B.Sc. ZOOLOGY LAB MANUAL

6th Semester

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Zoology

MIDNAPORE CITY COLLEGE

PREFACE TO THE FIRST EDITION

This is the first edition of Lab Manual for UG Zoology 6th Semester. Hope this edition will help you during practical. This edition mainly tried to cover the whole syllabus. Some hard core instrument based topic are not present here that will be guided by responsive teachers at the time of practical.

ACKNOWLEDGEMENT

We are really thankful to our students, teachers and non teaching staffs to make this effort little bit complete.

Mainly thanks to Director and Principal Sir to motivate for making this lab manual.

C13P: Developmental Biology Lab
List of Practical

1. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).
2. Study of the developmental stages and life cycle of Drosophila from stock culture.
3. Study of different sections of placenta (photomicropgraph/ slides).
4. Project report on Drosophila culture/chick embryo development.

C14P: Evolutionary Biology Lab
List of Practical

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.

DSE3P: Parasitology Lab Credits 02
List of Practical:

1. Study of life stages of *Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani* through permanent slides/micro photographs.
2. Study of adult and life stages of *Schistosoma haematobium, Taenia sajinata* through permanent slides/micro photographs.
3. Study of adult and life stages of *Ancylostoma duodenale, Brugia malayi and Trichinella spiralis* through permanent slides/micro photographs.
4. Study of plant parasitic root knot nematode, *Meloidogyne* from the soil sample.
5. Study of *Pediculus humanus*, *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.
6. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry.
7. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a by-product.

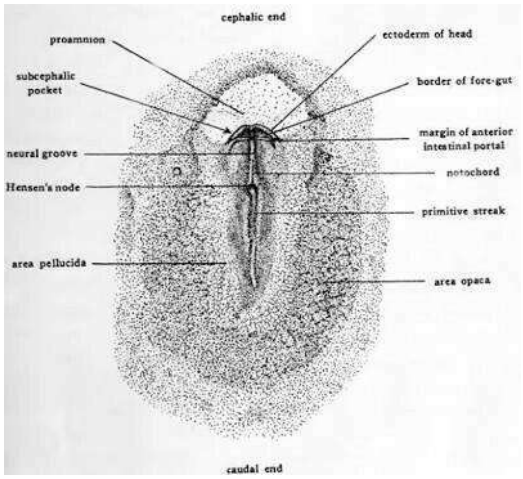
Submission of a brief report on parasitic vertebrates.

DSE4P: Biology of Insects Lab
List of Practical

1. Study of life cycle of Mosquito
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Mounting of insect wings, spiracles and genitalia of any insects
4. Methodology of collection, preservation and identification of insects.
5. Morphological studies of various castes of *Apis, Camponotus, Odontotermes*
6. Study of major insect pests of paddy and their damages
7. Study of Mulberry silk moth as beneficial insect

C13P: Developmental Biology Lab
List of Practical

Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).



i. 13 hours after incubation the primitive streak becomes so distinct that embryos are characterized as being in primitive streak stage
ii. In fixed and stained slide, w.m. is composed of central furrow, called as primitive groove lined by thickened primitive ridges.
iii. At the cephalic end of the primitive streak, closely-packed cells form thickened area, called as Hensen's node. Part of area pellucida adjacent to the primitive streak shows increased thickness and forms embryonic elliptical shape.
iv. Area pellucida assumes elliptical shape.
v. Elongated primitive streak represents long axis of future embryonic body.

Whole Mount of 18 Hours Chick Embryo:
1. It is a W.M. of 18 hours stage of chick embryo.
2. At this stage the dark peripheral area opaca and central translucent area pellucida are distinctly visible.
3. In the anterior part is present the pro-amnion, which is a small and comparatively more translucent region of area pellucida and is characterised by the absence of mesoderm.
4. In the middle of area pellucida, in the posterior half, runs a primitive streak having a primitive groove through its centre. The primitive groove is being bound by primitive folds.
5. In the anterior half of area pellucida, in the middle, runs a neural groove bound by neural folds.
6. The primitive streak and neural groove is separated by a thickening-the Hensen's node having a small depression in the centre-the Hensen's pit.
7. The primitive streak gives rise to an out-growth, the notochord immediately below the primitive groove.

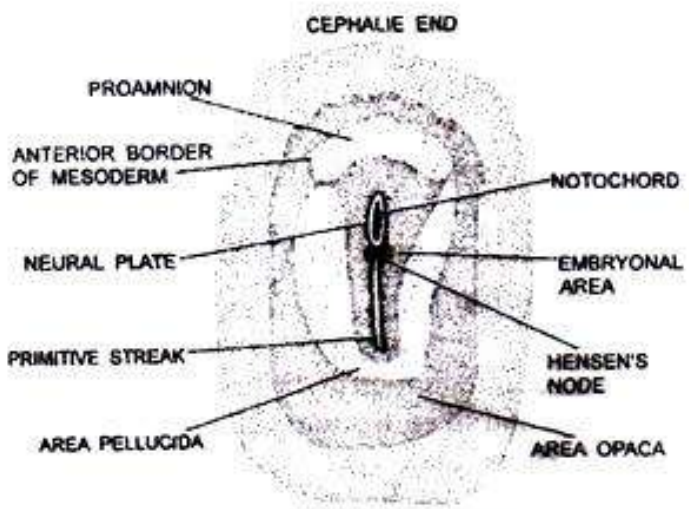


Fig. 17.3. W.M. of 18 Hr embryo of chick

Whole Mount of 21 Hours Chick Embryo:

1. It is a W.M. of 21 hours chick embryo.

2. At this stage the dark peripheral area opaca and central translucent and colourless area pellucida are distinctly visible.

3. In the anterior part are present the pro-anmnion, which is a small and comparatively more translucent region of area pellucida and is characterised by the absence of mesoderm.

4. In the middle of area pellucida, in the posterior half, runs a primitive streak having a primitive groove through its centre. The primitive groove is being bound by primitive folds.

5. In the anterior half of area pellucida, in the middle, runs a neural groove bound by neural folds.

6. The primitive streak and neural groove are separated by a thickening, the Hensen's nod having a small depression in the centre of the Hensen's pit.

7. The primitive streak gives rise to a small outgrowth, the notochord immediately below the primitive groove and to mesoderm on either side.

8. At this stage embryonic and extra ambryonic regions have also become distinguished in the area pellucida.

9. In the anterior most part the ectoderm has given rise to head fold, which is a pocket-like extension of neural folds.

10. With the ectoderm the underlying endoderm is also transformed into a pocket-like structure the -foregut.

11. The proambion is comparatively reduced in size.

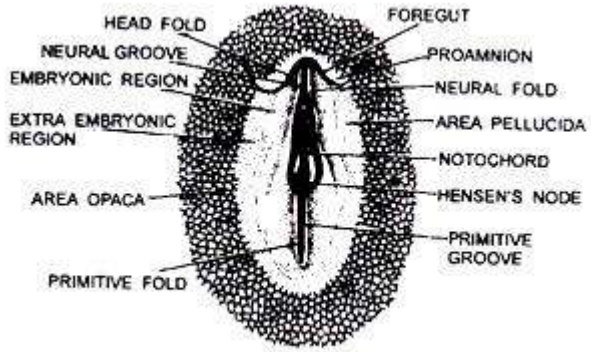


Fig. 17.4. W.M. of 21 hour chick embryo.

Whole Mount of 24 Hours or 4 Pairs of Somites Stage of Chick Embryo:

1. It is a W.M. of 24 hours 4 pairs of somites stage of chick embryo.

2. At this stage the dark peripheral area opaca and central translucent and colourless area pellucida are distinctly visible.

3. In the anterior part is present the proamnion, which is a small and comparatively more translucent region of area pellucida and is characterised by the absence of mesoderm.

4. In the middle of area pellucida, in its posterior half runs a primitive streak with a primitive groove in its centre. The primitive groove is bound by primitive folds.

5. In the anterior half of area pellucida, in the middle, runs the neural groove bound by neural folds.

6. The primitive streak and neural groove are separated by Hensen's node having a small depression in the centre-the Hensen's pit.

7. Immediately below the primitive groove the primitive streak gives rise to a small out-growth, the notochord and on either side to mesoderm.

8. In the area pellucida embryonic and extra embryonic regions also become distinguished.

9. In the anterior- most part the ectoderm has given rise to head fold, which is a pocket-like extension of neural folds. The underlying endoderm is also transformed into a pocket-like foregut. The proamnion is greatly reduced.

10. In front of Hensen's node the mesoderm of embryonic area differentiated into 3-4 pairs of mesodermal somites.

11. The neural canal, in the region of head fold, gives rise to forebrain.

12. The foregut extends on either side into an amino-cardiac vesicle.

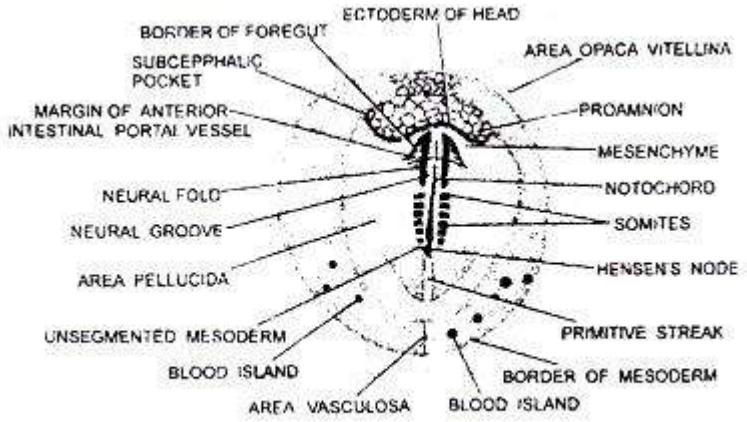


Fig. 17.5. W.M. 24 hours chick embryo.

Whole Mount of 30 Hours of 8-10 Pairs of Somites Chick Embryo:

1. It is W.M. of 30 hours of chick embryo or 8-10 pairs of somite stage of chick embryo.

2. At this stage the dark peripheral area opaca and central translucent and clourless area pellucida are distinctly visible.

3. In the anterior part is present the proamnion, which is a small and comparatively more translucent region of area pellucida and is characterised by the absence of mesoderm.

4. In the middle of area pellucida, in the posterior half, runs a primitive streak with a primitive groove running through its centre. The primitive groove is bound by primitive folds.

5. In the anterior half of area pellucida, in the middle, runs the neural groove bound by neural folds.

6. The primitive streak and neural groove are separated by Hensen's node having a small Hensen's pit in the centre.

7. Immediately below primitive groove the primitive streak gives rise to the notochord and on either side to mesoderm.

8. At this stage embryonic and extra embryonic regions have also become distinguished in the area pellucida.

9. In the anterior-most part, the ectoderm has given rise to head fold which is a pocket like extention of neural folds. The underlying endoderm has transformed into pocket like foregut. The proamnion is reduced.

10. The mesoderm, in front of Hensen's node, has given rise to 8-10 pairs of somites.

11. In the region of head fold the anterior part of neural canal has given rise to a distinct fore brain.

12. The foregut and cardiac vesicles are sufficiently developed.

13. The extra embryonic area has grown in size.

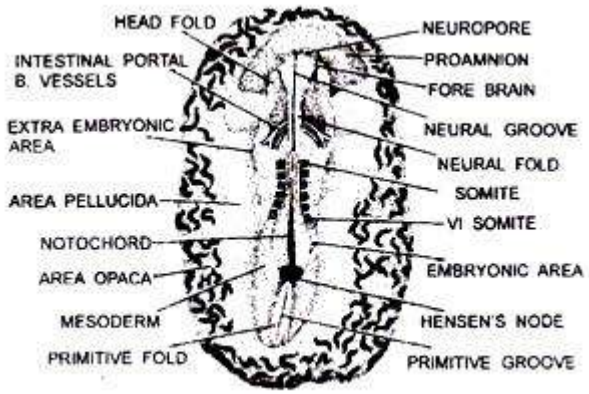


Fig. 17.6. W.M. of 30 hr chick embryo (8-10 somies)

Whole Mount of 33 Hour Chick Embryo of 11-12 Pairs Somites:

1. It is whole mount of 33 hours chick embryo.
2. At this stage the dark peripheral area opaca and central translucent area pellucida are not distinctly visible.
3. The primitive streak has been comparatively reduced because of great lengthening of neural canal and neural folds.
4. The extra embryonic area has grown in size.
5. The mesoderm, in front of Hensen's node, has given rise to 11-12 pairs of somites.
6. The foregut and cardiac vesicles are sufficiently developed.
7. The brain is differentiated into fore brain, mid- brain and hind brain.
8. The area opaca has changed into area vasculosa.
9. Proamnion has disappeared.
10. Anterior omphalomesenteric vein has developed.

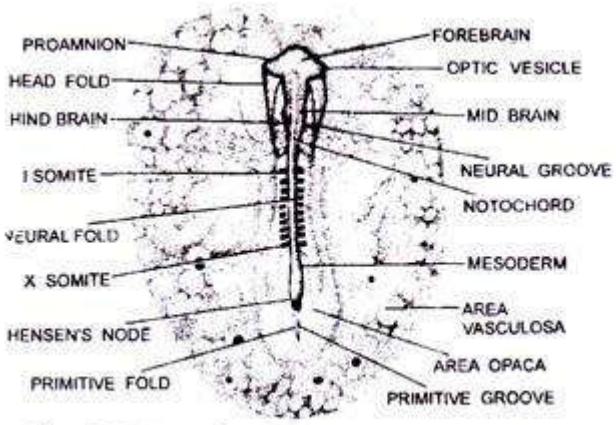


Fig. 17.7. WM. of 33 hr (11-somies) chick embryo.

Whole Mount of Chick Embryo of 13-14 Pairs Somites or 36 Hours:

1. It is Whole Mount of 36 hours chick embryo.
2. At this stage the dark peripheral area opaca and central translucent and colourless area pellucida are not visible.
3. The extra embryonic area has grown in size.
4. The primitive streak is comparatively reduced because of great lengthening of neural canal and neural folds. The notochord has extended from behind the brain up to the end of body.
5. The mesoderm, in front of Hensen's node, has given rise to 13-14 pairs of somites.
6. The brain is differentiated into fore brain, mid brain and hind brain.
7. In the fore brain region optic vesicles and in the hind brain region optic vesicles have developed.
8. The area opaca has changed into area vasculosa.
9. Proamnion has disappeared.
10. Anterior omphalomesentric vein and vitelline artery have developed.
11. The cardiac vesicle has given rise to heart.

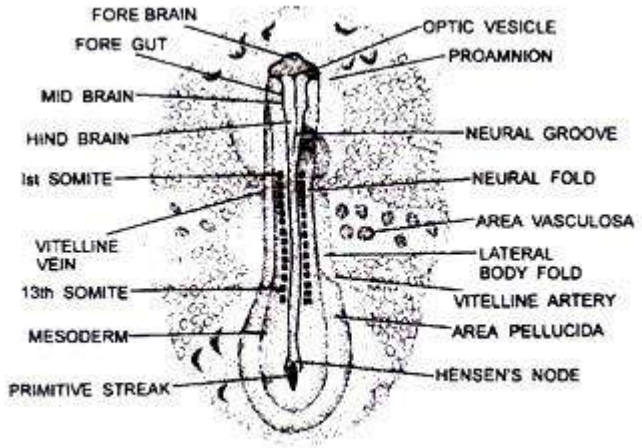


Fig. 17.8. W.M. of 36 hr (14 somits) chick embryo

Whole Mount of of 48 Hours Chick Embryo of 26-28 Pairs of Somites:

1. It is W.M. of 48 hours chick embryo.
2. At this stage the area opaca and area pellucida are not visible.
3. The extra embryonic area has grown in size.
4. Primitive streak has disappeared.
5. The mesoderm, in front of Hensen's node, has given rise to 26-28 pairs of somites.
6. The brain has differentiated into telencephalon, prosencephalon, mesencephalon, metancephalon and mylencephalon.
7. The heart has been differentiated into ventricle and atrium. Sinus venosus and truncusarteriosus have also started developing.
8. The eye has been differentiated into optic cup and lens and optic vesicle has also developed sufficiently.
9. The head region has curved on right side due to cranial flexion.

10. Three pharyngeal gill-slits have also been differentiated.

11. Behind Hensen' node a tail bud has also developed.

12. Lateral amniotic folds, anterior omphalomesentric vein and vitelline artery have appeared.

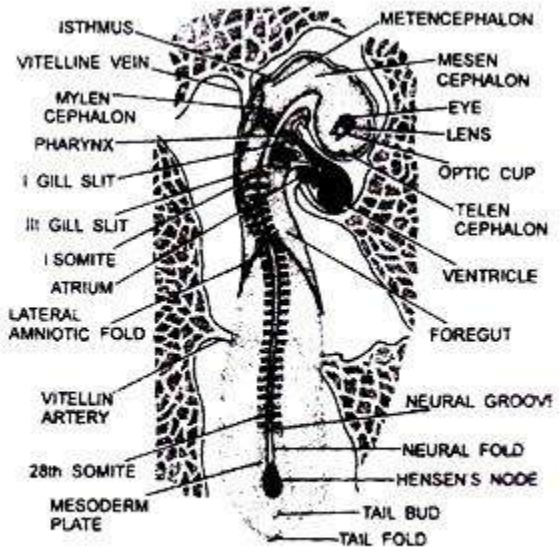


Fig. 17.9. W.M. of 48 hr (27 pairs somites) chick embryo.

