Department of Agricultural Entomology
Uttar Banga Krishi Viswavidyalaya
Pundibari, Cooch Behar
West Bengal-736165

Volume I

PRACTICAL MANUAL

FUNDAMENTALS OF ENTOMOLOGY

(ENT-151/152)

Nripendra Laskar
Jaydev Ghosh
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Practical Manual

FUNDAMENTALS OF ENTOMOLOGY

ENT-151 (3+1) (For Agriculture)
ENT-152 (2+1) (For Horticulture)

Name of the student:……. Reg. No……..

Faculty:…… Term/Semester……. Roll No…….....

Expt. No.	Date	Topic	Sig. of Course Instructor	Remarks

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Signature of Course Instructor Signature of External Examiner

Expt. No. 1

EXTERNAL STRUCTURE OF GRASSHOPPER

Body is divisible into three distinct regions.viz., head, thorax and abdomen

1. HEAD- feeding and sensory centre

It is the most anterior and compact body division. Segmentation is not evident in head. The head bears a pair of antennae, a pair of compound eyes, three dorsal ocelli and the mouth parts. Head is strongly sclerotized. The sclerotized capsule minus the appendagesis called cranium. Head capsule is covered with hardened plates or sclerites. Softparts or joints between sclerites are called sutures.

Compound eyes are dorsolateral in position and are located on either side of the head. Each eye consists of a number of individual sensory units or ommatidia (ommatidium - singular). Externally these ommatidia are marked by hexagonal cuticular facets. Compound eyes are the major photoreceptors useful in image perception. In between the compound eyes are situated three simple eyes or dorsal ocelli. Out of three one is median in position and other two are placed above on each side. Each simple eye has a single lens. They are sensitive to light but not useful in image perception. Antennae are paired segmental ap~endages that articulate with the cranium between the compound eyes. Antennal segments are of uniform thickness and are thread like (Filiform).

Antennae are flexible and sensory in function. Mouth parts are mandibulate. They are suited for biting and chewing the food. Mouthparts consist of two lips (Labrum and Labium), two pairs of jaws (Mandibles and Maxillae) and a tongue like organ hypo-pharynx. Head is connected to thorax by a membranous region the neck or cervix. The cervical membrane is quite flexible and allows movement of head. Head is concerned with feeding and sensory perception.

2. THORAX -Locomotoin centre

It is the middle body region. It is heavily musculated and mainly concerned with locomotion. It is three segmented. The three segments of thorax moving ftom anterior to posterior are termed the prothorax, mesothorax and metathorax. Each thoracic segment consists of a dorsal sclerite called the notum and ventral sclerite called the sternum and on either side is the pleuron which is membranous. The notum of prothorax is called pronotum which is saddle shaped. There are two pairs of respiratory openings (Spiracles or Stigmata) located laterally on mesothorax and metathorax.

Each thoracic segment bears a pair of segmented legs. Each leg consists of five segments viz., coxa, trochanter, femur, tibia and tarsus. Tarsus ends in pretarsus. Pretarsus consists of a pair of claws and a median lobe, arolium. Foreleg and middle legs are suited for walking while the hind leg is suited for jumping. Swollen femur helps in Jumpmg.

The wing bearing thoracic segments viz., mesothorax and metathorax are collectively called pterothorax. Mesothoacic wing is called forewing. Forewings are leathery and are known

as tegmina. They are protective in function. Metathoracic wing is called hindwing. Hindwings are larger and membranous. They are kept folded beneath the forewings at rest.

3. ABDOMEN - Reproduction centre

It is the posterior tagma. It is the longest of the three body regions. It is usually rather soft compared to the rest of the body. Body segmentation is more evident in abdomen. It consists of eleven telescopic segments. The segments are joined by intersegmental membrane called conjunctiva, which makes the abdomen more pliable. Abdominal flexibility is a requirement for copulationand oviposition. Each segment is made up of an arched dorsal sclerite, the tergum, and a small ventral plate sternum. There is no pleuron, The tergum is connected to the sternum by a thin membrane. An oval shaped transparent auditory membrane, tympanum is found laterally on either side of the first abdominal segment. There are eight pairs of abdominal spiracles. The first pair lies in tront of the tympanum on the first abdominal segment and the remaining seven pairs are found on the side of the tergum from second to eighth abdominal segments.

Posterior abdominal segments are modified for the purpose of mating and oviposition. The external sexual organs (Genitalia) of male grasshopper are present in the nineth abdominal sternite. Male genitalia consists of a median intromittent organ or aedeagus and lateral clasping organs called parameres. The female egg laying apparatus is called ovipositor. It arises trom eighth and ninth abdominal sternites. Ovipositor consists of two pairs of basal sclerites (Valvifers) and three pairs of elongated processes (Valvulae) viz., dorsal, inner and median valvulae. Both dorsal valvulae and ventral valvulae are short, hooked, highly sclerotised and are found at the terminal end of the abdomen which are useful to dig the soil during oviposition. Median valvulae are small and concealed by other valvulae and act as egg guide.

The triangular dorsal plate of eleventh segment is called **epiproct** and paired lateral plates are called **paraprocts.** A pair of short unsegmented cerci is present between the epiproct and paraprocts. They are sensory in function. Anal opening is found immediately below the epiproct.

Expt. No. 2

COLLECTION AND PRESERVATION OF INSECTS

I. COLLECTION

1. Hand picking: A tedious method suitable for large insects like beetles and grasshoppers. It is unsuitable for insects inflicting painful bites and stings.

2. Insect net: There are two types of insect nets.

i. Aerial net: (Butterfly net):

It is useful for catching active fliers like moths, butterflies, dragonflies, flies, wasps, etc. The net consists of three parts viz., hoop, handle and porous cloth bag made out of mosquito netting material. It has a small hoop (30-40 cm dia) and a long handle (100 cm).

ii. Sweep net:

This is heavier than the aerial net. It consists of a short handle, a large hoop and a muslin cloth bag. This is suitable for collecting leafhoppers, grasshoppers and other small insects. The net is swept over vegetation and quickly turned to fold the cloth bag over the hoop in order to prevent the escape of trapped insects.

Aquatic net

Telescoping D-Style Aquatic net

Sweep net

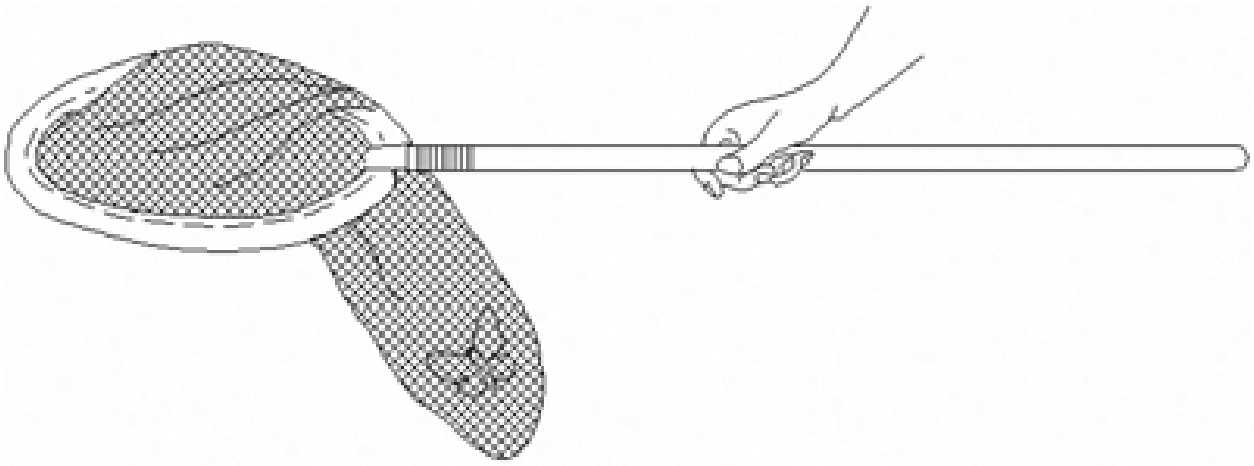


Fig: Twisting of insect net.

3. Aspirator (Pooter):

It is a device useful to collect all insects into a vial with no damage to the specimens. It is also useful for collecting insects from the insect net or any other surface.

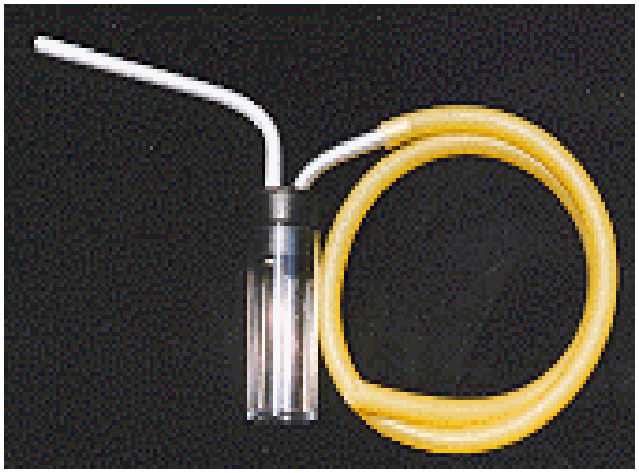


Fig: Aspirators of different size and dimensions.

4. Traps:

Traps can be used for collecting different types of insects.

Food lure trap - Flies
Sex lure trap- Moths
Water trap- Brown plant hopper
Light trap- Positively phototropic insects
Sticky trap- Whiteflies
Suction trap –Whiteflies

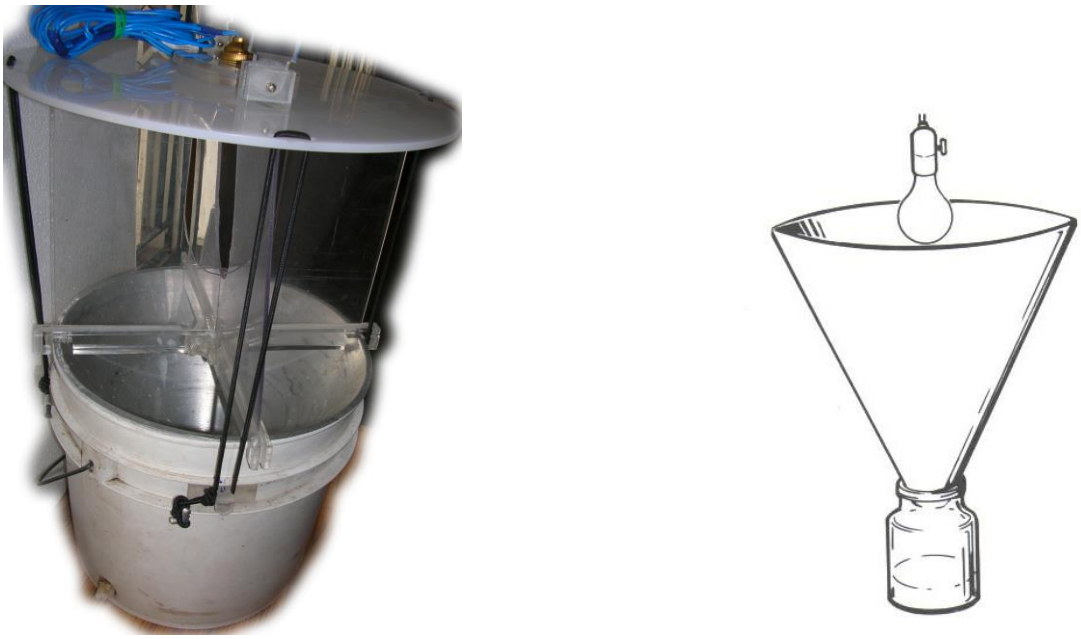


Fig: Light traps

Fig: Pheromone trap.

Fig: Pheromone trap.

Fig: Window pan trap

Fig: Combi trap

5. Berlese funnel

Soil dwelling insects can be collected by using Berlese funnel.

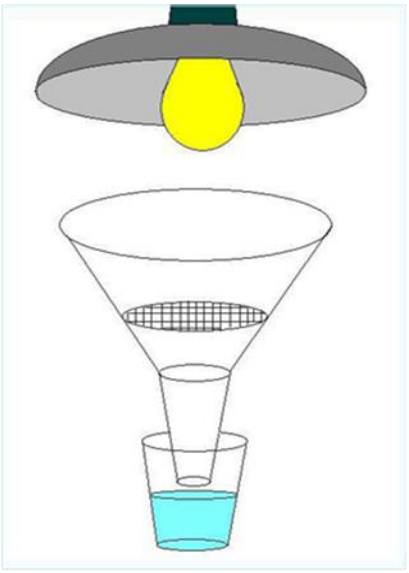


Fig: Berlese funnel

KILLING

Killing should be done immediately after capture. Potassium cyanide, ethyl acetate, carbon tetra chloride (carbona) and chloroform are commonly used for killing insects. Potassium cyanide kills the insect quickly but rigor mortis sets in quickly. Ethyl acetate kills the insects more slowly and does not last long. But the dead insects remain in a relaxed condition for a longer time without becoming brittle.

Pinching the thorax:

A butterfly or moth can be immobilized and killed in an emergency by giving a sharp pinch on the thorax.

Killing with alcohol:

Many insects can be killed by dropping them directly into 70 to 90% ethyl or isopropyl alcohol.

III. PRESERVATION

Materials required:

Paper folds (Paper envelopes):

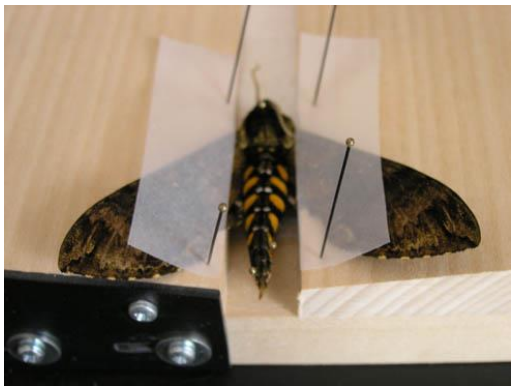
They are useful for temporary preservation and storage of large winged insects such as dragonflies, butterflies or moths. These triangular envelopes can be made from a sheet of notebook or by using absorbent type of paper used in duplicating machines.

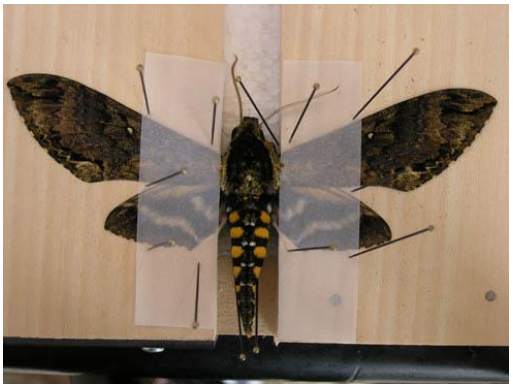
Cut the paper into rectangles with their sides in the proportion of 3:5. Bring the diagonally opposite comers together to leave two projecting flaps. Write the data regarding collection on the outer side of a projecting flap. Keep the immobilized insect in between the two overlapping triangles. Fold the flaps to produce a triangular envelope.

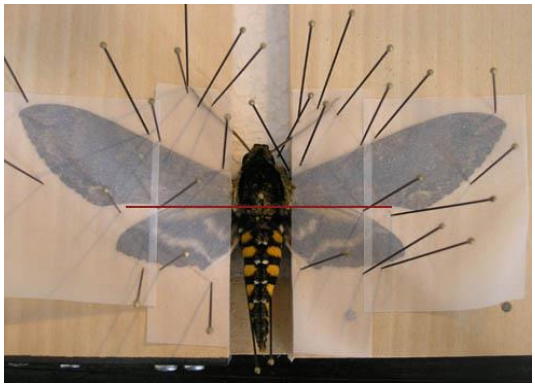
Setting board (Spreading board):

It is useful for spreading the wings of dead insects. It is a wooden board with a central groove in the middle. Flat cork strips are glued on either side of the groove and in the bottom of the groove to enable pinning. A thermocol sheet with a centrally cut groove can also be used as a substitute for the setting board.

Fig: Setting board







Relaxing container:

Setting or mounting an insect should be done within a day after killing. Otherwise the insect will become stiff and brittle. Stiffness in the dead insect can be removed by placing it in a relaxing container. High humidity inside the relaxing container permits water to be reintroduced into the specimens thus making them flexible. Fill a container with sand to 1/4th of its capacity. Saturate the sand with water. Add a few drops of carbolic acid or formaldehyde to prevent mould growth. Keep the dried specimens in a small open box or in an uncovered petridish to avoid direct contact of the specimen with moist sand. Close the lid tightly and allow them to remain for a day or two until they become flexible.

Pins:

Common pins are undesirable for pinning insects. Pins used for pinning insects should be slender, hard with a pointed tip and a small head. Pure nickel pins or nickel plated ones resist rusting. Commonly NO.16 and 20 pins are used for pinning larger and smaller insects respectively.

Micropins:

For pinning very small insects micropins are used. They are very thin, slender, delicate and headless pins. They do not rust. They are also known as insect pins minuten pins or entomological pins.

