# LECTURE 1.

## Definition of entomology and importance of insects.

## Introduction to Phyllum Arthropoda

### Definition of 'Entomology' and importance of insects

The term entomology is derived from two Greek words. *Entomon* means an
insect and logos means to study. The term 'insect' is derived from the Latin word
*insectum* which means 'cut into'.

Insects came into earth 480 million years ago. Man came to mother earth only
one million years ago. Out of 17 lakh living species on earth, 9.5 lakh species are
insects, 2.5 lakh species are plants and 0.45 lakh species alone are vertebrates.

Insects are harmful to man as pests of cultivated crops, animals, stored products, carries of human diseases and pests of household and industrial articles.

They are also helpful as producers of honey, lac, silk, dyes, etc., pollinators of crops
and as natural enemies of crop pests. They also serve as important link in the foodweb of biological cycle in ecosystem.

Insects are grouped with other animals with similar characteristics in the Phyllum Arthropoda.

### Introduction To Phylum Arthropoda

There are about 1-2 million species of animals in the world and more than 70
per cent of these are insects. These animals are assigned to 29 phyla. Of these only
nine phyla are large, and their representatives are common and familiar to us. These
are called the major phyla. The other phyla are small and their representatives are
uncommon and of uncertain relationships.

### Position of insects in animal kingdom and their relationship with other Arthropods

Insects are invertebrates grouped in the phylum **Arthropoda** (Arthro-joint, poda-foot) and subphylum Uniramia. Characters of the Phylum Arthropoda are

1. Segmented body
2. Segments grouped into 2 or 3 regions (tagma) known as Tagmosis.
3. Renewable chitinous exoskeleton
4. Grow by molting.
5. Bilateral symmetry of body.
6. Body cavity filled with blood and called as haemocoel.
7. Tubular alimentary canal with mouth and anus at anterior and posterior ends.
8. Dorsal heart with valve like ostia.
9. Dorsal brain with ventral nerve cord.
10. Striated muscles (with dark and light bands).
11. No cilia (hair like vibratile structure on the surface of the cell).
12. Paired, segmented appendages.

**Phylum Arthropoda is Classified in to 7 classes.**

1. Onychophora (claw bearing) e.g. Peripatus
2. Crustacea (Crusta - shell) e.g. Prawn, crab, wood louse
3. Arachnida (Arachne - spider) e.g. Scorpion, spider, tick, mite
4. Chilopoda (Chilo - lip; poda - appendage) e.g. Centipedes
5. Diplopoda (Diplo - two; poda- appendage) e.g. Millipede
6. Trilobita (an extinct group)
7. Hexapoda (Hexa- six; poda-legs) or Insecta (In- internal; sect – cut) e.g. Insects.

## LECTURE 2.

**Insect dominance**

Insects are the most dominant species on the earth as they originated on earth 480 million years ago. Among 1.7 million living species, 0.95 million species are insects.

**Insect Order Number of species**

Coleoptera (Beetles and weevils) 3,50,000
Lepidoptera (Butterflies and moths) 1,60,000
Hymenoptera (Bees, wasps and ants) 1,20,000
Diptera (Flies and mosquitoes) 1,20,000
Hemiptera (Bugs) 98,000
Orthoptera (Grasshoppers, crickets and locust) 20,000

**Measures of dominance:**

1. More number of species
2. Large number of individuals in a single species: e.g. Locust swarm comprising of $10^9$ number of individuals, occupying large area.
3. Great variety of habitats
4. Long geological history

**Reasons for dominance**:

There are several structural, morphological and physiological factors responsible for insect dominance. They are:

**1. Capacity for flight**

**2. More adaptability or universality**

**3. Smaller size**: Majority of insects are small in their size conferring the following physiological and ecological advantages.

**4. Presence of exoskeleton**: Insect body is covered with an outer cuticle called exoskeleton which is made up of a cuticular protein called **Chitin**. This is light in weight and gives strength, rigidity and flexibility to the insect body.

**5. Resistance to desiccation**: Insects minimise the water loss from their body surface

through prevention of water loss (wax layer of epicuticle, closable spiracles, egg shell)
conservation of water (capable of utilizing metabolic water, resorption of water from
fecal matter, use less quantity of water to remove the nitrogenous waste)
**6. Tracheal system of respiration**: This ensures direct transfer of adequate oxygen to
actively breathing tissues. Spiracles through their closing mechanism admit air and
restrict water loss.
**7. Higher reproductive potential**: Reproductive potential of insect is high
eg. Egg laying capacity (fecundity) of queen termite is 6000 - 7000 eggs per day for 15
long years. Short development period e.g., