Synecology of Parasitic Helminthes

11.2 Micro and Macro Environment of Parasites

The environment of parasites differs from that of free-living organisms in having two components. One, the microenvironment, is the host itself; the other, the macroenvironment, is the environment of the host.

The parasite lives at the expense of the host, but it is also dependent on its host in many other aspects. Parasitism is distinguishable from predation by its more extensive reproductive potential, its smaller size and thus limited visibility, and in its representing a lower level of evolutionary advancement. If the relationship described above is only temporary, then it is referred to it as temporary parasitism. In many cases, this is limited to one-time contact with the host that is nonetheless indispensable for further parasite development. Temporary parasitism is very similar to predation, especially when a single parasite species interact with numerous host species. In this instance, these parasites can be vectors of the infectious stages of other parasites. Parasitic relationships that lack metabolic dependence are referred to as nesting or social parasitism, which indicate that organisms using other organisms as nesting sites or for rearing offspring.

Most parasites have multifaceted life cycles with numerous morphological stages that infect discrete host cell types and tissues. This enormous variety of life cycles and tissue niches result in even greater diversity in the host immune response, targeting not only the different types of parasitic organisms but also the different life cycle stages of the same species within the mammalian host. The life cycle of *Plasmodium* within its mammalian host is extraordinarily complex, with both extracellular and intracellular life stages moving between different tissues. Pre-erythrocytic stage infection occurs though the inoculation of sporozoites into the skin by a mosquito vector; the sporozoites migrate to the liver and infect hepatocytes, where they multiply rapidly into exo-erythrocytic forms. Parasites egress from hepatocytes as merozoites, which infect red blood cells (RBCs) and initiate blood stage infection. The merozoites then multiply inside RBCs, which rupture to release new merozoites that infect further RBCs in cyclic intervals.

MICROHABITATS (biotopes or ecosystems) There are no species of parasites that infect all tissues and organs of the host's body equally, i,e. all species show preferences for certain microhabitats of varying degrees.. On *Prionotus punctatus*, a teleost fish from the cold-temperate coast of Argentina, only three species of gill and skin parasites were found. An isopod was recovered only once from the fins and no statements other than that it is an ectoparasite are possible about its microhabitats. Cysts of unknown nature are restricted to the gill filaments which they appear to infect more or less at random. The copepod *Blias prionoti* also occurs only on the gill filaments but prefers the first three longitudinal quarters and the tips of the filaments.

Microhabitats frequently are not static, that is, they change with the age of the parasites and/or with the age of the host. For example, larvae and young females and males of the copepod *Caligus diaphanus* live on the gill filaments of the gunard, *Trigla lucema*, at Helgoland, whereas adults infect the inner wall of the opercular cavity (Rohde, 1980b). In some cases seasonal microhabitat changes have been demonstrated or changes due to the effect of other parasites. Thus, sites of the acanthocephalan *Echinorhynchus gadi* in *Melanogrammus aeglefinus* undergo seasonal changes and the same parasite is more restricted to the posterior intestine when the nematode *Hysterothylacium clavatum* is also present. Conversely, H. clavatum is more restricted to the anterior intestine in the presence of *E. gadi* In some cases, morphological characteristics determine at least partly, whether a parasite can live in a certain microhabitat or not.For example, of three species of ectoparasitic helminths on the gills of *Seriolella brama* in New Zealand, *Syncoelium filiferum* is always attached to the spines of the gill rakers and arches by means of a stalked muscular ventral sucker which is not capable of attaching to gill filaments or smooth surfaces. In other cases, physico-chemical host stimuli were shown to be at least partly responsible for site specificity. Thus, ex-sheathment and development of certain nematode species were shown to require host stimuli. Although the stimuli themselves may not be very specific, they may act on larvae of different species under different conditions of redoxpotential and pH and thus determine their microhabitats (and hosts) However, all nematodes studied so far are nonmarine. With regard to the biological function of microhabitat restriction, that enhancement of the chances to mate may be an important factor responsible for such restriction. Evidence is that sexually mature and sessile species as well as species occurring in low densities often have the most clearly restricted microhabitats.

MACROHABITATS (biotopes or ecosystems) The macrohabitat of a parasite consists of those niche components which also represent the habitat of its host(s) . For example, according to Cannon (1977a, b), among nematode larvae of marine fish in southeastern Queensland, Anisakis occurs only in open water fish, *Contracaecum* (probably *Hysterothylacium*) only in inshore shallow water fish, and two others, *Phocanema* (= *Pseudoterranova*) and *Thynnascaris* (= *Hysterothylacium)* have intermediate distributions.

factors which affect the distribution of marine,parasites in different macrohabitats. The importance of chemical factors and particularly salinity was shown for parasites and especially ectoparasites in the Aral Sea. Some groups like Myxozoa and Ciliophora were absent in the saline part, and Monogenea and Trematoda were better represented in the freshwater part. Temperature affects, for instance, the trematode Derogenes varicus, which occurs in numerous fish species in cold surfacewaters. At low latitudes, it occurs only in deeper cold waters or in areas with cold currents. Ectoparasites sometimes must be able to withstand extreme conditions in the environment of their hosts, and sometimes rapid changes in those conditions. In long-lived parasites, higher infection may simply be due to a chance accumulation of parasites over time. Larger hosts, furthermore, eat more and come into contact with larger volumes of water which increases the chances of infection with endo- and ectoparasites, and they also represent a larger variety of larger microhabitats. Immune reactions which eliminate some parasites, as well as age resistance which may be due to thicker body layers preventing entry of parasites, counteract this to a certain degree. However, altogether an increase of parasite infections with age is more common than a decrease.The locations where parasites live, regardless of whether these are hosts of the external environment, are their habitats. Macrohabitats are the living environments of hosts. Microhabitat is the name used to refer to organs or sections of organs infected by parasites. The conditions of the various habitats determine whether or not particular parasites can settle there. Every organ is characterized by many morphological and physicochemical parameters, and differences are noted among them even within a single organ. Despite this, the habitats of parasites can nearly always be determined with great precision. The existence of a habitat is the result of the heterogeneity of each living organism. Different genes are expressed in different organs, which is why the environments offered to parasites differ in different parts of hosts. Helminths are most frequently particular about the places they choose to settle; these include designated regions of the intestines or the gills. There are, however, many species of parasite that are not 'picky' regarding habitat. These are most frequently cellular parasites. Some habitats are not always immediately available to parasites or their developmental stages, which is why migration is necessary, and makes it imperative to overcome defensive barriers that are also presented by the host organism. The location of parasite habitats impacts the migration process within host organisms, but also on the processes of releasing parasite eggs or larvae into the external environment. If external parasites make direct contact with the external environment, and mesoparasites do so thanks to organs which they inhabit and from which their eggs or larvae are released through natural channels, then internal parasites inside cells, tissues, or organs have no such possibilities. However, this process requires damaging the habitat, and vectors are useful for this, and it is indeed thanks to this process that some leech species transmit flagellates and haemogregarina.

11.3 Autecology and Synecology of Parasitic Helminthes

Ecology has been defined as the study of interactions between organisms and their environments and among the organisms inhabiting these environments. This is a complex field of study, which is why it should be investigated on various levels. In the ecology of parasites the niche, which is the entirety of the parasite-host relationship and fragmentation, is of fundamental importance.

