Practical Manual

INSECT MORPHOLOGY

APE 501 3(2+1)

For

M.Sc. (Ag.) Entomology

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Department of Entomology

College of Agriculture

Rani Lakshmi Bai Central Agricultural University

Jhansi- 284003

Practical Manual

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Contents

Suggested Reading:

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PRACTICAL NO. 1

COLLECTION AND PRESERVATION OF INSECT INCLUDING IMMATURE STAGES

Objective: To collect and preserve insects of different order

Tools and techniques for insect collection will vary based on the type of the insects to be collected. There are various method of insect collection.

Methods of insect collection

1. Hand picking: Large insects like beetles and grasshoppers are collected by hand picking.

2. Insect net

Aerial net: Light in weight, useful for catching active fliers like butterflies, moths, dragonflies, wasp, flies etc.

Sweep net: Heavier than aerial net. It consists of short handle, a large loop and dense cloth bag. This is suitable for collecting leafhoppers, grasshoppers and other small insects. The net is swept over vegetation.

D**ip nets:** Heavy canvas bag with mesh at tip for sampling aquatic insects.

3. Aspirator: It is used for collecting small insects into glass vials with no damage to the specimens.

4. Beating tray: This method is suitable for collecting crawling insects and those, which rest on branches. A beating tray is held under a branch, which is then hit sharply with a stick.

5. Berlese funnel: Debris including soil arthropods can be collected by using the light as the source of heat.

6. Traps:

Pheromone traps

Synthetic sex pheromones are placed in the traps to attract male moths. The rubberized septa containing the pheromone lure are kept in the traps designed especially for this purpose and used in monitoring, mass trapping and mating disruption programmes.

Yellow sticky traps: Aphids, whiteflies, thrips prefer yellow colour.

Probe trap: It is used by keeping them under grain surface to trap stored product pests.

Pitfall traps: Containers such as small plastic buckets, plant pots, glass jars or jam tins are sunk into the ground to trap flightless, ground-living insects and arachnids, especially beetles (ground beetles), cockroaches, crickets, spiders, harvestmen and mites.

Light traps: These are mainly used for attracting moths & other night flying insects which are attracted towards the light. Besides species of moths, beetles, flies, and other insects, most of which are not pests, are also attracted to artificial light.

Methods of preservation

Protection of Insect specimens

Collected Insects can be protected for longer time in insect collection box by putting the naphthalene balls on the corner side of box.

Preservation of insects

a) Temporary preservation

b) Permanent preservation: Insects can be permanently preserved either dry, in fluid, or on slides. The method of preservation depends on the type of insects. It can be done by the following methods-

Dry preservation- Insects that are to be preserved dry are best mounted in ways that facilitate study and permanent storage. Specimens should be mounted soon after killing, if possible while still soft.

Liquid preservation- It is done in 70 % ethyl alcohol + 4 % formalin solution.

Soft scale insects and mealybugs can be preserved in mixture of 4 parts 90 % ethanol and 1part glacial acetic acid whereas, **thrips** can be preserved in a mixture of 9 parts 60 %ethanol and 1 part glacial acetic acid. It is very important to periodically check and topup containers of a liquid collection.

Mounting on a microscopic slide- Small specimens have to be mounted on microscope slides so that they can be studied under a compound microscope. These include groups such as thrips, aphids, parasitic wasps, scale insects, booklice, lice and mites. Insect and spider body parts (e.g. mouthparts and genitalia), and larvae often have to be slide mounted.Microscope slide mounts may be temporary or permanent, but specimens maintained in collections require permanent mounts.

Relaxing container/Jar Relaxing is the process of re-softening the insects. Relaxing jar contains a layer of sand (5 cm thick) or any other absorbent materials (basal wood, pith, synthetic sponge) and few drops of formaline or carbolic acid is added to prevent mould/fungal growth and then covered with filter paper. Cleaning- Dust, pollens and dirt can be removed with a camel hairbrush dipped in water mixed with detergent.

than about 8 mm are usually mounted on pins pushed through the thorax. Insect pins are longer than ordinary pins, and are made of stainless steel that does not rust. A No. 2 or No. 3 entomological pin is suitable for most insects, although those with delicate bodies may require a size No. 0 or No. 1.

Entomological pins-There is three general series of pins viz.,

English pins: Sold by weight, range of 18-30 mm in length and stout, used to pin lepidopteran insects, which lies or kept low in the box.

Continental pins: Sold by 100s, Range 35 mm in length,(000,00,0 & 1-7 Nos.), No. 2 & 3 are useful for general purpose, 38 mm(No. 8-10), 50 mm(No. 11-12), 000 is the thinnest pin and No. 12 is the thickest pin.

Minute pin: Minutest and finest pins, used for pinning the insects meant to stage, for minute, softest and fragile insects.

Pinning

It is the best and common method to preserve hard bodied insects. They will dry and remain in perfect condition on the pins for long time without any further treatment. They are pinned vertically through the body. Depending upon the size of insect‘s pins has to be selected accordingly. Exact place of insertion of the pin varies among different groups of insects.

Pointing / gumming

The insect specimen is glued to a card, cut into a triangle of 10 mm height and 5 mm base. Bend down the tip of card to form as mall 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 insects to be mounted.

Activities:

1. Collect the insects from the field by using suitable method.
2. After collecting, transfer the insects into killing jar.
3. Preserve the insects by using different methods.

PRACTICAL NO. 2

EXTERNAL MORPHOLOGY OF AN INSECT

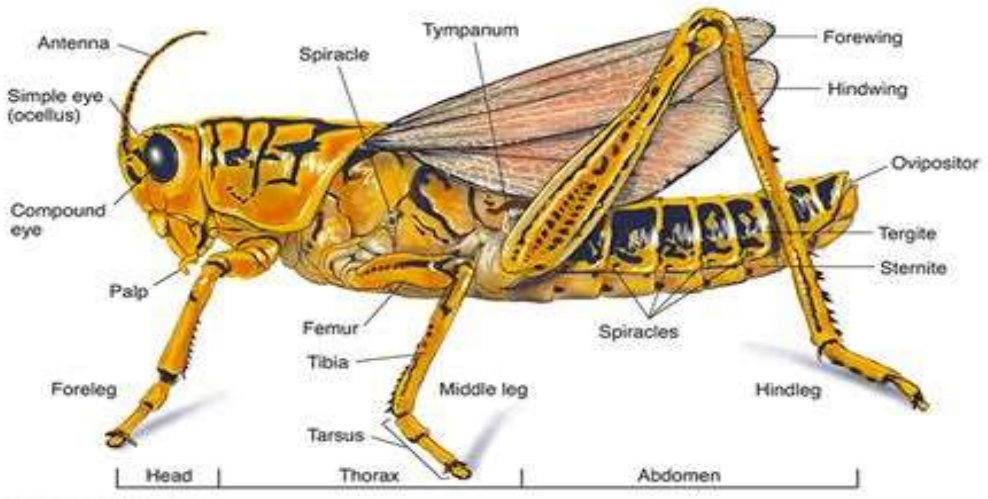
Objective: To know and understand external features of insects

In general, insect body is divided into series of segments, are referred as somite or metamere in primitive arthropods. During the evolution process, some of the segments are more or less united in to groups forming distinct trunk sections or tagmata. This type of grouping of segments in to body regions is called tagmosis and each region (grouping of body segments) is called tagmata (for example, in insects each region such as head, thorax and abdomen is called tagmata, where head is the first tagmata in insects). Insect body is differentiated into three distinct regions called head, thorax and abdomen

Head: The insect head contains a pair of compound eyes, simple eyes (ocelli), mouth parts (mandibles, maxillae and labium) and a pair of antennae.

Thorax: An insect thorax is three segmented, the prothorax (pro=first), mesothorax (meso=middle), and metathorax (Meta=last). Each segment consists of hardened plates, or sclerites. Dorsal sclerites are called nota or terga (singular notum), lateral sclerites are called pleura (singular pleuron), and ventral sclerites are called sterna (singular sternum). The terga of thoracic segments are called notum. Three pairs of legs and two pairs of wings arise from thoracic region.

Abdomen: The abdomen is the metabolic and reproductive centre, where digestion, excretion, and the sexual functions take place. Generally, abdomen consists of 11 segments. Posterior abdominal segments are modified for the purpose of mating and oviposition.



Activities:

1. Collect the insects from the field.
2. Observe and illustrate the external features (including the appendages of head, thorax and abdomen) of the collected insects

PRACTICAL NO. 3

INSECT HEAD AND ITS MODIFICATION

Objective: To understand different types and segments of insect head

The head is hard, and almost a completely sclerotized capsule formed due to fusion of six segments. It is composed of mainly rigid sclerites or sclerotized segments. The insect head contains a pair of compound eyes, a pair of simple eyes (ocelli), mouth parts (mandibles, maxillae and labium) and a pair of antennae.

ORIENTATION OF HEAD

The orientation of head with respect to the rest of the body varies. Insects have three basic types of head

i. Hypognathous (Hypo=below, Gnathous=Jaw); the mouthparts are directed downward, with the mouth parts in a continuous series with the legs, is a primitive type. This is also known as orthopteroid type. This orientation mostly occurs in vegetarian species living in open habitats. Eg: Grasshoppers, Cockroach.

ii. Prognathous (Pro=infront, Gnathous=Jaw); the mouthparts are directed forward. This is also known as coleopteroid type. This is is found in carnivores species which actively pursue their prey, and in larvae, particularly of coleopteran, which use their mandible for burrowing. Eg. Beetles, Ants

iii. Opisthorhynchous (Opistho=behind, gnathous=Jaw); the elongated proboscis slopes backwards between the front legs. This is also known as hemipteroid / opisthorhynchous type. Eg: Bugs, Mosquitoes.

SCLERITES OF INSECT HEAD CAPSULE

The head capsule is formed by union of number of hardened sclerites (or) cuticular plates (or) areas, which are joined together by means of cuticular lines (or) ridges (or) sutures. These sutures provide mechanical support to the cranial wall.

Occipital foramen connects the back of the head with the body. There are 10 sclerites in the head capsule.

1. Vertex (Epicranium)-the top or dorsal side of the head is known as vertex. It is situated in between the eyes at the back of frons. Ocelli and antennae are present on vertex.

2. Frons-It is present on the anterior face which lies between or below the epicranial arms. The median ocellus is located on it. It is bounded by the frontoclypeal suture ventrally. Clypeus-It is a tip like structure located between fronto-clypeal suture and labrum. It is attached with the frons. The labrum hangs below it or articulate be means of membranous connection between them.

4. Labrum-It is a simple fused sclerite, often called the upper lip, and moves longitudinally. It is hinged to the clypeus.

5. Gena (lateral sides)-It is the lower part of the head beneath the eyes and lies posterior to the frons. A general suture is present between frons and gena. The area directly posterior to the eyes is termed the post gena.

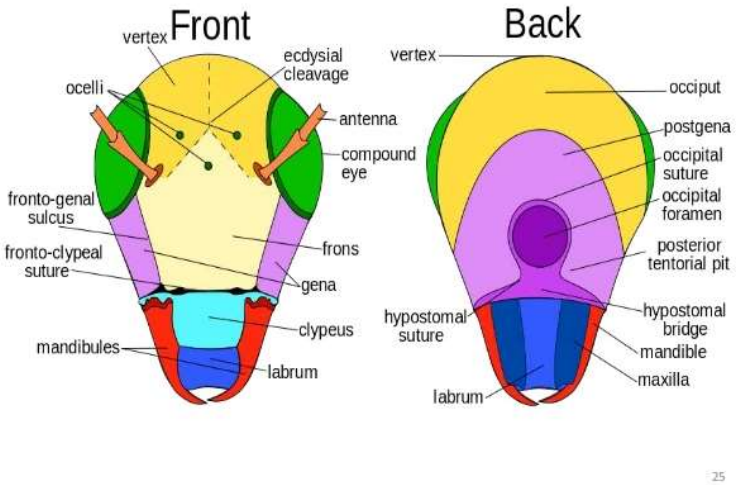
6. Post gena-sclerites below the genae and above the mandibles.

7. Occiput-It is the area comprising most of the back of the head. The occipital suture divides it from the vertex and genae.

8. Post-occiput- It forms the margin of the occipital foramen and narrow ring like in shape. The post-occipital suture divides it from occiput.

9. Occular sclerites: ring like structures around compound eye.

10. Antennal sclerites: these form basis for antennae and present around the scape which are well developed in plecoptera (stone flies).



SUTURES (LINES) OF INSECT HEAD:

The hard sclerites (segmental plates) are clearly separated by different lines or grooves called sutures or sulci. The areas of the head enclosed between sutures are called sclerites. There are eight sutures in the head capsule.

1. Epicranial suture (Ecdysial suture): It is an inverted 'Y' shaped suture separating vertex and frons. The epicranial suture also known as line of weakness or ecdysial suture, because the exuvial membrane spilts here along the suture during the process of moulting / ecdysis.

2. Fronto-clypeal suture (Epistomal suture): A line between frons and clypeus.

3. Clypeo-labral suture: A line between clypeus and labrum. It remains in the lower margin of clypeus from which the labrun hangs.

4. Fronto-Genal suture (genal suture): Lies on either side of the head below thecompound eyes separating facial part from gena.

5. Sub-genal suture: A line below the gena on either side of the head.

6. Occipital suture: A line between occiput and post occiput. It is 'U' shaped (or) horse shoe shaped.

7. Post-occipital suture: of these, post-occipital suture is the only real suture, separating maxillary and labial segments. This suture separates head from the neck, hence named as real suture.

8. Antennal suture: It is a marginal depressed ring around the antennal socket.

Activities:

1. Dissect the available insect head.
2. Draw the frontal and back view of the dissected insect.

PRACTICAL NO. 4

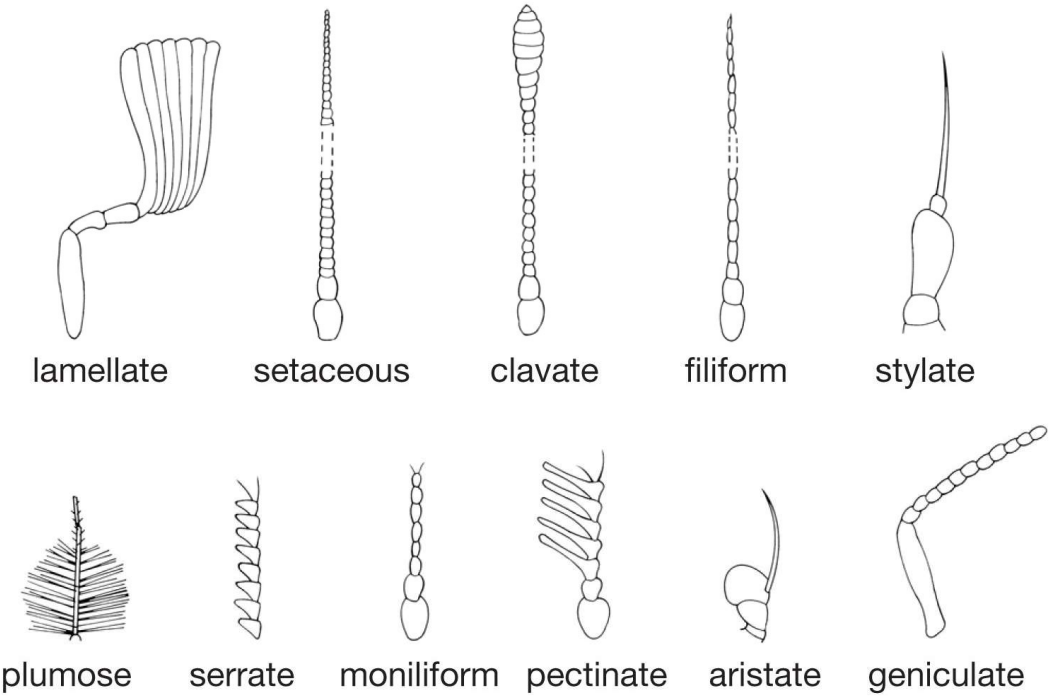
INSECT ANTENNA AND ITS MODIFICATION

Objective: To well acquainted with the various modification of insect antenna

The antenna consists of a basal, scape, a pedicel and a flagellum. The scape is inserted into a membraneous region of the head wall and joined on a single marginal point called antennifer, so it moves freely in all directions. Flagellum is divided into a number of similar annuli joined to each other by membranes so that the entire flagellum is flexible. The antennae of the insects are moved by levator and depressor muscles arising on the anterior tentorial arms and inserted into the scape, and by the flexor and extensor muscles arising in the scape and inserted into the pedicel.

Different types of insect antenna:

1. **Setaceous**: Bristle like, small sized, segment size decreases from base to apex and ends with a bristle. e.g. Leaf hopper, Dragonfly, Damselfly
2. **Filiform**: Thread like, Segments are many and cylindrical e.g. Orthopterans, Dictyopterans, moths
3. **Moniliform**: Beaded, Segments are either globular or spherical with prominent constriction in between e.g. Termites
4. **Clavate** - Clubbed, Antenna enlarges gradually towards the tip e.g. Blister beetle
5. **Capitate** - Knobbed, Terminal antennal segments enlarged suddenly, e.g. Butterfly
6. **Hooked** - Knobbed end of the antenna is hooked e.g. Skippers and sphingids
7. **Bipectinate** - Double comb like, Antennal segments processes long slender lateral process on both the sides e.g. Silkworm moth
8. **Unipectinate** - Comb like, Antennal segments with long slender processes on one side e.g. Sawfly
9. **Plumose-**Feathery, Segments with dense and long whorls of hails e.g. Male mosquito
10. **Pilose** -Hairy, Antenna is less feathery with few hairs at the junction of flagellomeres. e.g. Female mosquito
11. **Aristate** - Antenna with three segments and the terminal segment bears a dorsal bristle alled arista e.g. House fly
12. **Stylate** - Antenna three segmented and the terminal segment ends with a style like Process e.g. Robber fly, Horse fly
13. **Serrate** - Saw like, Segments have short triangular projection on one side. e.g. Long horned beetles, pulse beetle, jewel beetles, click beetles
14. **Lamellate** - Plate like, Small sized, antennal tip is laterally expanded to flat plates. e.g. Rhinoerous beetle, ground beetles
15. **Geniculate** – Elbowed, Basal scape is relatively long. Remaining segments are small and are arranged at an angle to the scape forming an elbow like joint e.g. Ant, weevil, honey bee.
16. **Flabellate** - Very small, third and subsequent segments with side processes giving an fan like arrangement e.g. Strepsipterans (or) Stylopids



Activities:

1. Collect different insects from the field with the help of insect collection net and transfer to the killing jar.
2. Dissect the antennae and observe under microscope. Record the observed features and draw their diagram.

PRACTICAL NO. 5

INSECT MOUTHPARTS AND ITS MODIFICATION

Objective: To dissect and study different parts of mouth and their modification in different insects.

These are organs concerned with uptake of food and feeding.

The 5 main parts of typical insect mouth are

1. Upper Lip or labrum: Simple fused sclerite, often called the upper lip, and moves longitudinally. It is hinged to the clypeus

2. Anterior Jaws or mandibles: Mandibles, or anterior jaws, are highly sclerotized paired structures that move at right angles to the body. They are used for biting, chewing and severing/cutting food.