Methods of preservation:

1. Pinning:

It is the best and most common method to preserve hard bodied insects. They will dry and remain in perfect condition on the pins without requiring any further treatment. During drying the outer exoskeleton remains intact while the inner soft tissues dry up. Insects can be pinned directly if they are big. They are pinned vertically through their body. During pinning the insect is held between the thumb and forefinger of one hand and the pin is inserted into the insect with the other hand.

While pinning 1/3rdlength of the pin should be above the insect to permit a comfortable finger hold. Exact place of insertion of the pin varies among different groups of insects.

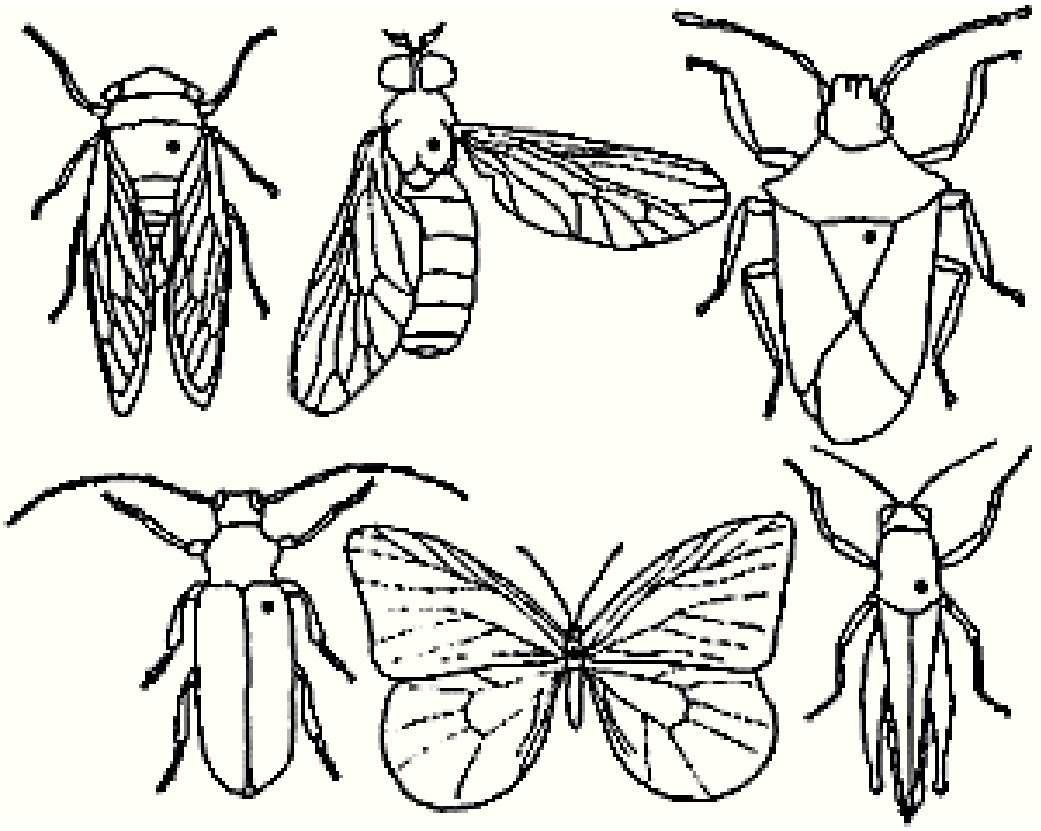
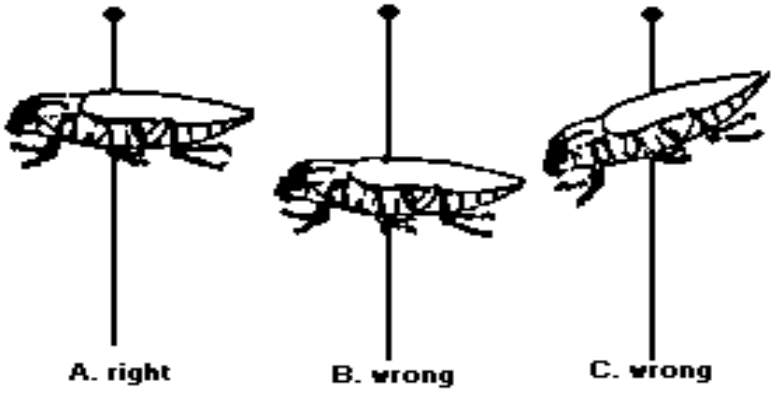
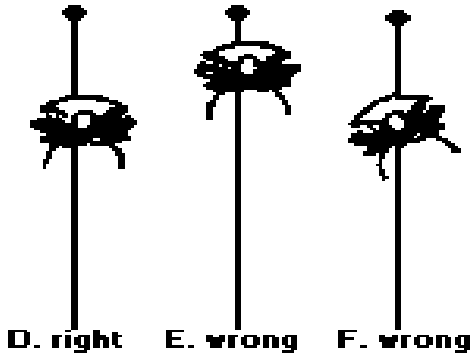


Fig: Pinning points of different categories of insects.





2. Double mounting:

Pinning is troublesome in smaller insects. Very small insects cannot be pinned because most of the body parts of the insects will be lost during pinning. For such insects double mounting can be followed.

Staging:

The stage is a narrow rectangular piece of pith or cork. The small insect is pinned correctly with a micro pin to the stage Later the stage is pinned in the insect store box with a bigger pin.

Carding:

A rectangular (5 x 8 mm or 5 x 12 mm) white card or celluloid bit may be used as stage. On the stage instead of pinning, the insect specimen is stuck on it by using transparent or stain free adhesive. A spot of good glue or white gum can also be used. The insect should not be embedded in the glue and only minimum quantity of the glue should be used. After mounting, the card is pinned to the insect storage box with a large pin.

Pointing:

The insect specimen is glued to a card or celluloid bit into a triangle of 10mm height and 5 mm base. Bend down the tip of the card to form a small surface to which the insect is stuck. Apply a drop of glue or adhesive by touching the point to the glue and to the thorax of the insect to be mounted. Press the right side of the specimen against angled and glued card tip. A bigger pin is inserted at the midpoint near the base for pinning the card with the insect to insect store box.

3. Liquid preservation:

Soft-bodied forms (nymphs, larvae and many adults) shrivel when mounted dry. Such insects can be preserved in preservative fluids like ethyl alcohol (70%) and formalin (4%). All these preservatives are highly volatile. Screw cap vials are satisfactory if the caps are tight fitting. Seal the stopper with paraffin wax and properly label.

4. Setting:

Setting insects is essential to stu4y the wing characters. It affords a better look to the preserved specimens. Wings of moths, butterflies, dragonflies and damselflies are set on either side. In grasshoppers, wings on one side alone are set. Setting boards are used for setting insects. Setting should be done before the insects become stiff.

IV. LABELLING:

Labels are must for every collection. Any collection should have a locality label giving particulars about date and locality of its capture. An additional label is often used that usually has the name or initials of the collector and the habitat or host from which the specimen is collected. Labels should be small, (12 x 6 mm) neat and made of stiff paper. Labels may be printed or hand written with micro tipped pen. They are inserted beneath the insects at 1/3rdheight from the base. The long axis of the label should coincide with the long axis of the insect. If more than one label is used then the label should be parallel. All labels should be oriented so that they read from left side.

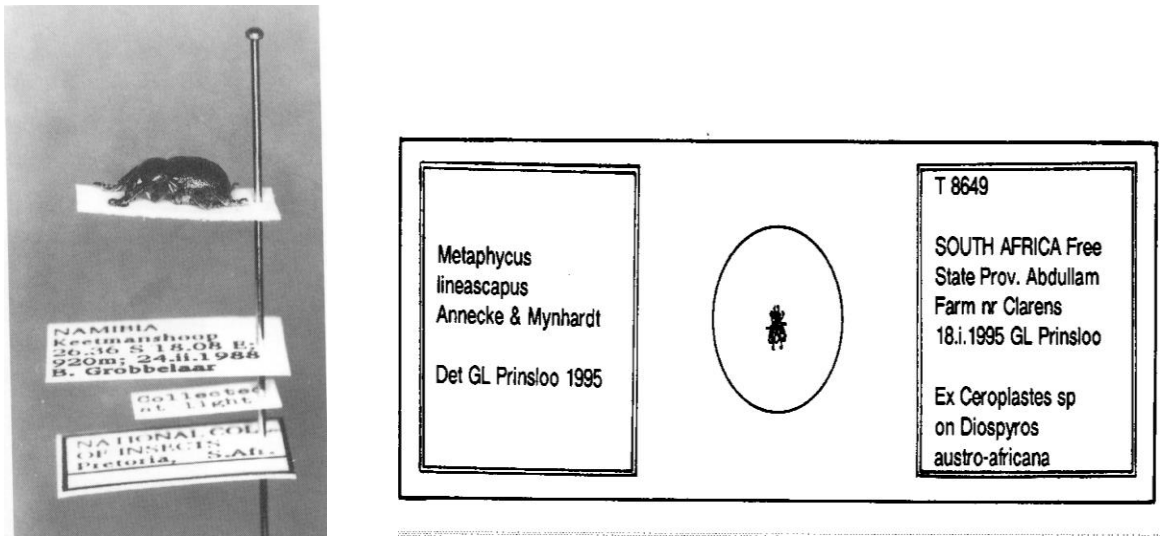


Fig: Procedures for lebelling.

V. DISPLAY:

Insect store boxes:

Commonly wooden boxes of dimension 45 x 30 x 15 cm are used as insect store boxes for displaying preserved insects. The box should be light in weight, airtight and moisture proof with a well fitting hinged lid. A cell is provided inside to keep repellents. Cork sheets are glued to the inside of the top and bottom of the box to permit pinning. Glass topped boxes can be used for displaying insect collections but the colour of the preserved insects fades due to constant exposure to light.

Repellents and preservatives:

Dermestid beetles, red flour beetle and psocids commonly attack preserved specimens. Naphthalene balls mounted on pins are pinned inside to repel museum insects. This is done by heating the head of a pin in flame and pressing it against a naphthalene ball. Naphthalene flakes can also be kept in perforated envelopes and can be pinned in the boxes. In the place of naphthalene, para-dichloro-benzene (PDB) crystals can be used.

Expt. No.: 3

TYPES OF INSECT HEADS AND ANTENNAE

A. TYPES OF INSECT HEADS

Based on the inclination of long axis of the head and orientation of mouth parts there are three types of insects heads.

1. HYPOGNATHOUS: (Hypo-below; gnathous-jaw)

This type is called Orthopteroid type. The long axis of the head is vertical. It is at right angles to the long axis of the body. Mouth parts are ventrally placed and project downwards. e.g.grasshopper.

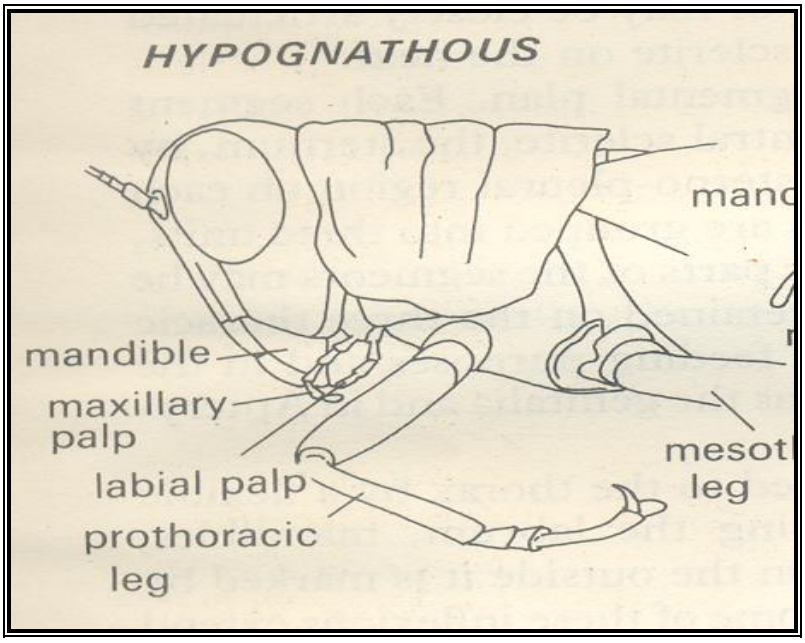


Fig: Hypognathous orientation of insect head.

2. PROGNATHOUS: (pro-in front ; gnathous - jaw)

This type is also called Coleopteroid type. The long axis of the head is horizontal. It is in line with the long axis of the body.

Mouth parts are directed forward. e.g. ground beetle.

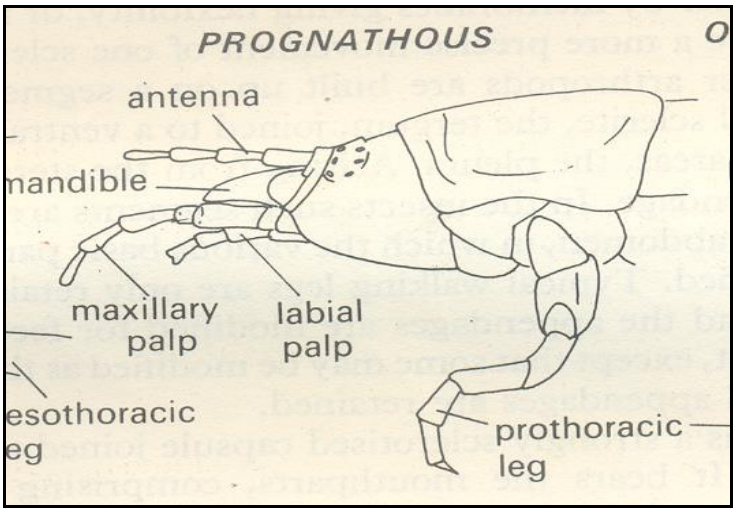


Fig: Prognathous orientation of insect head.

3. OPISTHOGNATHOUS: (Opistho-behind; gnathous-jaw)

This is also called Hemipteroid type or opisthorhynchous. Head is deflexed. Mouthparts are directed backwards and held in between the forelegs. e.g. stink bug.

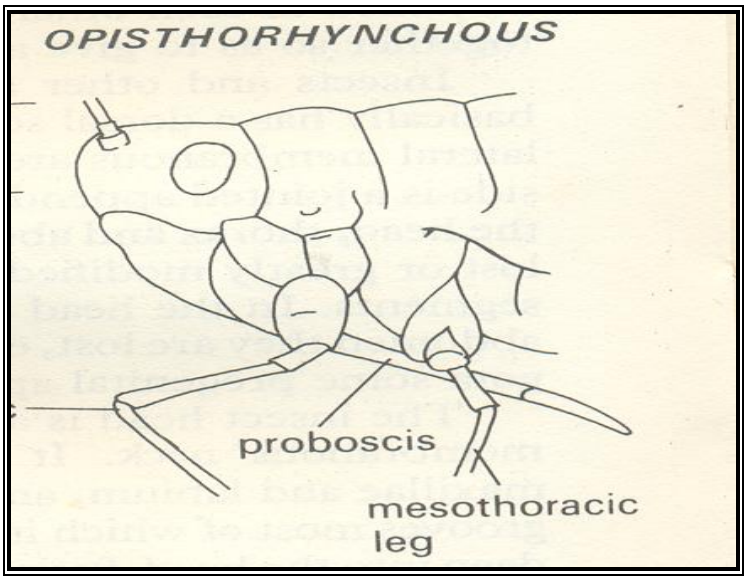


Fig: Hypognathous orientation of insect head.

B. ANTENNA:

Antennae are also called feelers. They are paired, highly mobile and segmented. Antennae are located between or behind the compound eyes. All insects except protura have a pair of antennae.

Antennae are well developed in adults and poorly developed in immature stages. The antenna is set in a socket of the cranium called antennal socket. The base of the antenna is

connected to the edge of the socket by an articulatory membrane. This permits free movement of antennae.

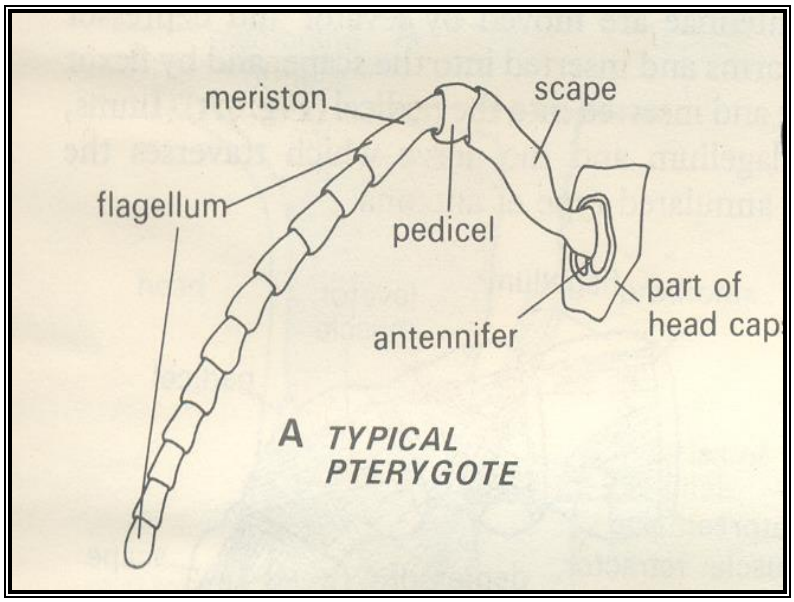


Fig: Insect antenna.