A niche is the entire set of biotic and abiotic factors (variables) that provides a population with living conditions. The number of variables that combine to shape a niche is large, and includes the environmental physicochemical parameters (salinity, temperature, light), host populations (abundance, fluctuations), variability of hosts occurring successively, the occurrence of parasitoids, and the character of the host resources exploited. This last variable occurs repeatedly in the subsequent divisions of the habitat, e.g., on fish gills where parasites that feed on epithelial cells and mucous can occur simultaneously with parasites that draw blood from the blood vessels. Overlapping niches are the main parameter in competition among species. Despite the large number of potential hosts, the parasite-host system can only exist when conditions are appropriate. The host must inhabit the same ecosystem as the parasite, have contact with the parasite, and offer it appropriate conditions for both life and survival. All of these conditions together are the selection mechanism that operates at the level of the parasite and host genome. Parasites can infect single or numerous hosts during the different developmental stages of their biological cycles; however, each stage has to overcome host metabolic and immunological barriers. The parasites that have, through evolution, developed the greatest ability to adapt to environments and to avoid defense mechanisms are the most successful at infecting and exploiting hosts. Success also depends on the creation of survival stages that can endure for certain periods of time in disadvantageous environmental conditions; these include protozoan and myxosporean cysts and helminth eggs. Developmental stages can also be dependent on the host to a certain degree. The parasitic stages of digeneans are sporocysts, rediae, adult stages, free-living miracidium, cercariae, and metacercariae

The physiological processes of parasites are dependent on the character of the site they inhabit, which is also its source of food. The mutual relationship between parasites and hosts is referred to as specificity, and it can be either narrow (e.g., Monogenea), or wide (e.g., most Nematoda). The older parasites are in phylogenetic development, the more specific they become. The functioning of the parasite-host system is possible when there is convergence between the activities of the particular developmental stages and the availability of food. This is linked also to the secretion by the parasites of digestive enzymes and metabolic regulation depending on their energy demands, which can be markedly decreased under disadvantageous conditions. An important factor to survival is the possibility of exploiting food reserves accumulated by previous developmental stages.

Both sides participate in the creation of the parasite-host system. Initial contact usually ends in parasite death which results from host defense reactions. Instances of host death are also noted when they are introduced into a new ecosystem. Thus, the younger the parasite-host system is, the more pathogenic are the parasites and the less tolerant of them are the hosts.

The aim of the formation and evolution of the parasite-host system is, among others, there productive success of both sides

The parasite-host relationship is a dynamic one for both partners. This is linked to morphological, physiological, and structural adaptations that render easier the competition for resources that are more beneficial under given environmental conditions and to biological and ecological factors that ease contact among organisms in the environment.

Parasites treating host organisms as environments to inhabit results in disruptions in host physiology, susceptibility to the impacts of toxins, and damage or the stimulation of pathological development of some tissues, and the depletion of nutritional substances. The degree to which these changes occur depends on many factors on the sided of both the parasites and the hosts. Where and how parasites infect hosts, parasite sizes, how they feed, and how they migrate are all significant. Hosts defend themselves against parasites with non-specific (phagocytes, inflammation) and specific (cellular or humoral reactions) immune responses. One must bear in mind that parasites do not associate with just one host for their lifespans. In most cases the reproductive stage of the developmental cycle requires changes of hosts and environments. In each instance, a parasite-host system is established, although this relationship is not usually as long as that between parasites and definitive hosts. When there is a transition from one generation to the next during developmental cycles, new generations have to establish their own systems with hosts. In consequence, this has led to various types of parasitism that require different adaptation strategies and various paths for that generation to become parasitic.

The concept of fragmentation is defined as how parasites are distributed throughout the biosphere. All parasite species, just as other species do, form different populations. A population is a group of organisms of the same species living simultaneously in the same environment and exerting a mutual influence on each other with equal likelihood of interbreeding. Such groups, or populations, are isolated geographically so that gene exchange among populations does not occur. In the case of parasites, it is difficult to draw the precise lines that demarcate population distributions, because it does happen that the same parasite species infects different host populations within one geographical region (e.g., in the same water basin) and they do not exchange gene pools. Parasites with a complex developmental cycle can be transported into another region by its intermediary hosts, and only those parasites with simple developmental cycles cannot move farther than their hosts.

A set of populations of different species that occupy, at least partially, the same habitat and can impact each other is referred to as a community. In ecological parasitology this term is, in a certain sense, the equivalent of the term “biocenosis”. The proper ecosystem functioning of populations and biocenoses has a defined structure. The structure of a population comprises it abundance, the distribution of organisms in the biotope, and the numerical ratio of juveniles to adults in the biocenoses. The structure of the biocenosis to the abundance, composition, and proportion of species that belong to it, the character of their links to the varied ecological factors, and trophic dependencies combine to create a whole that remains in a state of dynamic equilibrium in the natural environment.

Numerous studies have indicated that parasites do not occur in all the individuals of a species inhabiting a given ecosystem, and that parasites will occur in different numbers among species in which they can develop. The term prevalence is employed to describe this concept; it is the ratio of the number of infected host individuals to the number of individuals examined, and it is expressed in percentages. The mean number of parasites per infected host is the mean intensity of infection, while the number of parasites per individual in a population is the mean parasite density. The distribution of the parasite population among the host population is determined based on these parameters. Each infracommunity is characterized by a determined parasite species structure that inhabits host organisms. However, studies indicate that some species occur frequently, while others do so less frequently. However, parasite infracommunities are characterized by the occurrence of dominant species that are a constant element of its composition, and they also occur most abundantly. A permanent component are also influents, which do not occur as abundantly as the dominants, and accessory species that appear only sporadically. The range of the frequency of occurrence of parasites is also described by specific terminology that is also used to describe free-living organisms. Core species are those that occur frequently and abundantly. This term is the equivalent of a dominant species. Intermediate species do not occur as frequently as do core species, while satellite species are those that occur the least frequently and at low abundances.

The qualitative evaluation of the structural quality of communities is based on the terms of richness and diversity. The fist of these is expressed in the number and abundance of the species comprising the community, while the second describes the quantitative relationships between the species in an community.

The richness and diversity of parasite communities within a single host or in a host population undergo cyclical fluctuations that are dependent on the structure of the host population. This refers primarily to intermediate and satellite species which can appear only during determined seasons of the year or host life stages. These changes are linked primarily to the host lifestyle and dietary requirements.

The food requirements of the parasites necessitates introducing yet more terminology. Groups of species exploiting sources in similar ways are referred to as guilds. The way inwhich resources are exploited and their source determine the type of guild. Groups of parasites if different species that occur in a single host are known as aninfraguild. A component gild describes all of the infraguilds of a local host population. Such relationships occur when the host intestine is infected by an community of parasites – one feeds on blood, another on products of host digestion, and others that feed on the epithelium. The range of parasite specificity for hosts is described with the terms 'specialist ', 'generalist', and 'intercepted specialists'. The first group includes parasites that are linked to a small number of related host species, and often by just one host species Generalists are parasites that are not specialized, and have the ability to colonize many unrelated hosts. The third group comprises parasites that have a narrow specificity, which means they can only overtake and develop in a non-specific host only under specific conditions .The character of the development cycle is also linked by two different terms. The entire life cycle of autogenic parasites occurs within a single ecosystem. In the aquatic environment, such parasites have simple developmental cycles and the aquatic organism is also the definitive host. The second type of parasite has a complex developmental cycle and both invertebrates and vertebrates serve as intermediate or definitive hosts. Allogenic parasites are those in which only part of the developmental cycle runs its course in the studied ecosystem; the aquatic organism is the intermediate host and the definitive host is a terrestrial vertebrate, which can become infected in one ecosystem and then transfer the parasite to another.

Helminths directly or indirectly interact through predator–prey relationships, competition, and symbiotic or parasitic relationships with a diverse range of other organisms within the host, in the external environment, and even within the helminth itself, and these are explored in depth. Host intrinsic factors such as physiology, immune status, reproductive status, and nutritional status often influence the outcomes of ecological influences on the parasite.

For helminths that are transmitted through the food chain ('trophic transmission'), it is self-evident that predators that serve as the next host in the life cycle are critically important to the persistence of the helminth. When predators prey on the infected intermediate host, both host and parasite usually benefit as the host attains nutrients, and the parasite attains its next host. It has long been recognized that helminths can manipulate the morphology or behaviour of intermediate hosts, making them more susceptible to predation. Predation that occurs before the parasite is infective is disadvantageous to the parasite, as shown with plerocercoids of the tapeworm *Ligula intestinalis* transmitted from cyprinid fish to piscivorous aquatic birds . Non-host predators have the potential to reduce both parasite and host abundance and are sometimes considered biological control agents. Predation is also relevant to free-living stages of helminths that can be an important component of the diet of non-host consumers.

Autecology The study of interaction between individuals and its environment is known as “autecology” or “ecology of individual”. In autecology, at a given time, we study the influence of individual’s reactions to its natural environment and requirements together and affects of its interacting environment. In simple words how an organism or single species interacts (what it required and after interaction how it reacts) with its natural environment (i.e. under the present conditions prevailed by the organism). Individual species contribute as the unit of autecology study. In autecology, we study in details the morphology of individual effected by its prevailing environment, its geographical distribution based on the surrounding, influence of environment on the life cycle and growth of organism, its taxonomical position and several factors including those which effects different developmental stages of individual’s life cycle.

Evidence that an individual helminth responds to the number of conspecifics within the host has been known for decades. Some of the earliest work, done in tapeworms, focused on the ‘crowding effect’ observed when adult *Hymenolepis diminuta* from more heavily infected hosts had smaller mass. The expectation that the individual parasite will ‘suffer’ at higher intensities of infection due to competition for resources has been observed.

The scope of intensity-dependent relationships now extends to helminth mating strategies, host selection, and positive density dependence as observed through growth facilitation.

Furthermore, there is now evidence of inequality in an individual helminth’s response to high-intensity infection.

Infection intensity has been shown to be a determinant of whether additional parasites join the helminth population within the host and their site preference. *Mermithid* nematodes that infect *Culex pipiens pipiens* larvae avoid infected hosts. Both *Romanomermis iyengari* and *Strelkovimermis spiculatis* detect not only whether the host is infected but also the intensity of infection. They prefer to infect uninfected mosquito larvae, and the time required for pre-parasites to infect the larval mosquito increases with intensity of infection.

The relationship of parasite density with body size and egg production was explored in different species of monogeneans Body size of both species was positively

– not negatively – correlated both with infra population density and with the combined density of both species (infra community density),but fecundity was unaffected. Because the host response to both monogeneans involves mucus production and because mucus is a food resource for the parasites, high amounts of mucus may on balance benefit growth of both species of monogeneans . These examples of positive density dependence appear to be rare cases of facilitation of growth at higher intensities of infection.

The well-documented aggregation of helminths within a host population means that those parasites within the relatively few heavily infected hosts are most likely to experience density dependent reductions in survival or fecundity. It is often assumed that the average response of the infra population to infection intensity is representative of each individual's response

In 1896, Schrocter and Kirchner coined the term Synecology. Organisms of different species living in a group can affect each other's life in any possible way under their natural conditions. It's a more complex condition. Unlike autecology, where single organism is the unit of study, in synecology "group of organisms" are considered as the unit of study. Therefore, an ecological approach "group of organisms" as the unit of study is termed as synecology. Synecology can be divided into population, community ecology, and biome and ecosystem ecology.

In snails, there is considerable evidence that rediae-producing digeneans dominate over those that produce sporocysts. Like social insects, rediae of some digeneans have two morphologically distinct castes, larger rediae with small mouthparts that are responsible for producing cercariae (a 'reproductive caste'), and very small rediae with large mouthparts that attach to and ingest sporocysts of competing digenean species (a 'soldier caste') (Garcia-

When *Biomphalaria glabrata* snails were simultaneously infected with *Echinostoma caproni* and *Schistosoma mansoni*, echinostome rediae ingested sporocysts, reducing schistosome cercarial production and thus making the echinostome the dominant competitor. However, when snails were first infected with schistosomes, even though echinostome development was delayed, echinostomes remained the dominant competitor as echinostome cercarial release was always higher in co-infected snails

In the second intermediate host, sequence of co-infection shapes interspecific competition. Prior infection of the Pacific chorus frog with metacercariae of

Echinostoma trivolvis that live in the frog kidney negatively affected infection success of *Ribeiroia ondatrae*, whose metacercariae are found around the limb buds. A negative correlation between egg output of *Fasciola hepatica* and the less pathogenic digenean *Calicophoron daubneyi* in cattle and reported that the odds of *Calicophoron* infection were higher both in habitats suitable for the shared intermediate host. Considering the enormous diversity of helminth co-infections, the nature and relative impact of interspecific associations within and among helminth taxa have only begun to be explored.

11.4 Summary

- Ecology has been defined as the study of interactions between organisms and their environments and among the organisms inhabiting these environments. This is a complex field of study, which is why it should be investigated on various levels.
- Most parasites have multifaceted life cycles with numerous morphological stages that infect discrete host cell types and tissues. This enormous variety of life cycles and tissue niches result in even greater diversity in the host immune response, targeting not only the different types of parasitic organisms but also the different life cycle stages of the same species within the mammalian host.
- The environment of parasites differs from that of free-living organisms in having two components. One, the microenvironment, is the host itself; the other, the macroenvironment, is the environment of the host.
- Autecology The study of interaction between individuals and its environment is known as "autecology" or "ecology of individual". In autecology, at a given time, we study the influence of individual's reactions to its natural environment and requirements together and affects of its interacting environment.
- Synecology "group of organisms" are considered as the unit of study. Therefore, an ecological approach "group of organisms" as the unit of study is termed as synecology. Synecology can be divided into population, community ecology, and biome and ecosystem ecology.

11.5 Terminal Questions

1- Give a detail account on Microhabitat of parasite.

2- What is macrohabitat of Parasites.

3- Elaborate Different types of Ecology of Heleminthes with suitable examples.

UNIT-12 HOST- PARASITE INTERACTIONS

12.1 Introduction

Objective

12.2 Types of Host parasite Interactions

12.3 Physiology of host parasite interactions

12.4 Immunological control of vector borne and non vector born diseases

12.5 Population dynamics of helminthes

12.6 Bio-invasion and helminthes

12.7 Summary

12.8 Terminal Questions

12.9 Answers

12.1 Introduction: Host –Parasite Interactions

Host-Parasite relationship is the extreme case of animal association, in which both partners influence each others life by affecting each others metabolism and behaviour using different adaptive mechanisms in order to ensure their survival. Although the parasite leaves no stone unturned to establish itself fully in its host by utilizing its food, destroying its tissues, secreting poisons and by deceiving host's immune system by molecular mimicry. On the other hand the host tries its best to destroy the parasite by activating its immune system. Yet neither the host nor parasite succeeds to destroy each other completely. Host tries to avoid unwanted pathogenic, potent, prolific, parasitic guest and parasite tries to have an intimate relationship with its host so that it becomes a permanent guest, however at some point of relationship, one partner or both partners manage to remain independent, resulting in death of either host or parasite mostly of parasite. So it seems that the relation between host and parasite is eternal and are made for each other.

Among the most fascinating phrases of biology is parasitism dealing with the study of parasites and their relationship to their host species. It's a branch of medical sciences where parasitologists observe parasites and their pathogenic effects on the host at all trophic levels. A parasite is a living organism which receives shelter and nourishment from another organism called as host, where it lives. Parasitism is a negative non-mutual symbiotic relationship where parasite obtains benefits at the cost of host fitness. Total dependency on host could be seen in parasitism. The association can be temporary or permanent. Nearly 300 species are parasitic to humans out of which 17 species belongs to protozoans. Four phyla of invertebrates are parasitic to animal kingdom including protozoans, platehelminthes, nematodes and arthropods. Parasite and its host association is a complex interaction Parasitism is defined as a close and obligatory relationship between two heterospecific organisms during which usually the smaller of the two partners known as parasite is metabolically dependent on the host. Parasitism have great influence on mate choice and may alter the sex ratios of hosts or its behaviour and can induce sterility, can enhance the death rates and decrease the birth rate, can affect the nutritional status and energy demands thereby influencing the interspecific or intraspecific competitions by increasing the vulnerability of host to predation.

Objectives

The Study of this unit will help you to:

- Understand the concept of Host Parasite Interactions
- Know the Physiology of host parasite interactions
- Basics of immunological control of vector borne and non vector born diseases
- Fundamentals of Population dynamics of helminthes
- Basic concept of Bio-invasion and helminthes

12.2 TYPES of HOST – PARASITE INTERACTIONS

Parasites are completely dependent on host and this host- parasite interaction is very dynamic. Depending on the recognition of parasite on host it is classified as follows. Let us have a look at the classification based on their interactions with their hosts as well as their life cycles.