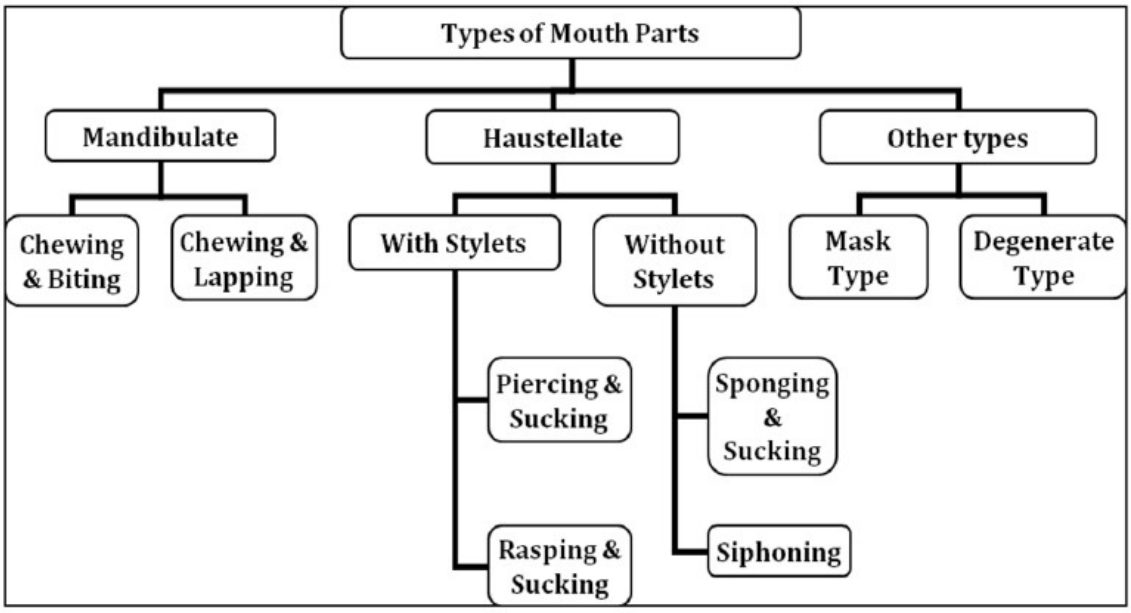
3. Accessory Jaws or maxillae: The maxillae or accessory jaws are paired structures that can move at right angles to the body and possess segmented palps. They are used for holding and sending food into mouth.

4. Lower Lip or labium: The labium (often called the lower lip), is a fused structure that moves longitudinally and possesses a pair of segmented palps.

5. Tongue like structure or Hypopharynx

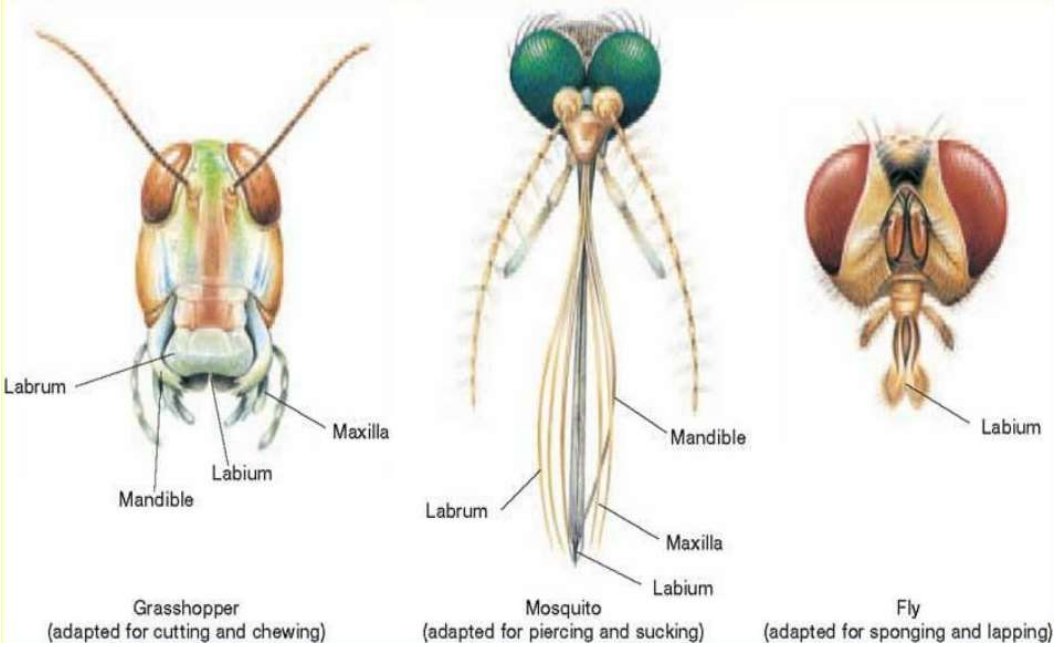
Mouthparts vary greatly among insects of different orders, but basically the mouth parts may be divided into two groups:

1. Chewing and Biting type (considered as primitive) (mandibulate)
2. Sucking type (haustellate)



Different modification of mouthparts

Biting & Chewing Type	Nymphs and Adults of Grasshoppers and Cockroaches, Adult beetles, Caterpillars
Piercing and Sucking Type	Aphids, Bugs, Mosquitoes, Lice
Rasping and Sucking Type	Thrips
Sponging Type	House fly
Chewing and Lapping Type	Honey Bee
Siphoning Type	Butter Flies, Moths
Mask type	Young ones (Naiads) of Dragon Fly
Degenerate type	Maggots



<u>Activities</u>:

1. Dissect and observe mouthparts of different specimens (Grasshopper, Bugs, Mosquitoes, Honeybees, etc)
2. Draw neat labelled diagram of the observed mouthparts.

PRACTICAL NO. 6

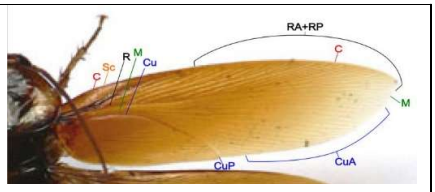
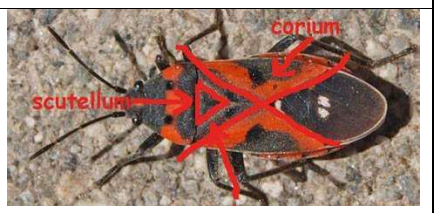
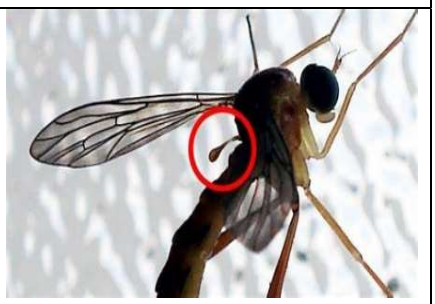
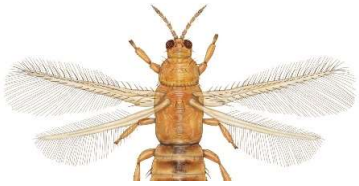
INSECT WING AND WING COUPLING MECHANISM

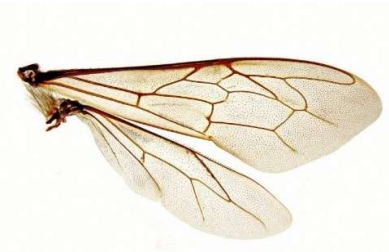
Objective: To understand insects wing structure, modification and wing coupling mechanism

An insect fossil indicated that wings are present from the carboniferous period. Endoterygota and exoterypgota possess two pairs of wings (forewing and hindwing) in meso and meta thorax which is collectively known as pterothorax.

Aterypgota does not possess wings.

Different modification of insect wings are:

1. **Tegmina:** (Singular: Tegmen) Wings are leathery or parchment like. They are protective in function. They are not used for flight. e.g. Forewings of cockroach and grasshopper.	
2. **Elytra:** The wing is heavily sclerotised. Wing venation is lost. Wing is tough and protective. It protects hind wings and abdomen. It is not used during flight. e.g. Fore wings of beetles and weevils.	
3. **Hemelytra:** 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. **Haltares**: In true flies the hind wings are modified into small knobbed vibrating organs called haltare. Each haltere is a slender rod clubbed at the free end (capitellum) and enlarged at the base (scabellum). 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. **Scaly 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.	
7. **Membranous wings**: Transparent wings are called membranous wings. They are thin and supported by a system of tubular veins. In many insects either forewings or hind wings or both fore wings and hind wings are membranous. They are useful in flight.	

Types of **wing coupling mechanism are**

1. **Hamulate** e.g. bees.
2. **Amplexiform** :. e.g. butterflies.
3. **Frenate** : Fruit sucking moth

Activities:

1. Observe different types of wings of insect specimens.
2. Observe the wing coupling apparatus of honey bee
3. Draw neat labelled diagrams of Insect Wing structure with angles, margins and venations

PRACTICAL NO. 7

INSECT LEGS AND ITS MODIFICATION

Objective: To understand structure of insect legs and its modification

Insects have three pairs of legs, one each on the thoracic segments. Hence the name 'Hexapods' is derived. Each leg consists of six segments, articulating with each other by mono condylic articulations. The six basic segments are coxa, trochanter, femur, tibia, tarsus and pre tarsus. They undergo many modifications and have been adapted to a wide variety of functions including swimming, prey capture, pollen collection and digging.

Ambulatorial (Ambulate - to walk; Walking leg) e.g. Fore leg and middle leg of grasshopper. Femur and tibia are long.Legs are suited for walking.

Cursorial: (Cursorial = adapted for running: Running leg) e. g. All the three pairs of legs of cockroach. Legs are suited for running. Femur is not swollen.

Saltatorial: (Salatorial = Leaping: Jumping Leg) e.g. hind leg of grasshopper.

Fossorial: (Forrorial =Digging; Burrowing leg) e.g. Fore legs of mole cricket.

Natatorial: (Natatorial = pertaining to swimming; Swimming leg) e.g. hing legs of water bug and water beetle.

Raptorial: (Raptorial=predatory; Grasping leg) e.g. Forelegs of preying mantids.

Scansorial: (Scansorial = Climbing; climbing or clinging leg) e.g. all the three pairs of legs of head louse.

Foragial leg: (Forage = to collect food material) e.g. Legs of honey bee.

i.Forlegs : The foreleg has three important structures (Eye brush, Antenna cleaner or strigillis and Pollen brush)

ii. Middle legs: It has two important structures.