Whole Mount of 72 Hours or 36 Pairs of Somites Stage of Chick Embryo:

1. It is W.M. of 72 hours chick embryo.

2. At this stage area opaca and area pellucida are not visible.

3. The extra embryonic area has grown in size.

4. Primitive streak has disappeared.

5. The mesoderm, in front of Hensen's node, has given rise to 36 pairs of somites.

6. The brain has differentiated into telencephalon, mesencephalon, metancephalon and mylencephalon.

7. The heart has been differentiated into ventricle and atrium.

8. The eye has differentiated into optic cup and lens and optic vesicle has also developed sufficiently.

9. The head region has bent on right side due to cranial flexion.

10. Four pairs of gill-slits have been differentiated.

11. Tail bud is greatly developed and has given rise to allentoic stalk and tail.

12. Lateral amniotic folds, vitelline artery and anterior omphalomesentric vein have developed.

13. In the middle region a pair of fore limb buds and in front of tail a pair of hind limb buds have developed, which will give rise to fore and hind limbs.

14. Olfactory pit, visceral arches, amnion, allantois and amniotic cavity have also developed.

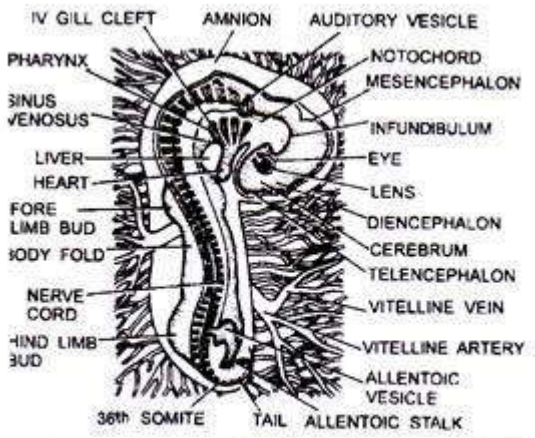


Fig. 17.10. W.M. of 72 hr (36 pairs somites) chick embryo

Whole Mount of 96 Hours Chick Embryo:

1. In the chick embryo of 96-hours of incubation, the entire body has been turned through 90 degree and the embryo lies with its left side on the yolk.
2. At the end of 96 hours the body folds have undercut the embryo so that it remains attached to the yolk only by a slender stalk.
3. The yolk salk soon become enclogated, allowing the embryo to become first straight in the mid-dorsal region and then convex dorsally.
4. The progressive increase in the cranial, cervical, dorsal and caudal flexures results in the bending of the embryo on itself so that its originally straight long axis becomes C-shaped and its head and tail lie close together.
5. Optic cup shows the more developed lens.
6. Endo-lymphatic duct arises from the auditory vesicle.
7. Visceral arches have become very much thickened.
8. Appendage buds increase rapidly in size and become elongated.
9. The number of somites increases to 41 pairs.
10. Allantois has also appeared.
11. Omphalomesenteric artery and omphalomesenteric vein are also developed.

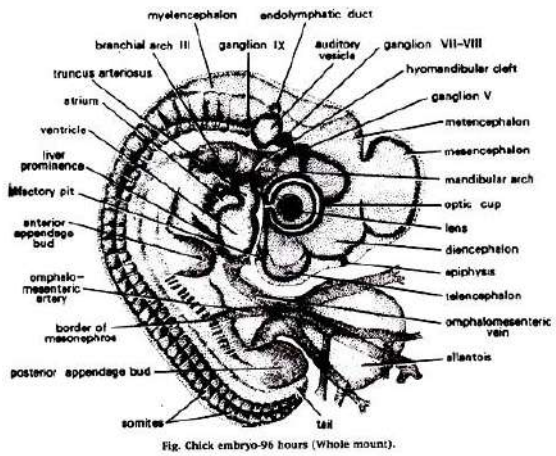
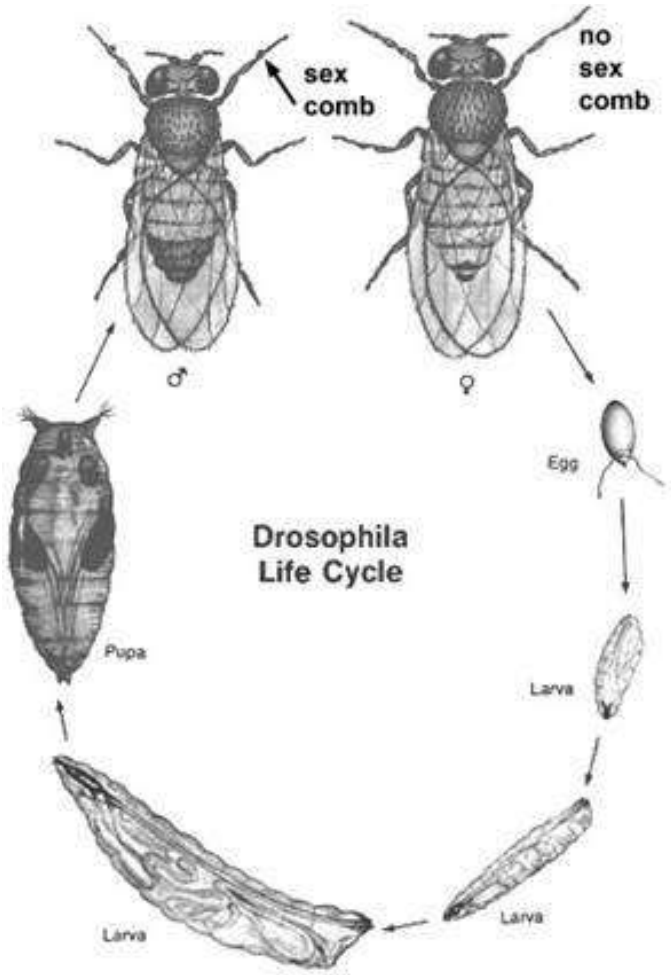


Fig. Chick embryo-96 hours (Whole mount).

Study of the developmental stages and life cycle of Drosophila from stock culture

Life cycle of Drosophila



Fruit flies are holometabolous insects; that is, they undergo complete metamorphosis during their life cycle. The life cycle consists of four distinct stages: egg, larva, pupa, and adult. The rate of development is dependent on temperature, being more rapid at higher temperatures. For instance, at 20°C, the life cycle is completed in 14 or 15 days, but at 25°C, the cycle lasts about 10 days.

Mating and Eggs: Mated females store sperm to fertilize eggs that are subsequently laid. Therefore, to ensure that the desired cross is achieved, it is necessary to place females that are virgins with their intended male mates. Female flies are unable to mate for several hours

after they have eclosed as adults from their pupal cases. Therefore, virgin females can be obtained by clearing all of the flies from a vial and collecting all newly-eclosed females several hours later. These virgin females can be kept separated from males for several days until needed for crosses.

Oviposition by the female starts as early as the second day after its emergence from its pupal case. It increases for about a week until a female adult may be laying 50-75 eggs per day for a total of approximately 400-500 eggs in 10 days. The egg is ovoid, covered outside with a thin but strong envelope (chorion) from which project anteriorly two thin stalks whose terminal portions are each flattened into a spoon-like float. The latter serve as "water-wings" to prevent the egg from sinking and drowning in a semiliquid medium. At the anterior end of the egg is a minute pore (micropile) through which the spermatozoa enter the egg as it passes down the oviduct into the uterus. Although many sperm may enter the egg as it passes down the oviduct, only one fertilizes the female pronucleus and the others are soon absorbed in the developing embryonic tissue.

Larva: The larva is a white, segmented, worm-shaped burrower with black mouth parts (jaw hooks) in the narrower head region. For tracheal breathing it has a pair of spiracles (air intakes) at both the anterior and posterior ends. Since insect skin will not stretch, the young small larvae must periodically shed their skins (cuticle) in order to reach adult size. There are two such molts in *Drosophila* larval development that are accompanied by shedding of the mouth parts as well as the skins. During each period between molts, the larva is called an instar, i.e. the first instar is between hatching and the first molt. Both the size of the larva and the number of teeth on the dark colored jaw hooks are an indication of which instar the larva has reached. After the second molt, the larva (now third instar) feed until ready to pupate. At this stage, the larva crawls out of the food medium onto a relatively dry place, ceases moving, and everts its anterior breathing spiracles.

Pupa: Soon after everting its anterior spiracles, the larval body shortens and the cuticle becomes hardened and pigmented. A headless and wingless prepupa forms. This stage is followed by the formation of the pupa with everted head, wing pads, and legs. The puparium (outer case of the pupa) thus utilizes the cuticle of the third larval instar. The adult structures that seem to appear first during the pupal period have actually been present as small areas of dormant tissues as far back as the embryonic stage. These localized preadult tissues are called **anlagen** (or **imaginal discs**) and because of the ease in which they can be isolated

have often been used in studies of developmental genetics. The main function of the pupa is to permit development of the anlagen to adult proportions. The breakdown of larval tissues to furnish material and energy for this development is therefore a prime feature of pupal metabolism.

Adult: Adults exhibit a typical insect anatomy, including compound eyes, three-part bodies (head, thorax, and abdomen), wings, and six jointed legs. The various types of bristles and hairs found on the body are characters that we will use to identify different phenotypes of flies.

Study of different sections of placenta (photomicropgraph/ slides)

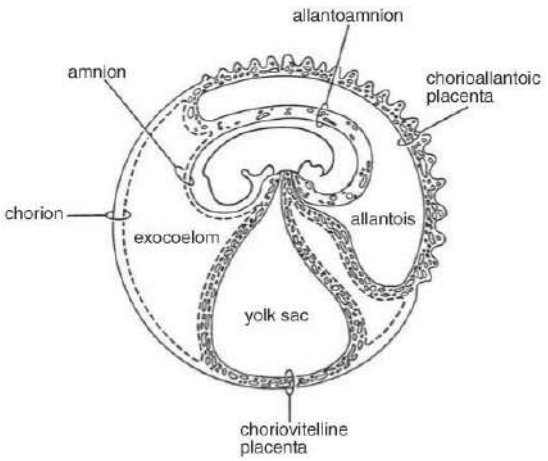
Depending on different criteria placenta may be divided in following types –

1. Depending on the involvement of embryonic tissue:

a. Chorio-vitelline placenta –(yolksac placenta)

In this placenta chorion of the embryo, vitelline circulation of yolk sac and epitheliumof the uterus together form an association known as Chorio-vitelline placenta.

Ex – *Didelphys* sp. *Macropus* sp.



b. Chorio-allantoic placenta –

The placenta in which chorion and allantois of the embryo and endometrium of the uterus together form a complex organ and through allantoic circulation nutrition and other essential elements from the maternal blood pass on to embryonic circulation is known as chorio-allantoic placenta.

Ex – All the utherine mammals.

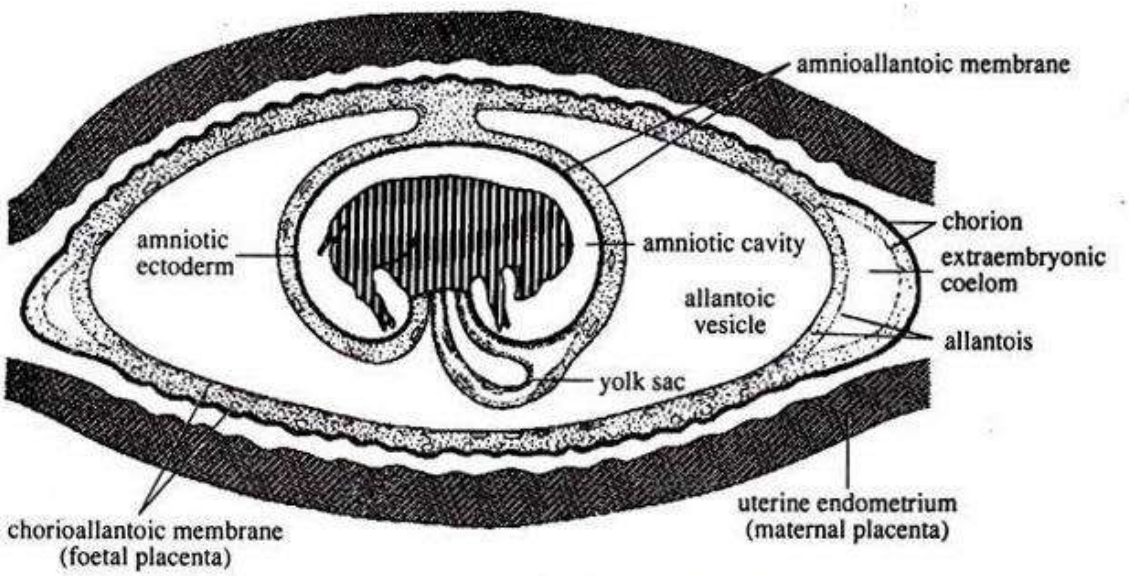


Fig. 5.51 : The mature extraembryonic membranes of the foetal pig, showing composition of foetal placenta (chorioallantoic membrane) and relation to endometrium of uterus.

2. Depending on the distribution of villi on chorion :

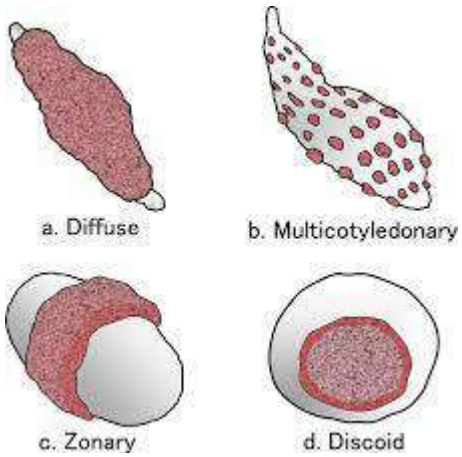
a. Diffuse placenta: The villi are numerous and distributed uniformly over the whole surface of the chorion with a diffused appearance. Such placenta are calleddiffuse placenta. Ex – Ungulates (Pig, Horse etc)

b. Cotyledonary placenta: In this placenta chorionic villi are found in groups or patches, while the rest of the surface of chorion remains smooth. The patches of villi appear as cotyledon. So the name cotyledonary placenta has been given.Ex –Ruminant (Cow, Camel)

c. Zonary placenta : In this placenta chorionic villi are found in a particular zone like a band in a semicircular fashion. As the villi are found in definite zone, sothe name has been given. Ex – Carnivores (Cats, Dogs)

d. Discoidal placenta: In this placenta the villi are restricted to a circular disc or plate on the dorsal surface of blastocyst. Ex – Insectivores, bat & rodents.

e. Metadiscoidal placenta: Primates have a special type of discoidal placenta in which villi are at first scattered but later on become restricted to one or two discs.



2. Based on the degree of involvement of foetal and maternal tissues:

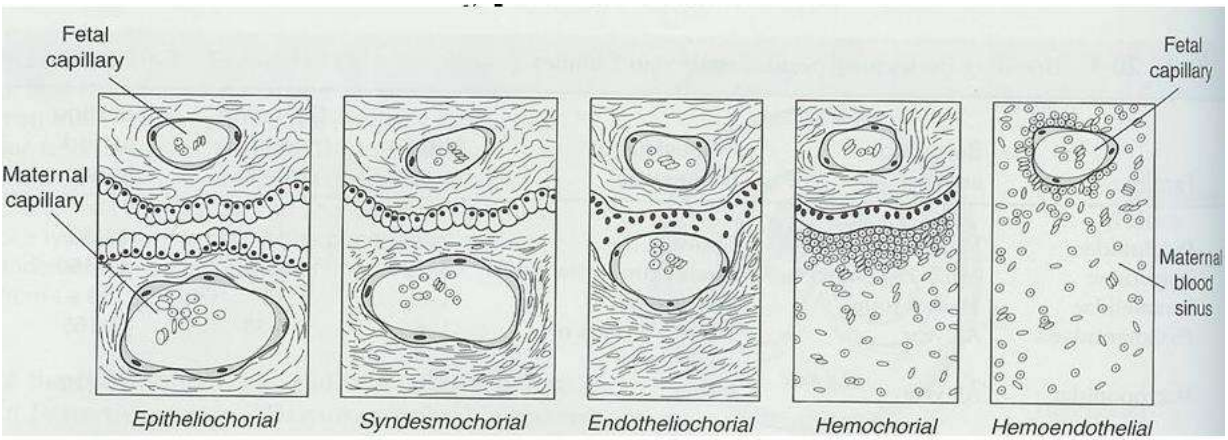
Epithelio-chorial placenta: This is a loose association of chorionic villi of the foetus with the epithelium of the uterus. The epithelium of the uterus folds to form pockets and within these pocket chorionic villi rests. So there are six barriers in between maternal and foetal blood. Ex – Pig, Horse, Marsupials etc.

Syndesmochorial placenta : The uterine epithelium disappears & the chorion of the foetus comes in direct contact with the connective tissue of the uterine wall of the mother. So there are five tissue barriers in between maternal and foetal blood. Ex. Sheeps, Giraffe, Deers etc.

Endothelio-chorial placenta: In this type of placenta the chorion of the foetus comes in direct contact with the endothelium of the uterine capillaries. Because both the epithelium and the connective tissue of uterine disappear, there are four tissue layers in between the maternal & foetal blood. Ex – Dog, Cat, Fox etc.

Haemo-chorial placenta : In this type of placenta endothelium of uterine blood vessels is lost so the chorionic epithelium is bathed directly in maternal blood. There are only three barriers of tissue layers. Actually the chorionic villi are surrounded by spaces (sinuses) devoid of endothelial lining, into which maternal blood enters through the arteries of the uterus and from which blood flows into the uterine vein. Ex –Primates including Man, Insectivores (moles, shrews) and Chiropterans (bats).

Haemo-endothelial placenta –In this type of placenta chorionic epithelium and connective tissue of foetus are lost as a result the endothelium of the foetal blood vessel come direct in contact with maternal blood and be the only barrier between foetal and maternal blood. Ex – Rodents (mouse, rat, guinea pig, rabbit).



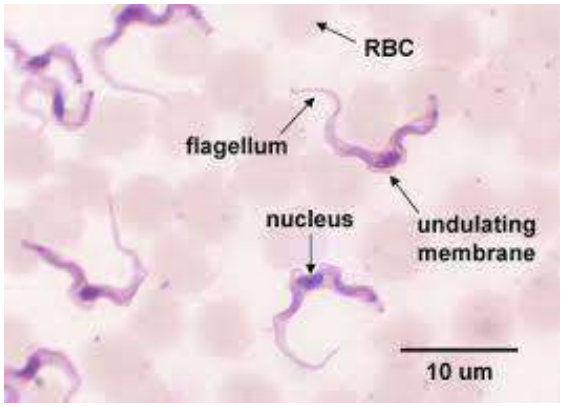
DSE3P: Parasitology

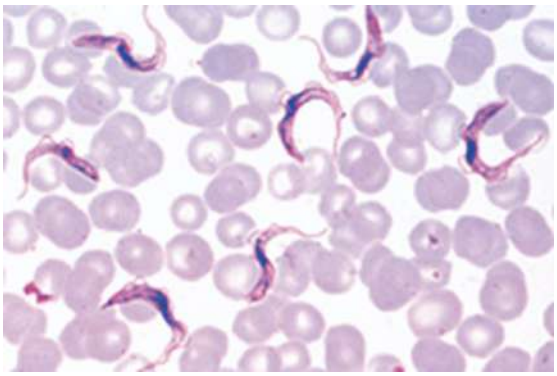
1. Study of life stages of *Giardia intestinalis*

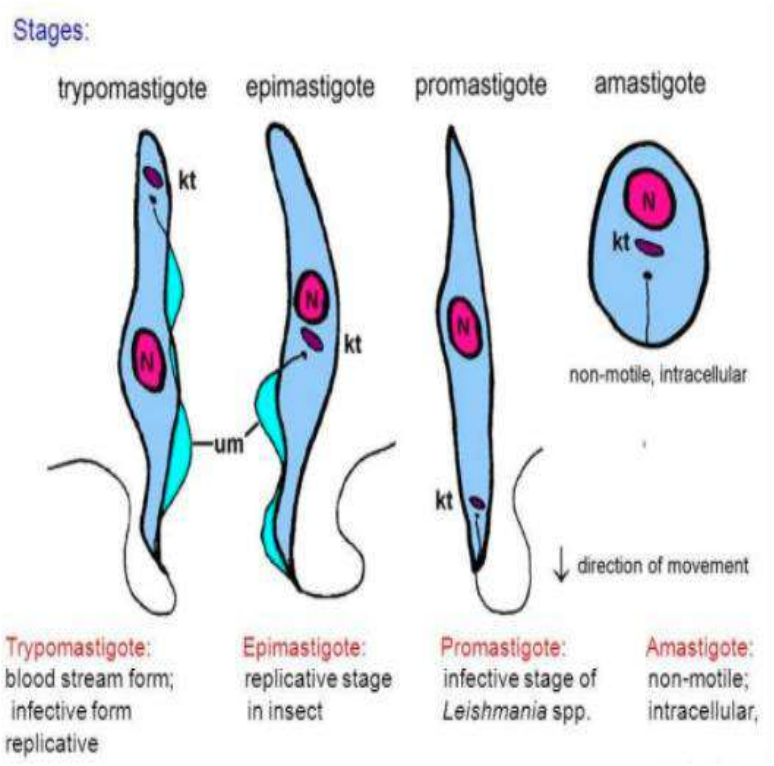
- TROPHOZOITE -vegetative active motile form
  -pear-shaped, 2 nuclei
  -4 pairs of flagellae
  -attaches to mucosa by ventral adhesive (suction) disk
  -does not survive in external environment

CYST -infective form
-oval, 4 nuclei
-thick cyst wall
-resistant to adverse environmental conditions

Study of life stages of *Trypanosoma gambiense*







Developmental stages of Trypanosomes

A. Amastigote:

Kinetoplast anterior to nucleus, no free flagellum, usually spheroid or subspheroid.

B. Promastigote:

Kinetoplast anterior to nucleus, no undulating membrane.

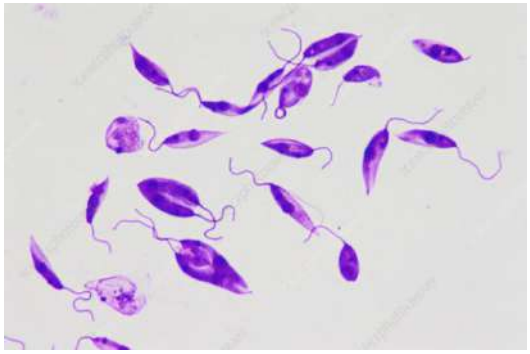
C. Epimastigote:

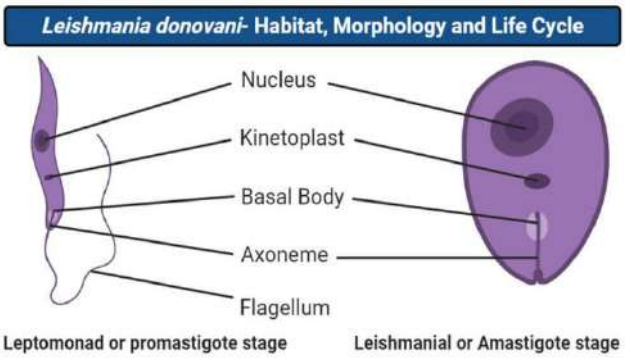
Kinetoplast anterior to nucleus, undulating membrane running a portion of the body.

D. Trypomastigote:

Kinetoplast posterior to nucleus, undulating membrane runs length of organism.

Study of life stages of *Leishmania donovani*





Amastigote form found in the mononuclear phagocyte and circulatory systems of humans.

It is an intracellular and non-motile form, being devoid of external flagellum.

The short flagellum is embedded in the anterior end without projecting out.

It is oval in shape, and measures 3–6 μm in length and 1–3 μm in breadth.

The kinetoplast and basal body lie towards the anterior end.

Promastigote is formed in the alimentary tract of the sandfly.

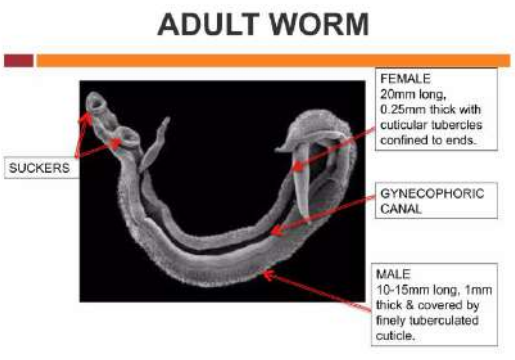
It is an extracellular and motile form. It is considerably larger and more highly elongated, measuring 15–30 μm in length and 5 μm in width.

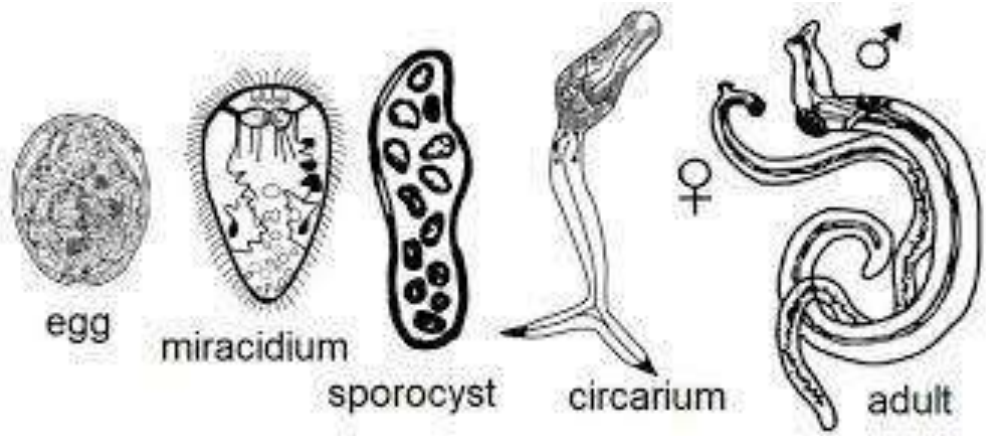
It is spindle-shaped, tapering at both ends.

A long flagellum (about the body length) is projected externally at the anterior end.

The nucleus lies at the centre, and in front of which are kinetoplast and basal body.

Study of adult and life stages of *Schistosoma haematobium*





Phylum: Platyhelminthes
Class: Trematoda
Order: Prosostomata
Family: Schistosomatidae
Genus: *Schistosoma*

i. *S. haematobium* is commonly called as vesical blood fluke, producing urinary or vesical bilharziasis, schistosomiasis haematobin;

ii. The adult worms are cylindrical, elongated with highly developed ventral sucker and live in the pelvic plexus of venous-uterine, prostatic and vesical plexuses of veins.

iii. Dioecious, female is lodged during copulation
The adult worms are also localized in the portal blood stream of host. The males are stouter and shorter; measuring 1.5cm by 1mm. male worm is covered with finely tuberculated cuticula and has 4 to 5 testes arranged in groups.

iv. The females are slender and long, measuring 2cm in length and 0.25mm in breadth. The ovary of females lies behind the middle of the body.

v. At one time nearly 20-30 eggs develop in the uterus of female adult worm. The couple show a long reunited form of male and female worm where they reunite about the middle of the body.
vi. The eggs of *S haematobium* are 150micrometer in length and 50micrometer in breadth and also have characteristic terminal spine.

Study of adult and life stages of *Taenia saginata/solium*

Taenia sajinata

Phylum: Platyhelminthes
Class: Cestoda
Order: Cyclophyllidea
Family: Taeniidea
Genus: *Taenia*

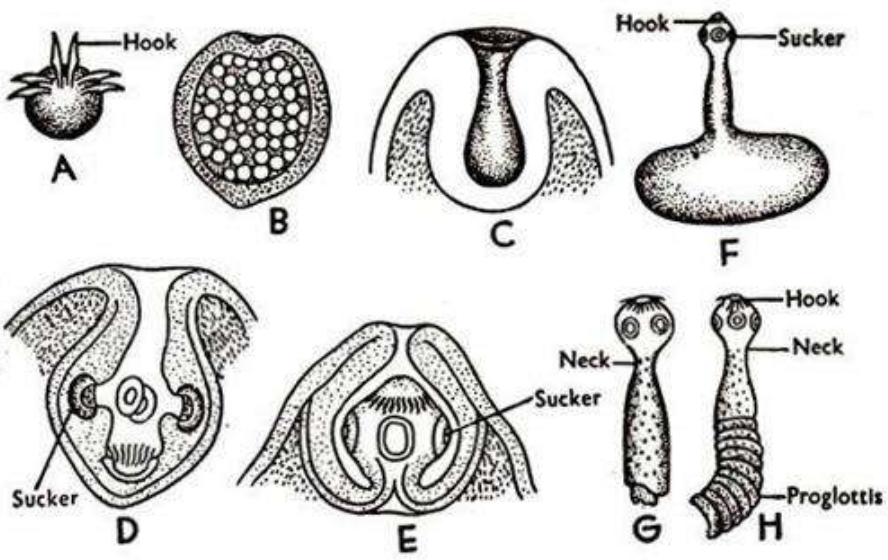


Fig. 23. *Taenia solium*. Life cycle
A. An onchosphere. B. Bladder-like stage. C. Early invagination. D. Appearance of hooks and suckers. E. A cysticercus. F. A cysticercus with evaginated scolex. G. Scolex with remains of bladder. H. Anterior end of a young *Taenia*

Characteristics

1. Body of *Taenia saginata* is ribbon-like, 5-6 meters long and consists of about 1200-1400 segments known as pro-glottides.

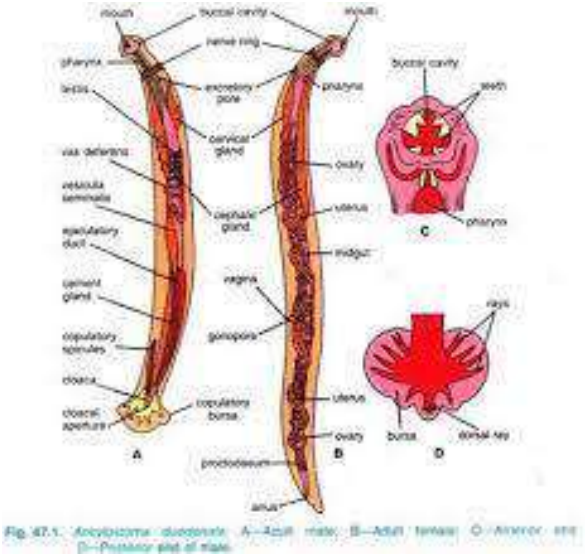
2. The pear-shaped head bears 28 curved chitinoid hooks arranged in two rows (in case of *T. solium*), and four adhesive suckers.

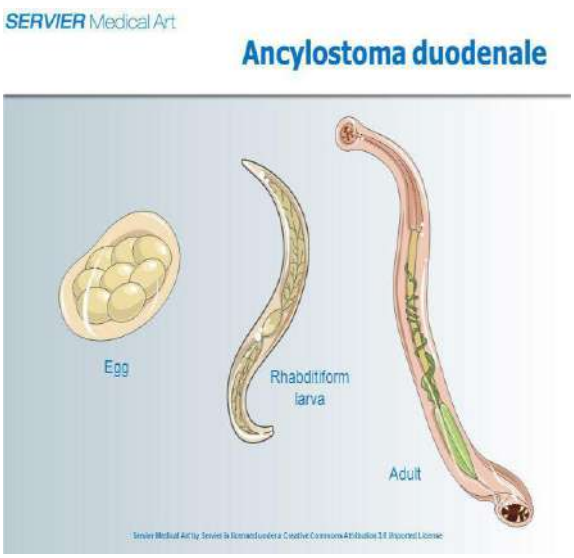
3. Just behind the head there is a small un-segmented region which may be called the neck.

4. Each proglottis is a complete hermaphrodite sexual unit.

5. The embryo now looks like a bladder with a head and neck of *Taenia* lying within it. This is known as bladder worm or cysticercus stage.

Study of adult and life stages of *Ancylostoma duodenale*





Phylum Nematoda

Class Chromadorea

Order Rhabditida

Family Ancyclostomatidae

Genus Ancyclostoma

Identifying Characteristics of *Ancyclostoma*

1. The mature worms are cylindrical in shape, plump, rigid and creamy-white in colour.

2. The anterior end is bent dorsally like a hook (hence the name is "hookworm") and provided with the dorsally placed oral aperture.

3. The oral aperture is provided with 6 sharp teeth (cutting plates) on the ventral aspect, two teeth are found on each side, and two on the dorsal surface.

4. The buccal capsule is large and conspicuous, and is lined with chitin-like substance.

5. The cuticle is with fine transverse striations.

6. A minute finger-like cervical papillae is present on each side, a little away from the anterior extremity.

7. Two cephalic glands, a small oesophageal gland and two pear-shaped cervical glands are connected to the oesophagus; the secretion of the oesophageal gland prevents clotting of the ingested blood.

8. Sexual dimorphism is distinct. The female is slightly larger and has a straight and pointed candal end. The male is characterized by bursa copulatrix (an invagination of the body-wall

around the genital aperture) at its caudal end. The bursa is supported by 13 rays. It has two protrusible spicules (1 mm in length) which assist in sperm transfer during the copulation.