The basal segment is called scape. It is conspicuously larger than succeeding segments. The second antennal segment is called pedicel, which immediately follow the scape. A mass of sensory cells called Johnston's organ is present in the pedicel. Both scape and pedicel are provided with intrinsic muscles. The remaining annuli or flagellomeres are known as flagellum or clavola, which lack individual muscle. Surface of the flagellum is supplied with many sensory receptors that are innervated by the Duetocerebrum of brain.

Antenna is useful to detect chemicals including food and pheromones (chemicals secreted into air by opposite sex). It perceives smell, humidity changes, and variation in temperature, vibration, wind velocity and direction. Antenna is useful to perceive the forward environment and detect danger. It is useful for hearing in mosquitoes and communication in ants. Rarely it is also useful to clasp the mate (e.g. Flea) and grasp the prey.

Types of insect antenna:

1. SETACEOUS: (Bristle like)

Size of the segments decrease from base to apex.

e.g. Dragonfly, Damselfly.

2. FILIFORM: (Thread like)

Segments are usually cylindrical. Thickness of segments remains same throughout

e.g. Grasshopper.

3. MONILIFORM: (Beaded)

Segments are either globular or spherical with prominent constriction in between e.g. Termite.

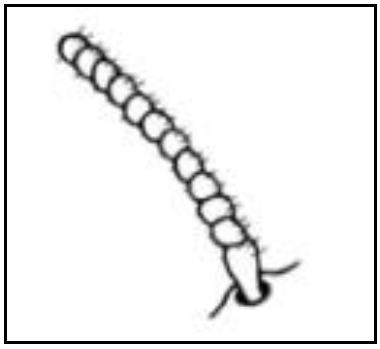


Fig: Termite

4. SERRATE: (Saw like)

Segments have short triangular projections on one side. e.g. Longicorn beetle

5. UNIPECTINATE: (Comb like)

Segments with long slender processes on one side e.g. Sawfly

6. BIPECTINATE: (Double comb like)

Segments with long slender lateral processes on both the sides e.g. Silkworm moth

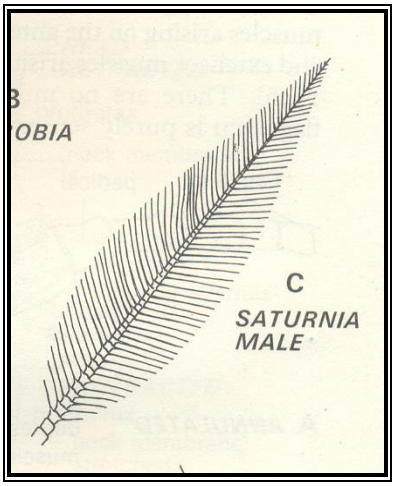


Fig: Bipectinate

7. CLAVATE: (Clubbed)

Antenna enlarges gradually towards the tip.

e.g. Blister beetle

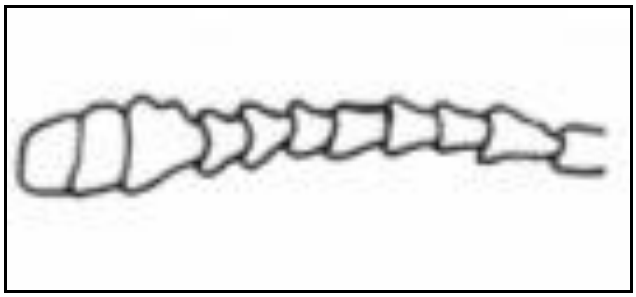


Fig: Clavate antenna

8. CAPITATE: (Knobbed)

Terminal segments become enlarged suddenl.

e.g. butterfly

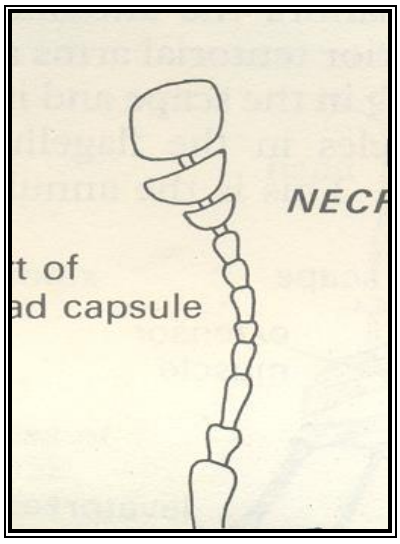


Fig: Clubbed antenna

9. LAMELLATE: (Plate like)

Antennal tip is expanded laterally on one side to form flat plates e.g. lamellicorn Beetle

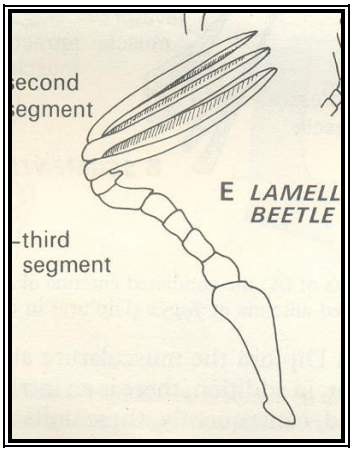


Fig: Lammelate antenna

10. ARISTATE:

The terminal segment is enlarged. It bears a conspicuous dorsal bristle called arista e.g. House fly

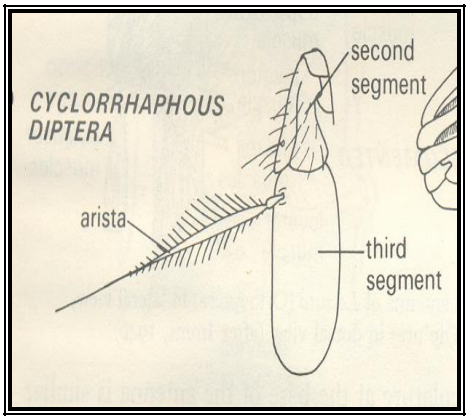


Fig: Aristate antenna

11. STYLA TE:

Terminal segment bears a style like procesfe.g. Horse fly, Robber fly.

12. PLUMOSE: (Feathery)

Segments with long whorls of hairs e.g. male mosquito

13. PILOSE: (Hairy)

Antenna is less feathery with few hairs at the junction of flagellomeres. e.g. Female mosquito.

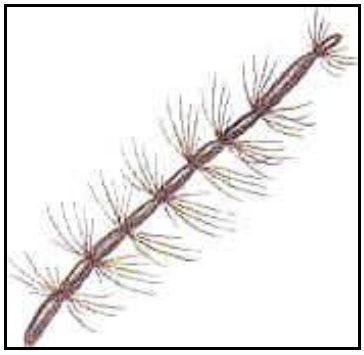


Fig: Pilose antenna

14. GENICULATE (Elbowed):

Scape is long remaining segments are small and are arranged at an angle to the first resembling an elbow joint. e.g. Ant, weevil and honey bee.

Fig: Geniculate antenna

Expt. No. 4:

STUDIES OF INSECT LEGS AND THEIR MODIFICATION

The legs are one of the most important thoracic appendages. They are associated with locomotion.

Structure of insect leg:

The insect leg consists of six segments:

- The basal *coxa* (pl. coxae)
- The small *trochanter*
- The large *femur* (pl. femora)
- The slender *tibia* (pl. tibiae)
- The segmented *tarsi* (sr. tarsus) and
- The terminal *pretarsus.*

The tarsal segments are only pseudo-segments called *tarsomeres* as they lack independent musculature. The pre-tarsus consists of *claws* and often either a single lobe-like *arolium* (pl.arolia) or the two pad-like *pulivilli* (sr. pulvillus) at the base of claws. The pulvilli may coexist with the arolium or a median bristle, the *empodium* (pl. empodia).

The Coxa:

It is the functional base of leg, often in the form of a truncated cone and articulated basally with the pleuron. There may single articulation with pleuron giving very much free movement. But frequently there is a second articulation with the trochantin which restrict the movement to some extend. In some higher forms there are rigid pleural and sternal articulations limiting movement of the coxa to swinging about these two points

The trochanter:

It is the second segment of leg with a dicondylic articulation with coxa because of which it can only move vertically. Usually trochantin is rigidly fixed with femur. In Odonata and Hymenoptera it is divided into two sub-segments. The second apparent trochanter derived from the base of the femur which is in fact a part of the femur.

The femur:

It is the largest and stoutest part of leg. Specially conspicuous in many jumping insects. It is more or less fixed with the trochanter and in this case there are no muscles to move it. Some times a single muscle arising in the trochanter is able to produce a slight backward movement or reduction of the femur.

The tibia:

The fourth division of leg. It is a long shank, often equal or exceeds the length of femur and articulated with femur by dicondylic articulation. It can move in vertical plane only. In some insects the basal part of it is bent. Near its distal extremity, it carries one or more tibial spurs.

The tarsus:

It is divided into sub-segments, typically 5 in number (max.). Sub-segments are called 'tarsomere'. No muscles in these sub-segments, movement of tarsus as whole is affected by the levator and depressor muscles arising from the apex of the tibia. Basal tarsomere is joined with the tibia by monocondylic articulation. The tarsomeres are connected with each other by flexible muscles.

The pre-tarsus:

Consists of a single claw like segment in primitive insects like Protura, Collembola and many holometabolous larva. Consists of a membranous base supporting a median lobe, the arolium. The arolium may be membranous or partly sclerotised and a pair of claws that articulate with the median process of the last tarsomere known as 'unguifer'.

Ventrally there is a basal sclerotised plate, the 'unguitractor'and between these and the claws are small plates called 'auxillae'. In Diptera, a membranous pulvillus arises from the base of each 'auxillae' while a median 'empodium' which is spine or lobe like arises from the 'unguitractor'. There is no 'arolium' other than the Tipulidae.

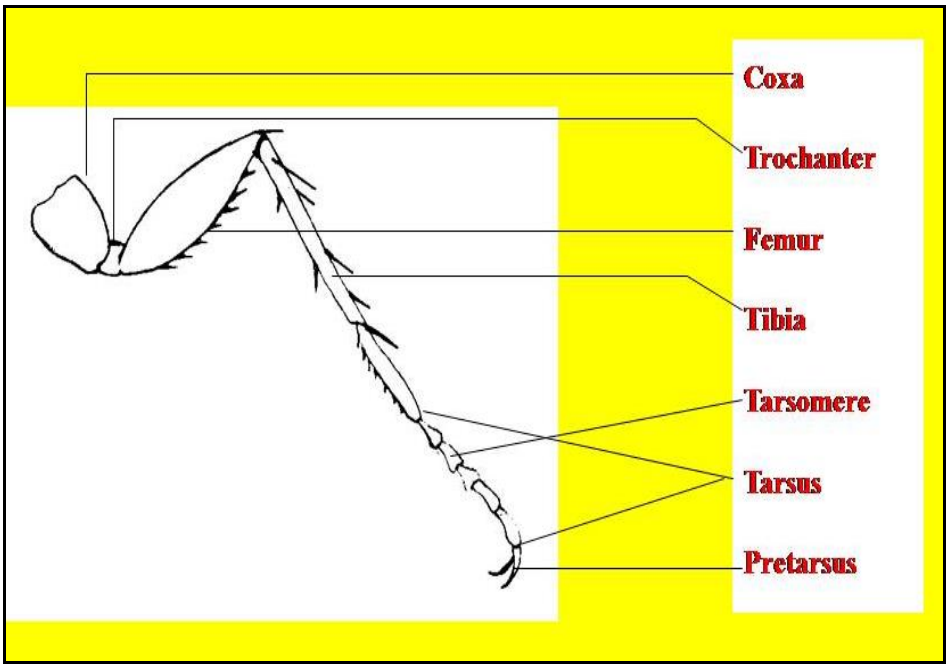


Fig: Structure of an insect leg.

Functional modification of insect leg:

The basic structure of leg may be modified to serve a number of diversified functions in different groups of insects.

1. Running or cursorial:

Very good runners, these insects have elongate, slimmer legs which permit longer strides with less friction.

e.g. cockroach.

2. Jumping or saltatorial:

These insects can hop (jump, leap, saltate, vault). Their enlarged hind femora accomodate powerful tibial levator muscles.

e.g. hind legs of grasshopper.

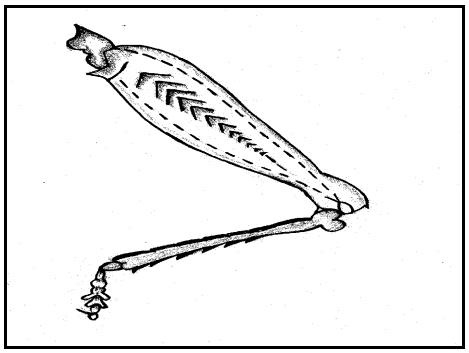


Fig: Jumping type of leg.

3. Walking or ambulatorial leg:

These legs are least specialized often adapted for walking.

e.g. the fore and middle legs of grasshopper.

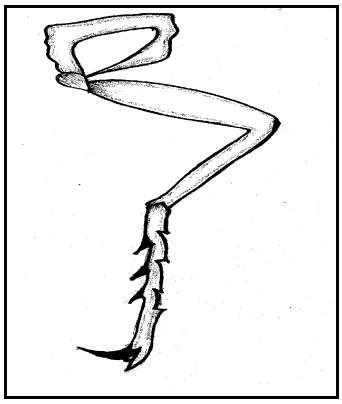


Fig: Ambulatorial leg.

4. Grasping or raptorial leg:

These predatory (hunting) insects hold or grasp their prey in between these legs. The coxa is elongate and outstretched while both the spiny, grooved femur and tibia work against each other grasping the prey in between. Often pincers are formed by the apposition of tibia on the femur.

e.g. the fore legs of preying mantids.

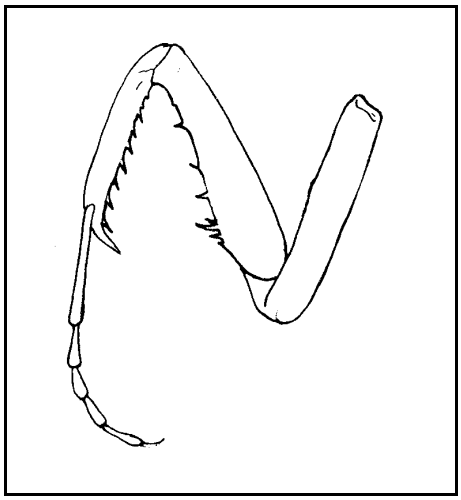


Fig: Grasping type of leg.

5. Digging or burrowing type of leg:

These subterranean (soil-inhabiting) insects burrow or rake through the soil to dislodge soil particles. In mole cricket the tibia is rake-like. In larval cicada the femur bears tooth-like projections.

e.g. the fore legs of mole cricket.

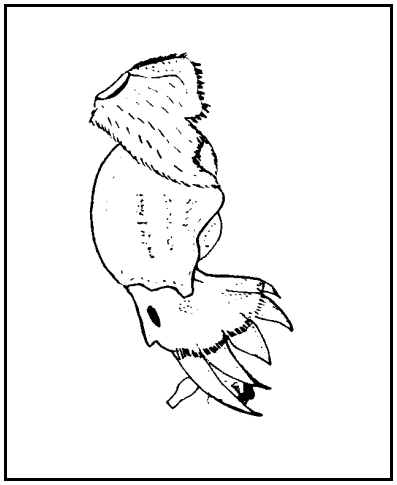


Fig: Grasping type of leg.

6. Natatorial of sweeming type of leg:

The segments are much flattened with rows of strong setae (hairs) adapted for rowing. Propulsion occurs on the back stroke (when the hairs are erect) and far less energy is expended in moving the legs forward on the recovery stroke (when the hairs collapse against leg and so reduce the resistance to movement). Modified for swimming purpose in aquatic insects.

e.g. hind legs of water beetles and water bugs.

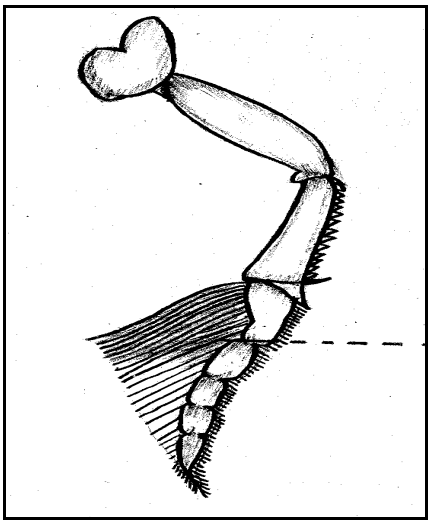


Fig: Natatorial type of leg.

7. Clinging type of leg:

Modified for clinging purpose. Tibia is stout, bearing at one end a thumb-like process with a distal spine.

e.g.Fore leg of head louse

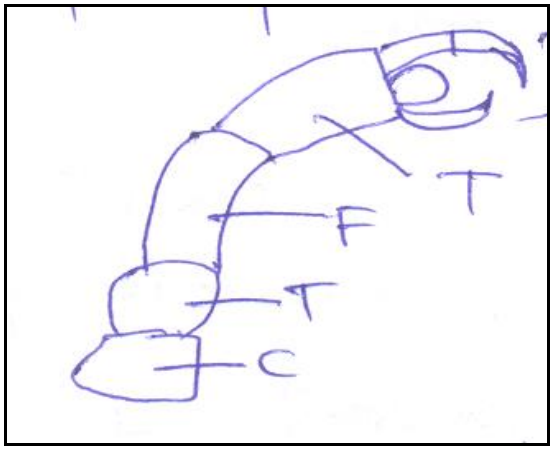


Fig: Clinging type of leg.