(a.) Pollen brush: Stiff hairs on basitarsus form pollen brush which is useful to collect pollen from middle part oftheir body.

(b.) Tibial spar: At the distal end of the tibia, a movable spur is present which is useful to loosen the pellets of pollen from the pollen basket of hind legs and to clean wings and spiracles.

iii. Hind legs: It has three important structures viz., pollen basket, pollen packer and pollen comb.

(a.) Pollen basket: It is also called corbicula. The outer surface of the hind tibia contains a shallow cavity. The edges of the cavity are fringed with long hairs. The pollen basket enables the bee to carry a larger load of pollen and propolis from the field to the hive.

(b.) Pollen packer: It is also called pollen press. It consists of pecten andauricle. Pecten is a row of stout bristles atthe distal end of tibia. Auricle is a small plate

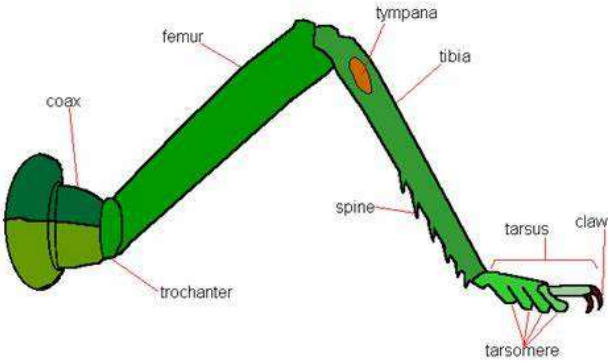
Climbing or Sticking leg: e.g. all the three pairs of legs of house fly. Clasping leg: e.g. Forelegs of male water beetle.

Prolegs: Caterpillars possess three pairs of thoracic legs (true-legs) and five pairs of abdominal legs (pro-legs) on 3rd, 4th 5th, 6th and last abdominal segments. In some, semi-loopers larvae, prolegs on 3rd and 4th abdominal

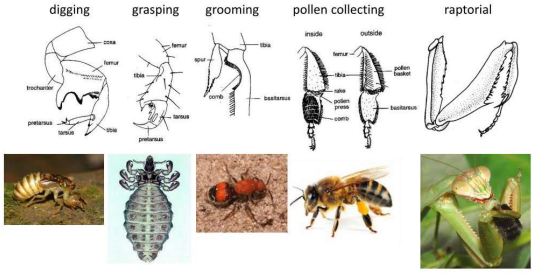
segments absent, and hence while movement, it looks like semi loop, in some, loopers, prolegs present only on 6th and last abdominal segments, and hence while movement, it looks like loop.

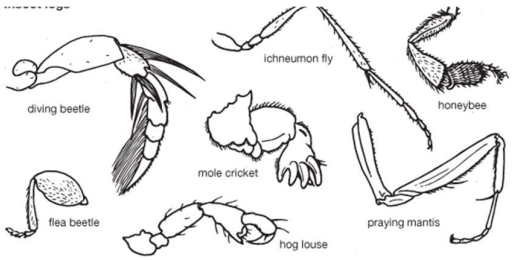
• Thoracic legs are also called the true legs, which are typically jointed and sclerotized.

• Abdominal legs are called prolegs. These are unjointed, short, fleshy with a flat surface at the bottom called planta. A number of hooks like structures called crochets are seen arranged in circular or semi cuticular form on the surface of the plants. In sawflies of Hymenoptera, the larvae have 3 pairs of true legs in thorax, and 6 or >6 pairs of prolegs in abdomen. This is the unique feature of sawfly larva, but these prolegs do not bear crochets, unlike lepidopteran larva.



Structure of typical insect leg





Modifications of insect leg

Activities:

1. Collect different insects from the field
2. Observe the legs of the insect and draw their diagram

PRACTICAL NO. 8

MALE GENITALIA OF INSECT

Objective: To study the external male genitalia of insect

The basic genital elements are derived from a pair of primary phallic lobes which are present in the ventral surface of segment nine of the embryo. These phallic lobes devide to form an inner pair of mesomeres and outer parameres, collectively known as the phallomeres. The mesomeres unite to form the aedeagus, the intromittent organ. The inner wall of the aedeagus, which is continnous with the ejaculatory duct is called the endophallus, and the opening of the duct at the tip of the aedeagus is the phallotreme. The gonopore is at the outer end of the ejaculatory duct where it joins the endophallus and hence is internal. In many insects the endophallic duct is eversible and so the gonophore assumes a terminal position during copulation. The parameres develop into claspers, which are very variable in form. In many insects

these basic structures are accompained by secondary structures on segments eight, nine and ten.

Modifications

i. In collembola and diplura there is no intromittent organ aedeagus.

ii. In thysanura terminal segments are similar to those in females, and sperm is not transferred directly to the female.

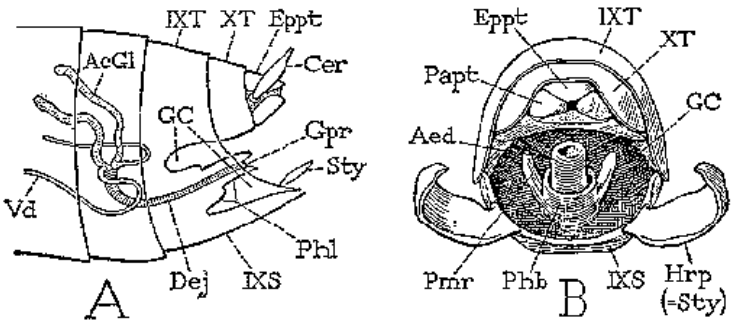
iii. In ephemeroptera and dermaptera paired penes are present.

iv. Claspers is derived from parameres and cerci in dermaptera and orthoptera or from parapraoct in damselflies.

v. In plecoptera there is no clasper.

vi. In culicidae, the aedeagus lies above the anus instead of below, as a result of 180 rotation of segment eight and behind soon after eclosion.

vii. In odonata intromittent organs are present in segment two and three. Appendages which are used to clasp the female are present on segment 10, but the genetal apparatus on segment nine is rudimentary.



Basic structure of male genetalia of pterygote insect

Activities: Draw a neat labelled diagram of male genitalia of insect.

PRACTICAL NO. 9

FEMALE GENITLIA OF INSECT

Objective: To study female genitalia of insect

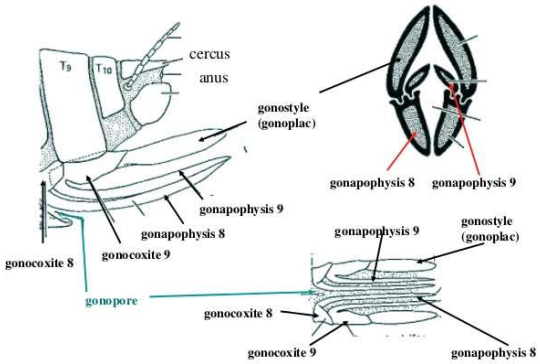
Female genetalia (the ovipositor): The gonopore of the female insect is usually situated on or behind the eigth or ninth abdominal segment, but in may flies and earwigs the gonopore is behind segment seven. In many orders there are no special structures associated with oviposition, although terminal abdominal segments are long and telescopic forming a type of ovipositor. Such structures are formed in lepidoptera, coleoptera and diptera. In house fly the telescopic section is formed from segments six to nine, when not in use it is telescoped within segment five. In tephritids the tip of the abdomen is hardened and forms a sharp point, which helps the fruit flies to insert its eggs into the fruit tissues. Basic forms of ovipositor

Thysanura: At the base of the ovipositor on each side are the coxae of segment eight and nine, known as first and second gonocoxae (first and second valvifers) and articulating with each of them is a slender process which curves posteriorly, known as first and second gonapophyses (valvulae) and together they form a shaft of the ovipositor. The second gonapophyses of the two sides are united, so that the shaft is made up of three elements fitting together to form a tube down which the egg passes. At the base of the

ovipositor there is a small scletite, gogangulum attached to the base of the first gonapophysis and articulate with second gonocoxa and the tergum of segment nine.

Orthoptera: An additional process is present in the second gonocoxa, known as gonoplac (third valvulae). It may or may not be a separate sclerite and may form a sheath round the gonapophyses. Gonoplac are well developed in orthoptera, where they form the dorsal valves of the ovipositor with the second gonapophyses enclosed within the shaft in tettigoniids or reduced as in gryllids. In orthoptera the gonangulum is fused with the first gonocoxa

Hymenoptera: The first gonocoxae is absent and second gonapophyses are united. The second gonapophyses slide on the first by a tongue and groove mechanism. In symphyta and parasitic groups the ovipositor retains its original function, but in aculeate it forms the sting. Here the eggs instead of passing down the shaft of ovipositor are ejected from the opening of the genital chamber at its base. In honey bees, the first gonapophyses are known as lancet and the fused second gonapophyses as the stylet. This forms an inverted trough, which is enlarged into a basal bulb into which the reservoir of the poison gland discharges.



Generalized female genitalia

Activities:

1. Dissect and observe the female genitalia under microscope
2. Draw the female genital organ of orthoptera order.

PRACTICAL NO. 10

PREPARATION OF PERMANENT MOUNTS OF TAXONOMICALLY IMPORTANT BODY PARTS OF INSECTS

Objective: To prepare permanent mounts of different appendages of insects body

Small soft-bodied insects are difficult to pinned as they are too small and structures like 'Genitalia' are mounted on microscope slides. Specimens need to be mounted on microscope slides are usually killed and preserved initially in fluids. The procedure followed in mounting a specimen on a microscope slide will vary depending on the type of mounting medium used. Preservation of specimens on microscope slides may be either for temporary or permanent use.

1. Temporary slide preparation: When the freshly collected and killed insects or the specimens preserved in fluids are to be mounted and studied instantaneously slides are prepared temporarily. They are prepared by placing the specimen on the slide with one or two drops of Glycerin and covering it with a cover slip. Such slides are durable for few hours and cannot be used as a permanent record.