9. The female worms measure about 10 to 13 mm x 0.6 mm while the males measure about 8 to 10 mm x 0.5 mm.

10. The female gonopore is separate and is located at the junction of the posterior and in the middle third.

11. The male has a cloaca where the ejaculatory duct opens.

12. The eggs are oval and colourless with broadly rounded extremities, and measure about 60 µm x 40 µm.

13. Each egg has a thin outer shell and a very fine vitelline layer.

14. When freshly passed the egg has the segmented ovum surrounded by a clear space. It is usually segmented into 2 to 8 cells.

Study of adult and life stages of Brugia malayi

Systematic position:

Phylum: Nematoda

Class: Chromadorea

Order: Rhabditida

Genus: *Brugia*

Species: ***B. malayi***

Identifying characteristics:

Phylum- Nematoda:

1. Pseudocoelomate and acoelomate worms, with no external segmentation.
2. Cylindrical body, tapered at both ends and covered with a multi-layered cuticle.
3. Presence of muscular pharynx, intestine, rectum, and posterior anus.
4. Respiratory and blood vascular system absent.

Class- Chromadorea:

1. Bodies usually have annules, their amphids elaborate and spiral, and they all have three esophageal glands.
2. They usually live in marine sediments, although they can live elsewhere.
3. They have a more sophisticated pharynx than most roundworms.

Subclass- Rhabditida:

1. Species are free living, parasite or both.

Specimen characters:

1. Long and threadlike, *B. malayi* and other nematode possess only longitudinal muscles and move in an S-shape motion.
2. Adults are typically smaller than adult *W. bancrofti*, though few adults have been isolated.
3. Female adult worms (50 mm) are larger than male worms (25 mm).

Morphology

Adult

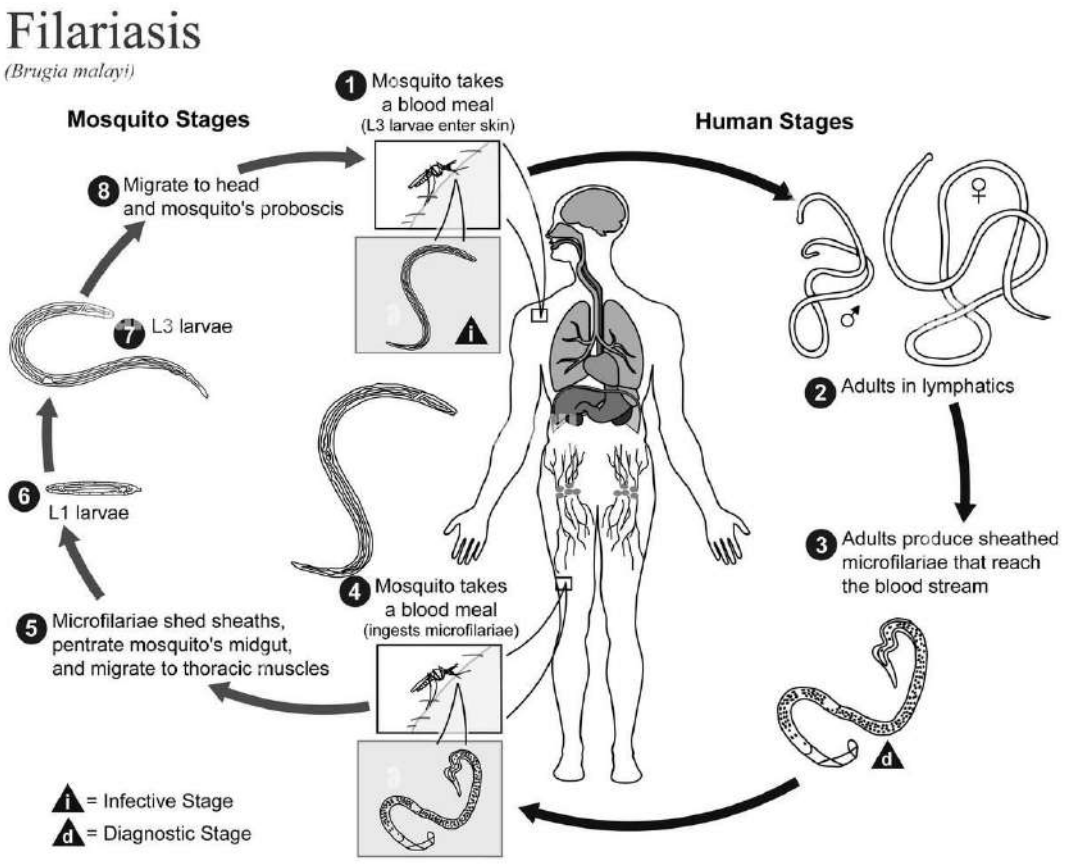
1. Adult worms resemble typical nematode roundworms.
2. Long and threadlike, *B. malayi* and other nematode possess only longitudinal muscles and move in an S-shape motion.

3. Adults are typically smaller than adult *W. bancrofti*, though few adults have been isolated. Female adult worms (50 mm) are larger than male worms (25 mm).

Microfilariae

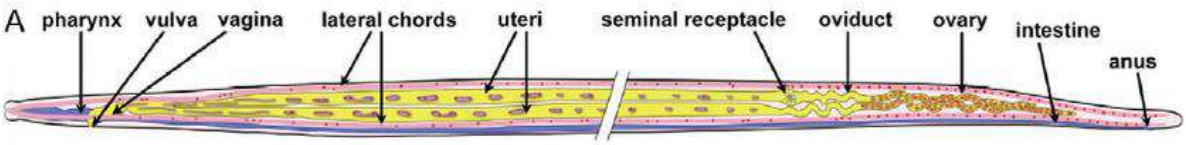
1. *B. malayi* microfilariae are 200–275 µm in length and have a round anterior end and a pointed posterior end.
2. The microfilariae are sheathed, which stains heavily with Giemsa.
3. The sheath is actually the egg shell, a thin layer that surrounds the egg shell as the microfilariae circulates in the bloodstream.
4. The microfilariae retain the sheath until they are digested in the mosquito midgut.
5. *B. malayi* microfilariae resemble *W. bancrofti* and *Loa loa* microfilariae with minor differences that can aid in laboratory diagnosis.
6. *B. malayi* microfilariae can be distinguished by the noncontinuous row of nuclei found in the tip of the tail.
7. There are two terminal nuclei that are distinctly separated from the other nuclei in the tail, whereas the tail of *W. bancrofti* contains no nuclei and *Loa loa* microfilariae nuclei form a continuous row in the tail. *B. malayi* microfilariae also have a

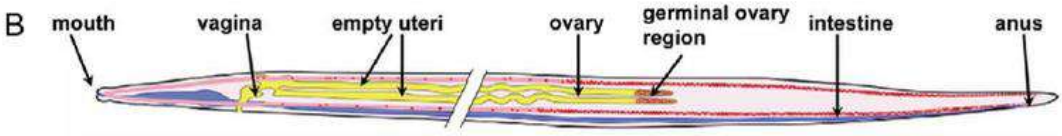
c

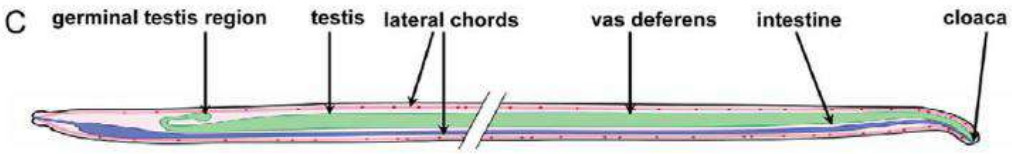


c space ratio of 2:1.

Adult


A
pharynx
vulva
vagina
lateral chords
uteri
seminal receptacle
oviduct
ovary
intestine
anus


B
mouth
vagina
empty uteri
ovary
germinal ovary region
intestine
anus


C
germinal testis region
testis
lateral chords
vas deferens
intestine
cloaca

B.

Systematic position:

Phylum:	**Nematoda**
Class:	**Enoplea**
Order:	**Trichocephalida**
Genus:	***Trichinella***
Species:	***T. spiralis***

Identifying characters:

Phylum- Nematoda:

1. Pseudocoelomate and acoelomate worms, with no external segmentation.
2. Cylindrical body, tapered at both ends and covered with a multi-layered cuticle.
3. Presence of muscular pharynx, intestine, rectum, and posterior anus.
4. Respiratory and blood vascular system absent.

Class- Enoplea:

1. amphids pocket like, not spiral, usually post-labial.
2. cuticle smooth or finely striated.
3. phasmids present or absent.
4. esophagus cylindrical or bottle-shaped with 3 to 5 esophageal glands, stichosome or trophosome may be present.
5. simple non-tubular excretory system, usually a single cell.

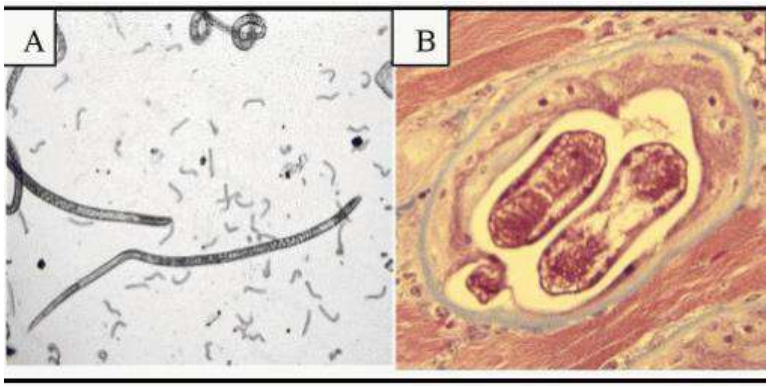
Order- Trichocephalida:

1. The anterior end is narrower than the posterior end in most of these worms, and the esophagus is slender and embedded in cells called stichocytes which form a stichosome.

Specimen characters:

1. Bilaterally symmetrical, ectothermic or heterothermic.
2. T. spiralis is the smallest known nematode parasite of humans. The males measure about 1.4 mm to 1.6 mm in length and the females are twice the size of the males.
3. The body of the worm is more slender at the anterior then at the posterior end.
4. In females the uterus is contained in the posterior portion of the worm and is filled with the developing eggs.
5. The anterior end of the female contains hatching juveniles.
6. This nematode has a cuticle with three or more main outer layers made of collagen and other compounds. The outer layers are non-cellular and are secreted by the epidermis. The cuticle layer protects the nematodes so they can invade the digestive tracts of animal.

Life stages of ***T. spiralis:***



A. Adult **B.** larva.

Adult Worm:

1. The adult *T. spiralis*, a small white worm just visible to the naked eye, is one of the smallest nematodes infecting humans. The male measures about 1.5 mm by 0.04 mm and the female about 3 mm by 0.06 mm (twice the length of male).
2. The anterior half of the body is thin and pointed, well adapted for burrowing into the mucosa epithelium.
3. The posterior end of the male has a pair of pear-shaped clasping papillae (termed as claspers), one on each side of the cloaca/ orifice that it uses to hold the female worm during mating.
4. The female worm is viviparous and discharges larva instead of eggs.
5. The lifespan of the adult worm is very short. The male worm dies soon after fertilizing the female and the female dies after 4 weeks to 4 months (16 weeks), the time required for discharging the larvae.

Larvae:

The larva becomes encysted in the striated muscle fiber and at the time of encystment measures 1 mm in length by 36 µm in diameter. The larva in the cyst is coiled and hence, the name spiralis.

Study of plant parasitic root knot nematode, Meloidogyne from the soil sample

Root-knot disease caused by *Meloidogyne* incognita leads to significant crop yield losses that may be aggravated by the association with pathogenic fungi and bacteria. Biological agents can be effectively used against the complex disease of root-knot nematode and pathogenic fungi.

Soil samples will be collected from a depth of 6-8 inches from at least 20 representative locations across the field. Soil core locations should target areas where the crop appears stunted, chlorotic or weak, and nematode damage is suspected. A field may be divided into sections for sampling purposes if either known or observed differences for nematode damage are present across the field. A minimum of one pint of soil is required per sample area for analysis. Root samples of both crop and weed plants that are present in the field should be submitted with the soil sample

Phylum:	**Nematoda**
Class:	**Secernentea**
Order:	**Tylenchida**
Family:	**Heteroderidae**
Genus:	***Meloidogyne***
Species:	***M. incognita***

Identifying Characteristics

i. Females of *M. incognita* are pear-shaped with no posterior protuberance.

ii. Their stylet ranges from 15-16 µm long, and knobs are rounded and offset.

iii. Perineal pattern is oval to rounded, typically with high dorsal arch, striae usually wavy, and lateral field absent or weakly demarcated.

iv. The male and female adult of Meloidogyne spp. exhibit sexual dimorphism.

v. Females displaying pear-shaped distended bodies, and males a vermiform morphology. The sedentary adult female is pearly white in colour, with a rounded to pear-shaped body and a protruding, sometimes bending, neck.

vi. Males have a not offset head with an elevated labial disc without lateral lips (usually). Their stylet ranges from 23-26 µm long, and knobs are rounded to oval and offset.

vii. Juveniles second stage body size range from 350-450 µm long. Their tail has rounded tip and range from 43-65 µm in length with 6-14 µm long hyaline regions.

Study of *Pediculus humanus*, *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.

Pediculus humanus

A. Systematic position:

Phylum- **Arthropoda**
Subphylum- **Mandibulata**
Class- **Insecta**
Subclass- **Pterygota**
Order- **Siphunculata**
Type- ***Pediculus***
Species- ***P. humanus***

Identifying characteristics:

Phylum- Arthropoda:

1. Bilaterally symmetrical and metamerically segmented.
2. Majority of the segments bear a pair of jointed appendages.
3. Body is covered with a thick chitinous exoskeleton.

Subphylum- Mandibulata:

1. Body usually divided into head, thorax, and abdomen.
2. One or two pairs of antennae present.
3. One pair of mandibles present.

Class- Insecta:

1. Body divided into head, thorax, and abdomen.
2. Three pairs of thoracic legs.
3. Antenna one pair.

Subclass- Pterygota:

1. With wings or secondarily wingless.

Order- Siphunculata:

1. Small wing less insects.
2. Dorsoventrally flattened body with dark marking along the side.
3. Short antennae.
4. Thoracic segments fused and contain clawed legs.
5. Abdomen swollen.
6. Eyes reduced or absent.

Specimen characters:

1. Small head bears a pair of short antennae and a pair of feebly developed compound eyes.
2. Piercing and sucking type mouth parts.
3. Swollen abdomen with small bristles on the side.
4. Clawed legs for clinging to the hair and clothes of the host.

Hence, the specimen seems to be ***P. humanus.***

Xenopsylla cheopis

Systematic position:

Phylum- **Arthropoda**
Subphylum- **Mandibulata**
Class- **Insecta**
Subclass- **Pterygota**
Super order- **Holometabola**
Order- **Siphonaptera**
Type- ***Xenopsylla***
Species- ***X. cheopis***

Identifying characteristics:

Phylum- Arthropoda:

4. Bilaterally symmetrical and metamerically segmented.
5. Majority of the segments bear a pair of jointed appendages.
6. Body is covered with a thick chitinous exoskeleton.

Subphylum- Mandibulata:

4. Body usually divided into head, thorax, and abdomen.
5. One or two pairs of antennae present.
6. One pair of **mandibles** present.

Class- Insecta:

4. Body divided into head, thorax, and abdomen.
5. Three pairs of thoracic legs.

6. Antenna one pair.

Super order- Holometabola:

1. Exhibits complete metamorphosis.
2. Wings developed internally.

Order- Siphonaptera:

1. Ectoparasite on birds and mammals.
2. Piercing and sucking mouth parts.
3. Antennae short, eyes simple, no ocelli.
4. Legs long, stout, adapted for jumping.
5. Small, wingless insects.
6. Abdomen without cerci.

Specimen characters:

1. Small laterally compressed body furnished with backwardly projecting bristles.
2. Head small, eyes simple.
3. Wings are absent.
4. Biting and sucking type mouth parts.
5. Legs long and stout, adapted for jumping.

Hence, the specimen seems to be ***Xenopsylla cheopis.***

Cimex. lectularius
Systematic position:

Phylum-	**Arthropoda**
Subphylum-	**Mandibulata**
Class-	**Insecta**
Subclass-	**Pterygota**
Order-	**Hemiptera**
Type-	***Cimex***
Species-	***C. lectularius***

Identifying characteristics:

Phylum- Arthropoda:

7. Bilaterally symmetrical and metamerically segmented.
8. Majority of the segments bear a pair of jointed appendages.
9. Body is covered with a thick chitinous exoskeleton.

Subphylum- Mandibulata:

7. Body usually divided into head, thorax, and abdomen.
8. One or two pairs of antennae present.
9. One pair of **mandibles** present.

Class- Insecta:

7. Body divided into head, thorax, and abdomen.
8. Three pairs of thoracic legs.
9. Antenna one pair.

Subclass- Pterygota:

1. With wings or secondarily wingless.

Order- Hemiptera:

1. Usually two pairs of wings, fore wing modified as hemi elytra, with membranous apex and leathery base to cover membranous hind wings.
2. Legs absent or adapted for running, jumping, digging, grasping prey or swimming.
3. Piercing and sucking mouth parts.
4. Gradual or incomplete metamorphosis.
5. Herbivorus and predaceous.
6. Beak arises from the front of the head end extends ventrally and posteriorly.

Specimen characters:

1. Flattened, oval body, usually without wings.
2. Fore wing in the form of spiny pad.
3. Head is short, broad and set inside the lateral extension of pro-thorax.
4. Mouth parts piercing and sucking, form a suctorial rostrum.
5. Prominent eyes at the sides of the head.
6. In male the abdomen is pointed at the end, while in female, it is rounded.

Hence, the specimen seems to be ***Cimex lectularius.***

Study of nematode parasites from the intestines of Poultry bird:

PROCESS:-

1. The fecal samples were scrapped and analyzed for eggs or cyst of intestinal parasites.
2. The medium was prepared by dissolving 400 g of NaCl in 1000 ml of warm distilled water.
3. The mixture was then filtered through double-layered gauze into a test tube and more media was added until a meniscus was formed.
4. A coverslip was placed gently on the test tube and allowed to stand on a level surface for at least 10 – 20 minutes.
5. The coverslip was carefully removed and placed on a glass slide and examined immediately for parasite eggs under x10 and x 40 objective lenses.
6. Identification of the eggs was aided by the addition of Lugol's Iodine solution to the sample on the glass slide.

A. Systematic position:

Phylum- **Nematoda**

Class- **Chromadorea**
Order- **Ascaridida**
Family- **Ascariididea**
Genus- ***Ascaridia***
Species- ***Ascaridia galli***

Identifying characteristics:

Phylum- Nematoda:

1. Pseudocoelomate and acoelomate worms, with no external segmentation.
2. Cylindrical body, tapered at both ends and covered with a multi-layered cuticle.
3. Presence of muscular pharynx, intestine, rectum, and posterior anus.
4. Respiratory and blood vascular system absent.

Class- Chromadorea:

4. Bodies usually have annules, their amphids elaborate and spiral, and they all have three esophageal glands.
5. They usually live in marine sediments, although they can live elsewhere.
6. They have a more sophisticated pharynx than most roundworms.

Order- Ascaridida:

1. Cream-colored, robust, and relatively long as nematodes go, being one to several inches in length.

Family- Ascariididea**:**

1. Short, heavy antennae, a four-valved ovipositor for laying eggs, and three-segmented tarsi (distal segments of the leg).

Specimen characters:

1. It is the largest nematode in birds, with females measuring 72 to 112 mm long.
2. The body is semitransparent, creamy-white, and cylindrical.
3. The anterior end is characterized by a prominent mouth, which is surrounded by three large, trilobed lips. The edges of the lips bear teeth-like denticles.
4. The body is entirely covered with a thick proteinaceous structure called cuticle. The cuticle is striated transversely through the length of the body and cuticular alae are poorly developed.
5. Two conspicuous papillae are situated on the dorsal lip and one on each of the subventral lips. These papillae are the sensory organs of the nematode.

6. *A. galli* is diecious with distinct sexual dimorphism. Females are considerably longer and more robust, with a vulva opening at the middle portion (roughly midway from anterior and posterior ends) of the body and anus at the posterior end of the body.
7. The tail end of females is characteristically blunt and straight. Males are relatively shorter and smaller (measuring 50 to 76 mm long), with a distinct pointed and curved tail.
8. Ten pairs of caudal papillae are found towards the tail region of the body, and they are arranged linearly in well-defined groups such as precloacal (three pairs), cloacal (one pair), postcloacal (one pair), and subterminal (three pairs) papillae. Eggs found in the feces of infected birds are oval with smooth shells and measure 73–92 by 45–57 microns.

Hence, the specimen seems to be *Ascaridia galli.*

B. Systematic position:

Phylum- **Nematoda**
Class- **Secernentea (Phasmida)**
Subclass- **Rhabditida**
Order- **Ascaridida**
Type- ***Ascaris lumbricoides***

Identifying characteristics:

Phylum- Nematoda:

1. Pseudocoelomate and acoelomate worms, with no external segmentation.
2. Cylindrical body, tapered at both ends and covered with a multi-layered cuticle.
3. Presence of muscular pharynx, intestine, rectum, and posterior anus.
4. Respiratory and blood vascular system absent.

Class- Secernentea (Phasmida):

1. Nearly all terrestrial, majority are parasites on vertebrates, invertebrates or plants.
2. Epidermal or caudal gland absent.
3. Possess phasmids.

Subclass- Rhabditida:

2. Species are free living, parasite or both.

Order- Ascaridida:

1. Large parasite with elongated and cylindrical body.
2. Mouth is surrounded by three prominent lips.

3. Teeth bearing cutting plates absent.
4. In males, the tail end is ventrally curved, containing two copulatory spicules.
5. Females are larger than the male and the tail end is bluntly pointed.

Specimen character:

1. Common round worm, having elongated and cylindrical body.
2. Unsegmented body, tapering on both ends with distinct lateral lines on both sides of the body.
3. Female is larger than the male and the tail end is bluntly pointed.
4. The tail end of male is vertically curved containing two copulatory spicules.
5. Hence, the specimen seems to be *Ascaris lumbricoides*.

Economic importance:

Ascaris is pathogenic to man. Larvae cause long inflammation and fatal pneumonia. Sometimes, fever, anaemia, leucocytosis and aosinofilia result. Mature Ascaris may cause, some abdominal discomfort and colic pains with vomiting, diarrhoea, and slight temperature. Appendicitis is also caused by Ascaris. Toxic substances produced by Ascaris cause convulsions, delirium, coma and general nervousness.

C. Systematic position:

Phylum- **Nematoda**
Class- **Secernentea (Phasmida)**
Subclass- **Rhabditida**
Order- **Strongylida**
Genus- ***Ancylostoma***
Species- ***Ancylostoma duodenale***

Identifying characteristics:

Phylum- Nematoda:

5. Pseudocoelomate and acoelomate worms, with no external segmentation.
6. Cylindrical body, tapered at both ends and covered with a multi-layered cuticle.
7. Presence of muscular pharynx, intestine, rectum, and posterior anus.
8. Respiratory and blood vascular system absent.

Class- Secernentea (Phasmida):

4. Nearly all terrestrial, majority are parasites on vertebrates, invertebrates or plants.
5. Epidermal or caudal gland absent.
6. Possess phasmids.

Subclass- Rhabditida:

3. Species are free living, parasite or both.

Order- Strongylida:

1. Teeth-bearing cutting plates present.
2. Mouth without distinct lips.
3. Males are small in size, posterior end expanded like a umbrella, possess copulatory bursa, genital opening posterior with cloaca.
4. Females are longer in size, posterior end tapering with no copulatory bursa, genital opening at the junction of posterior and middle third of the body.

Species characteristics:

1. Cylindrical worm, the anterior end is bent slightly towards the dorsal side with an oral aperture.
2. Buccal capsule is large and conspicuous and possesses six teeths.
3. Four teeths on the ventral surface are hook like, two teeths on the dorsal surface are knob like triangular plates.
4. The copulatory bursa is made up of three lobes, of which one is dorsal and two are lateral, thirteen chitinous rays support each.
5. Male small in size with expanded posterior end provided with copulatory bursa.
6. Female large in size with tapering posterior end.

Hence, the specimen seems to be *Ancylostoma duodenale.*

Economic importance:

Larvae of Ancylostoma cause lesions in the skin which include ancylostomal dermatitis and creeping eruption. Lesions in lungs causes bronchitis and broncho-pneumonia. Adult worm is responsible for a disease known as ancylostomiasis or hook worm disease characterissed mainly by anaemia.

D. Systematic position:

Phylum- **Platyhelminth**
Class- **Cestoidea**
Subclass- **Eucestoidea**
Order- **Taeniodea**
Type- ***Taenia***

Identifying characteristics:

Phylum- Platyhelminthes:

1. Body dorsoventrally flattened, unsegmented, bilaterally symmetrical and without coelom.
2. Incomplete digestive system, anus absent.
3. Skeletal, circulatory and respiratory systems are absent.
4. Excretory organs are flame cells.
5. Suckers, hooks or spines usually present.

Class- Cestoidea:

1. Endoparasites with attachment organ in the form of suckers, tentacles or hooks confined to the anterior region.

2. Gut completely absent.
3. Body divided into head, or scolex, neck and proglottids.
4. Each segments except the head and neck is provided with one or two sets of complete sex organs.

Subclass- Eucestoidea:

1. Elongated body divided into a number of segments and covered by cuticle.
2. Expanded scolex bears four suckers.
3. Life cycle involves free-swimming six hooked larva or intact egg entering gut of intermediate host.

Order- Taeniodea:

1. Scolex consists of four acetabulate suckers usually with rostellum.
2. Two host life cycle: invertebrate or vertebrate.

Specimen characters:

1. Ribbon like body. Body is differentiated into scolex, neck and a large number of immature, mature and gravid segments or strobila.
2. The mature segments contain fully developed hermaphroditic genital organs.
3. The adhesive scolex contains four suckers and round rostellum crowned with double row or hooks.

Economic importance:

The worms are responsible for causing severe symptoms, in children and adults. It causes nausea, abdominal pain and nervous disorder resembling epilepsy, anaemia and eosinophilia. Sometimes, bladder worm stage may harbour in man, causing a disease known as cysticercosis. The disease is very fatal. It infects eyes, brain, spinal cord and other delicate organs.

DSE4P: Biology of Insects Lab

Life-cycle of the Anopheles mosquito

There are four stages in the life cycle of a mosquito: egg, larva, pupa and adult. During its life-cycle the mosquito undergoes two changes (metamorphoses), from larva to pupa and from pupa to adult.

Egg stage

- The adult Anopheles female mates once and continues to lay eggs throughout its lifespan.
- Females must take a blood meal every 2-3 days. Blood is needed to develop eggs.
- Females will lay a batch of eggs before taking the next blood meal.
- Eggs are laid on water (rain pools, ponds, riversides, lakes, etc.) in batches of 50–200 eggs.
- The length of time the eggs take to hatch into larvae largely depends on temperature:
- At about 30oC, eggs hatch into larvae in about 2-3 days.
- In temperate zones (16oC), about 7-14 days.

Larval stage

- The larva has a well-developed head with "mouth brushes" used for feeding (filter feeders).
- The larva feeds on micro-organisms (e.g. algae, bacteria) and organic matter in the water where they breed.
- The Anopheles larva has no respiratory siphon. It lies parallel to surface of water in order to breath.
- There are four developmental stages of larva known as instars.
- The development from larva to pupa last about 5-10 days in normal tropical temperatures, depending on the species. Water temperature affects the time required for development, which is shorter in warmer waters.

Pupal stage

- The pupa is shaped like a comma and stays at the surface of the water. It has a pair of respiratory trumpets through which it breathes when at the surface.
- No feeding goes on during this stage but the pupa is motile and responds to stimuli.
- This is the resting or inactive stage during which there is a major transformation from living in water to emerging and living out of water.
- The pupa stage takes about 2-5 days.

Adult stage

- The adult usually emerges from the pupa at dusk.
- After emerging from the pupa, the adult mosquito rests for a short time in order to harden its body.
- Shortly after emergence the mosquitoes mate (Fig. 2). The males form large swarms, usually around dusk, and females fly into the swarms to mate.
- Both male and female mosquitoes feed on nectar for energy.
- After mating, the female mosquito searches for a blood meal for the development of her eggs. For some species one feed is enough to develop the eggs. In other species two feeds are required, at least for the development of the first batch of eggs.

• Duration from egg to adult Anopheles may vary between 7 days at 31ºC and 20 days at 20ºC.

Life Cycle of *Culex* Mosquitoes

It takes about 7-10 days for an egg to develop into an adult mosquito.

Eggs

1. Adult, female mosquitoes lay eggs on the surface of fresh or stagnant water. Water sources can include barrels, horse troughs, ornamental ponds, unmaintained swimming pools, puddles, creeks, ditches, and marshy areas.
2. A female *Culex* mosquito lays eggs one at a time. Eggs stick together to form a raft of 100 to 300 eggs. The raft floats on the water.

Larva

1. Larvae hatch from mosquito eggs and live in water.
2. Larvae can be seen in the water. They are very active and are often called "***wigglers***".
3. They feed on a variety of things found in the water.
4. Larvae shed their skin (molt) several times during this stage.

Pupa

1. Pupae live in water. Pupae do not have external mouthparts and do not feed during this stage.
2. An adult mosquito emerges from a pupa and flies away.

Adult

1. Adult female mosquitoes bite people and animals. Mosquitoes need blood to produce eggs.
2. After blood feeding, female mosquitoes look for water sources to lay eggs. Several days pass between feeding and looking for a place to lay eggs.
3. *Culex* mosquitoes don't fly long distances but have been known to fly up to 2 miles (3.2 km).
4. Some *Culex* mosquitoes prefer to live near and bite birds. They bite people when other animals are not nearby.
5. Because *Culex* bites animals and people, they live outdoors or near homes.

Life Cycle of *Aedes* Mosquitoes

Eggs

1. Adult, female mosquitoes lay eggs on the inner walls of containers with water, above the waterline.

2. Eggs stick to container walls like glue. They can survive drying out for up to 8 months. Mosquito eggs can even survive a winter in the southern United States.

3. Mosquitoes only need a small amount of water to lay eggs. Bowls, cups, fountains, tires, barrels, vases, and any other container storing water make a great "nursery."

Larvae

1. Larvae live in the water. They hatch from mosquito eggs. This happens when water (from rain or a sprinkler) covers the eggs.

2. Larvae can be seen in the water. They are very active and are often called "***wigglers.***"

Pupae

Pupae live in the water. An adult mosquito emerges from the pupa and flies away.

Adult

1. Adult female mosquitoes bite people and animals. Mosquitoes need blood to produce eggs.

2. After feeding, female mosquitoes look for water sources to lay eggs.

3. *Ae. aegypti* and *Ae. albopictus* don't fly long distances. In its lifetime, these mosquitoes will only fly within a few blocks.

4. *Ae. aegypti* mosquitoes prefer to live near and bite people.

5. Because *Ae. albopictus* mosquitoes bite people and animals, they can live in or near homes or in neighboring woods.

6. *Ae. aegypti* mosquitoes live indoors and outdoors, while *Ae. albopictus* live outdoors.