1. Ecto-parasites:

Ecto-parasites are the organisms, which inhabit on the skin or outgrowth of the skin of their host for various periods, and may be detrimental to the latter. Various ecto-parasites cause significant infestations in many kinds of domestic animals including livestock, pets, laboratory animals, poultry, fish and bees. Many of these ecto-parasites e.g. most lice are host specific, while others for e.g. many ticks parasitize a wide range of hosts. Several ecto-parasites currently associated with

domestic animals have been acquired by the introduction of either host or parasite into new regions, as animals have become domesticated throughout the world. For example cattle, goats, and other important domestic livestock species have been introduced into much of Africa, where they may now fall victim to the ravages of native tsetse flies (*Glossina* sp.) and ticks, as well as pathogens transmitted by these parasites. Relatively rapid intercontinental transportation of these animals has compounded the problem. The vast majority of ecto-parasites are invertebrates. Most invertebrate ecto-parasites are arthropods; insects and arachnids typically parasitize terrestrial domestic animals, while crustaceans are associated with fish.

2. Endo-parasites:

A parasite that inhabits the internal organs or tissues of an animal is called **endoparasites**.

Endo-parasites can exist in one of two forms:

I. Inter-cellular parasites that inhabit the spaces in the host's body or

II. Intra-cellular parasites that inhabits cells in the host's body.

These intra-cellular parasites like protozoa, bacteria or viruses, completely depend on a third organism termed as the carrier or vector. The vector does the job of transmitting them to the host. An example of this interaction is the transmission of malaria, caused by a protozoan of the genus *Plasmodium*, to humans by the bite of an anopheles mosquito.

3. Meso-parasite:

Those parasites living in an intermediate position, being half-ecto-parasites and half-endoparasites, are called as **meso-parasite**. For e.g. Certain birds who feed on the food left out in the teeth of crocodiles.

4. Facultative parasite:

An organism which is able to live either a free living or parasitic existence are called as facultative parasite; e.g., *Strongyloids stercoralis* of man, some free-living amoeba such as *Naegleria*. Fungi such as *Candida*.

5. Epi-parasite or hyper-parasite:

An **epiparasite** is one that feeds on another parasite. They are also called as hyperparasite, For eg. a protozoan living in the digestive tract of a flea living on a dog. And *Histomonas meleagridis*(a protozoan) is hyper-parasitic on the nematode worm ***Heterakis gallinae.***

6. Obligatory parasite:

They are the organisms, which has become completely dependent upon its host for itsexistence. E.g. *Trichomonas,Taenia solium, Trichinella*.

7. Incidental parasite:

This type of parasites occurs in hosts where it does not normally occur; e.g., *Fasciola* normally does not occur in man but is incidental if found in man's liver.

8. Periodic parasite/ temporary parasite:

Feeds on host but does not live on host; e.g., blood sucking flies like female anopheles mosquitos. *Fasciola hepatica* (Liver fluke), *Schistosoma, Ascaris, haemonchus*

9. Heterogenetic Parasites:

Heterogenic parasites are those who exhibit the alteration of generations. e.g.,Coccidial parasites and *Strongyloides*.

10. Social parasites:

This type of social parasites takes an advantage of interactions between members of social organisms such as ants or termites. eg. Parasitic ants parasitize other ants using aggression and deception

11. Klepto-parasitism: In klepto-parasitism, parasites approach the food gathered by the host. An example is the brood parasitism practiced by many species of cuckoo and cowbird, which do not build nests of their own but rather deposit their eggs in nests of other species and abandon them there.

12. Adelpho-parasite:

An adelpho-parasite is a parasite in which the host species is closely related to the parasite, often being a member of the same family or genus. An example of this is the citrus black fly parasitoid, *Encarsiaperplexa*, unmated females of which may lay haploid eggs in the fully developed larvae of their own species. These result in the production of male offspring. The marine worm *Bonelliaviridis* has a similar reproductive strategy, although the larvae are planktonic.

13. Parasitoids:

Parasitoids are organisms whose larval development occurs inside or on the surface of another organism, resulting in the death of the host. This means that the interaction between the parasitoid and the host is fundamentally different from that of a true parasite and shares some of the characteristics of predation.

3. TYPES OF HOSTS:

Hosts are the organisms on whom the parasites survive or obtain their nutrition. Let us have a look at different types of host and their importance.

1. **Definitive host:**

A definitive host is generally considered the main host. It includes animal or plant that nourishes and supports a parasite; it does not benefit the parasite and is often harmed by the association. For e.g. the malarial parasite mates and reproduces in the mosquito.

However, its gametocytes are formed in humans, making humans the definitive host and not the female mosquitoes.

2. **Intermediate/ secondary host:**

It is a temporary host, but is essential for the completion of a particular parasite's life cycle.

A vector is usually the intermediate host playing an active role in the transmission of the parasite. For e.g. parasitic helminthes larvae may have one, two or more intermediate hosts in their lifecycles.

3. **Accidental host:**

This type of host may be those that can function as the normal host, but is infected only occasionally for some reason. For eg.Zoonoses are human diseases that can be acquired from vertebrate animals. Humans are "accidental" hosts in that human infection is not required for propagation of the infectious agent in nature. Humans have become ill from zoonoses for as long as we have hunted or domesticated animals, and most newly emerging infectious diseases are zoonotic in origin. The causative agents of zoonotic disease can be viruses, bacteria, parasites etc.

4. Permissive host:

This type of host is either a definitive, intermediate, or accidental host that allows the parasite to complete its life cycle in part or the whole. Reservoir hosts are permissive host alternatives to definitive hosts, such that the infective stage can be passed from the host to the population of the definitive host. E.g. Influenza virus attacking human.

5. Non-permissive host:

It is a host organism that is not true definitive host and receives the parasite but the parasite finds itself in a dead end as the parasite not being able to complete its lifecycle and eventually dying within the 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.

6. Transport host:

It refers to a host organism other than true intermediate host that receives the parasite in the position of intermediate host so that the parasite is helped to go to the definitive host.For example *Echinococcus granulosus* normally passes to a dog through an intermediate host, such as a goat or sheep. But the parasite, instead of passing through the intermediate host, may come to infect a human being and remain, causing hydatiditis, and a dog has no chance to get it from a person.

Systemic Relationships Arranged by Effect Between "A" and "B"

	Effect on A	Effect on B		Type of Relationship
Ectosymbiotic	POSITIVE	POSITIVE	+2	Mutualism
Ectosymbiotic	POSITIVE	NEUTRAL	+1	Commensalism
	POSITIVE	NEGATIVE	+1-1	Antagonism
	NEUTRAL	NEUTRAL	0	Neutralism
	NEGATIVE	NEUTRAL	-1	Amensalism
	NEGATIVE	NEGATIVE	-2	Competition

Fig 12.1.: Diagrammatic representation of various types of symbiotic relationships based on the involvement of the two participants

12.3 Physiology of host- parasite Interactions

Each stage of a parasite's life cycle comes with hurdles that the parasite must negotiate if it is to achieve its overriding objective of reproduction. To be successful a parasite must:

- Achieve transmission
- Enter its host
- Migrate to an appropriate target tissue or site within the host
- Maintain its position within the host
- Find a mate

- Successfully reproduce in and release progeny from the host
- Undergo essential developmental changes within the host
- Cope with ambient physiological conditions within the host
- Evade destruction by the host immune system, at least until reproduction is complete

Effective transmission is essential for all parasites Transmission, the passage of a parasite to a host, is the most fundamental imperative for any parasite. All other life cycle concerns are moot if the parasite cannot reach a required host in the first place

Fecal–Oral Transmission Intestinal protozoa, as well as many intestinal helminths, rely on fecal–oral transmission to complete at least part of their life cycle. Such transmission suggests that propagules, the stage responsible for achieving transmission, are released in the feces. They may then contaminate food or water, which may be consumed by the subsequent host. Often the propagule is a relatively metabolically inactive egg or cyst, which can withstand long periods of time in the external environment. Its consumption by the next host is largely fortuitous, and the parasite expends little if any energy as it simply waits to be eaten.