8. Pollen collecting or foragial type of leg:

The posterior tibia is more or less dilated and either bears a large pollen brush or 'scopa' or is margined with long hairs. Thus it modified into 'corbicula' or pollen busket. Basitarsus is flattened on its inner aspects and provided with several rows of short stiff spines which form a brush.

e.g. Hind leg of honey bee

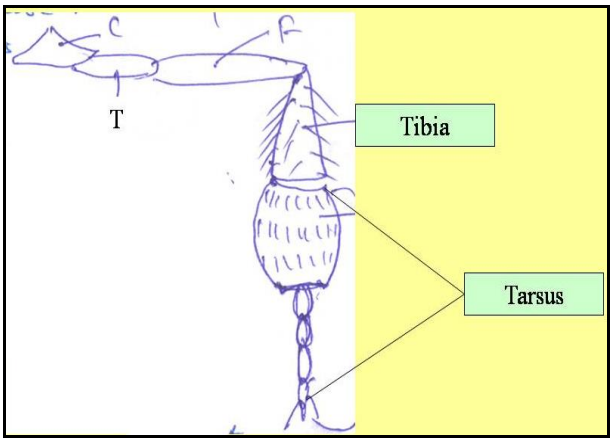


Fig: Foragial type of leg

9. Sticking type of leg:

Pad-like pulvilli present. Help in sticking purpose over the smooth surface like glass.

e.g. House fly

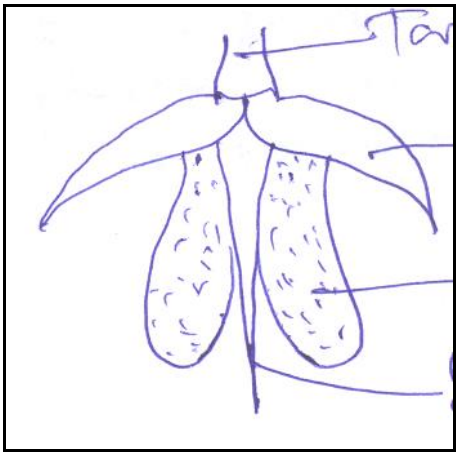


Fig: Sticking type of leg.

10. Grooming type of leg:

A basal notch in the meta-tarsus lined with spine like hairs. A flattened spur called the fibula extends down from the tip of the tibia in such that when the metatarsus is flexed against the tibia the fibula closes off the notch so as to form a complete ring. This ring is used to clear antenna.

e.g. Fore legs are modified in honey bee as toilet organ

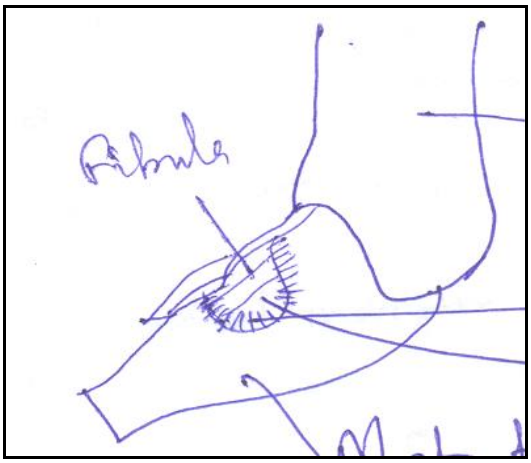


Fig: Grooming or toilet organ

Expt. No. 5:

STUDIES OF INSECT WINGS AND THEIR MODIFICATION

Wings are the most important locomotory organ of insect body. Mature wings are present in adult insect and mature wing is almost entirely a cuticular structure. The presence of two pairs of wings is a common feature. However some insects have only one pair of wings *e.g.* Diptera (flies). The primitive insects are wingless (*e.g.* silverfish). Some insects are secondarily wingless (*e.g.* headlouse).

In some insects the wings are present temporarily (*e.g.* ants, termites). The size, shape, texture, colour and venation of the wings vary widely. The wings are smallest in the parasitic Hymenoptera (wasps) and largest in moths and butterflies (*e.g.* wing expanse of the Atlas moth is 14").

Modifications of Insect WINGS:

1. Tegmina (singular - tegmen):

Wings are leathery or parchment like. They are protective in function and are not used for flight.

e.g. Forewings of cockroach and grasshopper

2. Elytra (singular - elytron):

The wing is heavily sclerotised venation is lost. Wing is tough and it is protective in function. It protects hind wings and abdomen. It is not used during flight but during flight they are kept at an angle allowing free movement of hind wings.

e.g. Fore wings of beetles and weevils

3. Hemelytra (singular - - Hemelytron):

The basal half of the wing is thick and leathery and distal half is membranous. They are not involved in flight and are protective in function.

e.g. Fore wing of heteropteran bugs

4. Haltare:

In true flies the hind wings are modified into small knobbed vibrating organs called haltere. Each haltare is a slender rod clubbed at the free end (capitellum) and enlarged at the base (scabellum).

On the basal part two large groups of sensory bodies forming the smaller hick's papillae and the large set of scapel plate. They act as balancing organs and provide the needed stability during flight.

e.g. true flies, mosquito, male scale insect.

5. Fringed wings:

Wings are usually reduced in size. Wing margins are fringed with long setae. These insects literally swim through the air.

e.g. Thrips.

6. Scally wings:

Wings of butterfly and moths are covered with small coloured scales. Scales are unicellular flattened outgrowth of body wall. Scales are inclined to the wing surface and overlap each other to form a complete covering. Scales are responsible for colour. They are important in smoothing the air flow over wings and body.

e.g. Butterflies and moths

7. Membranous wings:

They are thin, transparent wings and supported by a system of tubular veins. In many insects either forewings (true flies) or hind wings (grass hopper, cockroach, beetles and earwig) or both fore wings and hind wings are membranous. They are useful in flight.

e.g. wasp, bees, dragonfly and damselfly

Expt. No. 6:

STUDY OF CUTTING CHEWING TYPE OF MOUTHPARTS

It is the primitive and basic type of mouth parts. Mouth parts consist of the following parts.

i. Labrum: (Upper lip):

It is flap like, bi-lobed and attached to the clypeus by an articular membrane. It is movable, covering the mouth cavity from above. It helps to pull the food into the mouth. It holds the food in position so that mandibles can act on it. It forms the roof of the pre oral food cavity.

ii. Labrum - epipharynx:

Inner surface of the labrum is referred to as epipharynx. It is frequently membranous and continuous with the dorsal wall of pharnyx. It is an organ of taste.

iii.Mandibles:

There is a pair of mandibles. They are the first pair of jaws. They are also called as primary jaws or true jaws. Mandibles articulate with the cranium at two points. They are heavily sclerotised. They are toothed on their inner border. There are two types of teeth. Distal teeth are sharply pointed and are called incisor or cutting teeth and proximal teeth are called molar or grinding teeth. They act transversely to bite and grind the food into small fragments.

iv. Maxillae:

They are paired and more complicated than mandibles. They are called secondary jaws or accessory jaws, joins the maxilla to head. The second sclerite is called stipes which articulates with cardo. Stipes carries a lateral sclerite called palpifer which bears a five segmented antenna like maxillary palp. On the distal end of the stipes, there are two lobes. The outer lobe is called galea and inner lobe, lacinia which is toothed. Maxillae direct the food into the mouth. They hold the food in place when the mandibles are in action. They act as auxilIary jaws and assist in mastication of food. Sense organs connected with the perception of touch, smell and taste are abundantly found in palpi..

v. Hvpopharvnx :

It is a tongue like organ. It is located centrally in the pre-oral cavity. Salivary gland duct opens through it.

vi. Labium: (Lower lip):

It is a composite structure formed by the fusion of two primitive segmented appendages. It bounds the mouth cavity from below or behind. It forms the base of the pre-oral cavity. It consists of three median sclerites viz., submentum (large basal sclerite), mentum (middle

sclerite) and prementum (apical sclerite). On the lateral side of the prementum there are two small lateral sclerites called palpiger bearing three segmented labial palpi. Distally prementum bears two pairs of lobes. The other pair of lobes is called paraglossae and inner pair of lobes, glossae. Both pairs when fused are called ligula.

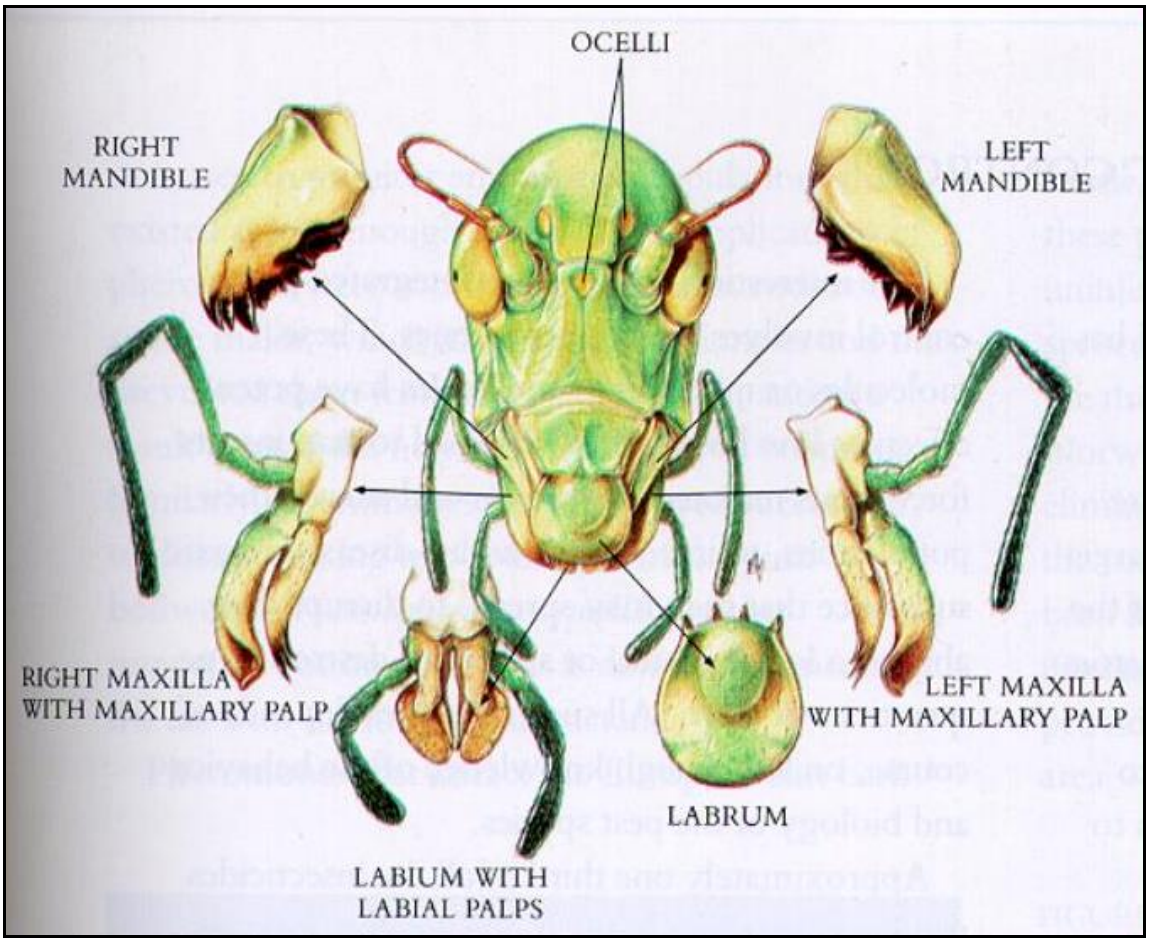


Fig: Cutting and chewing type mouthparts.

Expt. No. 7:

PIERCING AND SUCKING or HEMIPTEROUS or BUGTYPE MOUTHPARTS

Specimen supplied:

Labium projects downwards from the anterior part of the head like a beak. Beak is four segmented and grooved throughout its entire length.

At the base of the labium there is a triangular flap like structure called labrum. It functions as a protective covering for the four stylets (fascicle) found with in the groove. Both mandibles and maxillae are modified into long slender sclerotized hair like structure called stylets. They are lying close together and suited for piercing and sucking. The tips of the stylets may have minute teeth for piercing the plant tissue.

The inner maxillary stylets are doubly grooved on their inner faces. When these are closely opposed they form two canals viz., food canal and salivary canal through which plant sap and saliva are conducted respectively. Both palps are absent.

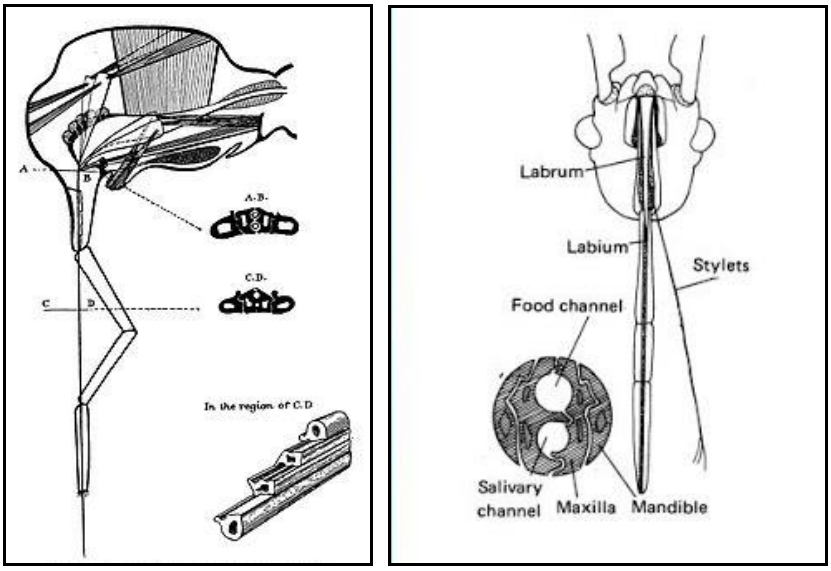


Fig: Piercing and sucking type of mouthparts.

Expt. No. 8:

CHEWING AND LAPPING TYPE

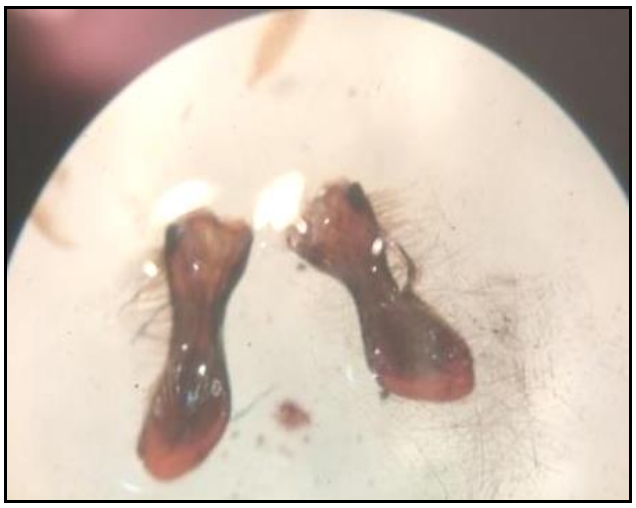
Specimen supplied: Honey bee

Labrum and mandibles are as in biting and chewing type of mouthparts. But mandibles are blunt and not toothed. They are useful to crush and shape wax for comb building; ingest pollen grains and other manipulative functions.

Maxillo-Iabial structures are modified to form the lapping tongue. The tongue unit consists of two galea of maxillae, two labial palpi and elongated flexible hairy glossa of labium.

The glossa terminates into a small circular spoon shaped lobe called spoon or bouton or flabellum, which is useful to lick the nectar.

Fig: Chewing lapping type of mouthparts.



Mandible

Maxillolabial complex

Expt. No. 9:

SPONGING TYPE

Specimen supplied: Butterfly/ Moth

The proboscis is fleshy, elbowed, retractile and projects downwards from head. The proboscis can be differentiated into basal rostrum and. distal haustellum. The proboscis consists of labium, which is grooved on its anterior surface. Within this groove lie the labrum-epipharynx (enclosing the food canal) and slender hypopharynx (containing the salivary canal).

Mandibles are absent. Maxillae are represented by single segmented maxillary palpi. The end of the proboscis is enlarged, sponge like and two lobed, which acts as, suction pads. They are called oral discs or labella. The surfaces of labella are transvered by capillary canals called pseudotracheae which collect the liquid food and convey it to the canal.

Labella function as sponging organs and are capable of taking exposed fluids. These insects often spit enzyme containing saliva onto solid foods to liquefy them.

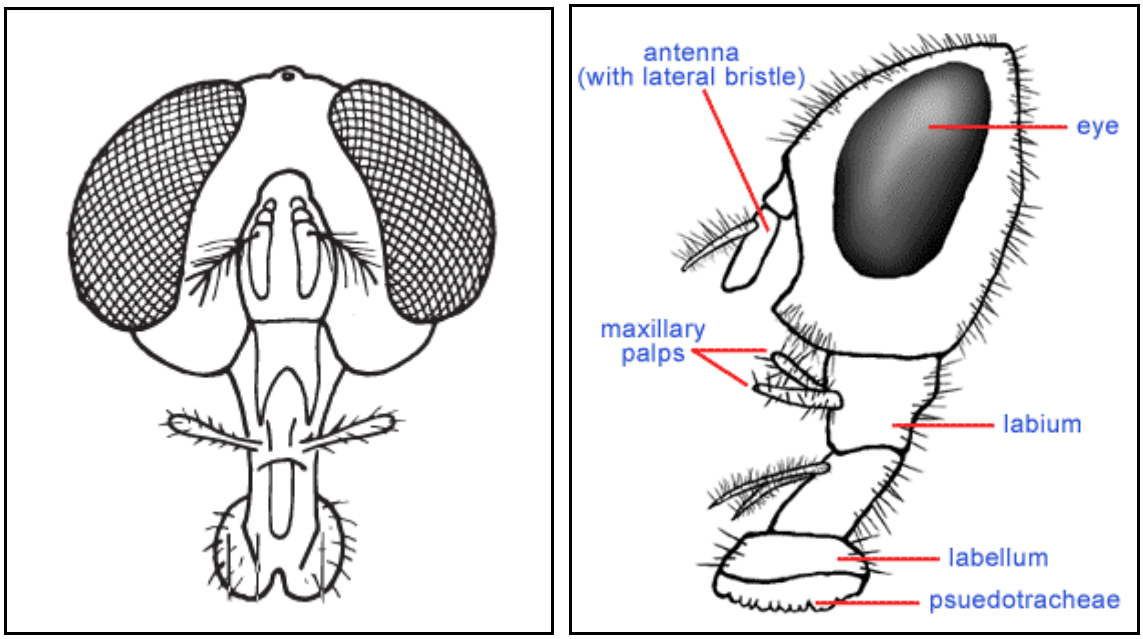


Fig: Sponging type of mouthparts.

Expt. No. 10:

SIPHONING TYPE

Specimen supplied: Butterfly/ Moths

Mouthparts consists of elongate sucking tube or proboscis. It is formed by two greatly elongated galeae of maxillae, which are zippered, together by interlocking spines and hooks. Galeae are grooved on their inner surface and when they are fitting together closely they form a suctorial food canal through which the nectar is sucked up.

The proboscis is coiled up like watch spring and kept beneath the head when it is not in use. By pumping of blood into galeae, the proboscis is extended.

The other mouth parts are reduced or absent except the labial palpi and smaller maxillary palpi.

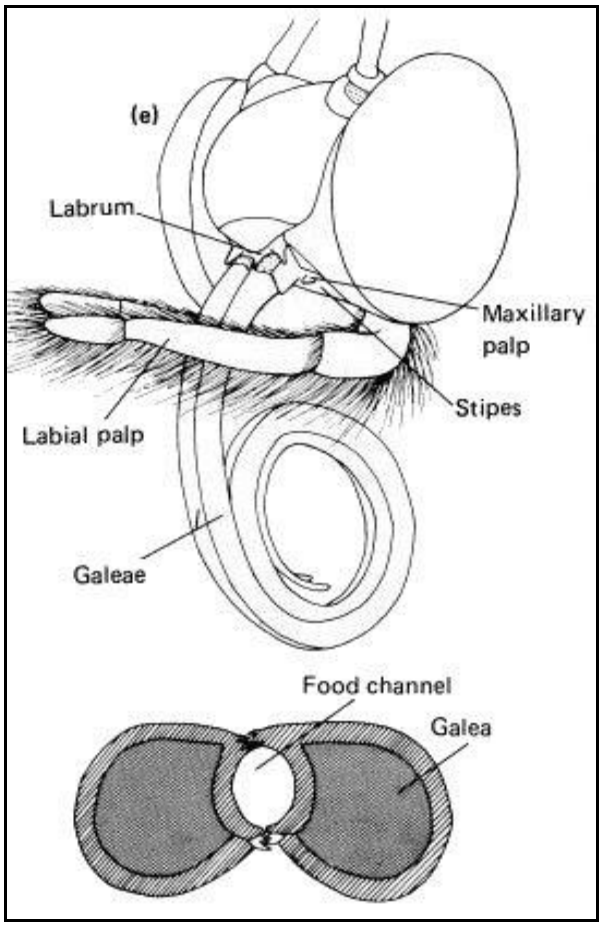


Fig: Siphoning type of mouthparts.

INSECT TAXONOMY

Expt-11.

STUDY OF INSECT ORDERS

Order- ORTHOPTERA:

Synonyms: Saltatoria, Saltatoptera

Etymology: Ortho - straight; ptera-wings

Common examples: Grasshoppers, Locust, Katydid, Cricket, Mole cricket

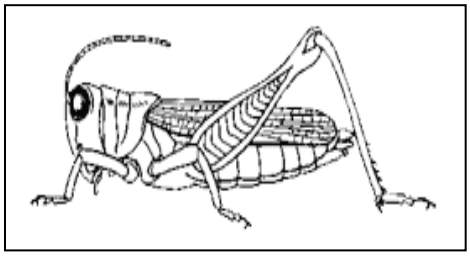
- They are medium to large sized insects.
- Antenna is filiform.
- Mouthparts are mandibulate.
- Prothorax is large, pronotum is curved, ventrally covering the pleural region.
- Hind legs are saltatorial.
- Forewings are leathery, thickened and known as tegmina. They are capable of bending without breaking.
- Hind wings are membranous with large anal area. They are folded by longitudinal pleats between veins and kept beneath the tegmina.
- Cerci are short and unsegmented.
- Ovipositor is well developed in female.
- Metamorphosis is gradual. In many Orthopterans the newly hatched first instar nymphs are covered by loose cuticle and are called pronymphs.
- Specialized stridulatory (sound-producing) and auditory (hearing) organs are present.

Classification

This order is sub divided into two suborders, viz., Caelifera and Ensifera.

I. Sub order: Caelifera

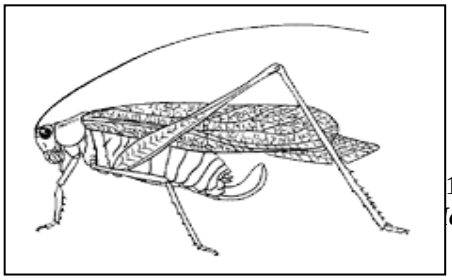
1. Acrididae: (Locusts, Grasshoppers)



- Antenna is short
- Tarsus is three segmented
- Ovipositor is short and horny
- Tympanum is located one on either side of the first abdominal segment.
- Sound is produced by femoro-alary mechanism. A row of peg like projections found on the inner side of each hind femur is rubbed against the hard radial vein of the closed tegmen.
- Locusts are a serious threat to tropical agriculture. They swarm under favourable conditions and mainly feed on grasses, cereals etc.

II. Sub order: Ensifera

1. Tettigonidae: (Katydids, Long horned grasshppers):

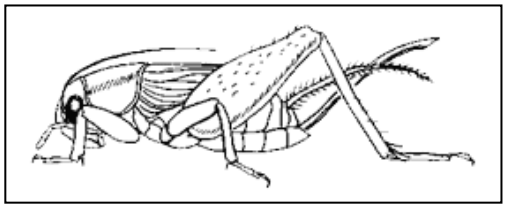


- Antenna is long, slender as long as

or longer than the body.

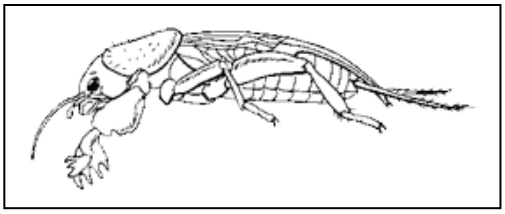
- Tarsus is four segmented.
- Ovipositor is sword like.
- Auditory organs are found in fore tibiae.
  In each fore tibia a pair of tympanum is present.
- The outer tympanum is larger than the inner.
- Sound production is alary type.
  A thick region on the hind margin of the forewing (scraper) is rubbed against a row of teeth on the stridulatory vein (file) present on the ventral side of another fore wing which throws the resonant area on the wing (mirrors) into vibrations to produce sound.

2. Gryllidae (Cricket):



- Antenna is long, tarsus is four segmented.
- Ovipositor is slender and needle like.
- Forewings are abruptly bent down to cover the sides of the body
- Hind wings are acuminate.
  They are produced into a pair of long processes which project beyond the abdomen.
- Cerci are long and unsegmented.
- Auditory organs and stridulatory organs are similar to long horned grasshopper. Males stridulate during night. They produce a shrill chirping noise. *Gryllus sp.* - household pest.

3. Gryllotalpidae: (Mole crickets):



- They are brown coloured insects found inside the burrows.
  Eyes are reduced.
- Pronotum is elongate, ovate and rounded posteriorly.
- Forelegs are fossorial.
  Tibiae are expanded and digitate.
- Hind wings are extended beyond the tegmina as a pair of processes
- Special stridulatory structure is absent. A humming sound is produced by rubbing the forewings.
- A pair of tympanum is found on the outer surface of the tibiae.
- Ovipositors vestigial.
- Mole crickets burrow into the soil and feed on tender roots of growing plants. *Gryllotalpa africana* is a pest on stored potatoes.

Order: HEMIPTERA:

Synonym: Rhynchota

Etymology: Hemi - half; ptera - wing

Taxonomic features:

- Head is opisthognathous.
- Mouthparts are piercing and sucking type. Two pairs of bristle like stylets which are the modified mandibles and maxillae are present. Stylets rest in the grooved labium or rostrum.
- Both labial palps and maxillary palps are atrophied.
- Mesothorax is represented dorsally by scutellum.
- Forewings are either uniformly thickened throughout or basally coriaceous and distally membranous.
- Cerci are always absent.
- Metamorphosis usually gradual; rarely complete. Alimentary canal is suitably modified to handle liquid food. (filter chamber)
- Salivary glands are universally present, extra-oral digestion is apparently wide spread.
- Abdominal ganglia fused with thoracic ganglia.

Classification: There are two suborders viz., Heteroptera and Homoptera.

Heteroptera (Hetero-different; ptera-wing):

- Head is erect or horizontal
- Bases of the forelegs do not touch the head
- Beak arise from the anterior part of the head
- Gular region of the head (mid ventral sclerotised part between labium and foramen magnum) well defined.
- Pronotum usually greatly enlarged.
- Scutellum (triangular plate found between the wing bases) well developed
- Forewings heavily sclerotized at the base and the apical half is membranous (Hemelytra)
- Wings are held flat over the back at rest and the left and right side overlap on the abdomen.
- Honey dew secretion uncommon
- Repugnatorial or odoriferous or scent glands present.
- Both terrestrial and aquatic
- Herbivorous, predaceous or blood sucking.

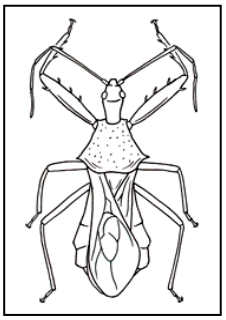
Homoptera (Homo-uniform; ptera-wing):

- Head is deflexed
- Bases of the forelegs touch the head
- Beak arises from the posterior part of the head
- Gular region not clearly defined

- Pronotum is almost always small and collar-like.
- Scutellum not well developed.
- Forewings are of uniform texture. They are frequently harder than hind pair.
- Wings are held roof-like over the back and wings do not over lap.
- Honey dew secretion common
- Wax glands usually present.
- Terrestrial.
- Herbivorous.

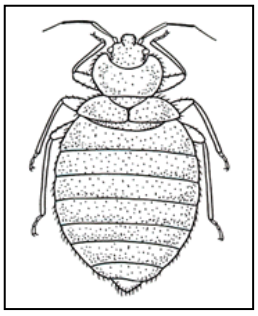
IMPORTANT FAMILIES OF HETEROPTERA

1. REDUVIIDAE: (Assassin bugs, Kissing bugs or (Cone nose bugs)



- Head is narrow and elongate, constricted behind the eye forming a neck. Beak is short, three segmented and fits into a groove in the pro-sternum. Abdomen is widened in the middle. Lateral margins of the abdominal segments are exposed beyond the wing.
- Many are predaceous on other insects. *Platymeris leavicolis* is a predator on coconut rhinoceros beetle. *Triatoma* sp., *Rhodnius prolixus* are the vectors of chagas disease caused by *Trypanasomatid* which causes human trypanasomiasis.

2. CIMICIDAE: (Bed bugs)



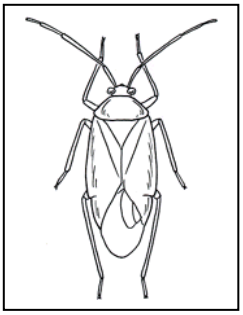
- Body is dorsoventral1y flattened so that they can hide in cracks and crevices. Body is oval in outline. It is dull reddish brown in colour. Stink glands are located in the dorsal surface of first three abdominal segments.
- Male bed bugs pierce the integument of the female and inject the sperm into the haemocoel during copulation (Haemocoelic or traumatic insemination).
- Beg bugs hide in crevices of beds, furniture, etc., during the day and emerge at night to seek a blood meal. They are blood sucking ectoparasites on birds and mammals. They are known for their irritating bite. *Cimex lectularis*, *Cimex hemipterus* are two important species affecting man in temperate and tropical conditions, respectively.

3. TINGIDAE : (Lacewing bugs)

- Pronotum has lateral expansions with lace like sculpturing. Scutellum is concealed by pronoturn.
- Forewings have elaborate lace like markings due to densely reticulate, raised wing venation.

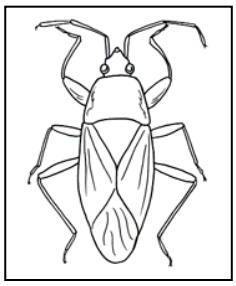
- Nymphs differ considerably from adults. They are usually spiny and lack lace like markings.
- Both nymphs and adults are found on the undersurface of the leaves in groups, suck the sap and produce white spotted appearance on the leaf.
- They secrete honey dew eg. Banana lace wing bug

4. MIRIDAE: (Plant bugs fir Leaf bugs)



- Beak and antennae are four segmented.
- Hemelytra with distinct corium, clavus and cuneus (a trianguiar apical piece of the basal part of forewing) Forewings are tilted downwards.
- Nymphs and adults feed on plant juice and some species cause phytotoxemia due to the injection of toxic saliva. A few are also predaceous. e.g. Tea mosquito bug *Helopeltis atonii causes* cankerous wart like growth on guava fruits.

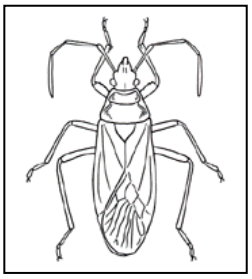
5. LYGAEIDAE: (Seed bugs or Chinch bugs)



- Cuneus is absent in hemelytra.
- Membrane has a few irregular veins (4-5 veins)

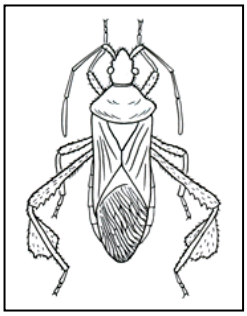
  arising from a transverse basal vein. e.g. Dusky cotton bug *Oxycarenus hyalinipennis* nymphs and adults suck the sap from seeds of injured or already opened bolls and reduce the seed quality.

6. PYRRHOCORIDAE: (Red bugs or Stainers)



- They are elongate oval bugs.
  They show warning colouration.
  They are brightly marked with red and black.
  Membrane is with more branched veins and cells.
  e.g. Cotton stainer *Dysdercus cingulatus.*
  Feeding injury caused by these bugs leads to the contamination by the fungus *Nematospora* resulting in yellowish brown discolouration of the lint.

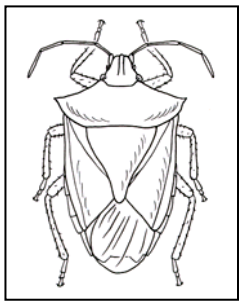
7. COREIDAE: (Squash bugs or leaf footed bugs)



- Membrane with many branching veins arise from a transverse basal vein.
- Stink glands are found inside the metathorax and glands openings are found on the sides of the thorax between middle and hind coxae. They emit a bad odour.
- Hind tibia and tarsi are expanded and leaf like.
- The edge of the abdomen is raised and wings lie in a

distinct depression. e.g. Pod bug, *Riptortus pedestris* nymphs and adults suck the sap from pods of pulses.

8. PENTATOMIDAE: (Stink bugs or Shield bugs)



- Antenna is five segmented. Scutellum is prominent and shield-like
- Adults and nymphs produce a disagreeable odour from stink glands located in metathorax and abdomen respectively. Some are phytophagous and some are predaceous e.g. Green stink bug *Nezara viridula* is a pest on millets.

IMPORTANT FAMILIES OF HOMOPTERA

1. MEMBRACIDAE: (Tree hoppers or Cowbugs)

- They are structurally modified to resemble thorns or other plant parts.
- Pronotum is large and it covers the head extended backward over the abdomen.
- Wings are concealed by pronotum
- Pronotal process is either partially developed or absent in nymphs.
- Nymphs and adults suck tree sap and are commonly attended by ants for honey dew.