2. Permanent slide preparation: Commonly used mounting media for permanent slide preparation are Canada balsam, Gum Arabic or Diaphane. Specimens mounted in balsam must be dehydrated before they are put into the balsam. Whereas the specimens to be mounted in gum Arabic or Diaphane need not be hydrated. The various steps involved in permanent slide preparation in general are as follows:

a. Dry specimens must be softened in 70% alcohol for half an hour

b. Dark coloured or thick bodied specimens must be cleaned in 10-15% potassium hydroxide (KOH) solution by soaking or boiling for few minutes depending on the sclerotization of the specimen

c. Specimens should be dehydrated by passing through different grades of alcohol i.e. 30%, 50%, 70%, 90% and absolute alcohol (95%) successively for 10-20 minutes in each solution d. If necessary the specimens should be stained in Acid fuchsin stain (Acid fuchsin 0.5 g + 10% Hydrochloric acid 250 ml + Distilled water 300ml) for 20 to 40 minutes and the excess stain should be washed with 95% alcohol

e. Specimens should be cleaned with clove oil

f. Specimens should be stored temporarily in Phenol - Xylol (equal volumes) mixture till mounting

g. Finally the specimens should be mounted in a few drops of mounting media using a cover slip without any air bubbles

h. Mounted slides must be kept horizontal in an oven or slide drier for about half an hour.

Activities: Prepare permanent mount of insect body parts (mouthparts, antenna, wings, legs, etc)

PRACTICAL NO. 11

METAMORPHOSIS OF AGRICULTURALLY IMPORTANT PESTS

Objective: To study different types of metamorphosis in insect

The young ones of insects which hatch out of the eggs are morphologically different from their parents. Before attaining the adult stage, the immature stages i.e. larvae and nymphs pass through changes in form which are collectively termed as metamorphosis. The changes are most pronounced towards the end of post embryonic development and are accompanied by physiological and biochemical changes.

Types of metamorphosis:

Insects can be grouped into two categories according to their type of post embryonic development.

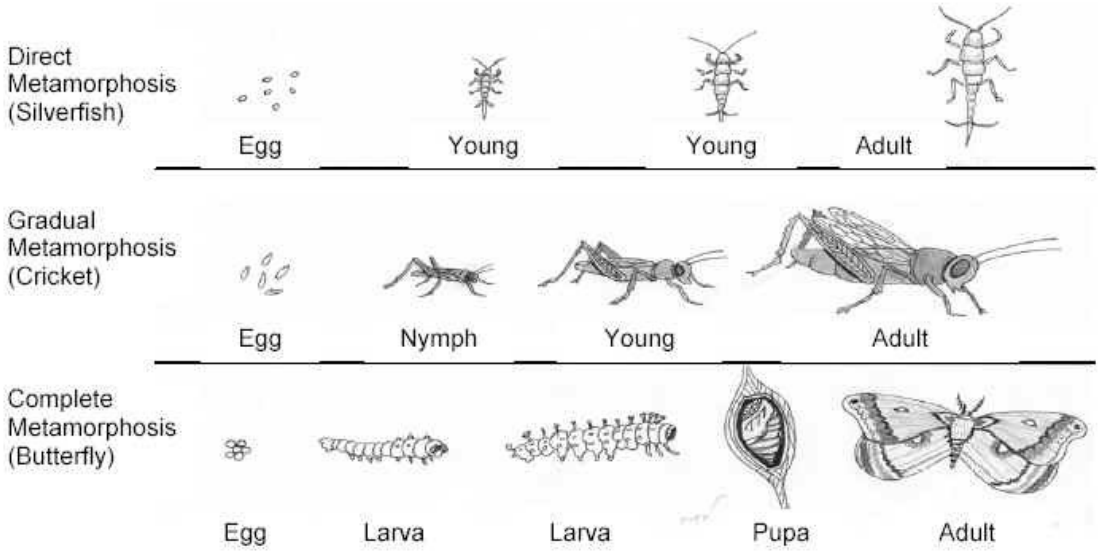
(1) Ametabolous/Ametabolic insects (No metamorphosis): These insects do not undergo metamorphosis. The immature stages resemble to adult except for its small size and the genitalia are under developed. At each moult the larva increase in size and the genitalia develops further. These are wingless throughout their life. E.g. Silver fish, spring tails.

(2) Metabolous/Metabolic insects: They undergo metamorphosis from egg to adult stage. The growing or immature stage is known as nymph or larva. They pass through three or four distinct stages. The metabolous insects are divided into two subgroups viz., Hemimetabolous and Holometabolous insects.

(a) Hemimetabolous/Hemimetabolic insects (Incomplete/simple metamorphosis): The immature stage popularly known as nymph resembles the adult in appearance and food habits but lack of well-developed wings and genitalia and it is smaller in size. In such insects, wings develop externally. They pass through three stages viz., egg, nymph and adult e.g., bugs, grass hopper, termite, mantid, dragonfly, louse etc.

(b) Holometabolous/Holometabolic insects (Complete/complex metamorphosis): The immature stage known as larva does not resemble to their parents and there is a pupal (quiescent) stage between the last larval instar and the adult. In such insects, wings develop internally. They pass through four distinct stages viz., egg, larva, pupa and adult. The larva and adult have different habits and habitates. e.g. Ant lion, moths & butterfly, beetles, bees, wasps, fleas, house fly etc.

(c) Hypermetamorphosis: Hypermetamorphosis is a kind of complete insect metamorphosis in which the different larval instars represent two or more different forms of larva. It is a highly specialized type of holometabolous/complete metamorphosis in which a developing insects passes through two or more markedly different larval instars. As the larva molts its morphology can change from that of a campodeiform larva to scarabaeiform (grub like) or to vermiform (maggot like). Some of these instars are very active, while instars closer to final pupation become less active. It is exhibited by certain parasitoid insects, notably the beetle families Meloidae and Ripiphoridae, the fly family Acroceridae, the parasitic wasp family Eucharitidae, and the order Strepsiptera.



Activities:

1. Collect the egg masses of insect belonging to different orders.
2. Keep the egg masses along with the leaves in Petri plate, providing sufficient moisture leaves by keeping water-soaked cotton underneath.
3. After hatching count the no. of larvae hatched out and provide sufficient food for their growth and development
4. Collect some larvae at each moult to make a life cycle chart.

PRACTICAL NO. 12

DIFFERENT FORM OF EGGS IN INSECT

Objective: To study different types of insect eggs

The first stage of development in all insects is egg. Majority of insects are oviparous. Egg stage is inconspicuous, inexpensive and inactive. Yolk contained in the egg supports the embryonic development. Eggs are laid under conditions where the food is available for feeding of the future young ones. Eggs are laid either individually or in groups. The outer protective shell of the egg is called chorion. Near the anterior end of the egg, there is a small opening called micropyle which allows the sperm entry for fertilization. Chorion may have a variety of textures. Size and shape of the insect eggs vary widely.

Types of eggs:

A) Singly laid:

1) Sculptured egg: Chorion with reticulate markings and ridges e.g., Castor butterfly.

2) Elongate egg: Eggs are cigar shaped. e.g., Sorghum shoot fly.

3) Rounded egg: Eggs are either spherical or globular. e.g., Citrus butterfly

4) Nit: Egg of head louse is called nit. It is cemented to the base of the hair. There is an egg stigma at the posterior end, which assists in attachment. At the anterior end, there is an oval lid which is lifted at time of hatching.

5) Egg with float: Egg is boat shaped with a conspicuous float on either side. The lateral sides are expanded. The expansions serve as floats. e.g., *Anopheles* mosquito.

Sculptured egg

Elongate egg

Rounded egg

Nit

B) Eggs laid in groups:

1) Pedicellate eggs: Eggs are laid in silken stalks of about 1.25mm length in one groups on plants. e.g., Green lacewing fly.

2) Barrel shaped eggs: Eggs are barrel shaped. They look like miniature batteries. They are deposited in compactly arranged masses. e.g., Stink bug.

3) Ootheca (Pl. Oothecae): Eggs are deposited by cockroach in a brown bean like chitinous capsule. Each ootheca consists of a double layered wrapper protecting two parallel rows of eggs. Each ootheca has 16 eggs arranged in two rows. Oothecae are carried for several days protruding from the abdomen of female prior to oviposition in a

secluded spot. Along the top, there is a crest which has small pores which permit gaseous exchange without undue water loss. Chitinous egg case is produced out of the secretions of colleterial glands.

4) Egg pod: Grasshoppers secrete a frothy material that encases an egg mass which is deposited in the ground. The egg mass lacks a definite covering. On the top of the egg, the frothy substance hardens to form a plug which prevents the drying of eggs.

5. Egg cass: Mantids deposit their eggs on twigs in a foamy secretion called spumaline which eventually hardens to produce an egg case or ootheca. Inside the egg case, eggs are aligned in rows inside the egg chambers.

6. Egg mass: Moths lay eggs in groups in a mass of its body hairs. Anal tuft of hairs found at the end of the abdomen is mainly used for this purpose. e.g. Rice stem borer.

Female silk worm moth under captivity lays eggs on egg card. Each egg mass is called a dfl (diseases free laying).

7. Eff raft: In *Culex* mosquitoes, the eggs are laid in a compact mass consisting of 200-300 eggs called egg raft in water.

Pedicellate eggs

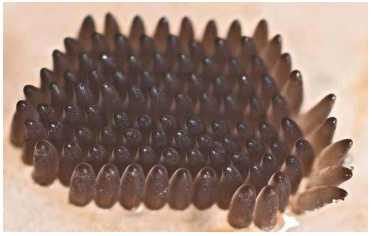
Barrel eggs

Ootheca

Egg pod

Spumaline

Eggmass



Egg raft

Activities:

1. Collect adult of various insects and observe their oviposited eggs
2. Identify the egg types and write their characters

PRACTICAL NO. 13

DIFFERENT FORM OF LARVA IN INSECT

Objective: To know different larval form of insect

Larvae of insect differ from adult insect in many ways. They have developed features which enables them to adapt a particular mode of life. This adaptation has given rise to the wide variation in the forms of larvae of insects. There are four main types of insect larvae namely:

(i) Protopod (ii) Polypod (iii) Oligopod and (iv) Apodous

i. Protopod larva: This is a primitive type of larva found in certain parasitic Hymenoptera. The egg of such species contains little yolk and the larva emerges in an early stage of embryonic development. They, survive easily because they are immersed in a highly nutritive medium during the development. Protopod larvae are typically found in the Platygasteridae e.g., *Platygaster herrickii*. They are devoid of segmentation in the abdomen and with rudimentary cephalic and thoracic appendages. The respiratory and nervous systems are undeveloped.

ii. Polypod larvae: They are also called eruciform larva e.g. larvae of moths, butterflies, sawflies and scorpion flies. Their essential features are as under:

1. Well defined segmentation
2. Abdominal limbs or prolegs, antennae and thoracic legs poorly developed
3. Generally with cylindrical body
4. Usually sluggish.

The polypod larvae are further grouped into caterpillar, semi looper and looper.

Caterpillar: They have 5 pairs of prolegs which are present on 3,4,5,6, and 10^{th} segment of the abdomen, over and above 3 pairs of thoracic legs.

e.g. Gujarat hairy caterpillar, sunhemp caterpillar, *Helicoverpa, Spodoptera*, mustard sawfly.

Semilooper: The larva which has 3 pairs of thoracic legs and 3 to 4 pairs of prolegs on 4,5,6 and 10^{th} segment of abdomen are known as semilooper. e.g. Castor semilooper

Looper The larva which has three pairs of thoracic legs and two pairs of prolegs, Which are located on 6^{th} and 10^{th} abdominal segment are known as looper. A loop is formed on abdomen when such

larva walk.

iii. Oligopod larva:

It has following features:

1. Presence of well-developed thoracic limbs
2. Abdominal limbs absent
3. Pair of abdominal cerci of caudal processes may be present
4. The head-capsule and its appendages usually well developed.

Oligopod larvae are further classified into (a) campodeiform and scarabeiform.

Their important features are as under

Campodeiform larva:

• It resembles to campodae.

• Typically, it has long more or less fusiform, somewhat depressed body which is well sclerotized.

• Head is prognathous type. (e.g., Larva of Chrysoperla)

• Thoracic legs are long and usually a pair of terminal abdominal processes present.

• Generally, these are predators.

• Differ, from those of exopterygote insects by way of the absence of compound eyes, dorsal ocelli and wing pads. e.g. Neuroptera, some Coleoptera.

Scarabaeiform larva

• It is stout sub cylindrical, 'C' shaped larva.

• Thoracic legs are shorter.

• Body is soft, fleshy and caudal processes absent.

• Lives less active life

• Such larvae are known as grub. e.g., Scarabaeidae (Rhinoceros beetle, white grub), Ptinidae and Anobidae

iv. Apodous larva: It has following features:

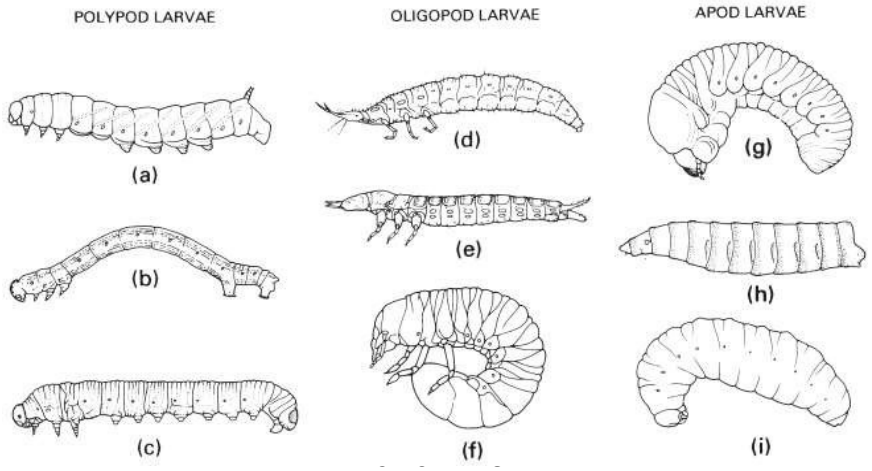
• Thoracic and abdominal appendages are totally absent.

• The head is poorly developed.

• Some may be blind and known as maggot. e.g. Larva of house fly, blue flies, [Tipulidae (Diptera)], [Curculionidae (Coleoptera)]

Activities:

1. Observe different specimens of larvae, study their characters and draw their diagram.
2. Name the form of larva given below:



PRACTICAL NO. 14

DIFFERENT FORM OF PUPA IN INSECT

Objective: To study different types of pupa in insect

It is the resting and inactive stage in all holometabolous insects. During this stage, the insect is incapable of feeding and is quiescent. During this transitional stage, the larval characters are destroyed and new adult characters are created. There are three main types of pupae.

1) Obtect: Various appendages of the pupa viz., antennae, legs and wings pads are glued to the body by a secretion produced during the last larval moult. Exposed surface of the appendages are more heavily sclerotised than those adjacent to body. Eg: moth pupa.

a) Chrysalis: It is the naked obtect pupa of butterfly. It is angular and attractively coloured. The pupa is attached to the substratum by hooks present at the terminal end of the abdomen called cremaster. The middle part of the chrysalis is attached to the substratum by two strong silken threads called gridle.

b) Tumbler: Pupa of mosquito is called tumbler. It is an object type of pupa. It is comma shaped with rudimentary appendages. Breathing trumpets are present in the cephalic end and anal paddles are present at the end of the abdomen. Abdomen is capable of jerky movements which are produced by

the anal paddles. The pupa is very active.

2) Exarate: Various appendages viz., antennae, legs and wing pads are not glued to the body. They are free. All oligopod larvae will turn into exarate pupae. The pupa is soft and pale. Eg: pupa of rhinocerous beetle.

3) Coarctate: The pupal case is barrel shaped, smooth with no apparent appendages. The last larval skin is changed into a case containing the exarate pupa. The hardened dark brown pupal case is called puparium. Eg: Fly pupa.

Obtect

Exarate

Coarctate

Activities: Collect, observe and identify the different forms of pupa of insects

PRACTICAL NO. 15

IDENTIFICATION OF IMMATURE INSECTS OF ORDER DIPTERA

Objective: To identify immature stages of dipteran insect using keys

The Diptera are commonly known as 'two-winged flies". They are one of the major insect orders and include the familiar mosquitoes, midges and house flies. The Order Diptera is divided into two suborders: the Nematocera and the Brachycera (= Muscomorpha of some authors). Keys for identifying dipteran insect are given below:

Key to families of aquatic larvae of diptera order

With modifications from Merritt and Cummins (1984)

1. Head capsule complete and external, mandibles or other mouthparts visible. Horizontally biting mouthparts, usually chewing type with opposable teeth ..... Suborder Nematocera...2

- Head capsule retracted and degenerate, mouthparts variously reduced. Vertically bitingmouthparts, usually with a pair of hooks which maybe protruding .....Suborder Brachycera ……...17

2. Head capsule complete and capable of partial or complete retraction into thoracic segment. Hind end of abdomen with distinctive respiratory disc containing paired spiracles often with fleshy lobes and anal gills. May grow quite large (up to 5 cm) ……. ..... TIPULIDAE

- Not as above 3

3. Head, thorax and first abdominal segment fused. Body divided into six segments, each division bearing a ventral sucker, and a pair of lateral gill tufts. Attached to rocks in clean fast-flowing water ..... BLEPHARICERIDAE

- Not as above 4

4. Prolegs present ……. 5

- Prolegs absent 13

5. Seven or 8 abdominal segments bearing elongate prolegs 6

- Prolegs present on no more than 3 abdominal segments 7

6. Eight pairs of eversible, crochet-tipped ventral prolegs. Body slightly compressed laterally; minute (<3mm long); delicate; antennae short and inconspicuous ..... NYMPHOMYIIDAE

- Seven pairs of stout, crochet-tipped lateral prolegs; antennae elongate and forked; body rather flat and robust..... DEUTEROPHLEBIIDAE

7. Abdomen bearing a long, slender, telescopic respiratory siphon. First three abdominal segments with a pair of ventral prolegs (may be very tiny), each bearing a single slender curved claw……..... PTYCHOPTERIDAE

- Not as above 8

8. Head directed forwards 9

- Head dorso-ventrally directed 12

9. Paired crochet bearing prolegs on 1st and usually 2nd abdominal segments; posterior abdomen bearing lateral, frequently setose lobes on each side of conical anal process ……..... DIXIDAE

- Prolegs present on thorax and/or posterior abdomen 10

10. Posterior of abdomen swollen. Head well developed with a pair of labral fans and conspicuous mouth-brushes for filtering food from flowing water. Attach to the substrate using a single sucker with radially arranged hooks on the base of their abdomen. Single thoracic proleg present. Retractile gills near anus……..... SIMULIIDAE

- Not as above 11

11. Pair of prolegs present on first thoracic and last abdominal segments (the front ones may be fused giving a single appearance). Narrow, elongated segmented body – segment length less than twice segment width. Finger like anal gills may be present near posterior prolegs. Terminal abdominal segment bears paired procerci, each with a tuft of setae which may be very long ……..….CHIRONOMIDAE

- Three pairs of elongate processes or filaments on the abdomen. A pair of anal prolegs with terminal claws present on ninth abdominal segment. Posterior portion of head capsule partially enclosed by the prothorax. Spiracles located on the lateral surface of the prothorax and dorsolateral surface of the 8th abdominal segment ……. ..... TANYDERIDAE

12. Prothorax with pair of short respiratory tubes and unpaired proleg. Abdominal segment 8 with pair of spiracles, flanked by finger-shaped processes. Last abdominal segment with unpaired proleg. Mouthparts hypognathous……..... THAUMALEIDAE

