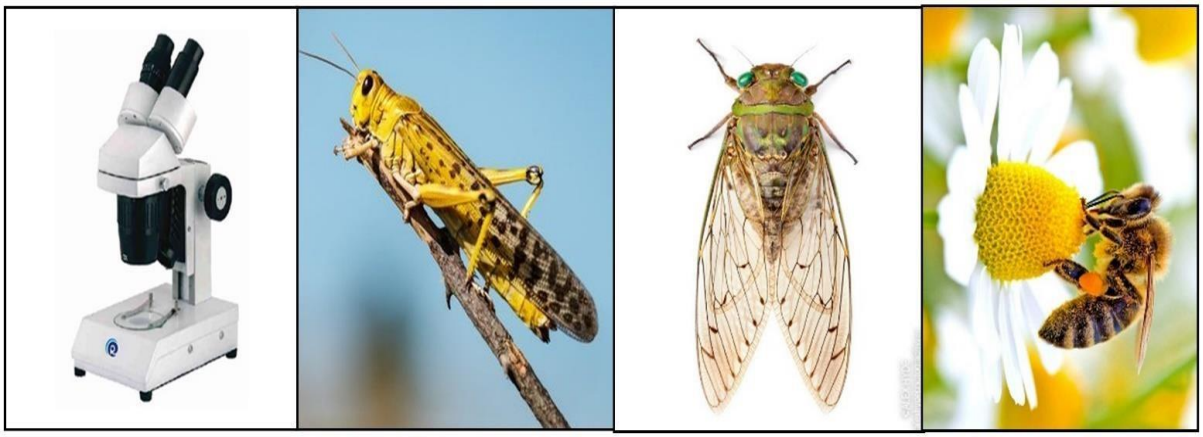
AmbujaNeotia

THE NEOTIA UNIVERSITY

ज्ञानम् आत्म प्रदीपाय

Practical Manual
Fundamentals of Entomology
(CC-AGP 214)



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PREFACE

The practical manual for the B. Sc (Agriculture) course "Fundamentals of Entomology" has been compiled following the prescribed syllabus of the revised ICAR Fifth Dean Committee. The manual would provide basic knowledge about the morphology, anatomy and taxonomy of insects to the undergraduate students of Agriculture. We are confident that this practical manual would be helpful as a handy reference to understand the basic principles and methodology of the experiments. It is our prerogative to thank Prof. Swapan Kumar Mandal, former-Head and Professor, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur and Visiting Professor, School of Agriculture and Allied Sciences, The Neotia University (TNU) for his valuable support and guidance during the preparation of this manual.

PRASUN KARMAKAR

KOUSHIK SEN

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PRACTICAL 1: METHODS OF COLLECTION AND PRESERVATION OF INSECTS

Objective:

1. To get acquainted with different methods of insect collection and preservation

2. To collect and preserve different groups of insects for morphological and taxonomic studies

Importance:

1. To preserve insects for future morphological and taxonomic studies, demonstration etc.

2. To understand the diversity of the class Insecta including their habit & habitat.

Procedure:

The process of insect collection and preservation involves several steps like collection, killing, preservation, labelling and display.

Location of Insects:

Insects are ubiquitous and diverse in nature. They can be collected from diverse natural habitats such as living plants, soil, water, decomposed organic matter, stored grains and their products, house hold goods (books, clothes, furniture etc.), animals and birds.

Methods of Collection: Insects can be collected in various ways:

i) **Hand picking**: Sedentary or slow-moving insects are generally collected using a fine camel hair brush or blunt forceps.

ii) **Knockdown:** Camouflaged insects on trees are collected by beating plant foliage with a stick. A sheet or fine net is generally spread under the tree. The insects dislodged or knocked down on the sheet or net are collected immediately.

iii) **Netting:** Aerial nets are used for collection of flying insects like moths and butterflies, dragonflies, bees, wasps, flies etc.; sweep nets are swung through the vegetation to collect insects present on upper region of plants; aquatic nets is effective for collection of aquatic insects.

iv) **Collection with aspirators:** Small agile insects like hoppers, whiteflies, beetles etc. are collected.

v) **Trapping:** Different types of traps that are in use include: a) light traps for phototropic insects, b) Water pan traps for aphids, whiteflies, hoppers etc., c) bait

traps for flies, d) pheromone traps for male moths, weevils etc., e) yellow sticky traps for aphids and whiteflies; f) suction traps for small insects like, white flies, aphids etc.) pit fall trapsfor collection of insects moving above the ground level.

vi) **Berlese funnel**: It is used to collect small insects in soil, leaf litters etc.

Killing of Insects: Once insects are collected, they must be killed immediately and stored in bottles with killing agents like potassium cyanide (KCN), ethyl acetate or chloroform; until they are mounted or preserved permanently. The killing bottles can be made using a wide mouth, strong glass bottle with well fitted lid by placing a layer of cotton (soaked in killing agent) at the bottom and then one or two layers of filter/ blotting paper over it.

Please note: Potassium cyanide (KCN) is highly poisonous and therefore, should be handled with care.

Preservation: The killed specimens are preserved either wet or dry.

Wet Preservation: Minute and soft bodied insects, and immature forms are preserved and stored in liquids like 70% ethyl alcohol and 4% formalin. However, other preservatives such as Pampel's fluid, Kahle's fluid, etc. may also be used. When small insects are stored in ethyl alcohol, addition of a few drops of glycerin may be helpful. The insectlarva often defecates if collected directly in the liquid preservative, thereby, making the preservative turbid. In such cases, the fluid needs to be changed after the death of the larvae.

Pampel's Fluid: 95% ethanol — 750 ml, 40% formalin — 250 ml, glacial acetic acid — 125 ml, distilled water — 1375 ml

Kahle's Fluid: Isopropyl alcohol (99%) — 15 parts, 40% formalin — 6 parts, glacial acetic acid — 1 part and distilled water — 30 parts

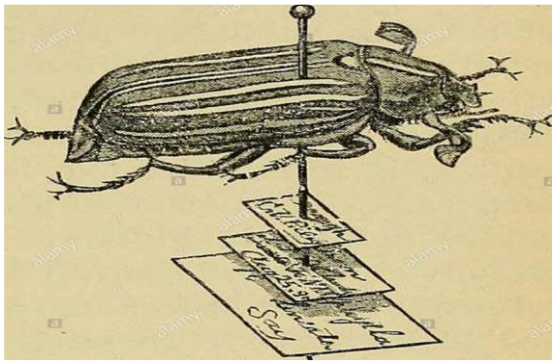
Please Note: Lepidopteran insects (moths and butterflies) should never be preserved in liquids. Preservative should be added in the vial whenever the fluid evaporates.

Dry Preservation: Lepidopteran insects are always preserved dry. The insects are pinned with suitable sized pins or mounted on cards (in triangular shape) with adhesive, after relaxing. The pinned insects are then dried at room temperature using a drying cabinet. The dried specimens are stored in insect boxes for display after labelling.

Pinning of Insects: The proper way to pin an insect depends on the type of insect that are collected. The correct way to pin various orders of insects is given below. Note that the pin is usually just slightly to the right of the midline of the insect (second segment of the thorax). The use of a pinning block will help in obtaining proper height and positioning. It is also worth mentioning that soft-bodied insects such as scales, caterpillars, mayflies, silverfish and others cannot be pinned.

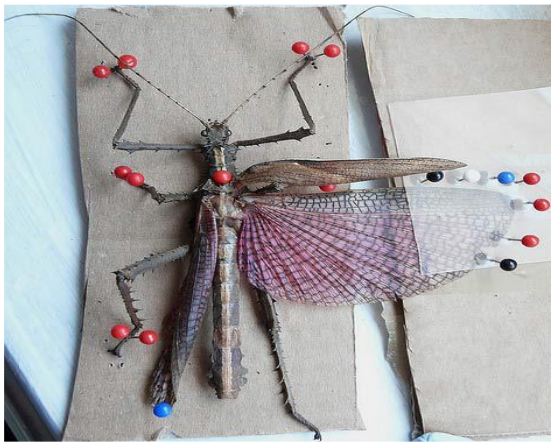
1. **Order: Odonata (Dragonflies and damselflies):** Pin through the centre of the thorax with wings displayed at both sides of the body; overlap of hind wings at 90° to the body. The front edges of the hindwings should be at right angles to the body. The forewings are set so that they are just a little in front of the hindwings.

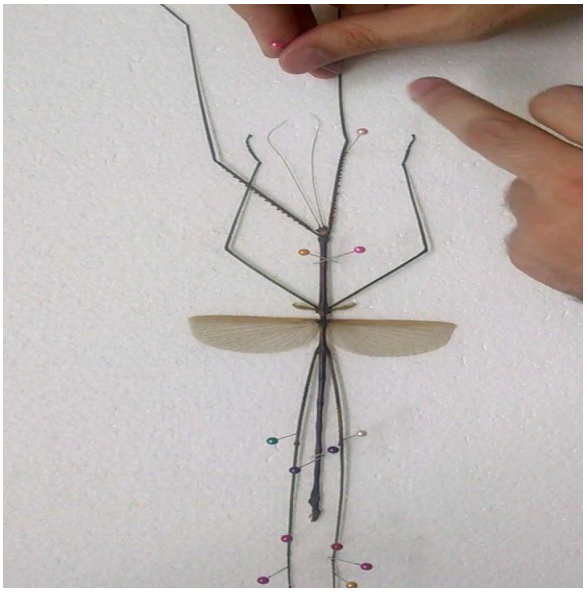
2. **Order: Coleoptera (Beetles):** Pin through right elytron (fore wing), midway on the overall body. Do not spared the wings. Leave both pairs of wings covering the abdomen and pass the pin through the right wing, instead of the centre of the thorax. The pin is inserted into the upper body surface through the front half of the right wing cover, so that the pin emerges between the bases of the second and third legs.