2. CICADELLIDAE: (Leaf hoppers or Jassids)

- Elongate insects with a wedge shaped body. Attractively coloured.
- Hind tibiae have a double row of spines.
- Ovipositor is well suited for lacerating the plant tissue.
- Nymphs and adults have the habit of running sidewise.
- They suck the plant sap and transmit diseases. e.g. Green leaf hopper *Nephotettix virescens* transmits tungro disease in rice.

3. CERCOPIDAE: (Spittle bug or Cuckoo-spit or Frog hopper)

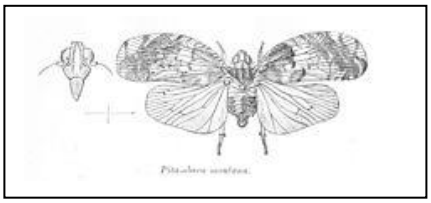
- Adults resemble tiny frogs. Nymphs are soft, whitish and live inside the froth.
- Froth comes from liquid freed from alimentary canal and from a mucilagenous substance created from the epidermal glands.
- These are beaten into froth by means of the caudal appendages of the insect. Spittle serves both as a protective device and a means of reducing evaporation.

4. DELPHACIDAE: (Plant hoppers)

- Small wedge shaped insect with large mobile flattened spur at the apex of hind tibia e.g. Brown plant hopper

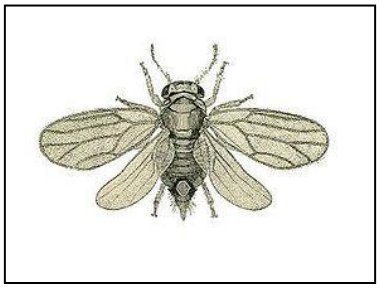
Nilaparvata lugens causes hopper burn and transmits viral diseases viz., grassy stunt and ragged stunt diseases in rice.

5. LOPHOPIDAE:



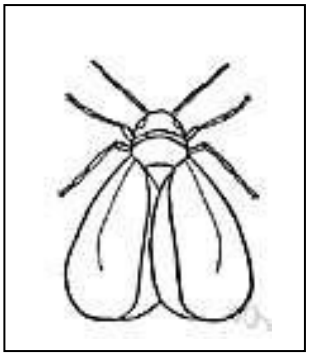
- Head is produced into a snout.
- Hind trochanter is directed backward
- Hind basitarsus is moderately long. e.g. Sugarcane leaf hopper *Pyrilla perpusilla* nymphs and adults suck the sap and reduce the quality and quantity of cane juice.

6. PSYLLIDAE: (Jumping plant lice)



- Small active insect, they resemble minute cicadas and move actively by leaping and f1ying.
- Hind leg is more muscular and suited for jumping.
- There is a prominent basal vein in the forewing formed by the fusion of radius, median and cubitus. Nymphs are sluggish. e.g. Subabul psyllid, *Heteropsylla cubana* is a serious pest on subabul.

7. ALEYRODIDAE: (Whiteflies)



- Minute insects which superficially resemble tiny moths.
- Wings are opaque and dusted with mealy white powdery wax. Wing venation is much reduced.
- Vasiform orifice is present in the last abdominal tergite. It is a conspicuous opening provided with an operculum. Beneath the operculum there is a tongue-like organ termed lingula. The anus opens at the base of the lingula through which honey dew is excreted in large amount.
- Immature instars are sessile, scale like, with waxy covering.
- Metamorphosis approaches the homometabolous type due to the presence of a quiescent stage prior to the emergence of adults. e.g. Cotton whitefly *Bemisia tabaci* transmits vein clearing disease in bhendi.

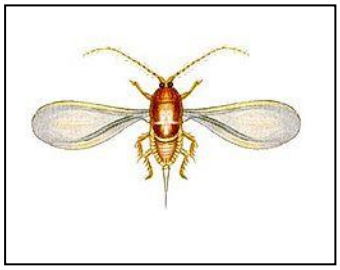
8. APHIDIDAE: (Aphids or Plant lice or Greenflies)

- Body is pear shaped
- Both apterous and alate forms are found.
- A pair of cornicles or siphunculi or wax tubes is present in the dorsum of fifth or sixth.
- Abdominal segments which secretes wax like substance.
- They excrete copious amount of honey dew on which an feed and sooty mould fungus grows.
- Aphids are known for their extraordinary fecundity, short life cycle and parthenogenetic reproduction. Life cycle is highly complex and it involves alternation of generation.

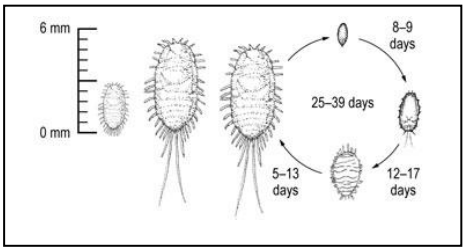
- They feed on plant sap and disseminate plant diseases.

9. COCCIDAE: (Scale insects, Soft scales, Wax scales)

- Sexual dimorphism is present.
- Male: They are gnat like, with long antennae, lateral eye and vestigial mouth parts.
- Mesothorax is enlarged bearing one pair of wings with one or two veins. Hind wings are reduced to haltares. A quiescent stage is present in the life history.
- Female: Body segmentation is indistinct. Body wall naked and covered with a waxy coating.
- They are wingless, legless and suck the plant sap.
- The first instar nymph is active and is known as crawler which moults and becomes legless. e.g. Coffee green scale *Coccus viridis.*



10. DIASPIDIDAE: (Armoured scale)
    - Adult female lacks antennae, legs, and wings.
    - The body is covered by a hard, waxy, shell like substance e.g. Coconut scale *Aspidiotus destructor.*
11. PSEUDOCOCCIDAE: (Mealy bugs)
    - Body is elongate oval in shape.
    - Body segmentation is distinct.
    - Body is covered by long radiating thread of mealy secretions.
    - Functional legs are present in all instars. Wings are absent. e.g. Coconut mealy bug, *Pseudococcus longispinus.* Nymphs and adults suck sap and affect the growth of spindle leaf.



Expt – 12

Studies on the Order DIPTERA:

Etymology: Di-two; ptera-wing
Common names: True flies, Mosquitoes, Gnats, Midges,
Taxonomic features:

- They are small to medium sized, soft bodied insects.
- The body regions are distinct.
- Head is often hemispherical and attached to the thorax by a slender neck.
- Mouthparts are of sucking type, but may be modified.
- All thoracic segments are fused together. The thoracic mass is largely made up of mesothorax. A small lobe of the mesonotum (scutellum) overhangs the base of the abdomen.
- They have a single pair of wings.
- Forewings are larger, membranous and used for flight.
- Hind wings are highly reduced, knobbed at the end and are called halteres. They are rapidly vibrated during flight. They function as organs of equilibrium. Flies are the swiftest among all insects.
- Metamorphosis is complete. Larvae of more common forms are known as maggots.
- They are apodous and acephalous. Mouthparts are represented as mouth hooks which are attached to internal sclerites. Pupa is generally with free appendages, often enclosed in the hardened last larval skin called puparium. Pupa belongs to the coarctate type.

Classification

This order is sub divided in to three suborders.
I. NEMATOCERA (Thread-horn)

- Antenna is long and many segmented in adult.
- Larval head is well developed.
- Larval mandibles act horizontally.
- Pupa is weakly obtect.
- Adult emergence is through a straight split in the thoracic region.

II. BRACHYCERA (Short-horn)

- Antenna is short and few segmented in adult.
- Larval head is retractile into the thorax
- Larval mandibles act vertically
- Pupa is exarate.
- Adult emergence is through a straight split in the thoracic region.

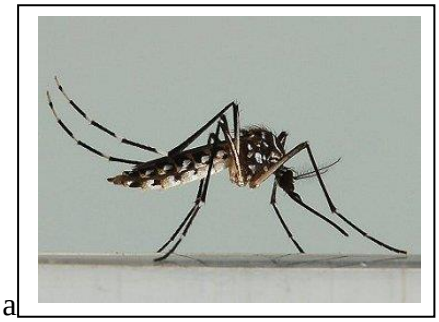
III. CYCLORRHAPHA: (Circular-crack)

- Antenna is aristate in adult.
- Larval head is vestigial with mouth hooks.
- Larva] mouth hooks act vertically.
- Pupa is coarctate.

- The coarctate pupa has a circular line of weakness along which the pupal case splits during the emergence of adult. The split results due to the pressure applied by an eversible bladder **ptilinum** in the head.

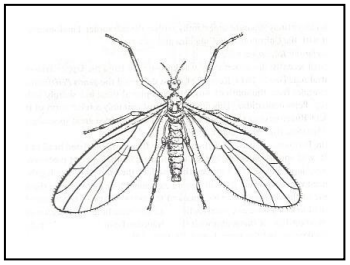
Sub order: NEMATOCERA

1. CULICIDAE:(Mosquitoes)



- They are delicate, fragile, slender insects.
- Females have piercing and sucking type of mouthparts with six stylets.
- Antenna is plumose (bushy) in male and pilose (less hairy) in female.
- Legs are slender, delicate and long.
- Wings are fringed with hairs and scales on hind margin a on some veins.
- Males are short lived and feed on nectar or decaying fruits.
- Females live long and are blood feeders.
- Larvae are called wrigglers. Larval head is large with chewing mouthparts and mouth brush aiding in filter feeding. Thorax is large without legs. Respiratory siphon is located in the penultimate abdominal segment. Anal gills are present at the terminal end of the abdomen.
- Pupa is known as tumbler. It is very active. It has a pair of prothoracic horns which houses the anterior pair of spiracles. A pair of anal paddles is present at the terminal end aids in swimming. Malarial mosquito: *Anopheles sp* transmits malaria, Filarial mosquito: *Culexsp* transmits filariasis.

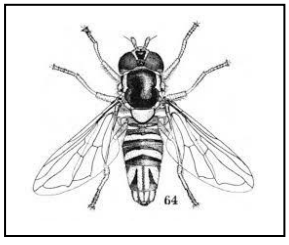
2. CECIDOMYIIDAE: (Gall midges)



- They are minute delicate, mosquito like flies. Antennae and legs are long.
- Wing venation is reduced. Wings are covered with long hairs.
- A dark sclerotized area is present mid-ventrally on the prothorax in the larva called 'chest bone'. e.g. Rice gall midge: *Orseolia oryzae* maggot feeding produces galls.

Sub order: CYCLORRHAPHA

3. SYRPHIDAE: (Hover flies, Flower flies)



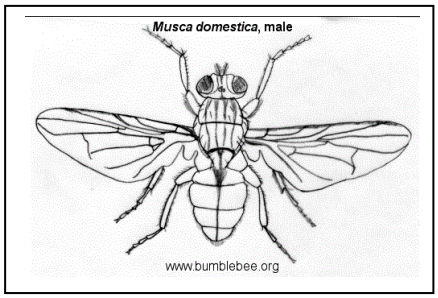
- They are brightly coloured and brilliantly striped. Abdomen has distinct black and yellow markings. Maggots prey on soft bodied insects especially aphids.
- Adults are excellent flies. They hover over flowers. They feed on pollen and nectar. They aid in pollination.

4. TEPHRITIDAE: (Fruit flies)
   - Wings are spotted or banded.
   - Female has a sharp and projecting ovipositor.
   - Maggots can hop. They are highly destructive to fruits and vegetables.
     e.g. Curcurbit fruit fly: *Dacus cucurbitae*

5. TACHINIDAE: (Tachinid flies)

   - Arista is completely bare
   - Abdomen is stout with several noticeable bristles.
   - They are non specific endoparasites on the larvae and pupae of Orthoptera, Hemiptera, Lepidoptera and Coleoptera.

6. MUSCIDAE: (House fly)



   - Antennal arista is plumose.
   - Mouthparts are sponging type.
     Labium is distally modified into a pair of oval shaped fleshy lobes called labella.
   - Pre-tarsus consists of two claws and two adhesive pads.
   - First abdominal segment is yellow in colour.
     Terminal abdominal segments are telescopic forming a not bristly on basal part,
   - Maggots are scavengers. Adults carry certain disease causing microbes on its legs, body hairs and mouthparts. Common house fly: *Musca domestica*

Studies on the Order HYMENOPTERA

Etymology: Hymen-membrane; ptera-wings.
Hymeno - god of marriage; ptera - wings,
(Marriage on the wings; union of fore and hind wings by hamuli)
Examples: Ichneumon flies, Ants, Bees, Wasps.

Taxonomic features:

- Mouthparts are primarily adapted for chewing.
- Mandibles are very well developed. In bees both labium and maxillae are integrated to form the lapping tongue.
- Thorax is modified for efficient flight. Pronotum is collar like. Mesothorax is enlarged.
- Metathorax is small. Both prothorax and metathorax are fused with meso thorax.
- Wings are stiff and membranous. Forewings are larger than hindwings. Wing venation is reduced. Both forwings and hindwings are coupled by a row of hooklets (hamuli) present on the leading edge of the hindwing.
- Abdomen is basally constricted. The first abdominal segment is called propodeum. It is fused with metathorax.

- The first pair of abdominal spiracles is located in the propodeum. The second segment is known as pedicel which connects the thorax and abdomen. Abdomen beyond the pedicel is called gaster or metasoma.
- Ovipositor is always present in females. It is variously modified for oviposition or stinging or sawing or piercing plant tissue.
- Metamorphosis is complete. Often the grub is apodous and eucephalous. Larva is rarely eruciform. Pupa is exarate and frequently enclosed in a silken cocoon secreted from labial glands.
- Sex is determined by the fertilization of the eggs. Fertilized eggs develop into females and males are produced from unfertilized eggs. Males are haploid and females are diploid.

This order is subdivided into two suborders:

a. SYMPHYTA and b. APOCRITA

Sub-order SYMPHYTA:

- Abdomen is broadly joined to the thorax.
- Larva is a caterpillar and belongs to eruciform type
- Stemmata are present
- Both thoracic and abdominal legs are present
- Ovipositor is saw like and suited for piercing the plant tissue

Sub-order APOCRITA:

- Abdomen is petiolated.
- Larva is a grub and it belongs to apodous eucephalous type.
- Stemmata are absent.
- Legs are absent.
- Ovipositor is not saw like and is suited for piercing in parasitic groups or for stinging in other groups.

I. Suborder: SYMPHYTA:

1. TENTHREDINIDAE: (Sawflies)
    - They are wasp like insects.
    - Abdomen is broadly joined to the thorax.
    - Ovipositor is saw-toothed and suited for slicing the plant tissue.
    - Larvae are eruciform. It resembles a lepidopteran caterpiller. It has one pair of ocelli and 6-8 pairs of abdominal legs.
    - Prolegs lack crochets. They are external feeders on foliage. Larvae while feeding usually have posterior part of the body coiled over the edge of the leaf. e.g. Mustard sawfly, *Athalia lugens proxima* is a defoliator of mustard and cruciferous vegetables.

II. Suborder: APOCRITA

1. VESPIDAE: (Yellow jackets, Hornets)
   - Lateral extensions of the pronotum reach the point of insertion of wings and do not form rounded lobes. Abdomen is conical.
   - They construct nest with 'wasp paper', a substance made from fragments of chewed wood mixed with saliva.
   - They are either solitary or social wasps. They are generally predaceous on Lepidopteran caterpillars. Many paralysed caterpillars are stored in the cells of their nests. Yellow banded wasp *Vespa cincta* is a bee enemy.

2. SPHECIDAE: (Thread waisted wasp, Digger wasp, mud dauber)

   - Petiole is slender. Nests are constructed by using mud or dug out in ground.
   - They use insects and spiders to provision their nests. Eggs are laid on the paralysed or killed host.

3. FORMICIDAE: (Ants)

   - They are common widespread insects. Antennae are geniculate.
   - Mandibles are well developed. Wings are present only in sexually mature forms.
   - Petiole may have one or two spines.
   - They are social insects with three castes viz., queen, males and workers.
   - Many species have established symbiotic relationship with homopteran insects. e.g. *Ammophila* sp.

4. APIDAE: (Honey bees)

   - Body is covered with branching or plumose hairs.
   - Mouthparts are chewing and lapping type. Mandibles are suited for crushing and shaping wax for building combs.
   - Legs are specialized for pollen collection. Scopa (pollen basket) is present on hind tibia.
   - They are social insects with three castes viz., queen, Drone and workers. Temporal separation of duties is noticed among workers. e.g. Indian honey bee *Apis indica* is a productive insect.