- Body segments bearing long fleshy tubercles and usually bearing setae ……..... some CERATOPOGONIDAE

13. Thoracic and abdominal segments similar, often more than twice as long as wide. Variable body shape but typically long, slender, white and worm like with no prolegs or gills. Live specimens may move in a sinuous 'S' shape. …….. ..... most CERATOPOGONIDAE

- Thoracic segments differentiated from abdominal segments; abdominal segment length often less than segment width 14

14. Three thoracic segments fused and enlarged, broader than abdominal segments. Thoracic and abdominal segments with prominent lateral fanlike tufts of long setae and/or terminal segment with an anal setal fan 15

- Elongate, usually darkly-sclerotized and setose, with conspicuous sclerotized head capsule that is not retracted; mouthparts sunk in preoral cavity. Trunk with 10 clearly demarcated segments (3 thoracic, 7 abdominal) and terminal region of two or more fused abdominal segments. Many body segments bearing dorsal sclerotized plates ……. ..... PSYCHODIDAE

15. Antennae prehensile (grasping), with long apical setae; mouth brushes absent ……..... 16

- Antennae not prehensile and with only short apical setae; prominent mouth brushes present on either side of labrum ……. ..... CULICIDAE

16. Antennae inserted close together medially and when at rest, lying laterally against the head capsule; a transverse row of a row of strong lateral spines on each side of head. Mosquito-like siphon. Terminal segment with a tuft of long setae ventrally……..……....CORETHRELLIDAE

- Antennae inserted far apart; Laterally compressed head capsule with prehensile antennae head without a transverse row of spines laterally; terminal segment with longitudinal fanlike row of setae. Nearly transparent in life (white in alcohol). Two prominent air sacs in each of abdominal segment 7 and the thorax……..... CHAOBORIDAE

17. Head capsule partially developed, with some sclerotisation visible and protruding from thorax, palps and antennae visible; mandibles usually sickle shaped. Without cephalopharyngeal skeleton ..... Orthorrhaphous Brachycera ..18

- Head capsule not developed, with no external visible sclerotisation. Antennae absent. Mandibles replaced by hooks attached to a characteristic cephalopharyngeal skeleton Tubercles, if present, restricted to posterior abdominal segment ..... Cyclorrhaphous Brachycera ..22

18. Posterior spiracles close together and concealed within terminal fissure of last segment 19

- Posterior spiracles quite widely separated, not concealed, on last segment 20

19. Terminal fissure of last segment vertical; body soft, cylindrical in form, usually white, green or some shade of brown in colour, often patterned with darker bands. The head capsule is completely retractable and includes a pair of curved mandibles. A respiratory siphon is present at the tip of the anal segment. Locomotion is achieved through a number of pseudopods which may be considerably extended in species that occur in fast-flowing streams …….....TABANIDAE

- Terminal fissure of last segment horizontal; head capsule complete, strongly sclerotized and nonretractile. Body flat with a strongly sclerotized head capsule, 3 thoracic and 8 abdominal body segments. The cuticle has a rough, honeycomb or mosaic appearance originating from calcium carbonate excretions. Tapering posterior end bearing an apical coronet of plumose hydrofuge hairs. ……..... STRATIOMYIDAE

20. First seven abdominal segments each bear a ventral pair of prolegs, and slender dorsal and ventral finger like projections. Apex of abdomen with one proleg and two long, hairy 'tails'. ..... ATHERICIDAE

- Larva not flattened, without lateral tubercles on abdominal segments 21

21. Anal segment with a single median projection below the posterior spiracles; if aquatic larvae than anal segment with several finger-like lobes and body with pseudopods or welts…… EMPIDIDAE

- Anal segment usually with 4 lobes, ventral pair the larger; sometimes 2 ventral lobes ..... DOLICHOPODIDAE

22. Posterior spiracular plates fused or very close together, usually on tip of telescopic respiratory tube 23

- Posterior spiracular plates always distinctly separated whether situated on a telescopic respiratory tube or not 24

23. Posterior spiracles narrowly separated on apex of long retractile breathing tube. Each spiracular plate with three oval spiracles and bordered by four branching hairs. Creeping ventral welts. Anterior spiracles arising on long tubular, retractile stalk, or with openings on a branched stalk. Cephalopharyngeal skeleton with well-developed mouth hooks. ……CANACIDAE

- Posterior spiracles fused on apex of long retractile breathing tube. Anterior spiracles, if present, borne on short to long tubular stalk. Cephalopharyngeal skeleton of aquatic larvae with a ribbed filter chamber instead of mouth hooks ..... SYRPHIDAE

24. Posterior spiracles with openings arranged in 2 pairs placed one behind the other; body often dorsoventrally flattened and bearing a series of spicules or tubercles. Anterior spiracles simple, each with one or more openings arranged on short projection …….....PHORIDAE

- Anterior spiracles either absent or bearing 2 or more short or branched papillae posterior spiracles with openings usually arranged in parallel or radiating pattern 25

25. Cephalopharyngeal skeleton with a sclerotized ventral arch connecting the mouth hooks on each side, its anterior margin usually toothed. Body segments often extensively covered with short, fine hairs; posterior segment often somewhat tapered. Paired posterior spiracles at apices of branches arising from a single base on the last segment. Thoracic segments usually more elongate than the abdominal ones……..……..... SCIOMYZIDAE

- Cephalopharyngeal skeleton lacking sclerotized ventral arch linking the mouth hooks. If body covered in short fine hairs, then respiratory siphon present, or each posterior spiracle sited on short tubular projection 27

26. Posterior spiracles recessed in a deep cavity; the three spiracular slits inclined in an almost vertical position; inhabit phytotelmata .....SARCOPHAGIDAE

- Posterior spiracles not located in a deep cavity but are well exposed terminally; one or more of the spiracular slits nearly horizontal 27

27. Posterior abdominal segment somewhat tapered, sometimes ending in a retractile respiratory tube; integument of posterior abdominal segments covered with setae or spinules, or with setaceous (setae-bearing) tubercles on some segments. Posterior spiracles may be extended on spines or at the apices of branches diverging from a common base. Both thoracic and abdominal segments rather short ..... EPHYDRIDAE

- Posterior abdominal segment rather truncate (cut off squarely) and/or integument with setae only on intersegmental areas 28

28. Typical maggots, tapered anteriorly and bluntly rounded posteriorly. Paired posterior spiracles flush with the surface of the last segment (rather than on any tubular extension). Posterior abdominal segment lacking tubercles other than those bearing spiracles. Cephalopharyngeal skeleton present; antennae small or absent; palps small or

absent, accessory oral sclerite present below mouth hooks Prothoracic spiracles, if present, fan-shaped and usually with fewer than 10 papillae. Often with ventral, creeping welts or several pairs of false legs (parapods). Long anal spiracular processes may be present. ……..... MUSCIDAE

- Posterior abdominal segment often with several pairs of tubercles surrounding spiracles; prothoracic spiracle a sievelike plate, or with many papillae arranged in a two-horned fan; accessory oral sclerite absent. Usually with ventral creeping welts. ……..…SCATHOPHAGIDAE

Activities: Prepare a key for the immature insect of dipteran order

PRACTICAL NO. 16

IDENTIFICATION OF IMMATURE INSECTS OF ORDER LEPIDOPTERA

Objective: To identify the immature insects of Lepidopteran order

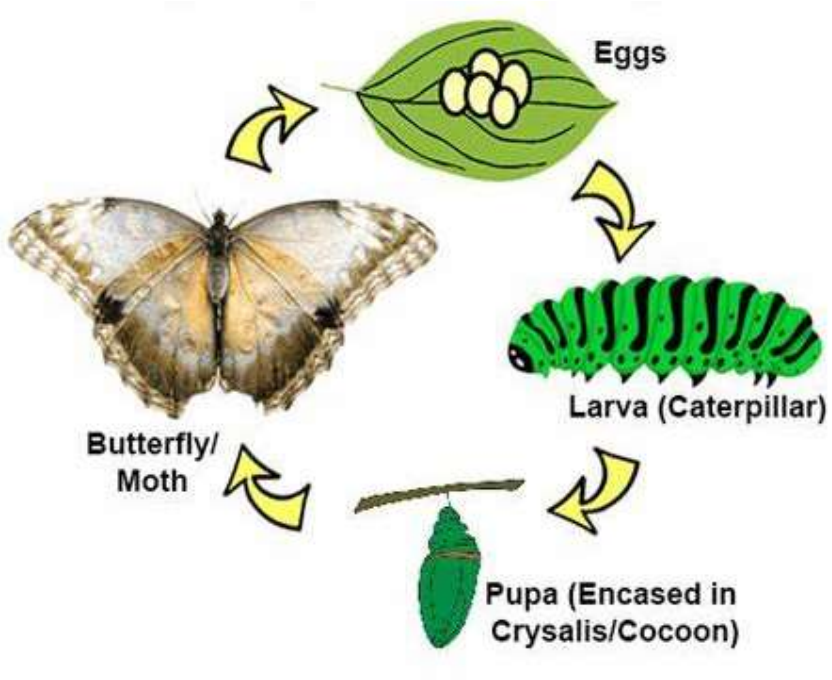
Lepidopteran insect follows complete morphosis. It comprises of egg, larva, pupa and adult. The immature stages are egg, larva and pupa.

Egg: Females may lay eggs singly or in clusters, depending on the species. Most species attach their eggs to the vegetation that will serve as the foodplant for the caterpillar. Some species, such as Orgyia antiqua, will deposit eggs on the silk surrounding the pupal skin. Other species scatter eggs on the soil surface. Egg production ranges from fewer than 100 eggs to more than 1,000 eggs per female.