3. **Order: Orthoptera (Grasshoppers, crickets, katydids), Dictyoptera (Praying mantids, cockroaches), Phasmatodea (Leaf and stick insects):** Pin through the right side of the mid-line pronotum. Set only the wings on left side. The front edge of the hindwing should be at right angles to the body. The forewings are set so that they are just a little in front of the hindwings. The large hind legs of the grasshopper are set in a

jumping position, using pins to hold the legs in place. The pin is inserted through the base of the right wing. In case of stick insects, pin through the metanotum.

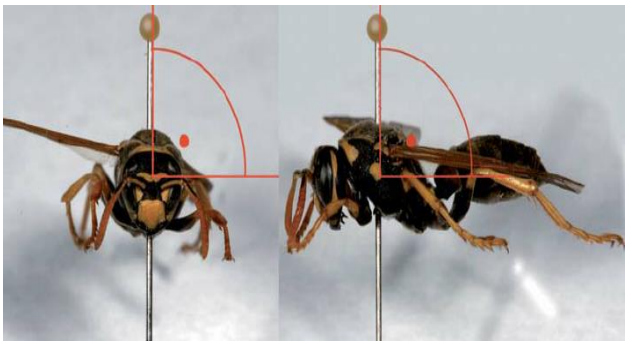


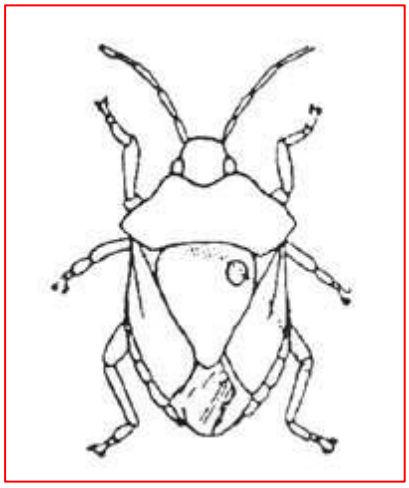
4. **Order: Diptera (True flies):** Pin through the centre of the thorax between the forewings, a little to the right of the centre. The front edges of the wings are placed at 45° to the body.

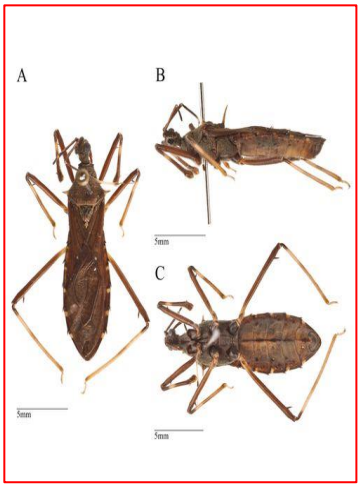
5. **Order: Hymenoptera (Bees, wasps, ants, sawflies):** Pin through the centre of the mesothorax slightly to right of the mid-line with wings displayed at both sides of the body; overlap of hind wings at 90° to the body. The fore and hindwings should be

coupled together and the front edges of the hind wings set at right angles to the body.



6. **Order: Hemiptera (True bugs):** Pin through the V shaped shield (scutellum), to the right of middle line. Do not spread wings. Leave both pairs of wings over the abdomen. Pass the pin through the centre of the scutellum, the triangular area behind the thorax.

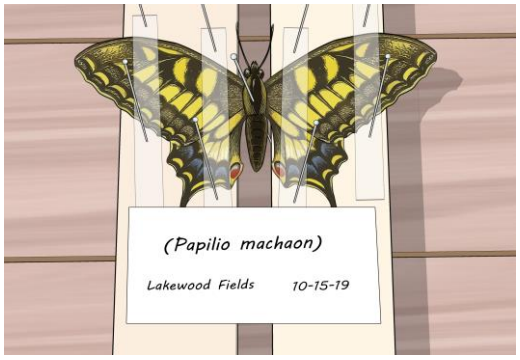


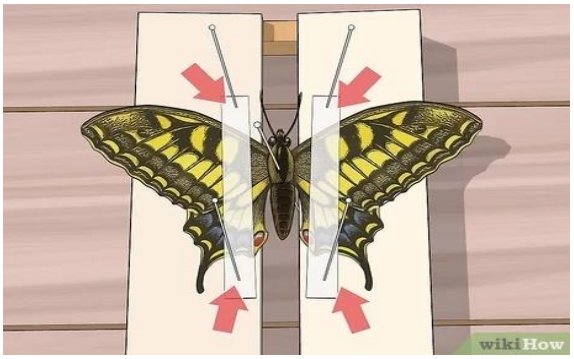


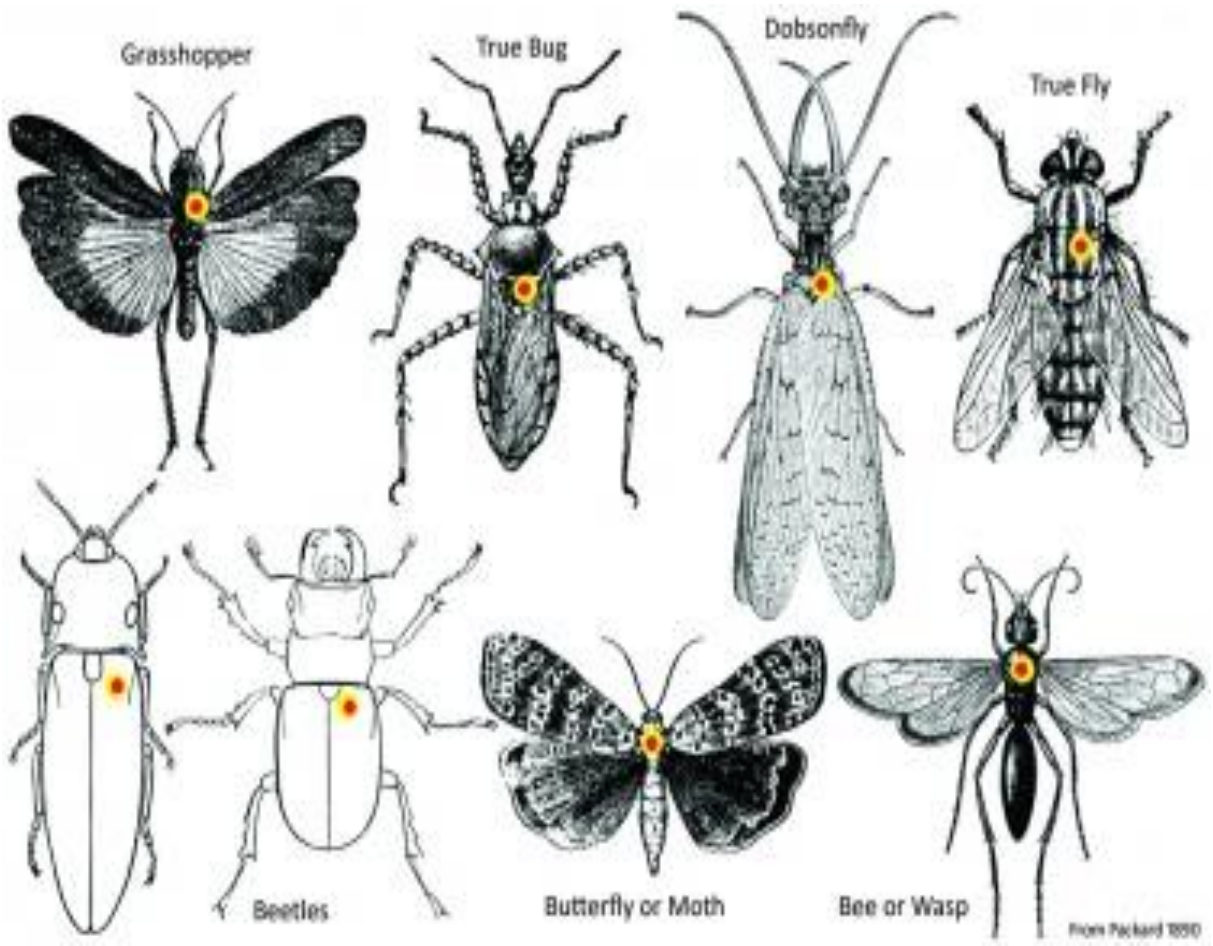
7. **Order: Neuroptera (Antlion, lacewings and dobsonflies):** Pinned through the right side of pronotum. First margin of rear wings at right angle to the body.

8. **Order: Dermaptera (Earwig):** Pinned through the right tegmen.

9. **Order: Lepidoptera (Butterflies and moths):** Pin through the centre of the thorax with wings displayed at both sides of the body; overlap of fore and hind wings at 90° to the body. The back edge of the forewing should be at right angles to the body. The front edge of the hindwing is tucked under the forewing, leaving a small 'V'. The abdomen is supported with a 'V' of pins.







The location of the red spots shows the location of the pin

Labelling and Display (Dry Preservation):

Line 1: *Common name of the host* (e.g. Weeds, Maize, Mango, Weeds near Soybean, Grasses etc.) or *insect collection method* (e.g. Light trap, Mixed collection, Sweep net etc.) First letter of the host should always be written in upper case.

Line 2: *Location of collection* (village or city name), State name in full (e.g. West Bengal).

No need to specifically write "state" after mentioning the State name.