Trophic Transmission The fecal–oral transmission described for the cestode parasites is only half of the story. Once the intermediate host is infected, transmission back to the definitive host is achieved when the definitive host consumes the intermediate host. That is, the parasite takes advantage of the established predator–prey relationship that exists between the definitive and intermediate hosts

Direct Penetration Some parasites take a more proactive approach to their transmission; they actively seek out their host and once they find it, they bore their way in. An example familiar to many tropical fish hobbyists is Ichthyophthirius multifiliis, a parasitic ciliate that causes the condition known as ich or whitespot (Figure 3.11). The condition is easily recognized when small white nodules, looking like grains of salt, appear on the fish's body, fins, or gills.

Vector Transmission Parasites typically move between vector and host as the vector takes a blood meal. Most vectors are arthropods, and the roster of parasites (eukaryotic, prokaryotic, or viral), which rely on arthropods to achieve transmission is long. The Anopheles mosquitoes involved in Plasmodium transmission may be the best-known example. A perfect vector would have all of these characteristics. Vectors with high capacity may serve as primary vectors—vectors able to maintain a parasite transmission cycle in the absence of other vectors. Competent vectors with low capacity may act as secondary vectors because they may be able to transmit a parasite but unable to maintain the transmission cycle in the absence of the primary vector.

Sexual transmission

Eukaryotic parasites may also be transmitted via sexual contact. The parasite generally resides in the foreskin of bulls, in which symptoms are generally unapparent. When transferred to the female reproductive tract, however, it can cause uterine infection (pyometra), infertility, and spontaneous abortion. In the past, this parasite imposed a large financial burden on the cattle industry. In recent years, the number of cases has declined as a result of the use of artificial insemination. Remarkably, however, it is now considered to be an emerging pathogen in cats, where, unlike cattle, it inhabits the intestinal tract and is excreted in the feces.

Vertical Transmission Vertical transmission refers to the transmission of parasites from mother to offspring, either across the placenta or through breast milk in the case of mammals or via infected gametes. Toxocara canis for example is a common nematode parasite of dogs. Puppies are frequently infected before birth as a consequence of transplacental transmission.

High reproductive rates are common in many parasite life cycles

A relatively high investment in reproduction is common among living things for which the likelihood that any single progeny will survive is low. Many plants and sessile aquatic animals, for instance, rely on broadcast reproduction. Propagules are released into the environment to be dispersed by wind or water currents. Most fail to survive. High fecundity allows these organisms to compensate for the high mortality incurred by their progeny. Many parasites also produce large numbers of relatively small progeny to counterbalance the low probability of success of any single egg or larva. Parasites, like other organisms, must contend with various potentially lethal abiotic and biotic factors. Parasites, however, must cope with the additional problem of transmission. The high host specificity of many parasites further complicates the problem of finding a suitable host environment.

Parasites may use strategies other than high fecundity to achieve transmission
Returning to the theme of high fecundity and parasitism, a caveat must be added: the relationship between parasitism and high fecundity is not always as straightforward as one might assume. Like all living things, parasites must balance many competing metabolic demands, and the observed fecundity for any parasitic species represents a trade-off with other life history characteristics. For example, it has been found that

parasitic copepods that use invertebrates as hosts produce far fewer eggs than those that parasitize fish. This difference is thought to reflect the relative ease of locating and attaching to a sedentary, benthic invertebrate as opposed to a highly mobile and active fish. Those relatively few eggs produced by species using invertebrates as hosts tend to be larger, reflecting the higher investment in each individual reproductive event. Numerous other factors might likewise act to influence the optimal fecundity of a parasite. These factors include but are not limited to adult size, life span of both the parasite and the host, and the host range of the parasite (Figure 3.16). In those species that engage in both asexual and sexual reproduction, there often seems to be a compromise of sorts regarding the amount of energy devoted to each of these two processes. Some cestodes in the genus Taenia, for example, reproduce asexually in the intermediate host, whereas others do not. In those that do, adult worms tend to be smaller. They also have shorter life spans relative to exclusively sexually reproducing species. Likewise, in mammalian schistosomes, some of the species with the highest rate of egg production in the definitive host produce the lowest number of cercariae per miracidium in the intermediate host.

Many parasites must migrate to specific sites or tissues within the host Reaching and entering an appropriate host is just the beginning. Once they have gained entry, many parasites make elaborate and often bewildering migrations within the host in an effort to arrive at a particular location. Such site specificity is a common feature in many parasitic infections. *Leishmania* spp. are found only in macrophages within their vertebrate host, whereas Plasmodium is restricted to either hepatocytes or erythrocytes in mammals, depending on the developmental stage. Internal parasites have a more complex task. Navigation within an environment that is dark, churning with digested food or flowing blood, and full of molecules such as antibodies designed to impede progress is far from trivial. The host environment, however, although complicated, is predictable. Because of anatomic similarity among members of the same host species and because of homeostatic mechanisms that maintain relatively constant chemical conditions in specific regions of the body, parasites are presented with a predictable set of navigational cues. Over evolutionary time, parasites have evolved to recognize such cues and alter their migration within the host accordingly. It has been shown that those parasites undergoing complex migrations within their hosts actually key in on a very small number of the environmental stimuli to which they are exposed. That is, such parasites live in a relatively limited sensory world and respond to only a few of the environmental signals that they encounter. Furthermore, unlike many animals that navigate by following a concentration gradient of airborne or waterborne chemicals, parasites are far less likely to rely on chemical gradients. In a tightly constrained environment, such as an intestine or blood vessel, such gradients cannot be established because fluid within the space is continually bounced back and forth as it encounters anatomical barriers. Consequently, animal parasites exhibit genetically programmed stereotypic behaviors when they encounter a particular threshold level of a given stimulus. Such behaviors help ensure that they respond in an appropriate manner. Parasites are adapted to maintain their position on or within the host The host environment is not particularly conducive to a stationary existence. Parasites inhabiting the digestive tract must contend with powerful peristalsis. Those found in the circulatory system must cope with the surge of rushing blood. Ectoparasites are confronted with environmental factors such as wind or rain or host behaviors such as grooming that make remaining in place more problematic. We have already mentioned some of the strategies used by various parasites to overcome this obstacle. Gut parasites may invade the intestinal epithelium, as we saw in the case of *Toxoplasma gondii*, or like *Giardia lamblia*, they may adhere with adhesive disks. Ectoparasites also employ a wide range of adaptations to maintain their position in a specific site. Of particular interest are the parasitic copepods, some of which appear to have stretched morphological plasticity to the limit in terms of their specific adaptations for adherence.

Finding a mate is a requirement for many sexually reproducing parasites The site specificity we have been discussing, as well as the adaptations that permit it, serve another purpose; for sexually reproducing parasites it facilitates finding a mate. This, of course, is not a problem for asexual or non reproducing life-cycle stages. Monoecious species are often preferential out crossers, but for those that readily self-fertilize, finding a mate is of reduced importance. However, for dioecious sexually reproducing parasites, finding a member of the opposite sex is less problematic when both sexes are homing in on the same target tissue. It has even been proposed that for dioecious parasites with indirect life cycles, trophic transmission evolved as an efficient way for parasites to meet a sexual partner, as it serves to concentrate parasites at a single location. Once they have arrived at their site of choice, evidence suggests that many parasites rely on chemoattractants to bring them into physical contact.

Propagules are released through a portal of exit Following parasite reproduction within a host, eggs or larvae must often be released to the external environment or must pass directly to the next host in the life cycle. The anatomical structure through which propagules move is called the portal of exit. For parasites of the gastrointestinal tract, the usual portal of exit is the anus. Vector-borne parasites rely on the feeding behavior of an arthropod both for host ingress and egress. Genital contact serves this same dual function for sexually transmitted parasites such as *Trichomonas vaginalis*. It is not always true, however, that the portal of exit is part of the same anatomical structure or even the same organ system as the one through which the parasite enters a host. Hookworms, for instance, infect their definitive host when larvae burrow through the skin. Following an extensive migration, they ultimately arrive in the intestine where they mature sexually. Fertile eggs exit the definitive host with the feces. In the schistosomes, cercariae enter the definitive host by direct penetration of the skin. Eggs, however, are released through the feces or the urine, depending on species.