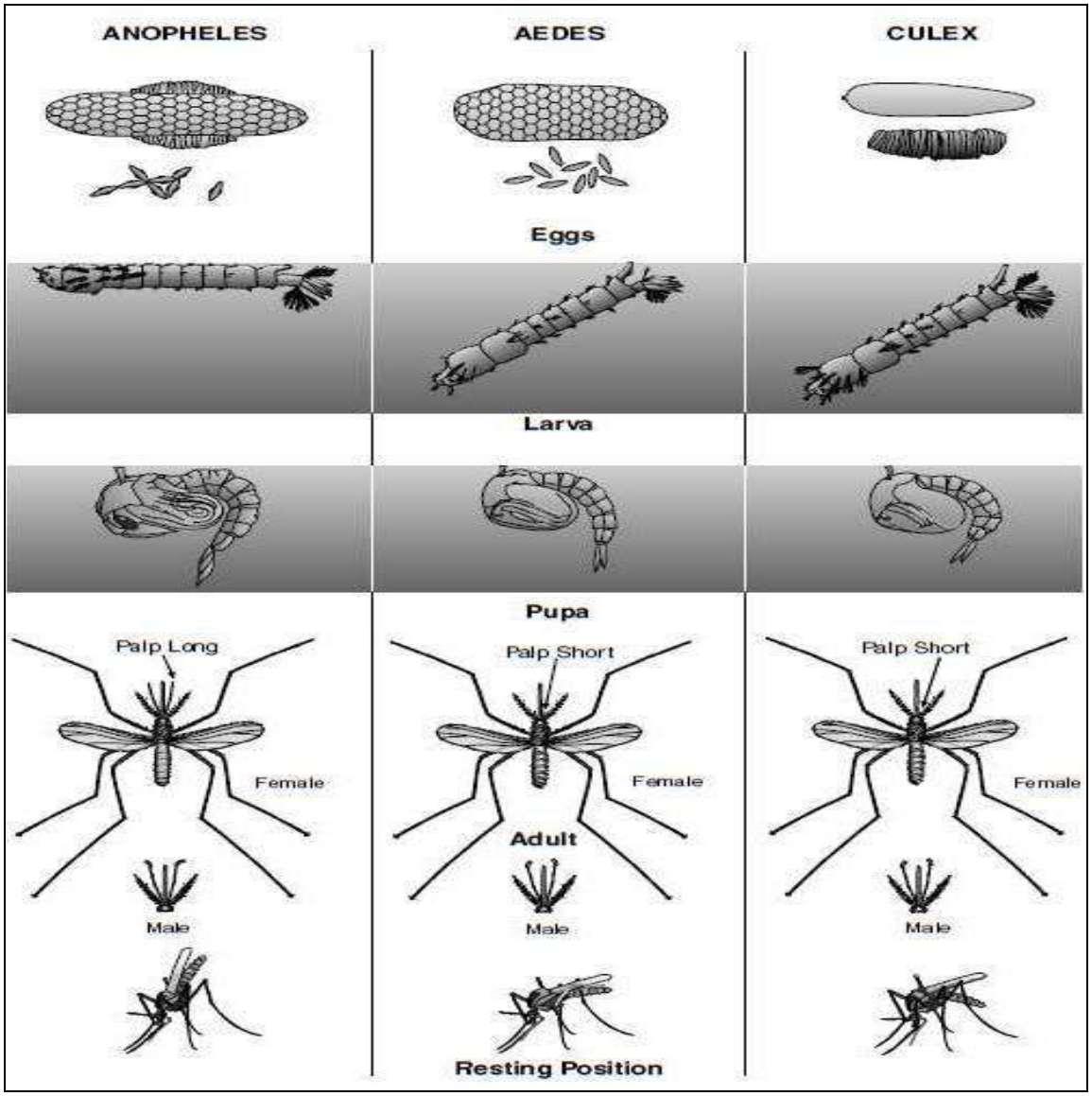


Fig: Life cycle of *Anopheles*, *Aedes* and *Culex* mosquitoes

TYPES OF ANTENNAE IN INSECTS

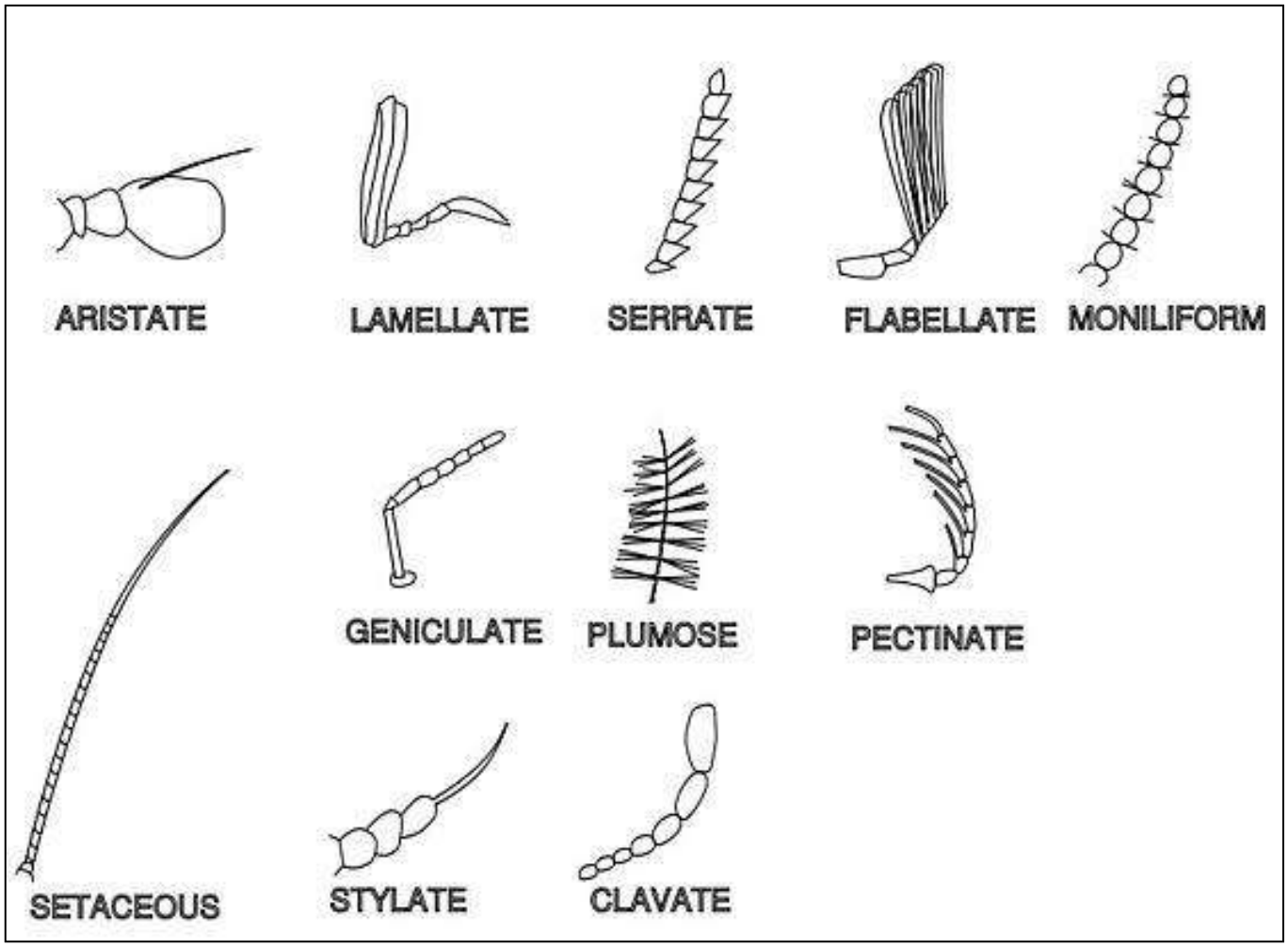


Fig: Types of antennae in insects

Aristate: Small, microscopic third segment enlarged and bears a bristle called arista on its dorsal side. **E.g.** House fly

Lamellate (Leaf like): The enlargement at the end is almost entirely towards one side from the axis of the antenna and forms broad, somewhat flattened plates. **E.g.** Dung roller, Rhinoceros beetle

Serrate (Saw like): Saw like or saw-toothed, segments have short triangular and have projections to one side. **E.g.** Pulse Beetle

Flabellate: The terminal segment gives the antenna a bifurcate appearance and the succeeding segments are seen to be enclosed it. **E.g.** Stylopids

Moniliform (like string of beads): Like a string of beads, Segments similar in size and more or less spherical or globular in shape With prominent constrictions between them **E.g.** Termite.

Geniculate (Elbowed): Elbowed, has a sharp bend like a flexed arm the first segment long and following segments small. **E.g.** Honey bee and Ants

Plumose (Brush like with dense hairs): Whorls of hairs arise from each joint of the segment. Each whorl contains a number of hairs. Plumose antennae have a feather-like shape. **E.g.** Male mosquito

Pectinate (Comb like): Comb like, most segments with longer slender lateral processes on one side **E.g.** Female Arctid moths, Fire colored beetles

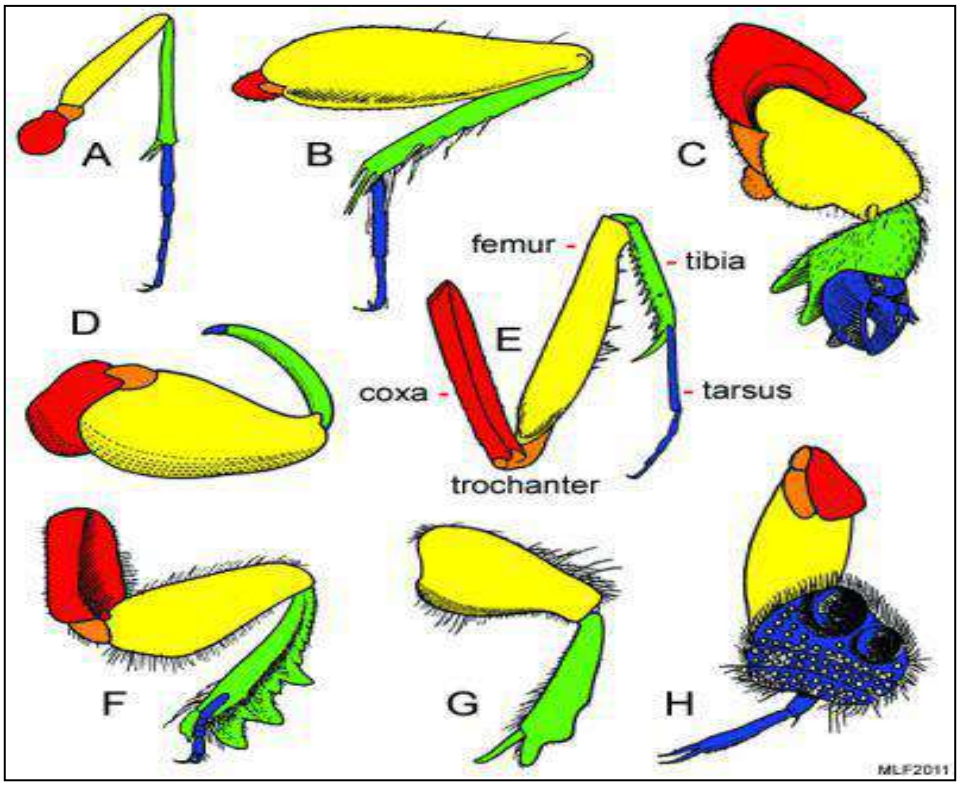
Setaceous (Whip like or bristle like): Bristle like Noticeable decrease in the size of segments from the base to the apex, so that the antenna tapers from a rather thick base to a very slender tip. **E.g.** Cockroach, dragonflies and damselflies

Stylate: The last segment bears an elongate terminal style like or finger like process, the style. **E.g.** Robber flies.

Clavate (clubbed): Club shaped, the segments increasing in diameter gradually towards the tip. **E.g.** Butterfly, Carrion beetles

MODIFICATIONS OF LEGS IN INSECTS

Fig:

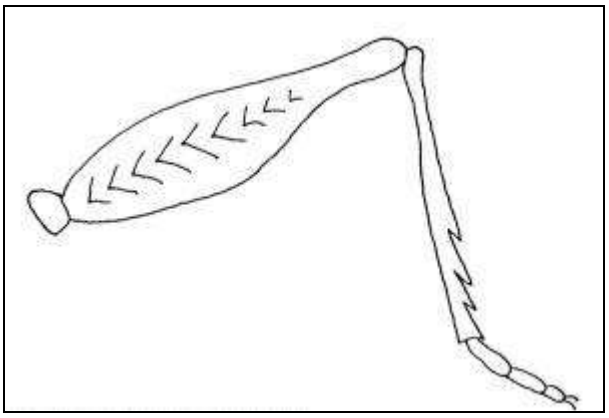


Modifications of legs in insects

Saltatorial: (Salatorial = Leaping : Jumping Leg)

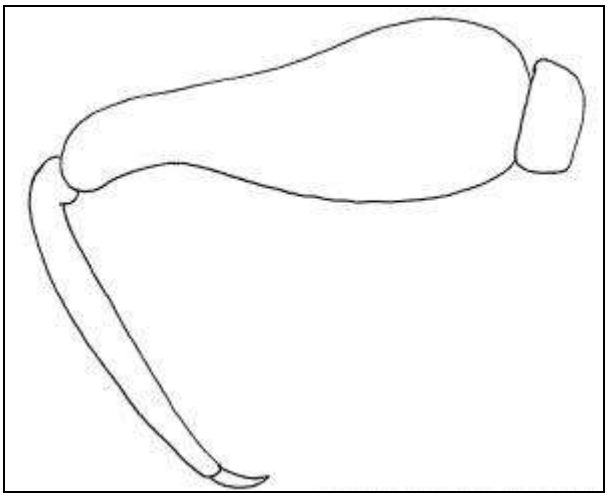
Saltatorial legs are jumping legs. Grasshoppers are the poster insects for saltatorial legs, but other jumping insects like fleas have them as well. Saltatorial legs work well for jumping because they are enlarged legs filled with bulky, strong muscles. All those muscles allow

insects with this type of leg to jump, propelling themselves forward very long distances very quickly. Saltatorial legs are usually hind legs. E.g. Hind legs of grasshopper.



Raptorial: (Raptorial = predatory; Grasping leg)

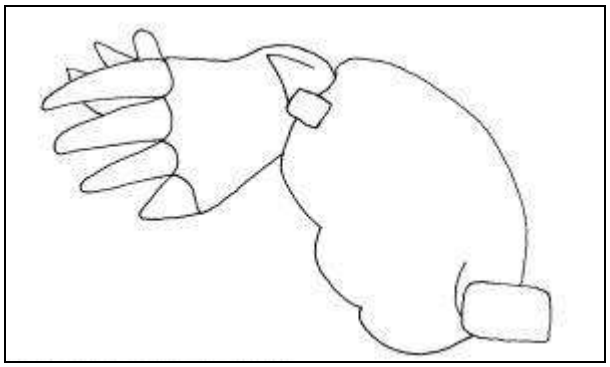
You are likely familiar with this sort of leg too. Raptorial legs are hunting legs, the kinds of legs you see on predatory insects such as mantids and giant water bugs. Like the saltatorial legs, these are enlarged legs full of strong, powerful muscles. However, these legs are usually at the front of the insect and are used to grab and hold prey bwhile they eat. Many insects with raptorial legs hold them out in front of their bodies, positioned so that they can strike at prey at any time. E.g. Forelegs of Praying mantis.



Fossorial: (Fossorial = Digging; Burrowing leg)

Insects with fossorial legs live underground and use their highly modified legs, usually the forelegs, to dig burrows. The mole cricket, the forlegs of which are pictured at left, are a prime example. Fossorial legs tend to be very broad, very flat, and very dense. They often

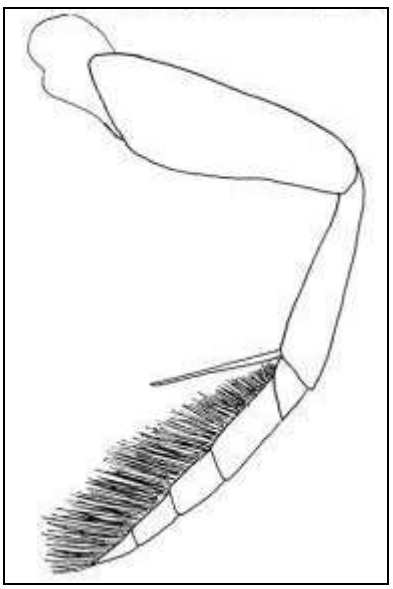
have big, strong claws. Fossorial legs work somewhat like shovels to rip soils apart quickly and easily and allow the insect to bury itself in the ground surprisingly quickly. This type of leg is much less common than the others, but it's a thrill to find an insect that has them! They're really impressive. E.g. Fore legs of mole cricket.



Natatorial: (Natatorial = pertaining to swimming; Swimming leg)

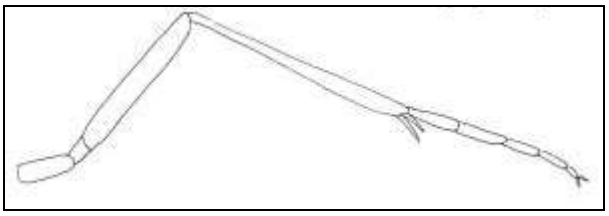
Natatorial is another word for swimming, so insects with natatorial legs are aquatic insects that require modified legs to move easily through water. Natatorial legs are often flattened, broad, and fringed with dense hairs, as in the image of the predaceous diving beetle hind leg pictured at right. These adaptations have the same sort of effect as human wearing flippers as they swim – they increase the surface area of the legs as they kick, allowing the insect to move more easily through water. Many aquatic insects exhibit natatorial legs, especially in the hind and middle pairs of legs, but not all of them do. They are especially common in aquatic beetles and bugs.

E.g. Hind legs of water bug and water beetle.



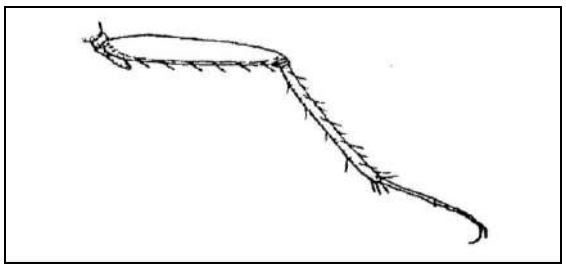
Cursorial: (Cursorial = adapted for running: Running leg)

These are the types of legs most people likely think of if they've ever pondered insect legs before. Cursorial is a fancy word for running, so these are the kinds of legs you see on swiftly moving insects such as roaches and tiger beetles. Cursorial legs tend to be long and narrow and are designed so that the insect can move very quickly. Things with this type of leg are often hard to catch – or hard to step on if you're dealing with roaches. E.g. all the three pairs of legs of cockroach. Legs are suited for running. Femur is not swollen.



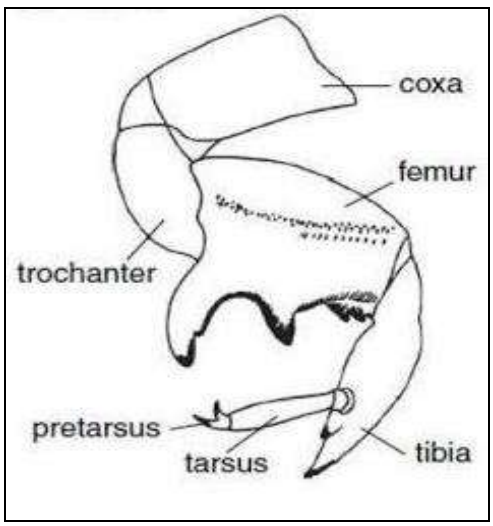
Ambulatorial (Ambulate - to walk; Walking leg)

E.g. Fore leg and middle leg of grasshopper. Femur and tibia are long. Legs are suited for walking.