Line 3: *Date of collection* [Date (e.g. 1-31). Month in Roman letters (e.g. I-XII). Year infour digits (e.g. 2020)]. Use only dots/full stop/period sign and not dash (-) sign.

Line 4: *Name of the collector* (Write initials followed by last name/surname) e.g. P. Karmakar, S. K. Mandal, etc. If more than one collector, give comma.

Line 5: *Project Name*, If NO information is available, just use four lines given above.

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Video link:

https://www.youtube.com/watch?v=QJhCEvxr1HY

https://www.youtube.com/watch?v=IbXeGFh7nj4

https://www.youtube.com/watch?v=Kal-kdvCUOw

EXERCISE

Draw insect collection apparatus like net, aspirator, Berlese funnel, killing bottle, setting board, insect collection box. Also draw a pinned insect.

PRACTICAL 2: STUDY OF EXTERNAL FEATURES OF GRASSHOPPER

Objective: To study the external features of an insect (Grasshopper)

Observation - The body of grasshopper is divided into three functional regions or tagmata - **head, thorax and abdomen.**

Head: It is the first anterior tagma which bears a pair of antennae, a pair of compound eyes, three dorsal ocelli and the mouthparts. Antennae are paired segmented appendages, situated between the compound eyes. Antennae are thread-like or **filiform** (longhorned grasshopper). **Compound** eyes are dorso-lateral in position on either side of head. Three simple eyes or **ocelli** are situated in between the compound eyes**.** Mouthparts are adapted for biting and chewing.

Thorax: It is the middle tagma which is associated with locomotion. It is three segmented, namely **prothorax, mesothorax and metathorax.** Each thoracic segment consists of a dorsal sclerite **(notum),** a ventral sclerite **(sternum)** and membranous **(pleuron)** on lateral side of the body. The **pronotum** (notum of prothorax) is shaddle-shaped in grasshopper. The thorax bears three pairs of segmented legs. Each leg consists of six segments namely, **coxa, trochanter, femur, tibia, tarsus and pretarsus. Pretarsus** consists of a pair of claws and a median lobe, **arolium. Hind legs** are modified for **jumping (saltatorial legs)**. Mesothorax and metathorax bears a pair of wings and these wing bearing segments are collectively termed as **pterothorax.** Fore wings are modified into **tegmina** (leathery in texture) and are protective in function. Hind wings are large and membranous and are kept folded beneath the forewings at rest.

Abdomen: It is the posterior tagma and consists of 11 segments in grasshopper. The eleventh abdominal segment has a dorsal plate **(epiproct)** and paired lateral plates **(paraprocts)**. **Tympanum** (auditory organ) is found laterally on either side of first abdominal segment. There are 8 pairs of spiracles on the lateral sides. The 8th and 9th abdominal segments bear the female genital apparatus called **ovipositor**. A pair of short, unsegmented **cerci** is present on 11^{th} abdominal segment. They are sensory in function.

Video Link:

https://www.youtube.com/watch?v=ss7WM6fmitk

https://www.youtube.com/watch?v=wfQqk03joS4

https://www.youtube.com/watch?v=xYh5Csdf7lo

DRAW A LABELLED DIAGRAM FOR EXTERNAL FEATURES OF A GRASSHOPPER

PRACTICAL 3: STUDY OF DIFFERENT TYPES OF MOUTHPARTS

A) BITING AND CHEWING TYPE OF MOUTHPARTS

Objective: To study the structure and function of biting and chewing type of insect mouthparts

Specimen: Grasshopper

Structure: This primitive type of mouthparts consists of the following parts:

Labrum (Upper Lip): It is a movable, flap like, bilobed plate which is attached to the clypeus. The labrum covers the mouth cavity from above and helps to pull the food into the mouth. Its innersurface called **labrum-epipharynx** which act as an organ of taste.

Mandibles (Upper Jaws): A pair of heavily sclerotized mandibles is provided with a sharp distalincisor tooth for cutting and a proximal molar tooth for grinding the food. The mandibles articulatewith the cranium at two points.

Maxillae (Lower Jaws): These are paired structures, which are situated below the mandibles. The **cardo** (basal sclerite) joins the maxilla to the head. The **stipes** (second sclerite) articulates with cardo. The distal end of stipes bears an outer hood-shaped lobe called **galea** and an inner toothed lobe called **lacinia**. **Palpifer** (lateral sclerite) bears five-segmented maxillary palpswhich are sensory in function. Maxillae act as auxiliary jaws and assist in holding the food for mastication.

Labium (Lower Lip): A composite structure which bounds the mouth cavity from below. It consists of three median sclerites, viz., **submentum** (basal sclerite), **mentum** (middle sclerite) and **prementum** (apical sclerite). The prementum bears laterally two small sclerites called **palpiger** bearing three-segmented **labial palps**. The prementum distally bears a pair of outer paraglossae and inner glossae, that is collectively termed as the **ligula**.

Hypopharynx: A tongue like organ, situated centrally in pre-oral cavity and attached to the innerwall of the labium. Salivary gland duct opens on the salivarium.

Video Link:

https://www.youtube.com/watch?v=_opn_gI9kNU

https://www.youtube.com/watch?v=WZMMHnSvEb8

https://www.youtube.com/watch?v=T66oe6-qYrw

DRAW LABELLED DIAGRAM FOR BITING AND CHEWING TYPE OF MOUTHPARTS

B) PIERCING AND SUCKING TYPE OF MOUTHPARTS (BUG TYPE)

Objective: To study the structure and function of piercing and sucking type of mouthparts

Specimen Studied: Cotton bug

Structure: The sucking tube (beak) in the Hemiptera is formed from the mandibles, maxillae and the labium. The **labium** forms the protective sheath that folds back during feeding. Labium carry the stylets within the groove and thereby protect them. At the base of the labium there is a small, non-segmented, triangular, dorsal flap; called **labrum.** Both mandibles and maxillae are modified into long, slender, sclerotized hair like structures, called **stylets.** The mandibles form the outer stylets that surround the inner stylets. The laciniae of the maxillae form the inner stylets with the food and salivary channels. The sucking pump is formed in the cibarium. The **maxillary stylets** are doubly-grooved on their inner faces, and when closely apposed, they form two canals viz. food canal and salivary canal, through which plant sap and saliva are conducted, respectively. Mandibular stylet fits against the maxillary stylet of that side. Both maxillary and labial palpi are absent.

Video Link:

https://www.youtube.com/watch?v=_opn_gI9kNU
https://www.youtube.com/watch?v=WZMMHnSvEb8
https://www.youtube.com/watch?v=T66oe6-qYrw

DRAW LABELLED DIAGRAM FOR PIERCING AND SUCKING TYPE OF MOUTHPARTS

C) CHEWING AND LAPPING TYPE OF MOUTHPARTS

Objective: To study the structure and function of chewing and lapping type of mouthparts

Specimen Studied: Honey bee

Structure: The **labrum** is a narrow, rectangular lobe which is attached with the clypeus. The **mandibles** are spatula-shaped used to mold the wax for comb building. The principal basal plate of maxilla is the stipes with long rod like **cardo** at its base. The laciniae are small and membranous and the galeae are enlarged and concaved on the inner surface. The maxillary palpi are reduced. In the labium, the prementum is a large sclerotized plate, having small triangular mentum at its base. The submentum is a transverse, 'V' shaped sclerite, articulating the cardo and supporting the base of the labium, called **lorum**. The glossa is greatly enlarged and ending into small circular spoon shaped lobe termed **flabellum.** The small paraglossae are membranous and clasping glossae basally. The labial palpi are long and 4-segmented.

Video Link:

https://www.youtube.com/watch?v=_opn_gI9kNU

https://www.youtube.com/watch?v=WZMMHnSvEb8

https://www.youtube.com/watch?v=T66oe6-qYrw

DRAW LABELLED DIAGRAM FOR CHEWING AND LAPPING TYPE OF MOUTHPARTS

D) SPONGING TYPE OF MOUTHPARTS

Objective: To study the structure and function of sponging type of mouthparts

Specimen Studied: Housefly

Structure: Sucking tube (proboscis) is a composite structure that includes the labrum, hypopharynx and labium. The mandibles are absent and the maxillae are represented by the maxillary palps. The tube is divisible into a basal **rostrum** or basiproboscis bearing the maxillary palps, a median flexible **haustellum** or mediproboscis and apical **labellum** or distiproboscis. The rostrum bears a pair of single segmented **maxillary palpi** at its distal end. The labellae are two- lobed broad sponging pads, equipped with **pseudotracheae** along which food passes to the oral aperture. The proboscis is grooved on its anterior surface within which lies **labrum- epipharynx** and the slender **hypopharynx** jointly forming the food channel. Salivary channel is situated in the hypopharynx. When not in use, the proboscis is withdrawn under the head.