Parasites undergo complex developmental changes in response to environmental cues The developmental changes that occur in all living things during their lives are especially noticeable in those organisms that use very different habitats at different points in their life cycle. For instance, striking changes in both body plan and physiology are typical of insects with aquatic larvae and terrestrial adults. Many parasites also undergo dramatic developmental changes as they move from one habitat or host to the next. Although we know a great deal about precisely what developmental changes transpire during a parasite's life cycle, we know comparatively little about how these changes occur. Many questions remain regarding the signals used by parasites to cue their developmental changes, how such signals are detected and transduced, how genes are differentially expressed in different stages of development, and the consequences of this differential expression. Yet some trends are evident and, as fields such as transcriptome analysis continue to advance, pieces of this puzzle are beginning to fall into place. One obvious trend is that, not surprisingly, most developmental changes occur either in anticipation of transmission or upon arrival in the body of a new host. These, of course, correspond to those times in the life cycle of any parasite when the environment is either about to change or has suddenly changed most radically. It is also becoming increasingly clear that parasites actively monitor their environment and, in doing so, are able to regulate their developmental changes to best insure either successful transmission or survival in the new host. Parasitic nematodes with free-living larval stages often arrest development of those stages when external environmental conditions are not compatible with larval survival. Such developmental arrest, called hypobiosis, makes sense from an adaptive perspective, as development in parasites is usually irreversible; once a parasite undergoes a developmental change, there is no going back. Consequently, the parasite must regulate development carefully to prevent premature development that may not allow survival or transmission. Hypobiosis may either be induced or ended as specific environmental cues are detected. Both hookworms and strongyloids are well-known examples. The stimuli that induce such arrest vary according to species, but they are generally assumed to include factors such as temperature, soil moisture, changing photoperiod, or some combination of these and other abiotic factors.

Epigenetic phenomena and co-opting of host signaling molecules may be important in parasite development Epigenetics refers to heritable changes in phenotype or gene expression caused by mechanisms other than an alteration in the DNA sequence. DNA methylation in eukaryotes, which can silence genes without changing those genes' nucleotide sequences, is a familiar example. An additional trend that is becoming increasingly clear is the importance of epigenetic processes in parasite development. In the transition of one parasite developmental stage to the next, histone acetylation in particular, which also results in a rapid change in a cell's transcription profile, may be particularly important.

12.4 POPULATION DYNAMICS OF HELMINTHES

The population dynamics of helminths, or parasitic worms, can be studied using mathematical models to understand how to control helminth diseases. Some key factors that affect population dynamics include:

Host density

As a microparasite negatively affects a host's survival and fecundity, host density fluctuations increase.

Population bottlenecks

During population bottlenecks, host density is more likely to drop to zero, which increases the chance of extinction for small host populations.

Parasite effects

Parasites that have little or no effect on host population dynamics can be modeled using the same models as parasites that reduce host density or contribute to host population extinction.

Aggregation

Increasing degrees of aggregation can allow multiple species of parasites to coexist.

Some examples of mathematical models that have been used to study helminth population dynamics include:

- Schistosome flukes: Models for schistosome flukes
- Intestinal nematodes: Models for intestinal nematodes
- Filarial infections: Models for filarial infections

Mathematical models provide a useful tool to predict transmission rates because transmission can be so complex, the use of mathematical models in parasite transmission studies has great appeal. Models provide a tool with which to explain complex biological phenomena in a simplified manner. They can also reveal the critical factors that are required to fully understand transmission dynamics. The simplicity of models compared to the almost overwhelming complexity of genuine biological processes is both the strength and weakness. It is a tall order indeed to reduce a biological phenomenon to a set of mathematical equations. Yet if the various assumptions inherent in any model are reasonable, mathematical models can have great predictive value and as such can provide valuable insight into the nature of parasite transmission. For example, climatic conditions, specifically rainfall and temperature, affect both the survival and development of Anopheles mosquitoes and the *Plasmodium* species that they transmit. A model incorporating rainfall and temperature patterns in sub-Saharan Africa can predict how these climatic parameters affect the ability of mosquito vectors to transmit *P. falciparum*. This has allowed researchers to predict the intensity of malaria transmission in various geographic locations. Specifically, the impact of rainfall and temperature on R_0, or the basic reproductive rate of infected mosquitoes, was considered. The R_0 value corresponds to the mean number of new cases that a single infected individual will cause in a population with no immunity to the disease in question. In this study, R_0 represented the average number of human *P. falciparum* infections caused by a single infected mosquito. When R_0 is less than one, transmission of any disease should eventually cease, provided infection rates remain constant. As R_0 rises above one, the disease will be able to spread in a population, and the larger the R0 value becomes, the more intense the transmission. The researchers found that the ability of Anopheles mosquitoes to transmit malaria (that is, their vector capacity) could be predicted based on rainfall and temperature. Vector capacity was then used to develop a model that could predict R_0 , and consequently the likelihood of malaria transmission in any geographic location. It was suggested that such a model could be used to determine how transmission of malaria and other diseases might change in response to global climatic change.

Mathematical models have repeatedly demonstrated their value in predicting the effectiveness of various intervention strategies to disrupt transmission. *Schistosoma japonicum*, for instance, is unusual in that, unlike other important human schistosomes, this species uses a wide variety of mammals as definitive hosts. By assessing the number of eggs released in the feces of various mammalian hosts, including humans, researchers developed a transmission model that assessed the roles of different mammalian hosts in *S. japonicum* transmission in the Philippines. The model predicted that larger animals such as water buffaloes and dogs played a relatively slight role in transmission to humans. Smaller mammals, including rats, were of much greater importance. This finding suggests that control efforts aimed at reducing infection in water buffaloes or dogs will have little impact on overall infection rates in humans. Rat control, however, could pay large dividends in reducing human disease prevalence and intensity.

12.5 Immunological control of vector borne and non vector borne diseases

Vector-borne diseases (VBDs) remain major threats to human health and well-being, and, as an epidemiological group, inflict a terrible and unacceptable public health burden on humankind. The developed world has been fortunate to have escaped much of the terrible burden that mosquitoes and their arthropod allies inflict on humans in countries endemic for diseases such as malaria and dengue.

- Immunological control: The use of antimicrobial peptides (AMPs) is a well-studied systemic response to vector-borne diseases. AMPs are small peptides that bind to and disrupt microbial cell membranes. **RNA-induced silencing complex (RISC)**: The use of RISC can induce an anti-viral state by binding to complementary RNAs. This causes the cleavage and degradation of viral RNA.**Insect repellent**: Using insect repellent is the best way to prevent bites.**Vaccination**: Travelers can get vaccinated for some vector-borne diseases. **National Vector Borne Disease Control Programme (NVBDCP)**: This program is an integral part of India's National Rural Health Mission (NRHM). The program's goal is to prevent and control vector-borne diseases like malaria, dengue, and chikungunya. **Climate change**: The rapid warming of the Earth is a long-term challenge for vector-borne disease prevention and control. Cold-blooded animals, or vectors, do better in a warmer world.

Immune response at the skin barrier

The skin's immune response is a vital first line of defense against pathogens. The skin contains antimicrobial peptides and proteins, and activates local immune cells to eliminate pathogens.

Immunizing vertebrate hosts

Immunizing vertebrate hosts can compromise the survivorship and fecundity of vectors.

Studying immune mechanisms

Studies on the immune mechanisms of vector defense against pathogens can help disrupt pathogen transmission.

Whole-genome sequencing

Whole-genome sequencing of disease vectors can help prevent transmission by targeting the biological aspects of vectorial capacity.

Genetic engineering

Genetic engineering technologies can be used to modify genomes to prevent transmission.

Modern scientific approaches have contributed a swath of information in laboratory-reared, genetically inbred organisms for arthropod vector immunity. However, the outcome of this knowledge does not always translate into the complex interaction between a microbe and an arthropod vector in nature. Organisms that reproduce quickly and have available a wide range of genetic tools are unique. They can be used to gather evidence and study biological processes in a short period of time. Yet, the diversity of immunological processes may be overlooked or become lost when concepts derived from these systems are strictly applied to non-model organisms. For instance, most microbes used to challenge the *Drosophila* immune system have not co-evolved and are not capable of being transmitted by this organism. This is in stark contrast to studies done in arthropod vectors where microbes are transmitted, but do not typically kill these species. Thus, differences in immune networks are being increasingly recognized between *Drosophila* and other arthropods. odel organisms will remain critical for obtaining novel mechanistic insights in medicine. However, more attention should be given to the type of immune response mounted (*i.e.*, resistance versus tolerance) and the ecology and life cycle of the arthropod being analyzed. The establishment of generalized principles in immunology with just a few model organisms is a recent phenomenon in science, centered on the development of genetic manipulation. However, given the relative lack in understanding of how tolerance, resistance and immune deployment affects vector competence, it would be wise consider the context of the experimental design in *Drosophila*. It would also be prudent to contemplate the genetic diversity, biotic and abiotic factors that affect the immune response in arthropod vectors outside laboratory settings.