Scansorial: (Scansorial = Climbing; climbing or clinging leg)

E.g. all the three pairs of legs of head louse.



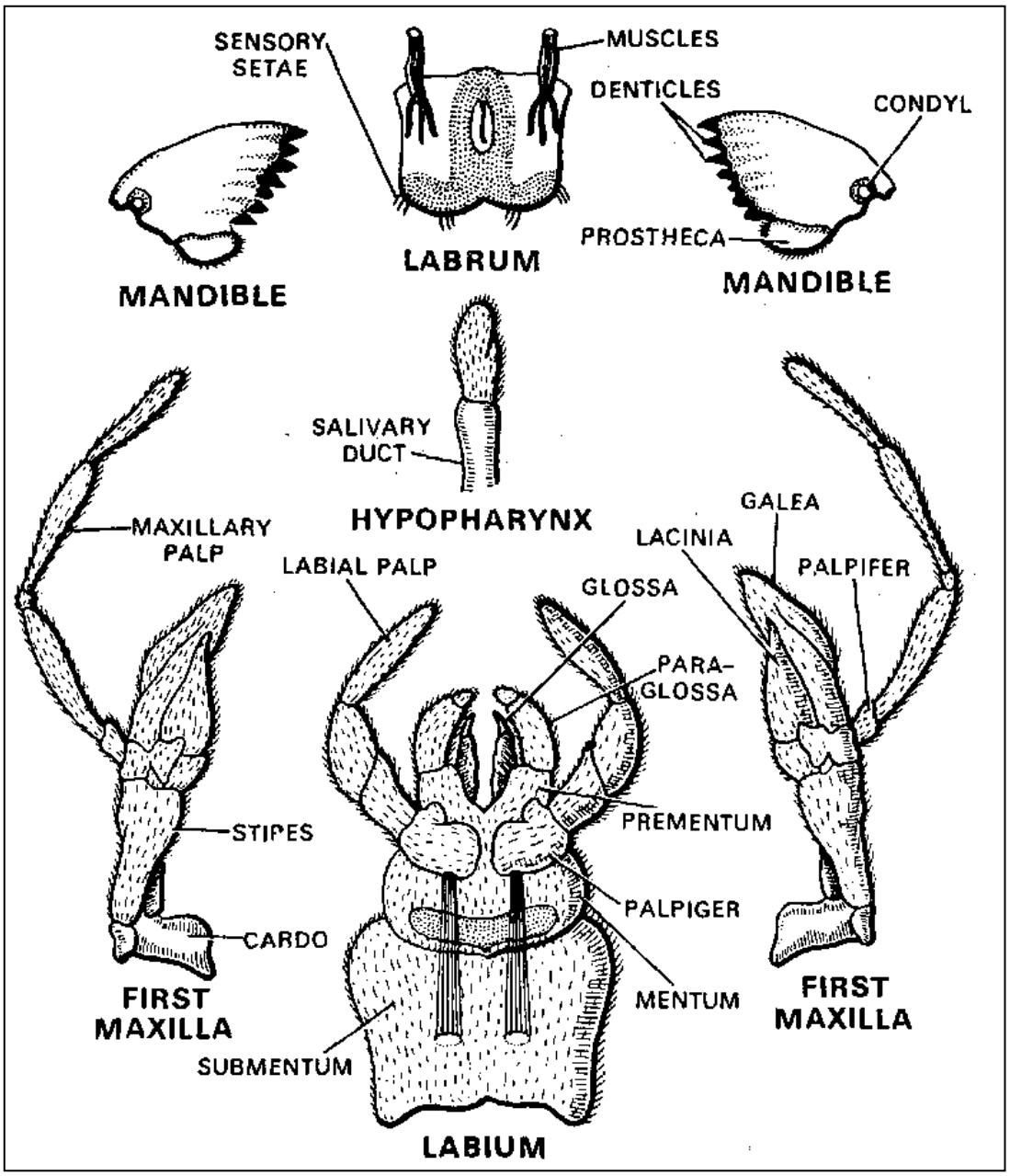
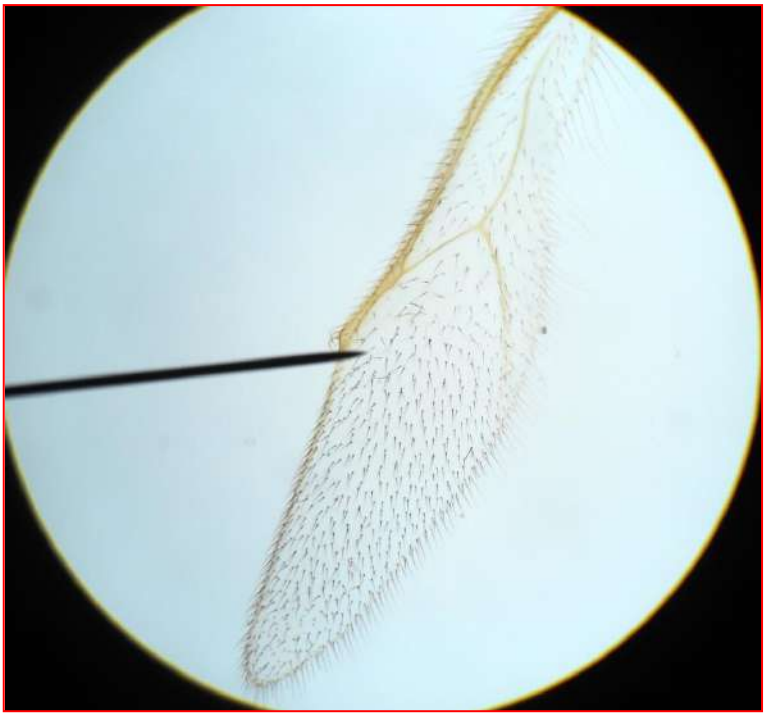


Fig: Mouthparts of cockroach

MOUNTING OF INSECT WINGS



Slide Mounts of Male Genitalia in Glycerin Jelly

1. Remove the tip of the abdomen or dissect out the genital capsule, and clear using standard procedures.

2. Remove from the clearing agent and rinse in distilled water. If heavily melanized the specimen may be bleached with hydrogen peroxide.

3. The genitalia may be stained if desired, 20-24 hours in Eosin-U (1% aqueous).

4. Remove from the stain and rinse in distilled water. Dissect under distilled water.

5. Remove from water and place in glycerin until glycerin has replaced water in specimen (at least 10-15 minutes).

6. Heat a small amount of glycerin jelly until melted (a few minutes in a stendor dish or spot slide on a hot plate set at 250°).

7. Place a small drop of glycerine jelly on a microscope slide.

8. Transfer genitalia. The specimen may be positioned as the jelly cools and solidifies. If necessary, the genitalia may be repositioned by warming the slide on the hot plate until the jelly begins to liquify.

9. The specimen may be permanently preserved by cutting the solidified jelly around the specimen on the slide with a scalpel or razor blade, carefully lifting it off the slide, and placing the jelly-enclosed genitalia into a small, corked genitalia vial which is then attached to the pin holding the specimen.

Entomology: Methods of Collection of Insects

Techniques for collecting insects are varied. However when collecting insects, we should remember/ keep in mind the following:

a) The requirements for collecting aquatic insects from rivers, streams, vegetation etc, would differ from those for collecting terrestrial insects from trees, soil, debris, etc.

b) The collecting method does not only depend on the insect type or group to be collected, but it also varies with the need of collecting live or dead insects.

c) The collecting method being chosen and the collecting supplies required also varies with the time of the day, collection would be carried out, thus, requirements vary for collection during the day from that at night.

Categorising the Methods of Collection:

The methods used for collecting insects may be divided into two categories – Active and Passive. In the first category, the collector is involved in an active search in finding out the insects either by hand or by using the apparatus suited according to one's needs. In the second category, the traps of different kinds are employed to do the work, and the collector participates only passively.

Active Collecting Methods:

Hand Collecting

When insects are collected by hand then one should have good knowledge or proper information as to which insects bite and which sting, and how far such attack can prove to be poisonous. Caterpillars with spines or hairs on their bodies should be avoided because some of these have venom associated with these structures. In case of collection by hand, the collector should be well equipped with tools like – hatchet, knife, small garden shovel, forceps, brush, gloves hand-lens, pocket knife, etc.

Hand collecting is useful for large but sedentary or slow-moving insects. Insects found in places such as under logs or rocks/ stones or loose bark or in buildings, in crevices or

beddings or timber, or in dung, or in different parts of the plants or in any other location where using any larger equipment is not possible, must be collected by hand.

Aspirators

Aspirators also known as 'pooters' are effectively used to capture small insect specimens in a convenient way. Insects that rarely fly might also be easily collected using this device. It consists of a glass or Perspex (plastic) or celluloid vial/ jar/ bottle or test tube as required, of the desired diameter and length, fitted or sealed with a cover; two pieces of rigid tubing of either glass of metal or plastic, one short and the other long ; a cover, provided with two holes in which the tubing will fit properly, and a piece of flexible tubing of either rubber or plastic, with a diameter just large enough to fit tightly over one end of shorter piece of the rigid tubing.

Beating

Wingless and/ or non-flying ad slow-moving insects can be easily collected using a beating sheet/ tray. Well camouflaged or hidden species of insects resting/ securely perched on bushes/ shrubs/ trees, thus, those difficult to be easily spotted, might be conveniently collected through this technique.

Sifters

Sifters are used for collecting concentrated quantities of litter and soil, containing many insect species. Sifters might be of different kinds. One kind has two hoops of heavy metal, each with a handle.

Separators and Extractors

A modification of the sifter is a separator. These devices usually depend on some physical aid such as light, heat, or dryness to impel the insects to leave the foreign matter. The simplest of such devices is the sweeping separator.

Soil Washing/ Floatation Samplers

To collect the insects in arid/ deep/ mineral soils with high clay content, this is an effective technique. Soil washing requires the ratio of water to soil to be about 4:1. This technique provides the complete life-history data of the insects collected.

Vacuum Sampling

Widely used power suction samples include "D-vac" and "McCoy Insect Collector", are used to collect insects through vacuum sampling.

Pupa Digging

This method requires a trowel, for digging and to lift the material containing the specimens. The insects are ultimately sorted out on a water proof white sheet.

Nets

The net is a very handy tool and considered a much valuable equipment for collecting insects, of the three commonly available insect nets, i.e., aerial of butterfly net, sweeping net and the aquatic net.

Type of Nets:

Aerial/ Butterfly Net: It is designed to collect specific groups of insects, namely – dragonflies, butterflies, moths, bees, wasps, flies, some smaller insect varieties, etc. The collecting bag is usually white in colour.

Sweep Net/ Beating Net: It is made up of much heavier, sturdier and a more durable material such as canvas or thick cotton cloth or strong muslin. This net is used to collect grasshoppers, bugs, beetles and chewing and sucking insects of varied sizes.

Passive Collecting Methods:

Traps

Anything that impedes or stops the progress of an insect is referred to as a 'trap'. The factors affecting the performance of a trap include construction of the trap, location of the trap, time of the year or day chosen for trapping, weather and temperature on the day of trapping, kind of the attractant used, if any.

Funnel Trap

The trap consists of an electric light source, with a funnel at the bottom directed either into a killing jar or a dark box, positioned below the funnel, to prevent the escape of any insects.

Pan Trap/ Yellow-Pan Trap/ Moericke Trap: In this trap, small, shallow pans, mostly yellow in colour filled with a liquid (water mixed with a surfactant), is used to trap insects.

Coloured object/ Sticky Trap: In this type of trap a piece of tape, simple plastic disposable drinking cups, a cylinder, board, cards, a pane of glass, a piece of wire net is required. The object is usually painted yellow, attracting diverse groups of insects, and coated with a sticky substance such as 'Flytac', Tangle foot etc.

Yellow Sticky Strip: Usually 11.5 inches X 6 inches, thin strips made up of plastic, bright yellow in colour and coated on both sides with a non-toxic, non-drying sticky substance. These strips are covered on either side with a removable waxed-paper.

Pitfall Trap

Pitfall traps are another kind of trap employed by the Bombay Natural History Society, for collecting insects. A pitfall trap consists of some type of cup or container like plastic buckets, jam tins, glass jars, can, dish are buried into the ground in a manner that the upper rim or lip or the top edge of the container, flushes with the ground/ soil surface.

Flight - Interception Trap (FIT)

Also known as barrier trap, this trap is used to collect small, weak flying species of insects; those fly upwards or fall downwards on being intercepted by a barrier into a container of some type, which is partially filled with a suitable liquid preservative/ killing agent.

Suction and Rotary Trap

These traps either pump a volume of air through a filter (Johnson, 1950) or use a mechanically rotated net, to obtain aerial insect fauna. Suction traps collect small slow-moving, fragile, winged insect specimens.

Electrical Grid Trap

In this kind of trap, insects are attracted to pheromone or any other kind of attractant which is placed in a chamber, and protected by a strongly charged electrical grid, hence, trapped.

Light

The fact that insects are attracted to light from any source is used to trap insects, especially those which are nocturnal in habit. Torch lights and lanterns are use to catch nocturnal beetles and moths.

Collecting Aquatic Insects:

When collecting aquatic insects, a general observation is that a sunny day, with the outside temperatures on the higher side, provides the collector with good results as both adults and the immature stages of aquatic insects get trapped. Different collecting equipment include –

NET: To collect insects many kinds of net might be used depending on the portion of the aquatic habitat the collector wishes to scoop. Water nets must be sturdy in nature, but the rims should be of diameter smaller than those used for collecting aerial or terrestrial insects.

Under-water Light Trap:A light trap is used in under water expeditions to capture the water bugs, the water beetles and the aquatic stages (nymphs and larvae) of the may flies, dragon flies and various other flies (Diptera).

Killing Agents

Killing jars: used for terrestrial insects. Consist of a glass jar with a thin layer of plaster-ofParis in the bottom. The plaster layer is saturated with ethyl acetate and the insects placed in the jar are killed by asphyxiation.

Ethanol: aquatic and soft bodied insects may be preserved in 70% EtOH.

Equipment and methods for preserving and mounting insects:

Pinning

Direct pinning: Pin is inserted directly through the body of the specimen. Pins are available in sizes from 000 to 7 but generally the insect is pinned with the thickest one it will take without damage. The specimen should be pinned through the thorax or elytra (see figures)

and arranged so the appendages are well displayed for study. Use the first level of the pinning block to obtain the correct level of the insect on the pin. Sufficient pin must be left exposed above the specimen to allow safe handling, so large, robust insects may have to be mounted by eye, rather than on the pinning block.

Pointing: Insects that are too small to be pinned directly may be mounted on a point. A point is a triangular piece of stout white paper that you can make with a point punch. A pin is inserted through the broad end of the point and the small end is bent with forceps at a right angle. A very small amount of glue is placed on this turned-over tip and this is then applied to the right side of the thorax of the insect (see figures). A correctly pointed specimen has its body horizontal when the pin is upright, with the long axis of the body at right angles to the point.

Gluing: Small Diptera (true flies) are mounted by applying a small amount of glue (clear finger nail polish) about below the top of the pin and then touching it to the right side of the thorax of the insect.

Preservation in Liquid: Most larvae and nymphs (immature insects) and some adult insects that are soft-bodied, must be preserved in liquid rather than pinned. It is best to kill the specimen in boiling water prior to preservation as this leaves them plump and limp and deactivates autolytic enzymes. A number of preservatives can be used but a solution of 70% alcohol, which preserves specimens in a supple condition, is one of the best. The specimens are stored in a stoppered vial with the data labels enclosed.

Slides: Many techniques have been developed for slide-mounting insects that are too small for pinning. Arrange object on slide so position suitable for study and customary for objects of its nature, that appendages or other structures are spread out and displayed. Various mounting media, some require dehydration and clearing of the specimen before mounting.