Video Link:

https://www.youtube.com/watch?v=_opn_gI9kNU

https://www.youtube.com/watch?v=WZMMHnSvEb8

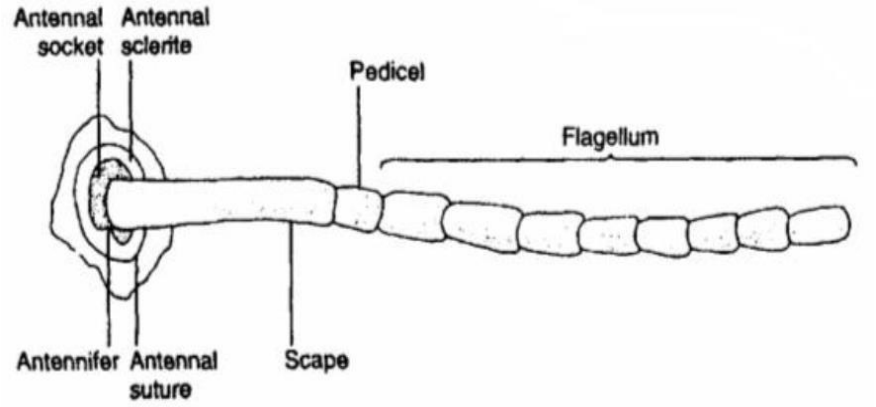
https://www.youtube.com/watch?v=T66oe6-qYrw

DRAW LABELLED DIAGRAM FOR SPONGING TYPE OF MOUTHPARTS

PRACTICAL 4: STUDY OF DIFFERENT TYPES OF ANTENNAE AND LEGS

Objective: To study the structure and different types of antennae

Structure: Antennae are paired, segmented appendages that articulate with cranium between compoundeyes in adults. The antenna is divided into **scape**, **pedicel** and **flagellum**. The scape is the first or basal segment which is inserted in the antennal socket and pivoted on a single marginal point known as **antennifer**. Pedicel is the second segment. The remaining portion, known as flagellum is composed of several **annuli** or **flagellomeres**.



Different parts of an insect antennae (Source: StudyBlue Inc.)

TYPES:

1. **Filiform (thread-like):** Antennal flagellum is threadlike or uniformly thin throughout its length. eg. grasshopper
2. **Moniliform (bead-like):** Segments are globular or spherical in shape and almost looks like astring of beads. eg. termite
3. **Setaceous (bristle-like):** Size of the segments decrease gradually and antenna tapers into a veryslender tip. eg. cockroach, dragonflies
4. **Serrate (Saw-like):** Saw-like antenna, with tooth-like extensions of the flagellomeres. eg. pulsebeetle (female)
5. **Pectinate (comb-like):** Segments of flagellum are extending on one side into long processeslike the comb. eg. Fire-coloured beetles
6. **Bipectinate (double comb-like):** Segments having long slender lateral projections on bothsides. eg. silkworm moth
7. **Clavate (club-like):** Antenna gradually clubbed towards the apex. eg. cabbage butterfly, carrionbeetle
8. **Capitate (knobbed):** Antenna abruptly clubbed at the end. eg khapra beetle

9. **Lamellate (Plate-like):** Distal annuli forms leaf-like plates. eg. ber beetle
10. **Plumose (feathery):** Antennae have a feather-like shape. eg. male mosquito
11. **Pilose (hairy):** Antenna less feathery than plumose type eg. female mosquito
12. **Geniculate (elbowed):** Antennae are hinged or bent like an elbow. eg: honey bee, weevil,ant
13. **Aristate (arista bearing):** Flagellum undivided, swollen and bears a conspicuous dorsalbristle known as arista. eg. house fly
14. **Stylate (style-like)** The terminal segment bears a style like process. eg. robber fly
15. **Flabellate (fan-like):** Basal annulus with fan-line processes. eg. male strepsipterans

Video Link:

https://www.youtube.com/watch?v=lL90Thp426g

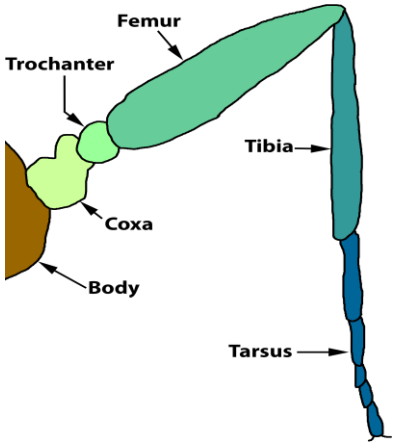
https://www.youtube.com/watch?v=JMqkbeIubss

DRAW LABELLED DIAGRAMS FOR DIFFERENT TYPES OF ANTENNAE

DRAW LABELLED DIAGRAMS FOR DIFFERENT TYPES OF ANTENNAE (CONT.)

Objective: To study the structure and function of insect legs

Structure of insect leg: The fore-legs are located on the prothorax, the mid-legs on the mesothorax, and the hind legs on the metathorax. Each leg has six major components, listed here from proximal todistal: **Coxa, Trochanter, Femur, Tibia, Tarsus** and **Pretarsus**. The tarsus is subdivided into two to five tarsomeres. Pretarsus usually consists of pair of claws; either with a lobe **(arolium)** or spine **(empodium)** between them, or paired cushion like structures **(pulvilli)** at their base.



Different parts of an insect leg (Source: Wikipedia)

TYPES OF INSECT LEGS

1. **Ambulatorial Leg (Walking):** It is the simplest form of insect legs usually adapted for walking. eg. fore and middle legs of grasshopper, all legs of ants
2. **Cursorial Leg (Running):** These legs are typically modified for running. The tarsus of such leg has a pad-like structure called plantulae. eg. legs of cockroach
3. **Saltatorial Leg (Jumping):** These legs are typically modified for jumping. These legsare characterized by an elongated femur and tibia. eg. hind legs of grasshopper
4. **Natatorial Leg (Swimming):** In aquatic insects, the tibia and tarsus bear a row of long hairs and are adapted for swimming in water. eg. hind legs of giant water bug, diving beetle
5. **Fossorial Leg (Digging):** Tibia is stout and are provided with pointed prolongations at its distal end. The tarsus is composed of 2 or 3 segments, with teeth like projections. These legs are modified for digging the ground. eg. fore legs of mole cricket
6. **Scansorial Leg (Clinging):** These legs are modified for clinging to the hairs of the host. The tibia is stout and possess a tibial thumb at its distal end. Tarsi 1-segmented and

bears a single long curved claw which fits against the tibial thumb.eg. louse

7. **Raptorial Leg (Preying):** These legs are modified for grasping the prey. The femur is thickly spinose and possess a central longitudinal groove along their lower side. Tibia narrow, blade like spinose and fits firmly into the groove of femur. The prey is held between the groove and is killed by the spinose femur and tibia. eg. fore legs of preying mantis
8. **Foragial leg (Pollen collecting):** Hind legs of worker honey bee are modified for collecting pollen. The **corbicula** (pollen basket) is formed by the rows of long curved hairs inside a shallow cavity on the outer surface of tibia. Rows of short stiff spines called **pollen comb** are present on the inner surface of an enlarged **basitarsus** (first tarsal segment). **Pollen comb** is used for brushing and collecting pollen from the body. A row of stout bristles called **pollen packer** or **pollen press** are present on the distal end of basitarsus. They are used to load pollen in the pollenbasket.

Video Link:

https://www.youtube.com/watch?v=y4puH9gUmj4

https://www.youtube.com/watch?v=gWh3xedrkSA

DRAW LABELLED DIAGRAMS FOR DIFFERENT TYPES OF INSECT LEGS

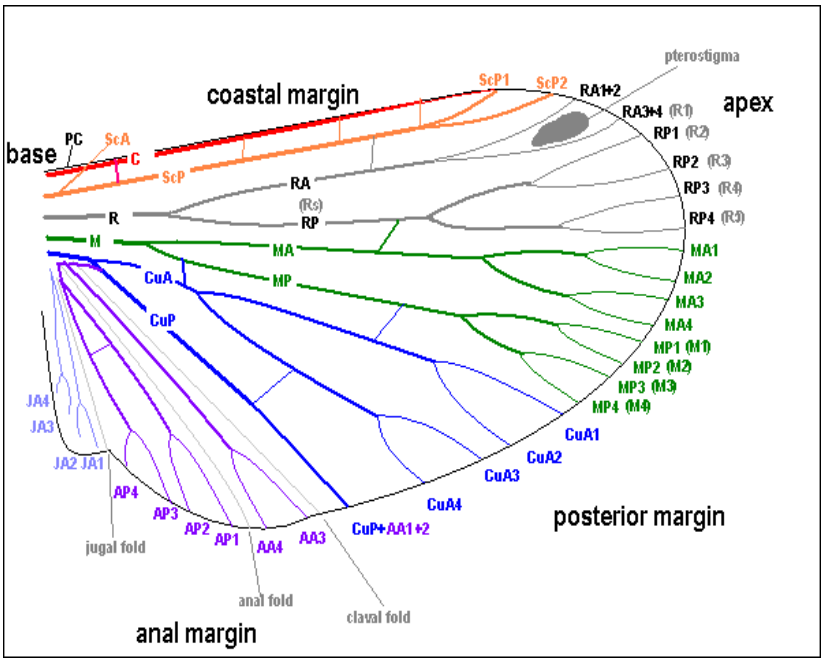
DRAW LABELLED DIAGRAMS FOR DIFFERENT TYPES OF INSECT LEGS (CONT.)

PRACTICAL 5: STUDY OF DIFFERENT TYPES OF WINGS, WING VENATION AND WING COUPLING APPARATUS

Insect wings are adult outgrowths of the insect exoskeleton that enable insects to fly. Functional wings exist only during the adult stage of an insect's life cycle. Winged insects typically have two pairs borne on the meso- and metathorax. Wings serve not only as organs of flight, but may also be adapted variously as protective covers (Coleoptera and Dermaptera), thermal collectors (Lepidoptera), gyroscopic stabilizers (Diptera), sound producers (Orthoptera), or visual cues for species recognition and sexual contact (Lepidoptera). In most cases, a characteristic network of veins runs along the wing membrane. These veins are extensions of the body's circulatory system. They are filled with hemolymph and contain a tracheal tube and a nerve. In membranous wings, the veins provide strength and reinforcement during flight. Wing shape, texture, and venation are quite distinctive among the insect taxa and therefore highly useful as aids for identification.

The margins of the wings: Insect wings have three margins, (a) the anterior or costal margin; (b) the outer or apical margin and (c) the inner or anal margin.

The angle of the wings: (a) the humeral angle at the base of the Costa; (b) the apex or angle between the costal and outer margins; and (c) the anal angle or tornus between the outerand inner margins.



Typical insect wing venation based on Comstock-Needham system (Source: Wikipedia)

MODIFICATIONS OF INSECT WINGS

Wing modifications	Order(s)
Elytra- hard, sclerotized front wings that serve asprotective covers for membranous hind wings	Coleoptera and Dermaptera
Hemelytra- front wings thickened proximally and membranous distally	Hemiptera (Heteroptera)
Tegmina- front wings thickened to form a leathery structure	Orthoptera, Dictyoptera
Halteres - Hind wing rudimentary, slender proximally and knobbed distally; serve as gyroscopic stabilizers during flight	Diptera
Pseudohalteres – Front wings are short and modified into pseudohalteres which are dumbbell shaped.	Strepsiptera
Fringed wings- wings are membranous and very narrow, butbear long bristles	Thysanoptera
Scaly wings- both wings covered with scales	Lepidoptera
Fissured or clefted wings - Forewings are longitudinally divided twice forming a fork like structure whereas hindwings are divided twice in to three arms. All the forks possess small marginal hairs. They are useful for flight.	Lepidoptera (Plume moth)

WING COUPLING

In pterygotes with two pairs of wings, the fore wings and hind wings may work independently (Odonata, Ephemeroptera and Neuroptera) or they remain coupled to one another in various ways and both of them on one side act as a unit.

Amplexiform: A linking structure is absent. Coupling is achieved by broad overlapping of adjacent margins e.g. Butterflies.

Jugate: The posterior lobe of the fore wing is a slender finger like organ termed as a jugal lobe,overlaps the anterior margin of the hind wing. eg: Mecoptera

Frenulate: In males, however, the frenular bristles are fused into a single stout structure. This is normally held by a curved process from the subcostal vein of the forewing. In female butterfliesis consist of a group of stout bristles lying beneath the extended forewing where it engages in areretinaculum formed from a patch of hairs near the cubitus.

Hamuli: A row of small hooks called hamuli is present on the costal margin of the hind wing. These hooks engage the folded posterior edge of fore wing (anal fold). eg. Hymenoptera.

Video Link:

https://www.youtube.com/watch?v=IcMzIaRs6Lg

https://www.youtube.com/watch?v=riKvlUChLEw

https://www.youtube.com/watch?v=SC2_DFJ_yHc

DRAW LABELLED DIAGRAMS FOR DIFFERENT TYPES OF INSECT WINGS

DRAW LABELLED DIAGRAMS FOR DIFFERENT TYPES OF WING COUPLING

PRACTICAL 6: TYPES OF LARVA AND PUPA

LARVA:

It is an active immature stage between the egg and pupal stage of insect exhibiting completemetamorphosis.

Types: Three main types of insect larvae namely **oligopod, polypod** and **apod**

A) Oligopod: Thoracic legs well developed. Abdominal legs absent. There are two subtypes.

1. **Campodeiform:** Body is dorso-ventrally compressed with sclerotized cuticle. Head prognathous. Thoracic legs long. A pair of terminal abdominal processes (anal cerci) are present.
2. **Scarabaeiform:** Body 'C' shaped, stout and sub-cylindrical. Head well developed. Thoracic legs short. Caudal processes absent.

B) Polypod (Eruciform): The body consists of an elongate trunk with a large sclerotised head capsule. Lateral ocelli or stemmata on either side of head. The larva possesses well defined segmentation of the body with three pairs of thoracic legs, 2-5 pairs of abdominal prolegs (3^{rd} to 6^{th} and 10^{th} abdominal segment). Bottom of proleg is called planta which bears rows or circlet of short hooked spins or crochets.

1. **Hairy caterpillar:** Body covered with dense hairs arranged in tufts
2. **Slug caterpillar:** Larva with poisonous scoli distributed all over the body
3. **Semilooper:** Prolegs rudimentary in 3^{rd} and 4^{th} abdominal segments
4. **Looper:** 2 pairs of prologs present on 6^{th} and 10^{th} abdominal segments

C) Apod or Apodous: Larvae without appendages for locomotion. There are three subtypesbased on the degree of development and sclerotization of head capsule.

1. **Eucephalous:** Larvae with well-developed head capsule with functional mandibles, maxillae, stemmata and antenna.
2. **Hemicephalous:** Head capsule reduced and can be withdrawn into thorax.
3. **Acephalous:** Head capsule absent. Mouthparts represented by a pair of curved mouth hooksand associated internal sclerites.

Video Link:

https://www.youtube.com/watch?v=S9GYc6S5qF8

https://www.youtube.com/watch?v=oAWQUKAHcuk

https://www.youtube.com/watch?v=UpFqZJJoREo

https://www.youtube.com/watch?v=3EC3BDbKBFE

DRAW LABELLED DIAGRAMS FOR TYPES OF LARVA

PUPA:

It is the resting stage and inactive stage in all holometabolous insects. Pupa is incapable of feeding and remains quiescent. During this stage, the larval characters are destroyed andnew adult characters are created.

Main types of pupa are:

1. **Obtect:** Various appendages i.e., antennae, legs and wing pads are glued to the body by a secretion produced during the last larval molt. Eg: moth pupa
2. **Exarate:** Appendages viz., antennae, legs and wing pads are not glued to the body. They are free. Eg: pupa of rhinoceros beetle
3. **Chrysalis:** It is the naked obtect pupa of butterfly. The pupa is attached to the substratum by hooks present at terminal end of abdomen called cremaster. The middle part is attached to substratum by two strong silken threads called girdler.
4. **Tumbler:** It is comma-shaped, with rudimentary appendages. Breathing trumpets are present in the cephalic end. Anal paddles are present at the end of the abdomen. Eg: pupa of mosquito
5. **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 pupalcase is called puparium. Eg: Fly pupa

Video Link:

https://www.youtube.com/watch?v=oAWQUKAHcuk

https://www.youtube.com/watch?v=UpFqZJJoREo

https://www.youtube.com/watch?v=V6pVKOeA2c0

https://www.youtube.com/watch?v=3EC3BDbKBFE

DRAW LABELLED DIAGRAMS FOR TYPES OF PUPA

PRACTICAL 7: DISSECTION OF DIGESTIVE SYSTEM IN INSECTS

Specimen studied: Cockroach

Objectives: To dissect and study the alimentary canal in cockroach

Materials Required: Cockroach, dissecting tray, pins, dissecting needles, forceps and scissors

Procedure:

1. Take a chloroformed cockroach with dorsal side facing upwards and cut off the antennae, wingsand legs leaving the coxae intact
2. Make an incision along the lateral sides using a sharp scissor starting from the posterior end ofthe abdomen to the neck
3. Pin the cockroach in the dissection tray
4. Care should be taken while pinning such that the intersegmental membranes of abdomen are not damaged
5. Insert the pins in such a way that they stand outwards
6. Pour water in the dissection tray such that the insect specimen is thoroughly submerged in water
7. Open the cut edges of the body wall using two pins and pin the body wall laterally on either side
8. Remove all the fat bodies with the help of brush and forceps and expose the alimentary canal anddisplay it on one side of the body
9. Observe the different parts of alimentary tract and label all the parts

Video Link:

https://www.youtube.com/watch?v=mi2L77FYqvQ

https://www.youtube.com/watch?v=P_jEmEfocdk

https://www.youtube.com/watch?v=N1aRRNg8kXQ

https://www.youtube.com/watch?v=gFa-XH9RHL4

https://www.youtube.com/watch?v=9CpfgeDtwCw

Observations: (Draw the diagram of dissected alimentary canal)

PRACTICAL 8: DISSECTION OF REPRODUCTIVE SYSTEM IN INSECTS

Specimen studied: Cockroach

Objectives: To dissect and study the reproductive system in male and female cockroach

Materials Required: Cockroach, dissecting tray, pins, dissecting needles, forceps and scissors

Procedure:

A) Male Reproductive System:

1. Take a chloroformed male cockroach with dorsal side facing upwards and cut on either lateralside and pin the insect in the dissection tray
2. Without disturbing the fat bodies, remove the tergal plates one by one carefully
3. Cut the alimentary tract at the oesophageal end
4. Gently pull back the alimentary tract and pin it on dissecting tray without cutting the rectal end
5. Locate the paired testes with whitish honey comb like markings, embedded in fat bodies onthe lateral side of abdomen close to the arthrodial membrane from segment 4 to 6
6. After locating testes, gently remove the alimentary canal
7. Trace vas deferens from the posterior end of testis using a fine needle
8. Insert a piece of black paper beneath the testis
9. Locate the mushroom shaped gland and conglobate gland at the posterior end of the abdomen
10. Cut and remove the distal end of ventral nerve cord to set free the conglobate gland
11. Label all the parts

Video Link:

https://www.youtube.com/watch?v=MQnAdSLNRpo
https://www.youtube.com/watch?v=lopc1CrGCX4
https://www.youtube.com/watch?v=GHsZ0AACmuU

Observations: (draw the diagram of dissected male reproductive organs)

B) Female Reproductive System:

1. Take a chloroformed female cockroach with dorsal side facing upwards and cut on eitherlateral side and pin the insect in the dissection tray
2. Without disturbing the fat bodies, remove the tergal plates one by one carefully
3. Cut the alimentary tract both at oesophageal and rectal ends
4. Locate two white prominent ovaries in the posterior part of abdomen
5. Locate the highly branched, milky white colleterial glands present in the posterior part ofabdomen
6. Carefully remove the fat bodies on either side of the ovaries with the help of the forceps andbrush
7. Locate two lateral oviducts on the either side attached to posterior margin of ovary using afine needle
8. Locate a hard sclerotised plate, gonapophysis, where the two lateral oviducts meet
9. Gently cut and remove the lower portion of the ventral nerve cord
10. Gently pull down the gonapophysis using a needle to expose the common oviduct
11. Locate the small globular spermatheca near the common oviduct
12. Insert a piece of black paper behind the lateral and common oviducts
13. Label all the parts

Video Link:

https://www.youtube.com/watch?v=MQnAdSLNRpo
https://www.youtube.com/watch?v=lopc1CrGCX4
https://www.youtube.com/watch?v=GHsZ0AACmuU

Observations: (draw the diagram of dissected female reproductive organs)

PRACTICAL 9: TAXONOMIC STUDY OF THE ORDER ODONATA, ORTHOPTERA AND DICTYOPTERA

A. Order: Odonata
(Dragonflies and Damsel flies)

1. Head is globular and constricted into a petiolate neck
2. Compound eyes are large and prominent
3. Antennae is short and filiform
4. Mouthparts are adapted for cutting and chewing
5. Legs are antero-ventrally placed and suited for holding and grasping prey
6. Wings are equal or sub-equal, membranous with complex reticulation of small crossveins; pterostigma present at costal margin; wing flexing mechanism is absent
7. Abdomen elongate and slender
8. Male functional copulatory organ developed on 2nd abdominal sternite

B. Order: Orthoptera
(Grass hoppers, locusts, crickets, mole crickets etc.)

1. Antennae filiform
2. Mouthparts are adapted for cutting and chewing
3. Hind legs are saltatorial and modified for jumping
4. Forewings are modified into tegmina. Hindwings are membranous with enlarged anal lobe
5. Cerci are short and unsegmented
6. Females bear well-developed ovipositor
7. Tympanum present

Two suborders:

1. **Caelifera** (Short horned grasshoppers, locusts etc.)
2. **Ensifera** (Long horned grasshoppers / bush crickets / katydids, crickets, mole crickets etc.)

Suborder: Caelifera

Family: Acrididae (Short horned grass hoppers and locusts)

1. Tarsi 3-segmented, arolium is present
2. Auditory organ (Tympanum) is situated on lateral sides of first abdominal segment

3. Ovipositor is short and well-developed Eg. Rice grass hopper (*Hieroglyphus banian*)

C. Order: Dictyoptera
(Cockroaches and Mantids)

1. Antennae filiform
2. Mouth parts are adapted for cutting and chewing
3. Fore wings are modified into tegmina; hind wings are membranous with large anal lobe
4. Legs cursorial or raptorial; tarsi 5-segmented
5. Cerci are short and many segmented

Two suborders are recognized: Blattaria (Cockroaches) and Mantodea (Mantids)

	Blattaria	**Mantodea**
1	Pronotum is shield shaped and completely covering the head	Pronotum is elongate and not covering the head
2	Legs are cursorial and adapted for running	Forelegs are raptorial and adapted for preying

Video Link:

https://www.youtube.com/watch?v=58jKWMXXFwM

https://www.youtube.com/watch?v=13lYUvYm1ew

https://www.youtube.com/watch?v=z7qFVncXW94

https://www.youtube.com/watch?v=JqgyHWJFItc

PRACTICAL 10: TAXONOMIC STUDY OF THE ORDER ISOPTERA, THYSANOPTERA AND HEMIPTERA

A. Order: Isoptera

(Termites / White ants)

1. Social polymorphic insects exhibit well-developed caste system
2. Antennae moniliform
3. Compound eyes are present in reproductive forms
4. Mouthparts are cutting and chewing type with powerful mandibles
5. Wings present in primary reproductives. Workers and soldiers are apterous. Both fore and hind wings are very similar in shape, size and venation; when at rest the wings are held flat over the body and extend beyond the tip of abdomen. Wings are membranous with reduced venation and are capable of being shed from basal humeral suture; anterior veins strongly sclerotized
6. Tarsi 4-segmented
7. Anal cerci are short or very short

Workers: These are sterile wingless adults. They are pale in colour, lack compound eyes.

Soldiers (Mandibulate): These are also sterile wingless adults with greatly enlarged head andmandibles. Slightly larger than workers, may or may not have compound eyes.

Physogastric queen: Queen with large abdomen due to expansion of intersegmental membrane to accommodate the large ovaries and fat bodies.

Seven families are recognized in this order: Mastotermitidae, Kalotermitidae, Hodotermitidae, Termopsidae, Termitidae, Rhinotermitidae and Serritermitidae.

Family - Termitidae:

1. Tarsi 4-segmented
2. Hind wings are without anal lobe; anterior wing scales small, not overlapping hind wing scales;venation is reduced
3. Ocelli present

eg: *Odontotermes, Microtermes* spp.

B. Order: Hemiptera

(True bugs, jassids, aphids etc.)

1. Mouthparts are piercing and sucking type with labium modified into a dorsally grooved rostrum (beak); mandibles and maxillae modified into bristle-like stylets; palps are absent

2. Forewings are modified into hemelytra (basally thickened and apicallymembranous) in Heteroptera. Forewings are uniformly membranous in Homoptera

3. Cerci are absent

Two Suborders: Heteroptera and Homoptera

	HETEROPTERA	HOMOPTERA
1	Head is porrect; base of rostrum never extending between fore-coxae	Head is deflexed; base of rostrum extends between fore-coxae
2	Wings are held flat over the body at rest	Wings are held in a roof-like mannerover the body at rest
3	Forewings are modified into hemelytra	Forewings are uniform in consistency

Important families under suborder Heteroptera:

Coreidae:

1. Membrane of hemelytra with more than 5 longitudinal veins, originating from a transverse basal vein
2. Hind tibia and tarsi are expanded and leaf-likeeg. Brown coreid bug (*Riptortus* spp.)

Pyrrhocoridae:

1. Ocelli are absent
2. Membrane of hemelytra with 4 or 5 longitudinal veinseg. Cotton stainer (*Dysdercus cingulatus*)

Lygaeidae:

1. Ocelli present
2. Cuneus is absent in hemelytra
3. Membrane of hemelytra with 4 or 5 longitudinal veins eg. Dusky cotton bug (*Oxycarenus hyalinipennis*)

Pentatomidae

1. Body is highly sclerotized
2. Pronotum is shield shaped and scutellum covering about half of the abdomeneg. Green stink bug (*Nezara viridula*)

Important families under suborder Homoptera:

Delphacidae

1. Minute to small, wedge shaped insects
2. Hind tibiae bear a large movable flattened spur at the apex eg. Brown plant hopper of rice (*Nilaparvata lugens*)

Cicadellidae

1. Minute to small, wedge shaped insects
2. Hind tibiae have double rows of longitudinal spines on lateral margin eg. Rice green leaf hopper (*Nephotettix* spp.)

Aphididae

1. Minute, pear shaped insects with apterous and alate forms
2. A pair of cornicles or siphunculi is present on the dorsal side of 5^{th} or 6^{th} abdominal segmenteg. Mustard aphid (*Lipaphis erysimi*)

Aleyrodidae

1. Minute insects with white, opaque wings
2. Vasiform orifice is present in the last abdominal tergite eg. Cotton whitefly (*Bemisia tabaci*)

Pseudococcidae:

1. Males with a single pair of transparent membranous wings
2. Females are apterous and covered with filamentous waxy secretions eg. Cotton mealybug (*Phenacoccus solenopsis*)

C. Order: Thysanoptera

(Thrips)

1. Minute to small, slender bodied terrestrial insects
2. Antennae is short with sense cones on 3^{rd} or 4^{th} segments
3. Mouthparts are rasping and sucking type, asymmetrical with right mandible rudimentary,palps present
4. Wings when fully developed are long and narrow with highly reduced venation. The wings arefringed with long hairs on the margins
5. Tarsi 1 or 2-segmented, with terminal protrusible vesicle
6. Cerci absent
7. Ovipositor present or absent

Two suborders: Terebrantia and Tubulifera

	Terebrantia	**Tubulifera**
1	Wings with microtrichia; forewings with at least one longitudinal vein reaching to apex	Wings without microtrichia; veinsabsent
2	Tip of abdomen conical in femalesor bluntly rounded in males	Tip of abdomen tubular
3	Ovipositor is saw-like	Ovipositor is absent

Suborder: Terebrantia

Family: Thripidae

1. Ovipositor is well-developed and curved downwards
2. Antennae 6 - 9 segmented with simple sense-coneseg. Cotton thrips (*Thrips tabaci*)

Video Link:

https://www.youtube.com/watch?v=58jKWMXXFwM

https://www.youtube.com/watch?v=S3e5yeToOJg

https://www.youtube.com/watch?v=b3nBSlopYFM

https://www.youtube.com/watch?v=j4YR5lexvcw

https://www.youtube.com/watch?v=j8fWfxbxO1Q

https://www.youtube.com/watch?v=JlFncJu0eAg

https://www.youtube.com/watch?v=3yZXBmMXrRY

PRACTICAL 11: TAXONOMIC STUDY OF THE ORDER NEUROPTERA, LEPIDOPTERA AND HYMENOPTERA

A. Order: Neuroptera

(Alder flies, snake flies, Lace wings, Ant lions)

1. Antennae elongate with or without terminal club
2. Mouthparts are adapted for cutting and chewing
3. Wings very similar, membranous, with numerous costal veinlets; wings held in a roof-like manner over the body
4. Cerci absent

Two suborders: Megaloptera and Planipennia

Suborder: Planipennia

Family: Chrysopidae

1. Body pale green in colour with golden yellow eyes
2. Antennae filiform and longer than forewings

eg. Green lacewings (*Chrysoperla carnea*)

B. Order: Lepidoptera

(Moths and Butterflies)

1. Body, wings and appendages are covered with broad overlapping scales
2. Mouthparts are siphoning type with a long coiled suctorial proboscis, which is formed bythe galeae of maxillae and held beneath the head when not in use
3. Wing coupling apparatus is present
4. Tarsi 5-segmented

Major suborders: Monotrysia and Ditrysia

Important families:

Pyralidae:

1. Cu2 vein (Cubitus2) is absent in forewing and well-developed in hindwing. The Sc+R1 (Sub-costa + Radius1) vein in hindwing are approximated to or partly fused with Rs (Radial sector) distally
2. Tympanum is present at the base of the abdomen

eg. Rice yellow stem borer (*Scirpophaga incertulas*)

Noctuidae:

1. The Sc+R1 vein in hindwing separates from Rs vein and connected with the cell by a bar

2. Well-developed frenulum is present

eg. Fall armyworm (*Spodoptera frugiperda*)

Arctiidae:

1. The Sc+R1 vein in hindwing connected with cell to or beyond the middle
2. Well-developed frenulum is present

eg. Bihar hairy caterpillar (*Spilarctia obliqua*)

Sphingidae:

1. Large-sized, stout moths with very long proboscis
2. Antennae is thickened and hooked at the apex
3. Fore wings are elongate with oblique outer margin. The Sc+R1 vein in wings are connectedwith Rs vein by a cross vein and approximated to Rs vein beyond the cell
4. Well-developed frenulum is present

eg. Death's head moth (*Acherontia styx*)

Papilionidae:

1. Antennae clubbed distally
2. Hind wings having swallow tail-like prolongation with one anal vein

eg. Citrus butterfly (*Papilio* spp.)

C. Order: Hymenoptera

(Bees, wasps, ants)

1. Mouthparts are adapted for chewing and lapping
2. Wings are membranous with greatly reduced venation; wings are interlocked by hamuli (hooklets) present along the costal margin of hind wings
3. Abdomen usually basally constricted to form pedicel or petiole. The 1st abdominal segment fused with metathorax and known as propodeum.
4. Ovipositor is modified for sawing, piercing or stinging

Two suborders: **Symphyta** and **Apocrita**

Symphyta	Apocrita
Abdomen is broadly attached to the thorax,no marked constriction between 1st and 2nd abdominal segments	Abdomen is basally constricted between 1st and 2nd abdominal segments
Fore tibiae usually with 2 spurs	Fore tibiae usually with 1 spur
eg. Sawflies	eg. Bees, ants, wasps, parasitic wasps

Suborder: Symphyta

Family: Tenthredinidae

1. Trochanter is two-segmented, front tibiae with 2 apical spurs

2. Female with saw-like ovipositor

3. Eight pairs of prolegs present in larva and the larva is called pseudo caterpillar

eg. Mustard saw fly (*Athalia lugens proxima*)

Suborder: Apocrita

Family: Ichneumonidae

1. Antennae long with more than 16 segments

2. Petiole long and curved

3. Ovipositor is usually longer than body

4. Forewings with two recurrent veins

5. Trochanter two-segmented; legs with conspicuous tibial spurs; tarsi 4-segmentedeg. *Xanthopimpla* sp.

Family: Braconidae

1. Forewings with one recurrent vein

2. Abdomen sessile or sub sessile or petiolate

eg. *Bracon brevicornis*

Family: Trichogrammatidae

1. Very minute insects (0.3 - 1.0 mm long)

2. Fore wings with rows of microscopic hairs

3. Tarsi 3- segmented eg. *Trichogramma chilonis*

Family: Apidae

1. Hind tibiae with pollen basket known as corbicula

2. Forewings with three sub-marginal cells

eg. Honey bees

Video Link:

https://www.youtube.com/watch?v=Rw_qt1b3nNw

https://www.youtube.com/watch?v=58jKWMXXFwM

https://www.youtube.com/watch?v=FfXy0NgWDDg

https://www.youtube.com/watch?v=magNI4EIqLw

https://www.youtube.com/watch?v=eZJYt4eXoS4

https://www.youtube.com/watch?v=XbBc3TQt8hM

https://www.youtube.com/watch?v=9lxtJeMIUjY

PRACTICAL 12: TAXONOMIC STUDY OF THE ORDER COLEOPTERA AND DIPTERA

A. Order: Coleoptera
(Beetles & Weevils)

1. Body is highly sclerotized
2. Antennae variable, usually 11 segmented
3. Mouthparts are adapted for cutting and chewing
4. Forewings are modified into elytra, which meet to form a straight mid-dorsal suture, veins absent. Hind wings are membranous, folded transversely beneath the elytra at rest
5. Tarsi 5-segmented; 4th segment is small and concealed in the notch of the bilobed 3rdsegment

Important suborders: Adephaga and Polyphaga

Important families of Polyphaga:

Scarabaeidae (Dung beetles):

1. Antennae with a lamellate club
2. Head sometimes with toothed or bilobed frontal horn
3. Elytra not completely covering the abdomen
4. Fore tibiae dentate with one apical spur
5. Pygidium present

eg. Rhinoceros beetle (*Oryctes rhinoceros*)

Coccinellidae (Ladybird beetles):

1. Small sized, hemispherical, convex insects with brightly coloured elytra
2. Head partly concealed by pronotum
3. Elytra completely covers the abdomen

eg. Predatory lady birds (*Coccinella* spp.)

Chrysomelidae (Leaf beetles):

1. Upper surface of body shiny, frequently with metallic colouration
2. Abdomen short with 5 visible sternites

eg. Red pumpkin beetle (*Aulacophora foveicollis*)

Curculionidae (Weevils):

1. Head forms a prominent snout
2. Antennae geniculate and clubbed

eg. Red palm weevil (*Rhynchophorus ferrugineus*)

Cerambycidae (Longicorn beetles):

1. Large, elongate, cylindrical insects
2. Antennae is mostly 11 segmented, at least two-thirds as long as body, capable of beingflexed backwards

eg. Mango stem borer (*Batocera rufomaculata*)

Bruchidae (Pulse beetles):

1. Antennae serrate or pectinate
2. Hind femur is thickened and toothed beneath

eg. Pulse beetle (*Callosobruchus chinensis*)

B. Order: Diptera

(True flies)

1. Hind pair of wings are modified into halters
2. Mouthparts are generally sponging or piercing-sucking type
3. Tarsi are 5-segmented

3 suborders: Nematocera, Brachycera and Cyclorrhapha

Suborder: Nematocera

Family: Cecidomyiidae (Gall midges):

1. Antennae moniliform with whorls of hairs
2. Wings with 3-5 longitudinal veins, mostly unbranched and without cross veins

Eg. Rice gall midge (*Orseolia oryzae*)

Suborder: Cyclorrhapha

Family: Tephritidae (Fruit flies):

1. Sub-costa in wings bends apically formed at almost right angle and then fade out withoutreaching the margin
2. Females with well-developed, flat and horny ovipositor

eg. Melon fruit fly (*Bactrocera cucurbitae*)

Family: Tachinidae (Tachinid flies):

1. Small to medium-sized parasitic flies with long, conspicuous bristles on abdomen
2. Post-scutellum is prominent
3. Arista on antennae are usually bareeg. *Sturmiopsis inferens*

Family: Agromyzidae (Leaf miners):

1. A pair of stout bristles are present on either side of face called vibrissae

2. Wings usually hyaline with costal break point at the apex Sc

eg. Red gram pod fly (*Melanagromyza obtusa*)

Family: Muscidae (Shoot flies):

1. Fine erect hairs are present on the ventral side of mesothorax
2. The wing vein Cu2 + 2A is short and do not reach the wing margin

eg. Jowar shootfly (*Atherigona soccata*)

Video Link:

https://www.youtube.com/watch?v=Rw_qt1b3nNw

https://www.youtube.com/watch?v=58jKWMXXFwM

https://www.youtube.com/watch?v=0yO14iLUKXE

https://www.youtube.com/watch?v=aXtcFrgVJsE

https://www.youtube.com/watch?v=Isx3jDNdmdE

PRACTICAL 13: INSECTICIDE FORMULATIONS

An insecticide formulation is a combination of active and inert ingredients that forms an end-use insecticide product. Insecticides are formulated to make them safer or easier to use. This is because many insecticide active ingredients, in "pure" (technical grade) form, are not suitable for application. In their concentrated form, some are extremely toxic, many do not mix well with water, some are unstable, and some are difficult (or unsafe) to handle, transport, or store. To address these problems, manufacturers add inert ingredients to end-use insecticide products. Inert ingredients have no pesticidal activity, and some simply serve as diluents or carriers.

A formulated product may consist of:

- A carrier or diluent, such as an organic solvent of mineral clay.
- Surface-active ingredients, such as stickers and spreaders.
- Other additives, such as stabilizers, dyes, and chemicals, which make the product safer orenhance pesticidal activity.

Liquid insecticide products are usually one of the following:

- A solution
- A suspension
- An emulsion

A **solution** is made by dissolving a substance in a liquid. A true solution is a mixture, but it cannotbe separated by filtration or other mechanical means.

A **suspension** is also a liquid mixture. However, a suspension is formed by dispersing fine (very small), solid particles in a liquid.