To understand the dynamics of vector immunity to invading parasites and pathogens it is essential to understand the initial processes involved in gaining access to particular insect host tissues. Different invaders adopt different strategies for entry although routes are mainly limited to the outer cuticle and various epithelia lining the cuticle, gut, reproductive system and tracheae. Most human parasites/pathogens are ingested during blood feeding by vectors with biting mouthparts, but the subsequent events in the host vary significantly. The basic insect immune response can be elicited in response to foreign invasion following wounding or in the gut, the haemocoel, the haemocytes, the fat body, the salivary glands and other tissues following ingestion. Recognition is mediated by means of pattern recognition receptors (PRRs) located on/in immune tissues which bind to pathogen-associated molecular patterns (PAMPS) of invading parasites and microbes. This recognition and binding can directly activate innate immune responses like phagocytosis and also initiate various signaling pathways leading to transcription of immune effector genes and the secretion of immune proteins/cytokines for eliminating invaders. The insect effector immune factors include antibacterial peptides (AMPs), lectins, prophenoloxidases (PPOs, for melanisation), reactive oxygen species (ROS), nitric oxide (NO), antiviral factors, cytokines and many more Much of the knowledge of these processes was gleaned by work on *Drosophila* while valuable contributions have also been made with other species including *Aedes/Anopheles* mosquitoes. Insect immunity is usually described as consisting of interacting humoral and cellular elements. The humoral components, often derived from the immune tissues, involve immune proteins and pathways, mentioned above, such as the antimicrobial peptides and melanisation reaction, while cellular elements include coagulation, phagocytosis, nodule formation and encapsulation-type responses

Vector Cellular Immunity

Central to many of the immune responses are the haemocytes which can be free in the circulation or sessile and associated with tissues such as the heart ostia of mosquitoes. Some haemocyte types are extremely fragile, including those from vector species, and usually degranulate and break down rapidly on exposure to air. The use of an anticoagulant solution stabilises the cells and allows examination under phase optics to observe both the structure and some functions of these cells.

Haemocyte Types

The huge diversity of insects is also reflected in variations in the form of the different types of haemocytes present, although the use of phase observations of stabilised cells can distinguish which cells are phagocytic or involved in coagulation reactions due to granule discharge. Studies on 15 insect orders identified the main haemocyte types as prohaemocytes, plasmatocytes, granular cells, oenocytoids, spherule cells and coagulocytes, with the number of these classes present varying with different insect species and during various stages of development. The recent ability to study the function of single haemocytes , using single-cell RNA sequencing (scRNA-seq) combined with gene silencing and functional studies, is a breakthrough in typing these cells. In *Drosophila*, scRNA-seq has identified many subpopulations of plasmatocytes at different stages of development, while in mosquitoes immune cell subsets, their differentiation and lineages have also been defined.

Haemocytes in vectors have mainly been studied in mosquitoes and triatomines. In mosquitoes, three main cell types, namely, prohaemocytes, granulocytes and oenocytoids, have previously been described.

Cellular Defence Mechanisms

These include coagulation, phagocytosis, nodule formation/encapsulation, apoptosis, autophagy and extracellular traps. Dividing immunity into cellular and humoral reactions is often arbitrary as these components frequently interact in most immune responses.

Coagulation of insect haemolymph occurs in most studies of different species and is an essential process limiting the excess loss of haemolymph and preventing the entry of parasites and pathogens. Haemolymph coagulation has been reported in mosquitoes, triatomines, blackflies ,tsetse flies and lice. It basically occurs in two phases, initially involving the cross-linking of clot components from the plasma and haemocytes and depending on transaminase activity followed by phenoloxidase hardening and melanising the soft clot material.

Phagocytosis by insect haemocytes has been widely reported as an important defence process in vector insects. Detailed studies of the interaction of the haemocyte cell surface and free pattern recognition receptors (PRRs) with the pathogen-associated molecular patterns (PAMPs), as well as the role of plasma opsonins, have mainly been confined to mosquitoes. The comprehensive studies published on the immune system of the mutants of *D. melanogaster* provide useful guides for comparison with mosquitoes as does RNA interference (RNAi) utilising the multiple mosquito genome sequences available.

Similar to phagocytosis, nodule formation and encapsulation (often referred to together as capsules) occur rapidly following invasion of a range of insects by parasites and pathogens. The encapsulation response may be humoral and melanotic, as in some dipterans with limited numbers of haemocytes, solely cellular as in lepidopterans like *Galleria* or even formed by a combination of humoral and cellular responses]. The formation of these structures is controlled by interacting cytokines and effector molecules, details of which have been identified mainly in *Drosophila*, lepidopterans and non-vector insects. During this process, granule-containing cells stick together due to their release of a viscous material identified as hemocytin which is a homologue of the mammalian von Willebrand factor. The degranulation of the haemocytes occurs after recognition of PAMPs by PRRs, activation of a haemolymph serine proteinase and Spätzle1, and with Toll signalling releasing 5 -HT and eicosanoids to aggregate the cells . In addition, although good progress has been made in understanding aspects of phagocytosis and capsule formation in model insects, like *Drosophila*, *Galleria* and *Bombyx*.

12.6 Bio Invasion and Helminthes

Invasions are one of the main generators of ecological novelty: biological systems (organisms, communities, ecosystems) produced as a result of human activity with few or no historical analogs. Parasites (we use the term to refer collectively to macroparasites, microparasites, and parasitoids) are fre-quent partners or players in biological invasions because they are either introduced into new communities along with invading species, or are left behind in the ancestral range of the host, affording the host ‘enemy release’. More-over, parasites are frequently implicated in altering the outcome or impact of invasions, changing the strength of interactions between invasive and native species . Emerging infectious diseases (EIDs) can be considered to be another class of potentially invasive parasites that spread into new host populations or species. Recent articles recognize the relevance of biological invasions and changing distributions for the spread of zoonoses; we consider here the broader implications of invasion for wildlife disease. In this review we focus on the relationship between parasitism and invasion, acknowledging similar-ities between the processes of invasion and disease emer-gence , and examine the mechanisms by which parasites influence, and are influenced by, invasion, and the con-sequences of these interactions for species, communities, and ecosystems. We go on to examine the need for new policy, risk analysis, and biosecurity measures to manage or mitigate some of these issues.

Biological invasions, i.e. the establishment of non-native species outside of their natural range, represent a major threat to the diversity, integrity and functioning of ecosystems. They consist of the large-scale redistribution of species across the Earth, mostly as a consequence of human activities, and without the time necessary for gradual evolutionary adjustments of the native fauna and flora. For example, the intensification and globalisation of transport by ships has created repeated opportunities for the rapid introduction of small founder populations of aquatic alien species to new areas via ballast water. Despite growing efforts to reduce invasion risk along multiple routes of introduction, recent estimates indicate that the rate at which alien species are detected shows no sign of slowing down.

Biological invasions can implicate parasites in many ways. Freeliving alien species may (i) succeed in a new area because they have been introduced without their parasites, (ii) be introduced along with their parasites with the latter then infecting native species, (i) or acquire native parasites following their introduction, leading either to the dilution or amplification of infection risk for native species. Parasites may also be introduced to new areas without their original hosts, wreaking havoc on native hosts with no coevolutionary history with, and therefore no defenses against, these novel parasites.

The introduction of species and their naturalization is presently considered one of the important mechanisms responsible for global change, leading to profound alterations in ecosystem structure and function, homogenization of biota, reduction of biodiversity and to the extinction of species. Biological invasions and species introductions have fascinated biologists for a long time. Darwin, in his 1859 book "On the origin of the species", alluded to the fact that some domesticated animals that were taken by navigators from Europe to America and Australia had multiplied very quickly, sometimes affecting the survival of native species. A biological invasion occurs when an organism, of any kind, reaches a site beyond its former area of distribution, becomes established and spreads; that is, invasions occur when a species colonizes and persists in a new geographic area.