NOTE: VIALS AND SLIDES SHOULD NOT BE STORED IN THE SAME BOX AS DRY SPECIMENS

Spreading: The wings of many insects show important taxonomic characters and should be mounted in a manner that will allow their examination. If the wings do not spread naturally when pinned, they must be spread manually. Spreading is done using a special board, called a spreading board. The spreading board has a central groove for the insect's body and a surface on either side of the groove on which the wings are pinned. Fresh, pliable specimens must be used (older specimens can be relaxed and then pinned). The wings are manipulated by inserting the point of a very fine pin (000 preferably) behind a main longitudinal vein. In

most insects the fore wings are pushed forward until their posterior margins are in line with each other and at right angles to the body. Next, the hind wings are brought forward in the same manner until the anterior margin of each is just underneath the posterior margin of the fore wing. The wings are held in place by pins, or by strips of paper held down by pins. The abdomen and antennae may need to be supported by pins to prevent drooping. Larger specimens should remain on the board for 3 weeks to ensure complete drying. Spreading board (From Elzinga 2000)

Labelling collected insect specimens: An unlabeled specimen is incomplete and unacceptable. Labels should not be larger than 6x16 mm. Labels should be written in pencil, or computer-generated. Every specimen must have the following information on the label:

1st line – Specimen number and order

2nd line - Place of collection (country, state and county)

3rd line - Place of collection (nearest post office)

4th line - Date collected

5th line - Name of collector

Morphological studies of various castes of *Apis*, *Odontotermes*

Chapter 10.7

Identification of Same Beneficial Insects

Insects are the largest number of animal formed in this universe and are of great importance to man. Beneficial insects are very few in number. There are a few species, whose laborious products are used by the man for his own advantage. One of them is silkworm. The continuous silken thread which builds the cocoon serves as the source of the silk of our requirement. Second is honeybee. Honey and wax come from beehive; man for several purpose uses these two products. The third is lac–insects. It liberates a resinous product as exudate which forms a crust around the insect. From this exudate stick-lac of commerce is manufactured. Many insects are considered to be of great value of pollinators.

Identification :

1. ***Bombyx sp. :*** See chapter 1.1.1. Non chordate: Arthropod, item no 45.

2. ***Antheraea sp. :*** See chapter 1.1.1. Non chordate: Arthropod, item no 48.

3. **Butterfly :** See chapter 1.1.1. Non chordate: Arthropod, item no 50.

4. ***Apis sp.* (Honey bee) :**

Habit and Habitat :

Honeybee is a social insect. The nest of the honeybee is known as bee-hive. It is commonly seen on tall trees and ceiling of houses. They can be reared in artificial hives. Its food is nectar and pollen of flowers. Thousand of individuals, who live in the hive are of three different forms viz., **workers, drones** and **queens.**

Systematic Position :

Phylum	**Arthropoda**
Sub Phylum	**Mandibulata**
Class	**Insecta**
Subclass	**Pterygota**
Super order	**Holometabola**
Order	**Hymenoptera**
Type	***Apis***

Distinctive features :

1. Triangular head bears three ocelli in the middle.

2. Antennae two, short and many jointed.

3. Mouth parts both sucking and chewing type.

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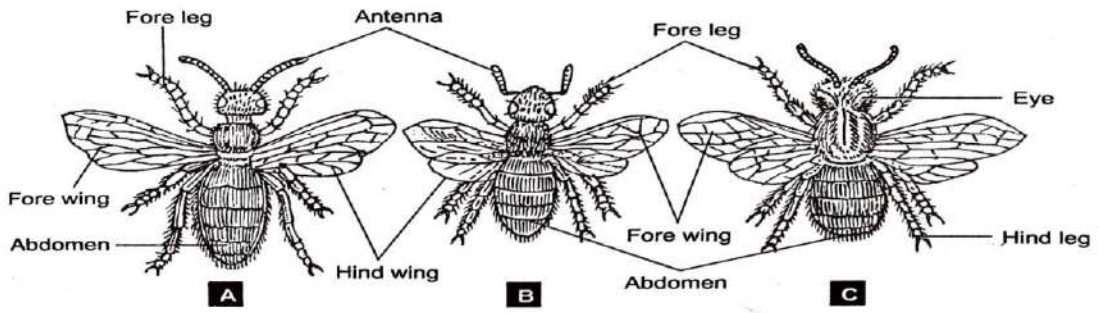

Fig. 10.7.1 : *Apis sp.* A–Queen, B–Worker, C–Drone.

4. Tibia of prothoracic leg is provided with soft hairs called **eye brushes** and on the first tarsal segment presents stiff bristles, **pollen brushes.**

5. In addition to pollen brushes, tibia of mesothoracic legs bears a **wax spine stick.**

6. The first tarsal segment of metathoracic legs bears at its inner part **pollen combs.** Near the junction of tibia and first tarsal segment **pollen packers** are present and the tibia bears **pollen basket.**

7. Abdominal segments seven in drones but six in workers and queen.

8. Queen and workers bear in the last abdominal segment a sting.

Worker :

1. Size small.
2. Body is densely covered with hairs.
3. Abdominal segments six and possess wax glands and stings.

Queen :

4. One and a half times as large as the worker bee.
5. Abdomen is greatly distended; wings are short.
6. Pollen baskets and wax glands are absent.
7. Abdominal segments seven and last segment bears sting.

Drone :

8. Medium size, larger than worker.
9. Body is comparatively broad and abdomen is blunt without any sting.
10. Head is quite round with long eyes.
11. Wax glands and pollen basket absent.
12. Abdominal segments seven.

Identification with reasons :

State classification and characters up to—

Superorder—**Holometabola** as those of *Hispa* (see chapter 1.1.1, item 38).

Order—**Hymenoptera :**

1. Mouth parts are of both sucking and chewing types.
2. Wings membranous, the hind wings smaller than the forewing and interlocked with the hind wings by means of hooklets.
3. The first abdominal segments fused with the metathorax.
4. Metamorphosis complete.
5. Ovipositor always present and modified for sawing, piercing or stinging.

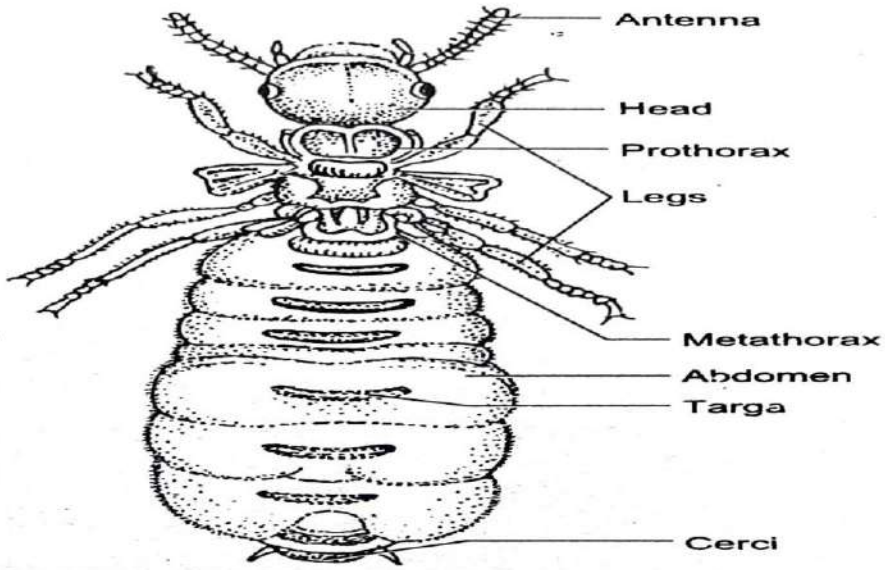

Fig. 1.1.1.118 : *Termite queen*

27. TERMITE QUEEN

Habit and Habitat

Subterranean; lives underground in a chamber, the royal cell with in the termite colony; fed by worker termites with regurgitated saliva and fungal hyphae.

Systematic Position

Phylum	**Arthropoda**
Subphylum	**Mandibulata**
Class	**Insecta**
Subclass	**Pterygota**
Order	**Isoptera**
Type	**Termite Queen**

Distinctive Features

1. Head and thorax comparatively smaller but abdomen is enormously elongated.
2. Remnant of paired wings present.
3. Soft elongated body with small head and short, beaded antennae.
4. Targa and Sterna on abdomen do not grow.
5. Social insect living in colony.

Identification with Reasons

State classification and characters up to—

Subclass—*Pterygota* as in **Dragon fly.**

Order—*Isoptera* :

1. Social forms with soft exoskeleton.
2. Members of the colony differentiated as reproductive members, workers and soldier.
3. With biting mouth parts.
4. Head bears slender, short beaded antennae.
5. Wings when present, similar, with basal fractures at point where they break when shed.

Type—Termite Queen : State distinctive features as in above.

Economic Importance

Termites are remarkably destructive of wooden structures, such as homes, trees but are extremely important in nutrient and energy recycling especially in tropical areas. Every year termites cause huge loss to buildings and libraries. Termites are **Eusocial** *i.e.*, truly social insects. They form colonies composed or more or less sterile workers and one or more reproductive queens. Queen is protected and cared by her offspring.

27A. MEMBERS OF TERMITE COLONY

Termites are soft bodied, social insects, pale in colour. Mouth parts biting and chewing type. Thorax wide at its junction with the abdomen. Terminates are polymorphic and include two forms, viz., (a) reproductive and (b) sterile.

Identification

1. **Macropterous or winged forms :** (winged Kings and Queen).

Characters :

1. Yellow, brown or black in colour. Body well sclerotized.
2. Wing two pairs, larger than the body and very well developed. Ultimately, these wings are discharged.
3. Compound eyes are two, large and widely separated.
4. Adapted for a brief aerial life.

Economic Importance : Adapted for a brief aerial life and forms the new colonies.

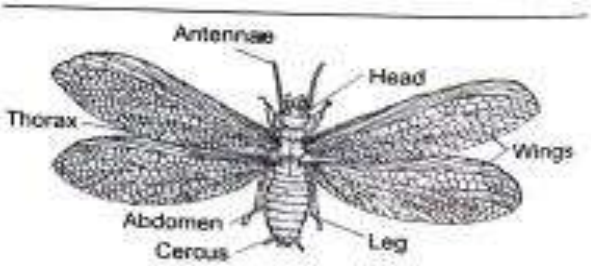

Fig. 1.1.1.118A : *Winged termite* (male)

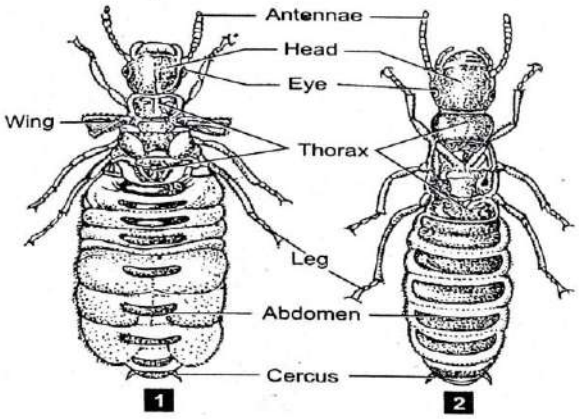

Fig. 1.1.1.118B : *Macropterous form*
1–Dealated queen, 2–King.

2. Brachypterous or short winged forms : (Supplementary reproductive forms, consisting both Kings and Queens)

Characters :

1. Body is usually less sclerotized and pigmented then primary reproductives.
2. Straw-coloured or greyish white in colour.
3. Compounds eyes are generally reduced.
4. Two pairs of wings are vestigial, short and stump like.

Economic Importance : Not normally found in colonies. They appear after one or both primary reproductives die and replace them so that the colony can continue.

3. Apterous or wingless forms :

Characters :

1. Body is not pigmented.
2. Wigs are completely absent.
3. Compound eyes are vestigial.
4. Ocelli are completely lacking.

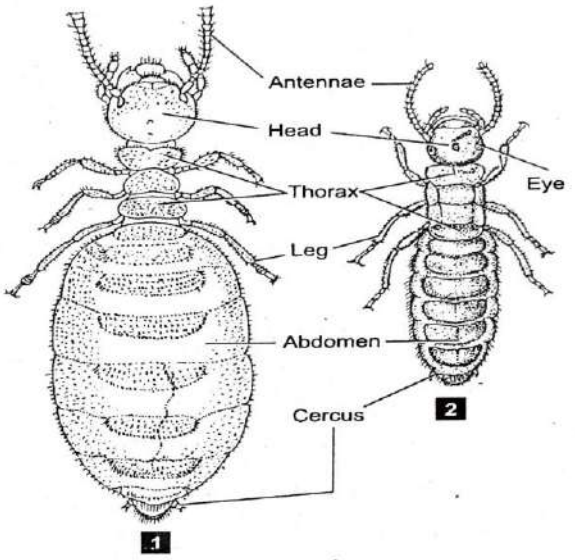

Fig. 1.1.1.118C
1–Apterous queen, 2–Brachypterous form.

4. Workers (Sterile castes) :

Characters :

1. Small white insects, without wings.
2. Head is directed down words, with small, broad jaws.
3. Compound eyes are absent.
4. Mandible powerful and adapted for gnawing wood and other vegetable tissue.

Economic Importance : They show marked care for the eggs and young. They also feed and tend the Queens, forage for food, cultivate fungus garden and excavate the **gallaries** and tunnels which serve for the nest.

(5) Soldiers :

Characters :

1. Bigger in size than workers.

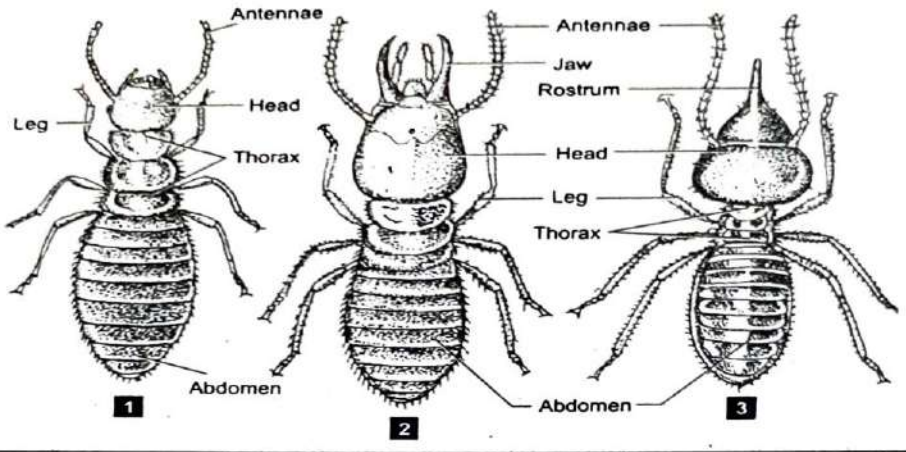

Fig. 1.1.1.118D : 1–Worker, 2–Mandibulate soldier, 3–Nasute soldier.

2. Head is large and strong and highly sclerotized.
3. Pointed jaws are placed ventrally in front of the head.

Two types of soldier

(a) ***Mandibulate type*** :

Characters : With large and powerful jaws but no frontal rostrum.

(b) ***Nasute type*** :

Characters: Median frontal rostrum, but jaws are small or vestigial.

Economic Importance

Their work is to defend the colony and attack the intruders into the colony.

STUDY OF MAJOR INSECT PESTS OF PADDY AND THEIR DAMAGES

Leptocorisa sp.:

Systematic Position:

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta

Subclass: Pterygota

Order: Hemiptera

Genus: Leptocorisa

Species: *L. acuta / L. Varicornis*

Importance:

Rice bugs feed by inserting their needle like mouthparts into new leaves, tender stems and developing grains. Excessive feeding can cause yellow spots on the leaves. This reduces photosynthesis and, in extreme cases, can damage the vascular system of the plant. Puncture holes also serve as points of entry for several plant pathogens, such as the fungus that causes sheath rot disease. The most economically important damage is caused when the adults and nymphs feed on the developing grains. Such damage causes discoloration of the grains, which reduces market quality.

Scirpophaga sp.:

Systematic Position:

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta

Subclass: Pterygota

Order: Lepidoptera

Genus: Scirpophaga

Species: *S. incertulus*

Importance:

This moth is a major pest of paddy in India. Only the caterpillars are destructive which bores tunnel into the stem of the paddy plant. The plants attacked in early stages produces ears devoid of grain known as white ear.

Hispa sp.:

Systematic Position:

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta

Subclass: Pterygota

Order: Coleoptera

Genus: Hispa

Species: *H. armigera*

Importance:

It is a major pest of paddy particularly in north India. Both adult and larva causes damage to the crop.

Apion sp.:

Systematic Position:

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta

Subclass: Pterygota

Order: Coleoptera

Genus: Apion

Species: *A. corchori*

Importance:

Adult female bores a hole in the jute stem generally in the apical region and particularly at the base of the petioles for oviposition, thus, adversely affects the development of fibres. Hatched out larvae feed on surrounding tissue causing extensive damage to the fibre crop.

Sitophilus sp.:

Systematic Position:

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta

Subclass: Pterygota

Order: Coleoptera

Genus: Sitophilus

Species: *S. oryzae*

Importance:

This beetle causes heavy damage to rice, wheat, and sorghum particularly in monsoon. This pest of stored grain also attacks oats, barley and cotton seeds. These weevils destroy more than they feed on.

STUDY OF MULBERRY SILK MOTH AS BENEFICIAL INSECT

Bombyx sp.:

Systematic Position:

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta

Subclass: Pterygota

Order: Lepidoptera

Genus: Bombyx

Species: *B. Mori*

Importance:

The secretion of silk gland after coming into contact of air, harden to produce shiny silken thread to be used for formation of cocoon. This thread called as silk is a natural fibre and is of immense importance. Silk is used for:

- For making expensive garments,

- For certain industrial and electrical items.