An **emulsion** is a special kind of suspension: a mixture made by suspending droplets of one liquid in another. Each ingredient retains its unique properties and identity.

Some insecticide products are sold in concentrate form and must be mixed or diluted before use. Concentrates come in both liquid and solid form. An emulsifiable concentrate is an example of a **liquid concentrate (LC)**. **Wettable powders (WP)**, **soluble powders (SP)**, and **water- dispersible granules/dry flowable (WDG/DF)** are examples of concentrated materials sold in solid form. Other formulations are sold ready to-use. You can apply ready-to-use products with no further dilution or mixing. Examples include liquids prepared as end-use dilutions and **aerosol (A)**, **dust (D)**, **pellet (P)**, **granule (G)**, and **most bait (B)** formulation products.

LIQUID FORMULATIONS:

Emulsifiable Concentrates (E or EC):

Advantages:

- Relatively easy to handle, transport, and store
- Easy to pour and measure
- Little agitation required; will not settle out or separate when equipment is running
- Not abrasive
- Will not usually plug screens or nozzles
- Leave little visible residue on treated surfaces

Disadvantages:

- High concentration of active ingredient(s) makes it easy to overdose or underdose through mixing or calibration errors. May damage treated plants or surfaces (petroleum-based solvents or overdosing may cause phytotoxicity)
- Easily absorbed through skin of humans or animals
- Splashes and spills are relatively difficult to clean up and/or decontaminate
- Many have a strong odour
- May cause pitting or discoloration of painted finishes or other treated surfaces
- May be corrosive

Ready-to-Use (RTU) Formulations:

- Low-Concentrate Solutions
- Concentrate Solutions (C, LC, or WSC/WSL)

Flowable (F or AF): Some active ingredients are insoluble solids: substances that will not dissolve in either water or oil. These may be formulated as flowable. (Most manufacturers use the letter "F" by the trade name to designate that the formulation is a flowable.

Aerosols (A): Aerosol formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient.

There are two types of aerosol formulations:

- Ready-to-Use Aerosols
- Formulations for Smoke or Fog Generators

DRY OR SOLID FORMULATIONS:

There are two general types of dry formulations. Some are ready-to-use. Others are

concentrates,which must be mixed with water and applied as a spray.

- Dusts (D)
- Granules (G)
- Pellets (P or PS)
- Wet table Powders (WP or W)
- Water-Dispersible Granules (WDG) or Dry Flowable (DF)
- Soluble Powders (SP or WSP)

OTHER FORMULATIONS:

This section describes other formulations that:

- Are not easily classified as liquid or dry/solid.
- Are formulated and/or applied as gases.
- Have some special packaging or delivery method.
- May require the use of specialized application equipment.
- Some have specific temperature requirements.

Fumigants- Fumigants are insecticides that deliver the active ingredient to the target site in theform of a gas.

Microencapsulated Insecticides (M)- Microencapsulated insecticides are dry particles or liquiddroplets surrounded by a coating.

Water-Soluble Packaging (WSB or WSP)- More and more insecticide products are available inwater-soluble bags (WSBs).

Impregnates- Fertilizers may also be impregnated with insecticides.

Insecticide Mixture- Sometimes, product manufacturers combine insecticides with other insecticides or fertilizers for sale as premixes (see "Insecticide-Fertilizer Combinations" above).

Adjuvants- An adjuvant is a chemical that can affect how a insecticide works.

- Improve the action of an insecticide.
- Change the characteristics of an insecticide formulation or a spray mixture (suspension or solution).

Video Link:

https://www.youtube.com/watch?v=OFkJZRzhcfA

https://www.youtube.com/watch?v=sbPkhzR5C3M

EXERCISE ON INSECTICIDE FORMULATIONS

Fill the following information in the table.

Insecticide Name	Trade Name	Manufacturer's Name	Commercial formulations available in the market

PRACTICAL 14: PESTICIDE APPLIANCES

Appliance used in the pest management are duster, granule application, sprayer, fogging machine, smoke and vapor generators, flame thrower, agricultural aircrafts etc.

a) **Duster** – These are useful, less expensive and easy to operate with little maintenance cost. There are four types of duster viz, bellow type duster, plunger duster, rotatory duster and mist blower duster.

b) **Granule Sprayer** – These are dry formulation of a particular size ranging between 250-200µ. Granules are normally applied in the seed furrow or the leaf whorls. Hand held applicators whichwork on the principle of gravity.

c) **Sprayer** – They are normally used to spray chemicals used to control insects, millets, weeds and disease. Main function of a sprayer in general is to atomize the spray fluid, which may be a suspension, as emulsion or solution into finer droplets and eject them safely and properly.

Types of Sprayer:

1) **Manually operated hydraulic sprayer** – In this type, hydraulic pump acts on spray fluid and discharges it.
2) **Hand sprayer (kitchen sprayer)** – The tank capacity is 1.7 litres and the tube is directly attached to the piston, which discharges the spray fluid during the pressure flow.
3) **Foot sprayer** – This foot sprayer is carried to operate and can be used in spraying tall crops as well as the fruit traces up to 4m high.
4) **Rocker sprayer** – The rocker sprayer consists of the pump assemble, a platform, an operating lever, a pressure chambers a situation with stains a delivery hose and an extension rod with a spray nozzle.
5) **Knapsack Sprayer** – The sprayer is used for spraying low crop vegetable, nursery, shrubs, and trees up to 2.5 m high
6) **Compression sprayer** – Those are also known as pneumatic sprayers became air is employedfor forcing the liquid thorough the nozzle for atomization.
7) **Compression Knap Sack Sprayer** – Compression Knapsack sprayer consist of a tank for holding the sprayer with compressed air, a vertical air pump with a handle, a filler hole spray lance with a nozzle and cut of device.
8) **Motorized Knap Sack sprayer (power sprayer)** – These is also known as a power operated gaseous energy knap sack sprayer. An air current generated in the machine blows out the spray fluid.

9) **Tractor mounted sprayer** – It consist of a pump, one or more drums, control valves, pressure gauge, pressure regulator and relief value and spray book fitted either nozzle.
10) **Injector sprayer** – These continuously meter concentrated pesticide into the spray system as needed others are adjusted based on a constant travel speed.
11) **Fogging machine** – Fog is a fine aerosol. The droplets of aerosol are very small, ranging between 1 and 50µ in size, hence unable to contact with stationary objects even if some is left. It is less than the effective dose.
12) **Smoke and vapor generator** – These also have limited applicability but are highly sensitive andeffective in achieving the instant kill of insects.
13) **Flame thrower** – There the burning liquid is thrown with trust and flame and is at the tip and gets the continuous supply of vaporize kerosene oil.

Types of nozzle:

1. **Flat-fan spray nozzle** – Flat-fan nozzle are widely used for broadcast spraying of herbicides andsome insecticides.
2. **Folding fan nozzle** – It produce a wide angle, flat spray pattern and are used for applyingherbicides and mixture of herbicide and liquid fertilizer.
3. **Hollow cone nozzle** – It is generally used to apply insecticides and fungicides to feed crops werecomplete coverage of a leaf surface is important.
4. **Full cone nozzle** – The full cone nozzle produces a shrill and a counter inside the nozzle thatresult in a full cone pattern.
5. **Rotary nozzle** – The rotary nozzle uses centrifugal force instead of pressure to produce droplets.This process is known as control droplet application (CDA)

Controlled Droplet Applicator (CDA)

Controls droplet application means producing only the size of spray droplet of particular application.This is achieved by special design spinning disc rotary atomizers which break up the spray liquid very evenly, resulting in a narrow range of Spray droplets sizes. Most spraying machines till breakup spray liquid by a hole – commonly referred through as a hydraulic nozzle.

Video Link:

https://www.youtube.com/watch?v=4IoKgezgrGY

https://www.youtube.com/watch?v=TPpt1CIA5H8

https://www.youtube.com/watch?v=dBM1BE5yDVE

DRAW A LABELLED DIAGRAM OF A KNAPSACK SPRAYER

PRACTICAL 15: SAMPLING TECHNIQUES FOR ESTIMATION OF INSECT POPULATION AND DAMAGE

Objective- To get acquainted with different methods/ techniques of sampling for insect populationand damage

Sampling Techniques:

Absolute sampling - To count all the pests occurring in a plot

Relative sampling - To measure pest in terms of some values which can be compared over timeand space e.g. Light trap catch, Pheromone trap

Methods of sampling:

a. In situ counts - Visual observation on number of insects on plant canopy (either entire plot orrandomly selected plot)

b. Knock down - Collecting insects from an area by removing from crop and (Sudden trap)counting (Jarring)

c. Netting - Use of sweep net for hoppers, dragonfly, grasshopper

d. Narcotised collection - Quick moving insects anaesthetised and collected

e. Trapping –

- Light trap - Phototropic insects
- Pheromone trap - Species specific
- Sticky trap - Sucking insects
- Bait trap - Sorghum shootfly - Fishmeal trap
- Emergence trap - For soil insects

f. Crop samples - Plant parts removed and pest counted e.g. Bollworms

Stage of Sampling:

- Usually most injurious stage counted
- Sometimes egg masses counted - Practical considerations
- Hoppers - Nymphs and adult counted

Sample Size:

- Differs with nature of pest and crop
- Larger sample size gives accurate results

Decision Making:

- Population or damage assessed from the crop
- When pest level crosses ETL, control measure has to be taken to prevent pest from reducing EIL

Video Link:

http://hortipm.tamu.edu/ipmguide/ento/chapters/sampling.html

https://www.youtube.com/watch?v=BXfja44UKnA

https://www.youtube.com/watch?v=kWIWPsZCJaM

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