The invasion process varies according to multiple factors, namely: the traits of the invasive species, the traits of the invaded ecosystem, and the interactions with native species. The majority of the invasions occur in habits affected by human activities, particularly those under considerable disturbance, but this might only be a consequence of the fact that species are more easily transported to those sites.

Two helminths, the liver fluke, *Fasciola hepatica*, of cattle and sheep and the swimbladder nematode, *Anguillicola crassus*, of eels are shown to be useful as model parasites for the study of animal invasions and environmental global change. Introductions of *F. hepatica* have been associated with imports of cattle or other grazing animals. In various target areas, susceptible lymnaeid snails serving as intermediate hosts were either naturally present and/or were introduced from the donor continent of the parasite (Europe) and/or from other regions which were not within the original range of the parasite, partly reflecting progressive stages of a global biota change. In several introduced areas, *F. hepatica* co-occurs with native or exotic populations of the congeneric *F. gigantica*, with thus far unknown implications. Over the fluke's extended range, in addition to domestic stock animals, wild native or naturalized mammals can also serve as final hosts. Indigenous and displaced populations of *F. hepatica*, however, have not yet been studied comparatively from an evolutionary perspective. A. crassus, from the Far East, has invaded three continents, without the previous naturalization of its natural host *Anguilla japonica*, by switching to the respective indigenous eel species. Local entomostrac crustaceans serve as susceptible intermediate hosts. The novel final hosts turned out to be naive in respect to the introduced nematode with far reaching consequences for the parasite's morphology (size), abundance and pathogenicity. Comparative infection experiments with Japanese and European eels yielded many differences in the hosts' immune defence, mirroring coevolution versus an abrupt host switch associated with the introduction of the helminth. In other associations of native hosts and invasive parasites, the elevated pathogenicity of the parasite seems to result from other deficiencies such as a lack of anti-parasitic behaviour of the native host compared to the donor host which displays distinct behavioural patterns, keeping the abundance of the parasite low.

12.7 Summary

- Host-Parasite relationship is the extreme case of animal association, in which both partners influence each others life by affecting each others metabolism and behaviour using different adaptive mechanisms in order to ensure their survival.
- Parasites are completely dependent on host and this host- parasite interaction is

very dynamic. Parasitism: A relationship where one organism, the parasite, benefits at the expense of the other, the host. Mutualism: A symbiotic relationship where both species benefit. Commensalism: A symbiotic relationship where one species benefits while the other is not affected.

- The physiology of host-parasite interactions is a complex topic that involves the study of how parasites and hosts interact with each other, and how these interactions can cause physiological changes in the hostAfter emergence of the parasite, the host is immobile and lies in a flaccid state. The parasite, therefore, controls the physiology of the host to suit its own needs.
- The population dynamics of helminths, or parasitic worms, can be studied using mathematical models to understand how to control helminth diseases. Mathematical models provide a useful tool to predict transmission rates because transmission can be so complex, the use of mathematical models in parasite transmission studies has great appeal. Models provide a tool with which to explain complex biological phenomena in a simplified manner.
- Biological invasions, i.e. the establishment of non-native species outside of their natural range, represent a major threat to the diversity, integrity and functioning of ecosystems. They consist of the large-scale redistribution of species across the Earth, mostly as a consequence of human activities, and without the time necessary for gradual evolutionary adjustments of the native fauna and flora

12.8 Terminal Questions

4- Elaborate Immunological control of vector borne and non vector borne diseases

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5- Write a brief note on Bio invasion with examples.

6- Describe Host parasite interactions and its type.

4- Give ca detail account on physiology of host parasite interactions

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SQ 5- Plasmodium is a example of ------------------

SQ6- Example of mathematical models that have been used to study helminth population dynamics -----------------

SQ7- Brood parasitism is a example of ------------------

SQ8- Bio invasion is well studied in Two helminths, --------------and ------------------

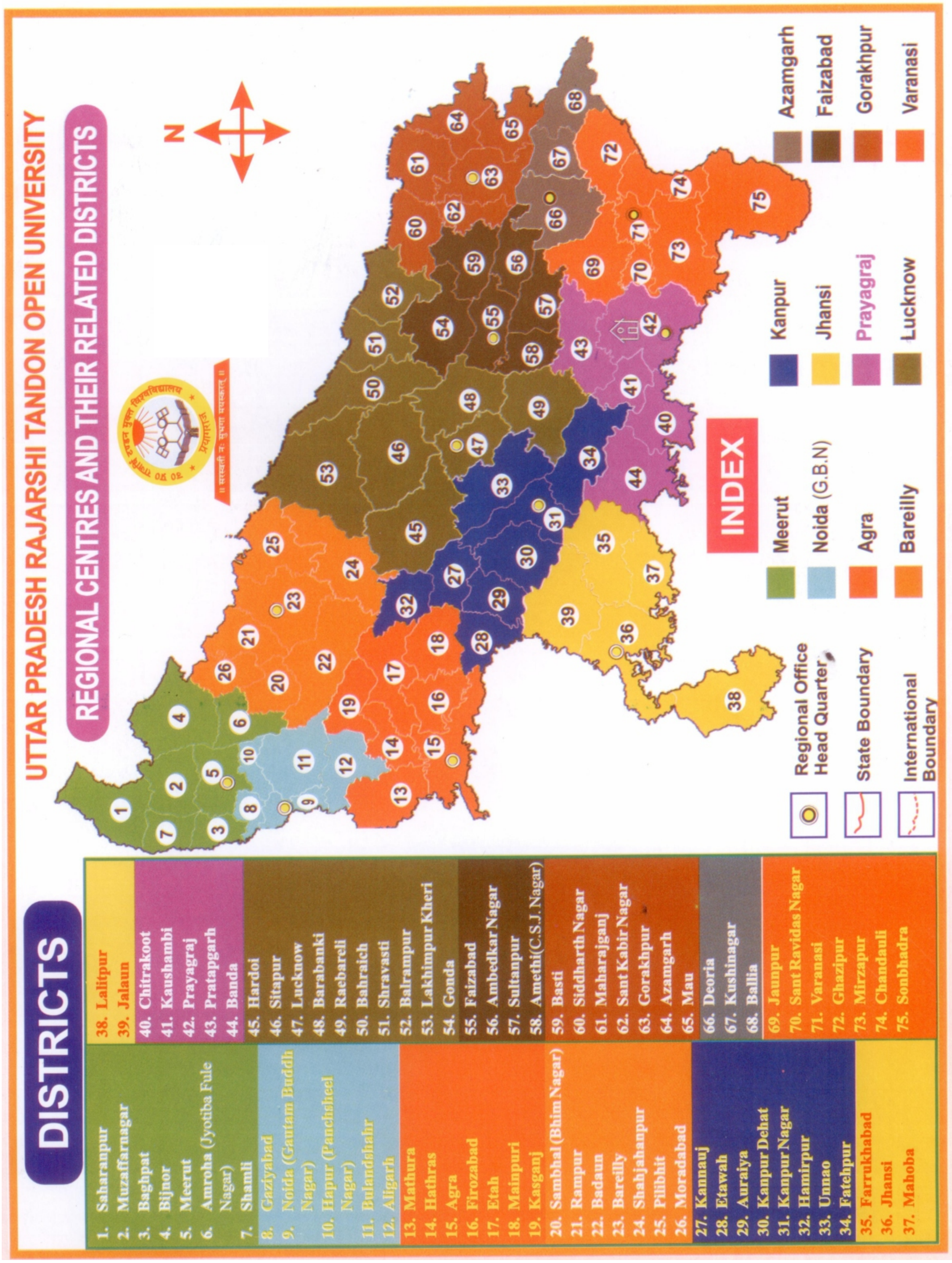
12.9 Answers

Q 5- Endoparasite

Q6- Schistosome flukes

Q7- klepto-parasitism

Q8- *Fasciola hepatica*, *Anguillicola crassus*



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