Expt - 13

Studies on the Order COLEOPTERA

Synonym: Elytroptera

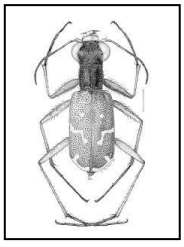
Etymology: Coleo –Sheath; ptera-wing
Examples: Beetles, Weevils
Taxonomic features:

- They are minute to large sized insects. Antenna is usually 11 segmented.
- Mouthparts are chewing type. Mandibles are short with blunt teeth at the mesal face in phytophagous group. In predators the mandibles are long, sharply pointed with blade like inner ridge. In pollen feeders teeth are absent and the mandibles are covered with stiff hairs.
- Prothorax is large, distinct and mobile. Mesothorax and metathorax are fused with the first abdominal segment.
- Forewings are heavily sclerotized, veinless and hardened. They are called elytra. Forewings do not overlap and meet mid-dorsally to form a mid-dorsal line. It is not used for flight. They serve as a pair of convex shields to cover the hind wings and delicate tergites of abdomen.
- Hind wings are membranous with few veins and are useful in flight. At rest they are folded transversely and kept beneath the elytra. In some, weevils and ground beetles the forewings are fused and hind wings are atrophied.
- A small part of the mesothorax known as scutellum remains exposed as a little triangle between the bases of elytra.
- Cerci and a distinct ovipositor are absent. Metamorphosis is complete. Larva is often called grubs. Pupae are usually exarate and rarely found in cocoons.
- It is the largest order that includes predators, scavengers and many crop pests. They also damage stored products.

Classification: This order is divided into two sub-borders, viz.,
Adephaga (devourers) and
Polyphaga (eaters of many things)

FAMILIES OF PREDATORS

1. CICINDELIDAE: (Tiger beetles)



- Head is usually wider than prathorax.
  Eyes are fairly larger and they have very keen vision.
- Legs are long and tarsi slender which enable to run fast.
- Elytra have spots and stripes.
- Larva excavates vertical pits for prey capture.
- Both grubs and adults are active predators.

2. CARABIDAE: (Ground beetles)

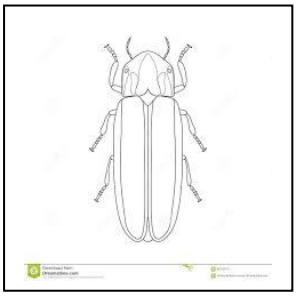
- Adults are often black in colour and some are brightly spotted.
- Some cannot fly because they have fused elytra and atrophied hind wings.
- Legs are suited for running. They are nocturnal. Ground beetles are voracious predators both as adults and larvae. They feed on soft bodied caterpillars and other insects. Six spotted carabid *Anthia sexguttata*

3. DYTISCIDAE: (True water beetles, Predaceous diving beetles)

- Body is long, oval, smooth and shiny.
- Head, thorax and abdomen are compactly joined. Antenna is filiform.
- In some male beetles the fore tarsi are provided with cup like suckers which are useful in clasping the mate. Hind legs are flattened, fringed with hairs and suited for swimming. Air is stored beneath the elytra.
- Adults and larvae are aquatic predator.

4. COCCINELLIDAE: (lady bird beetles)

- They are hemispherical. The body is convex above and flat below. Their body appearance resembles a split pea.
- Head is small, turned downward and received into a prominent notch of prothorax.
- Elytra is strongly convex, brightly coloured and variously spotted.
- Grubs are compodeiform and spiny.
- Except the genus *Epilachna*, others are predators on aphids, scales, mites and whiteflies.

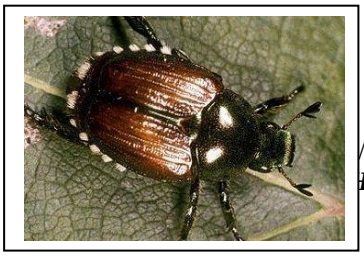


6. LAMPYRIDAE: (Fireflies, Glow worms)

- They show sexual dimorphism.
- Photogenic organ is found in sixth and seventh abdominal segments.
- Larvae are with sickle like mandibles. They are carnivorous and feed on snails.
- Extra intestinal digestion is common in larvae.
- All life stages are luminous to varying degree. The luminescence is produced by the oxidation of a substance luciferin in the presence of an enzyme luciferase. The function of luminescence is to bring the sexes together.

FAMILIES OF SCAVENGERS:

1. Scarabaeidae: (Scarabs, Dung beetles)



- Middle legs are widely separated.

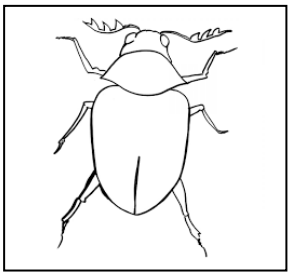
- Adults and larvae are scavengers.
  They feed upon the droppings of animals and human excreta. They role on the dung into balls and bury them in underground chambers.
- They use their head and forelegs for handling dung and digging pits in the soil. Head is used as an excavator and fore-tibia as shovel. They show remarkable parental care.
  Common Indian dung beetle: *Heliocopris bucephalus*

2. Hydrophilidae: (Water scavenger beetles)

- They are black or dull coloured.
- Body is convex above and flattened below.
  Maxillary palps are long and look like antennae
- Middle legs are flattened and suited for swimming.
- Metasternum is produced into a spine posteriorly.
  Air is stored beneath the elytra and over the undersurface of the body.
- Adults and larvae feed on decomposing vegetable matter.

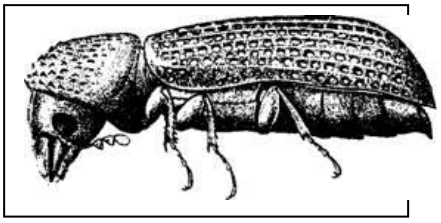
FAMILIES OF STORED PRODUCT PESTS:

1. Anobiidae: (Wood worms, Wood borers)



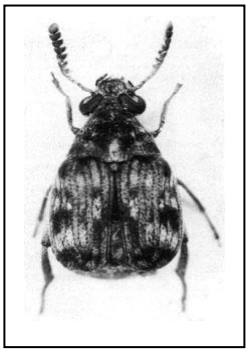
- Body is oval shaped or cylindrical.
- Head is concealed by pronotum which is helmet like.
- Grub is fleshy with larger abdominal segments.
  Cigarette beetle: *Lasioderma serricorne*.is the most serious pest of tobacco in factories and cigar stores.

2. Bostrychidae:



- They are small, elongate and cylindrical beetles.
- Head is concealed by the pronotum which is hood like.
- Antenna is either smooth or sculptured.
- Lesser grain borer: *Rhizopertha dominica* larvae bore into the stored grains and eat the inner contents completely.

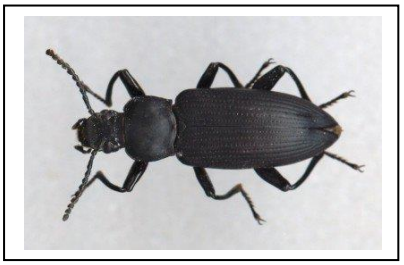
3. Bruchidae: (Pulse beetles, Seed beetles)



- They are small, short beetles.
- Head is small and the snout is blunt.
- Antenna is serrate. Hind femur is thick.
- Elytra are short and not cover the abdomen fully.
- Eggs are whitish, scale like and glued to the pods or seeds by a glutinous secretion.

- Grubs feed exclusively on seed legumes.
  Pupation occurs within the seed. Adult emerges by cutting a circular exit hole. Development is similar to hypermetamorphosis. Pulse beetle, *Callosobruchus chinensis.* It is a serious pest on stored pulses.

4. Tenebrionidae: (Meal worms)



- Body is flat and elongate.
- Elytra are often sculptured.
- Legs are heteromerous with a tarsal formula of 5-5-4.
- Lalvae are called meal worms.
  Red flour beetle: *Triblium castaneum.*
  It is an important pest of milled products.

FAMILIES OF CROP PESTS

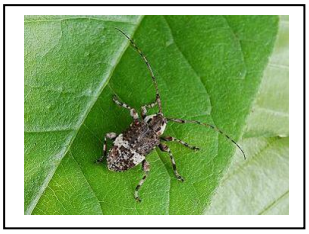
1. Apionidae:

- Head is produced into a snout.
- Antenna is not elbowed.
- Grubs are apodous.
  Sweet potato weevil: *Cylas formicarius.*
  It attacks sweet potato both in fields and in storage.

2. Cassididae: (Tortoise beetles)

- Adults look like a small tortoise.
- Head is concealed under the prothorax.
- Head is inferior in position.
- Prothorax and elytra are convex, wider and form a shell.
- Leg tips alone are exposed outside the shell.
- Larva is dorsally spiny to which excreta and exuviae are attached forming a faecal shield. Sweet potato beetle: *Aspidiomorpha miliaris.* They primarily feed on sweet potato.

3. Cerambycidae: (Longicorn beetles)



- Body is cylindrical.
- Compound eyes are notched.
- Antenna is as long or longer than the beetle itself.
  Antenna can be flexed backwards.
  It is surrounded at the base by compound eye.
- Pronotum is with one to three laterally located spines.
- Grubs are called round headed borers. They are apodous but have pseudopods both on dorsal and ventral side. They are wood borers. They develop beneath the bark and tunnel into the branches or main stem. Mango stem borer: *Batocera rufomaculata*

4. Curculionidae: (Weevils, snout beetles)

- Minute to large sized insects.
- Frons and vertex of the head

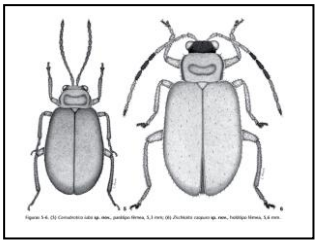
are produced into snout.
It is cylindrical and in some
species larger than the beetle itself.

- Mouthparts (Mandibles and maxillae)
  are present at the tip of the snout.
  It is useful to feed on internal tissues
  of the plant and provide a place for egg laying.
- Antenna is geniculate and found usually in the middle of the snout. Grubs are apodous and eucephalous. Weevils are important crop pests occurring both in field and storage.
  Coconut red palm weevil: *Rhynchophorus ferrugineus.*

5. Dynastidae: (Unicorn beetles, Rhinoceros beetles)

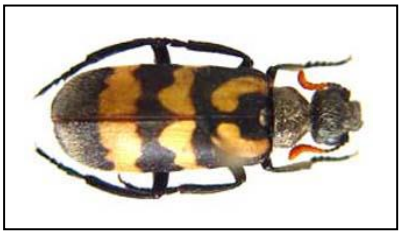
- Mandibles are bent, expanded,
  leaf like and visible from above.
- Horns are usually present in male in
  the head and thorax.
  Coconut rhinoceros beetle: *Oryctes rhinoceros.*
- Cephalic horns are found in both the sexes.
  In male the horn is longer and recurved.
  In female it is shorter and straight.
- Adults are injurious to coconut and
  grubs are found in dying palms and manure pits.

6. Galerucidae: (Pumpkin beetles)



- Antennae are closely approximated.
- Third tarsomere is deeply bi-lobed.
- Larvae are root feeders.
- Adults bite holes on leaves.
  Red pumpkin beetles: *Raphidopalpa foveicollis.*

7. Meloidae: (Blister beetles, Oil beetles)



- They are cylindrical, soft bodied beetles.
- Head is connected to thorax by a distinct neck.
- Legs are heteromerous with a tarsal formula of
  5-5-4. Claws show longitudinal splitting.
- Forewings are soft and leathery.
  They give off a fluid containing the oily principle
  cantharidin**,** when disturbed which causes blisters.
- Development involves hypermetamorphosis**.** Eggs hatch into active triangulin larvae which may feed on eggs *of* grasshoppers.
- Adults feed on foliage and flowers. e.g. banded blister beetle, *Mylabris pustulata*

Studies on the Order LEPIDOPTERA

Synonym: Glossata
Etymology: Lepido-scale; ptera-wings.
Examples: Moths, Butterflies, Skippers

Taxonopmic features:

- Body, wings, appendages are densely clothed with overlapping scales, which give colour, rigidity and strength. They insulate the body and smoothen air flow over the body.
- Mouthparts in adults are of **siphoning** type. Mandibles are absent. The galeae of maxillae are greatly elongated and are held together by interlocking hooks and spines. The suctorial proboscis is coiled up like a watch spring and kept beneath the head when not in use.
- Wings are membranous and are covered with overlapping pigmented scales. Forewings are larger than hind wings. Cross veins are few. Wings are coupled by either **frenate or amplexiform** type of wing coupling.
- Larvae are **polypod-eruciform** type. Mouthparts are adapted for chewing with strong mandibles.
- A group of lateral oelli is found on either side of the head. The antenna is short and three segmented. There are three pairs of five segmented thoracic legs ending in claws.
- Two to five pairs of fleshy unsegmented **prolegs** are found in the abdomen. At the bottom of the prolegs crochets are present.
- Pupa is generally **obtect.** It is either naked or enclosed in a cocoon made out of soil, frass, silk or larval hairs.

Classification

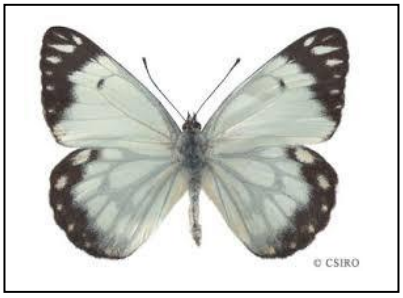
Majority of Lepidopteran insects (97%) are grouped under the suborder **Ditrysia** in which the female insects have two pores. The copulatory pore is located in eighth abdominal sternite and the egg pore in ninth abdominal sternite. Remaining insects are grouped under the suborder **Monotrysia** in which the female insects have one pore.

BUTTERFLY FAMILIES:

1. Nymphalidae: (Brush footed or four footed butterflies)
   - Forelegs are short, functionless, hairy and folded on thorax.
   - Foretibia is short and covered with long hairs. Larva is with many processes or spines on the body. e.g. Castor butterfly: *Ergolis merione,* It is a defoliator.
2. Lycaenidae: (Blues, Coppers, Hair streaks)
   - Compound eyes are white rimmed.
   - Antennae are with white rings.
   - Upper wing surface is either metallic blue or coppery. Lower wing surface is lighter in colour.

- Hind wing is often with delicate hair like prolongations and two or three black spots. Larvae are flattened with retractile head. e.g. Pomegranate ftuit borer: *Virachola isocrates.*

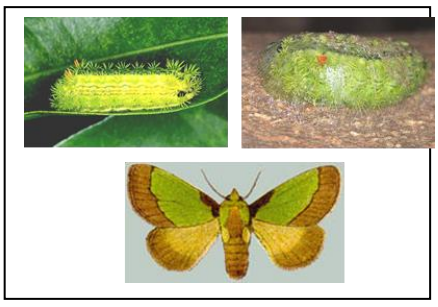
3. Papilionidae: (Swallow tails)
   - They are often large and brightly coloured.
   - Prothoracic legs have tibial epiphysis. In many species hind wings has tail like prolongation.
   - Amplexiform type of wing coupling is present. Larval body is either smooth or with tubercles. Retractile osmeteria are present on the prothoracic tergum of the caterpillar e.g. Citrus butterfly, *Papilio demoleus.*



4. Pieridae: (Whites or Sulphurs)
   - They are white or yellow or orange coloured with black markings.
   - Larva is green, elongate and covered with fine hairs.
   - Larval body segments have annulets. e.g. Daincha caterpillar, *Eurema hecabe.*
5. Satyridae: (Browns, Meadow-browns)
   - They are dull brown or blackish in colour.
   - Wings are with eye like spots both on the upper and lower surface. e.g. Rice homed caterpillar, *Melanitis ismene.*

MOTH FAMILIES:

6. Arctiidae : (Tiger moths)
   - Wings are conspicuously spotted or banded.
   - They are nocturnal and attracted to light.
   - Larva is either sparsely hairy or densely hairy (wooly bear). e.g. Black hairy caterpillar, *Estigmene lactinea.*
7. Bombycidae: (Silk worm moths)
   - Antenna is bipectinate.
   - Larvae is either with tuft of hairs or glabrous with medio dorsal horn on the eighth abdominal segment.
   - Pupation occurs in dense silken cocoon. e.g. Mulberry silk worm, *Bombyx mori* important source of natural silk.
8. Cochlididae (Slug caterpillar)
   - They are medium sized moths with stoutly built body.
   - Larva resembles the slug. Larva is thick, short, fleshy and stout. Larval head is small and retractile. Thoracic legs are minute. Abdominal segmentation is indistinct.
   - Prolegs are absent. Poisonous urticating hairs are present on the body.



- Pupal cocoon is hemispherical with urticating hairs
  e.g. Castor slug caterpillar *Latoia lepida.*

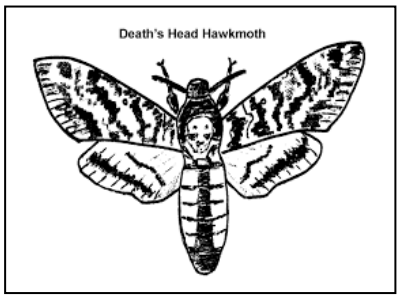
9. Crambidae (Grass moths)
   - Labial palps are extended.
   - Forewings are narrow and elongated. At rest they are wrapped around the body.
   - Larva bores into root, stem or crown of graminaceous plants. e.g. Sorghum stem borer, *Chilo partellus.*
10. Gelechiidae:
    - Forewings trapezoidal and narrower than hind wings.
    - Caterpillars bore into the seeds, tubers, and leaves. e.g. Cotton pink boll work, *Pectinophora gossypiella.*
11. Geometridae (Loopers)
    - Both pairs of wings are angular and thin.
    - Larva is naked and elongate. It shows protective resemblance to twigs or stems.
    - Only two pairs of prolegs are present in sixth and tenth abdominal segments. It walks by drawing the posterior part.

13. Noctuidae (Noctua moths)
    - They are medium sized, stoutly built moths.
    - They are nocturnal and attracted to light.
    - Labial palp is well developed.
    - Crochets on the larval prolegs are all of one size and arranged in semi-circle. Some larvae are semiloopers. They have either three or four pairs of prolegs.
    - Larvae attack the plants during night. Larvae of some species remain concealed beneath the surface of the ground or litter on the surface during day and feed on plants during night. They often cut small seedlings close to the ground and hence they are called cut worms. e.g. Tobocco cut worm, *Spodoptera.*
14. Pterophoridae (Plume moths)
    - They are small lightly built months
    - Forewings are elongate with two to four clefts or fissures.
    - Hindwings have three divisions.
    - Legs are long, slender and armed with prominent tibial spurs.
      e.g. Redgram plume moth, *Exelastis atomosa.*

15. Pyraustidae:
    - Proboscis is vestigial in many species.
    - Labial palp is snout like.

- Larval habit varies. It may live among aquatic plants and bore into the stem or remain in silken web among spun up plant parts. Some larvae are aquatic and gill breathing. e.g. Rice stem borer, *Scirpophaga incertulas.*

16. Satuniidae (Moon months, giant silk worm moths)
    - They are large sized moths.
    - Antenna is bipectinate.
    - Transparent eye spots are present near the centre of each wing. The spots are either circular or crescent shaped.
    - Larva is stout and smooth with scoli. Cocoon is dense and firm. e.g. Tusser silk worm, *Antherea paphiayields* silk.
17. Sphingidae: (Hawk moths, Sphinx moths, Horn worms)
    - They are large sized stoutly built moths.
    - Antenna is thick towards middle and hooked at the tip.
    - Proboscis is very long.
    - Forewings are elongated and pointed with very oblique outer margin.
    - Hindwings are reduced in width fitting into the margin of forewings.



    - They are powerful fliers.
    - Larva is smooth with a mid-dorsal horn (anal horn) on the eighth abdominal segment.
    - Pupation takes place in earthen cells. In many species the proboscis is enclosed in a separate sheath. e.g. Death's head moth, *Acherontia styx* is a defoliator on gingelly. Markings present on the thorax of the adult moth resemble skull.
18. HESPERIIDAE: (Skipper)
    - Antennae are widely separated at the base. They are dialated apically to form a gradual club. Each antenna is apically prolonged beyond the club into a hook or small recurved point.
    - Wings are comparatively small. They are often held partly open at rest.
    - Larval head is large. There is a constriction beyond the head. Larva tapers towards both extremities. Larvae are often concealed in the host foliage. e.g. rice skipper, *Pelopidas mathias.*

INSECT ANATOMY

Expt- 14

Studies on digestive system of insect

Alimentary canal of Grasshopper

The alimentary canal is a tubular structure running down from mouth to anus and is divided into three mainregion-the foregut or stomodacum, midgut or mesenteron and the hindgut or proctodacum. In many insects these region are sub dividedinto various functionalparts of which the most usual are pharynx, oesophagous, crop, proventriculus in the foregut, the gastric caeca in midgut and the pylorus, ileum and rectum in the hindgut.

Procedure:

Grasp the grasshopper gently but firmly and remove the wings with small scissors. Lay down the insects on its ventral surface grasshopper can be opened by cutting along the mid dorsal line from anal end to base of head. (Exposing dorsal side towards you) on the wax tray and insert a pin through the headand fix obliquely . Then open the target plate of the abdomen with pins.

Pour enough water to cover the insect. Using the scissor, needles and forceps, carefully uncoil the digestive tract. Then observe the different parts of digestive system.

Observation:

Foregut:

(i) Pharynx: The pharynx cannot be seen very well in a dorsal dissection.
(ii) Oesophagous: The oesophagous is a tube of narrow diameter that follows the pharynx.
(iii) Crop: The crop is sac like structure that follows the oesophagous but there is no divoision to separating them.
(iv) Proventriculus: it is a cup like at the end of crop.

Midgut:

(i) Gastric caeca: It is spindle shaped structure malpighian tubes are attached at the juncture of the midgut and the hindgut.

Hindgut:

(i) Ileum: Just behind the malpighian tubuls is a short tappering ileum.
(ii) Colon: The remainder of intestine is a longer tube which tappers slightly until it reaches the rectum.
(iii) Rectum: It is bulbous structure and leads to the anus.

Dissect and observe the digestive system of Grasshopper in the following way:

- Give a longitudinal cut on mid dorsal side of the body and fix in the dissection tray fully immersed in water.

- Pin the cut ends of the body over the wax of tray.
- Pour fresh water and clean the muscles, fat bodies and other unwanted matters.

Observe the following structures of digestive system:

- Pharynx (a short narrow tube just after mouth or buccal cavity)
- Oesophagous (a narrow tube just after pharynx and upto crop)
- Crop (a bulbous structure after oesophagous)
- Proventriculus (a small round body parts after crop)
- Gastric caeca (a finger like diverticula, 6-8 in number)
- Mid gut (A short tube just after proventriculus upto malpighian tubules)
- Intestine (a long coiled tube from MT to rectum)
- Rectum (a short bulbous tube at the end of intestine)
- Salivary gland (a pair of salivary glands in anterior end of fore gut)

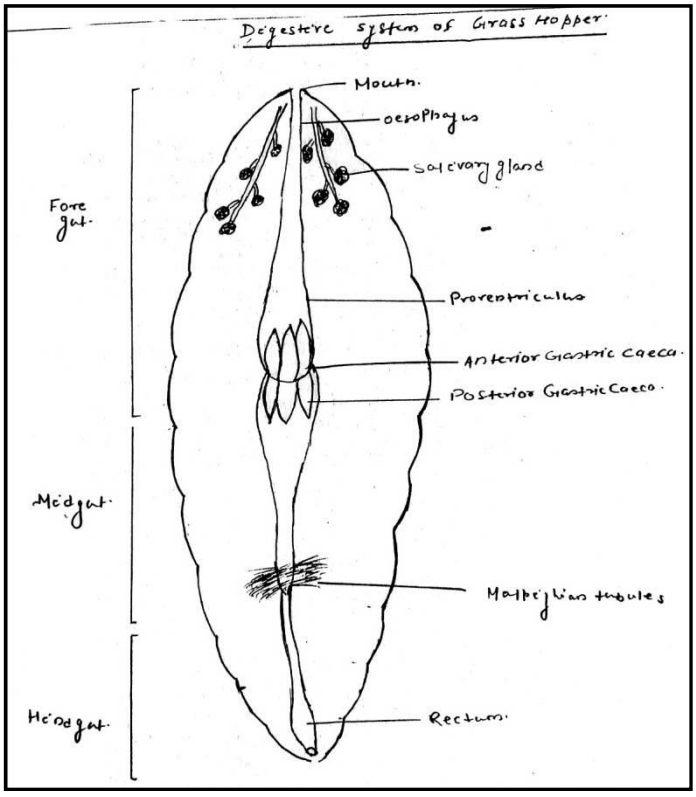


Fig: Digestive system of grasshopper

Expt- 15

Studies on reproductive system of insect

Dissection of male and female reproductive system:

Reproductive system of Grasshoppers

The male reproductive system consists of testes (4^{th}, 5^{th} & 6^{th} abdominal segment), vas diferentia, ejaculatory duct, aedegus and accessory gland. The female reproductive system comprises of ovaries, oviduct, sprmathica, vagina and accessory glands.

Procedure:

Grasp the grasshopper gently but firmly and remove the wings with small scissors. It can be opned by cutting along the mid dorsal line from anal end to thorax region. Keep the grasshopper on wax tray and insert a pin through head and fix obliquely. Pour enough water to cover the insect. Spread the dorsum and secure it with pins. Separate the gonads from alimentary canal and display them by pinning each ovary or testis to the side. Trace the oviduct or vas deferens posteriously towards the end of the abdomen. Locate the other parts of the system.

Observation: Trace or locate the following parts.

Male:

(i) Testis
(ii) Vas diferens
(iii) Ejaculatory duct
(iv) Accessory Gland

Female:

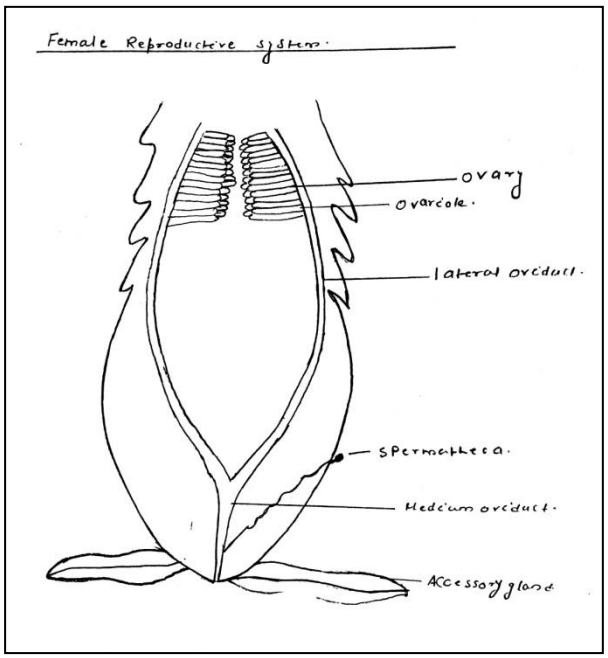
(i) Ovary
(ii) Oviduct
(iii) Sparmathica
(iv) Accessory Gland

Dissect and observe the female reproductive system of Grasshopper in the following way:

- Give a longitudinal cut on mid dorsal side of the body and fix in the dissection tray fully immersed in water.
- Pin the cut ends of the body over the wax of tray.
- Pour fresh water and clean the muscles, fat bodies and other unwanted matters.

Observe the following structures of female system:

- Gonads: Observe the mass of yellow structures in the middle of the body
- Lateral oviduct: Trace a pair of lateral oviduct just behind the gonads.
- Common oviduct: Two lateral oviducts united to form a common oviduct behind the lateral oviduct
- Spermatheca: a pouch like organ arising from common oviduct
- Accessory gland: a pair accessory glands arising from common oviduct.



Dissect and observe the male reproductive system of Grasshopper in the following way:

- Give a longitudinal cut on mid dorsal side of the body and fix in the dissection tray fully immersed in water.
- Pin the cut ends of the body over the wax of tray.
- Pour fresh water and clean the muscles, fat bodies and other unwanted matters.

Observe the following structures of digestive system:

- Testes: Observe the mass of yellow structures in the middle of the body
- Vas diffentia: Trace a pair of Vas diffentia just behind the gonads.
- Seminal vesicle: A pair of tubes on the posterior portion of vas differentia.
- Common ejaculatory duct: the two seminal vesicle united to form common ejaculatory duct.
- Accessory gland: a pair of accessory glands arising from common ejaculatory duct.

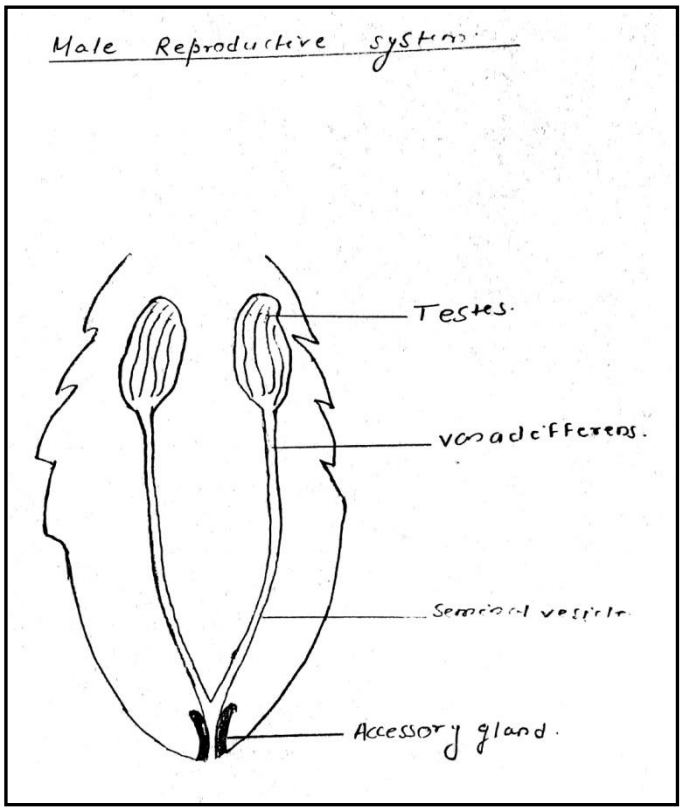


Fig: Male reproductive system

Class wise Breakup of Course
ENT-151: Fundamentals of Entomology (3+1)
(For Agriculture)
(As per Vth Dean's Committee Recommendation)

Sl. No.	Content of the Course	No. of classes alloted
	Part – I:	
1.	History of Entomology in India. Major points related to dominance of Insecta in Animal kingdom.	1
2.	Classification of phylum Arthropoda upto classes. Relationship of class Insecta with other classes of Arthropoda.	
3.	Morphology: Structure and functions of insect cuticle and molting. Body segmentation.	2
4.	Structure of Head, thorax and abdomen.	2
5.	Structure and modifications of insect antennae, mouth parts, legs.	5
6.	Wing venation, modifications and wing coupling apparatus.	2
7.	Metamorphosis and diapause in insects. Types of larvae and pupae.	2
8.	Structure and functions of digestive, circulatory, excretory, respiratory, nervous, secretary (Endocrine) and reproductive system in insects.	5
9.	Types of reproduction in insects. Major sensory organs like simple and compound eyes, chemoreceptor.	1
Total		**20**
	Part – II:	
10.	Insect Ecology: Introduction, Environment and its components.	1
11.	Effect of abiotic factors–temperature, moisture, humidity, rainfall, light, atmospheric pressure and air currents.	3
12.	Effect of biotic factors – food competition, natural and environmental resistance.	
Total		**4**
	Part -III:	
13.	Categories of pests.	3
14.	Concept of IPM, Practices, scope and limitations of IPM.	
15.	Classification of insecticides, toxicity of insecticides and formulations of insecticides.	3
16.	Chemical control-importance, hazards and limitations.	
17.	Recent methods of pest control, repellents, antifeedants, hormones, attractants, gamma radiation.	3
18.	Insecticides Act 1968-Important provisions.	3
19.	Application techniques of spray fluids.	
20.	Symptoms of poisoning, first aid and antidotes.	
Total		**12**

Part – IV:		
21.	Systematics: Taxonomy –importance, history and development and binomial nomenclature.	1
22.	Definitions of Biotype, Sub-species, Species, Genus, Family and Order.	1
23.	Classification of class Insecta upto Orders.	
24.	Basic groups of present day insects with special emphasis to orders and families of Agricultural importance.	
24.1	Orthoptera: Acrididae, Tettigonidae, Gryllidae, Gryllotalpidae; Dictyoptera: Mantidae, Blattidae and Odonata.	1
24.2	Isoptera: Termitidae; Thysanoptera: Thripidae; Hemiptera: Pentatomidae, Coreidae, Cimicidae, Pyrrhocoridae, Lygaeidae, Cicadellidae, Delphacidae, Aphididae, Coccidae, Lophophidae, Aleurodidae and Pseudococcidae.	2
24.3	Neuroptera: Chrysopidae; Lepidoptera: Pieridae, Papiloinidae, Noctuidae, Sphingidae, Pyralidae, Gelechiidae, Arctiidae, Saturnidae and Bombycidae.	1
24.4	Coleoptera: Coccinellidae, Chrysomelidae, Cerambycidae, Curculionidae, Bruchidae and Scarabaeidae.	1
24.5	Hymenoptera: Tenthridinidae, Apidae. Trichogrammatidae, Ichneumonidae, Braconidae and Chalcididae.	1
24.6	Diptera: Cecidomyiidae, Tachinidae, Agromyziidae, Culicidae,Muscidae and Tephritidae.	
Total		**8**
Total number of classes required		**44**

Class wise Breakup of Course

ENT-151: Fundamentals of Entomology (3+1)

(For Agriculture)

(As per Vth Dean's Committee Recommendation)

(For Faculty of Horticulture)

Course No.: ENT – 152 Fundamentals of Entomology Semester -II Credit Hour: 2+1

Sl. No.	Content of the Course	No. of classes required
	Part – I:	
1.	Introduction to phylum arthropoda. Importance of class Insecta. Insect dominance.	5
2.	History of entomology in India. Importance of entomology in different fields. Definition, division and scope of entomology.	
3.	Comparative account of external morphoology-types of mouth parts, antennae, legs, wings and genetalia.	6
4.	Structure, function of cuticle & moulting and body segmentation.	3
5.	Anatomy of digestive, Circulatory, Sensory, respiratory, glandular, excretory, nervous and reproductive systems.	6
7.	Types of reproduction. Postembryonic development-eclosion. Metamorphosis.	2
8.	Types of egg larvae and pupa.	2
9.	Classification of insects upto orders, sub-order and families of economic importance and their distinguished characters.	6
10.	Plant mites – morphological features, important families with examples.	2
Total number of classes required		**32**