Caterpillar (Larva): Caterpillars are the active, feeding, immature stage of moths and butterflies. With few exceptions, caterpillars are herbivorous. Few species of caterpillars are predaceous, feeding on animals. Most caterpillars feed on foliage, but some feed on roots, seeds and flowers, and within branches and woody stems. Caterpillars of many species are monophagous or foodplant specialists, meaning they have restricted ranges of plants upon which they can feed. Specialist species may feed either on only one plant species, on only a few related plant species, or on many species within one genus of plant. Many caterpillars are polyphagous, or generalist feeders. That is, the caterpillar can feed upon a wide range of plant species, typically covering five or six plant families, and still develop into a normal-sized adult in the usual period of time. While caterpillars might be less obvious at first glance, they can be very abundant on certain plants at certain times of the year. Within a given environment caterpillars can be found in a variety of habitats and microhabitats. In general, they may be aquatic or terrestrial. They can be found in fruits, roots and stems as borers or miners; in foliage as miners; on the surface of foliage as skeletonizers or chewers; in galls; or in the nests of other insects, such as ants and bees. Caterpillars develop in the egg and then emerge through the eggshell, which they sometimes eat. They increase in size each time they molt or shed their skins. The period between molts is termed an instar, and typically a caterpillar passes through five instars as it eats and grows In certain species a caterpillar that will develop into an adult female may develop through an additional instar and thus grow bigger than the male. However, based on external morphology, it is usually very difficult to distinguish between the sexes prior to pupation. Most caterpillars feed and develop as solitary individuals, but a few species aggregate. Some aggregating caterpillars construct nests. Caterpillar growth rates are strongly influenced by temperature and the nutritional quality of foodplants. Generally, the cooler the temperature, the slower the growth rate. The nutritional value of vegetation depends on its protein (nitrogen), water, and allelochemical content. Most plants contain between 1% and 7% nitrogen by weight, and the higher the content, the more nutritious it is. The same holds for water content. The closer water content is to the higher end of the plant's normal range, the more nutritious it is. Allelochemicals are plant-derived chemicals—terpenes, alkaloids, phenolics, and various proteins—that can stimulate or deter feeding. Some are toxic to caterpillars and some are not. Some that are not toxic to caterpillars, are toxic to one or more of their predators. In turn, some unaffected

caterpillars have developed mechanisms whereby they store toxins as a defense against their predators. Many of the poisonous caterpillars are aposematic, meaning they are brightly colored, with the colors serving to warn away would-be predators.

Pupa: Metamorphosis occurs inside the pupa. A butterfly pupa is called a "chrysalis." A moth pupa, called a "cocoon," may be covered in silk, or naked, and can be encased in rolled foliage or in the soil. Once a caterpillar has attained a critical size, it changes behavior and stops feeding and begins searching for or creating a site to pupate. Pupation can be quick, lasting 2 to 3 weeks, or prolonged, lasting more than one year. The pupa is the overwintering life stage in many species. Typically, overwintering pupae are in diapause, a state within which development of the adult is arrested or slowed down to a low rate. The adult will not mature and emerge from a pupa in diapause unless the pupa is first exposed to a period of cold, followed by a period of increased warmth.



Life cycle of lepidopteran insect

Activities:

1. Collect the immature stages of lepidopteran insect from the field.
2. Prepare keys to identify immature stages of lepidopteran insect

PRACTICAL NO. 17

IDENTIFICATION OF IMMATURE INSECTS OF ORDER HYMENOPTERA

Objective: To identify immature stages of Hymenopteran order

Hymenoptera are holometabolous, their life cycle consists of four phases: egg, multiple instars, pupa, and adult. "Complete metamorphosis" is the common term for this life cycle. Immature Hymenoptera look very different from adults. Most resemble grubs or maggots, but some, such as sawfly larvae, look very similar to caterpillars. Generally immature hymenoptera are not encountered because many are very small internal parasites of other insects, or protected by adults (social wasps, bees, and ants) and therefore left alone.

Types of Hymenoptera

Hymenoptera can be divided into four informal groups: sawflies and horntails, wasps, bees, and ants.

Sawflies and Horntails: The immatures of the sawflies and horntails look very similar to caterpillars and are generally foliage feeders (see Sawfly photo, above), but some feed internally on wood. The females have a well-developed ovipositor used for inserting the eggs into the host plant, thus the common names sawflies and horntails. All members of this group lack venom glands and cannot sting.

Wasps: The "wasps" are a very large group of about 55 families mostly composed of species that are small and parasitic on other arthropods. Only a small portion has venom glands and can sting. Immatures are reduced and grub-like, generally without legs or eyes. They grow within the body of a host or in the case of non-parasitic wasps, like mud daubers and paper wasps, are fed insect and spider prey by their parents.

Bees: Queen deposits egg at the base of cell and fastens with mucilaginous secretion. After 3 days egg hatches and workers provide pearly white food in which “C” shaped larva floats. Cell is sealed when larva is fully grown. In the sealed cell it turns into pupa from which adult emerges. Larva sheds skin five times during development. The sealed cells containing worker and drone brood and honey can be differentiated on the basis of appearance adult.

Egg: Shaped: Sausage-shaped poppy seeds. Egg size varies from 1 to 1.5 x 0.5 mm. Each egg has a small opening at the broad end of the egg, the micropyle, that allows for passage of sperm. Vertical on the cell bottom, attached by one end, then oblique, and become horizontal on the third day. Hatching takes place three days after egg laying.

Larva: Upon hatching, the larva is almost microscopic, resembling a small, white, curved, segmented worm lacking legs and eyes. For the first 2-3 days, all larvae are fed a diet of royal jelly. Beginning the third day, worker larvae are fed honey, pollen and water, while the larvae destined to become queens continue to receive royal jelly throughout their larval lives. Molts five times during its larval stage. Larval weight increases 5 1/2x during the first day, 1500x in six days

- 5.5 days for queens (fertile females),
- 6 days for workers (sterile females), and
- 6.5 days for drones (fertile males)

Pupa: The pupal stage is a stage of massive reorganization of tissues. Organs undergo a complete reorganization, while body changes from the wormlike larval body shape to the adult body shape with three distinct body regions. Pupation periods vary:

• queens require up to 7.5 days,

• workers require 12 days

• drones require14.5 days

Ants (Formicidae): Ants are easily recognized by their geniculate (elbowed) antenna and the one or two nodes between their thorax and gaster. All ants are eusocial, the most derived form of social behavior, where there is an overlap of generations, division of labor, and older individuals help to raise younger individuals. Ants are incredibly important in ecosystems and provide an enormous number of ecological services such as predation of insects, cleanup of dead plant and animal matter, and addition of nutrients to the soil

Activities:

1. Collect immature stages of hymenopteran insect
2. Identify the immature stages of hymenopteran insect using keys

PRACTICAL NO. 18

IDENTIFICATION OF IMMATURE INSECTS OF ORDER COLEOPTERA

Objective: To identify immature stage of coleoptera insect using keys

Any member of the insect order Coleoptera, consisting of the beetles and weevils. It is the largest order of insects, representing about 40 percent of the known insect species. Among the over 360,000 species of Coleoptera are many of the largest and most conspicuous insects, some of which also have brilliant metallic colours, showy patterns, or striking form. They undergo complete metamorphosis. There are four different life stages-egg, grub, pupa and adult. The immature stages comprise of egg, grub and pupa.

Eggs: Eggs vary in form, may be laid singly or in groups, and usually are laid at a site that allows proper development of the larva—on a leaf of a host plant (leaf-eating species), in bark, or in tree trunks (wood borers). Eggs also may be laid near roots, in flowers, in fruits, in tree injuries, on water plants, or under rocks.

Larvae: There are several types of coleopteran larvae. Carabid larvae have a tapering, flattened, smooth body, as do those of staphylinids (rove beetles) and silphids (carrion beetles); larvae of the Dytiscidae (diving beetles), although somewhat similar to those of carabids, have a lobed air float at the end. Larvae of click beetles (Elateridae) are cylindrical or flat and slender and have a hard surface. Some click beetle larvae, called wireworms, feed on newly planted seeds and roots of plant crops (e.g., maize, cotton, potatoes); others feed in deadwood or on wood-boring beetle larvae (Cerambycidae). Larvae of Buprestidae (metallic wood borers), which are soft-bodied and slender, bore under the bark of trees or burrow beneath the surface of leaves.

Larva of the seven-spotted ladybird beetle

Dermestid larvae, somewhat tapering and cylindrical, have whorls of short bristles and some longer ones and resemble hedgehogs or porcupines. Coccinellid larvae—flattened, broad in the middle, and tapering at the back—sometimes have a few low projections (tubercles) bearing short hairs and are often strikingly coloured with red or yellow and black. Larvae of the plant-feeding epilachnas often are yellow with black bristles. Scarabaeid larvae are soft-bodied, thick, strongly C-shaped, and somewhat flattened beneath and round above. Cetonine larvae, similar to those of geotrupids and lucanids, are often short, less C-shaped than most scarabaeids, hairy, active, and capable of locomotion on their backs through movement of body segments. Passalid larvae, white and slender, are found with their parents. Chrysomelid larvae are short, are flattish or fat, and sometimes have lobes at the sides or

appendages at the hind end. Cerambycid larvae are long and slender, with swellings at the sides of the segments. They are pale, almost hairless, and fairly soft; they have either minute legs or none at all; and the eyes are poorly developed. Weevil larvae, usually white and soft, are fatter in the abdominal region than at the head end. The head capsule may be hardened, be brown in colour, and have strong mandibles.

Some beetles undergo hyper metamorphosis, in which they have different larval types in different instars (the stages between molts). The early larval stages usually are active, and the later stages are parasitic on other organisms. The active young larvae of most Meloidae (blister beetles), called triungulins, for example, hatch from eggs laid on flowers, become attached to bees visiting the flowers, and thus are carried to a bee nest, where they become parasitic on bee larvae.

Pupae: Pupae of beetles usually have a form similar to that of the adult except that the elytra are represented by pads on the exterior of the body; the colour, generally white, is sometimes pale brown or patterned. As the time for emergence of the adult approaches, the pupa may darken, especially the mandibles and eyes. After emerging from the pupal skin, the adult rapidly assumes its final adult form and coloration, although metallic colours may take some days to develop their final appearance.

Activities:

1. Collect immature stages of coleopteran insect
2. Identify the immature stages of coleopteran insect using keys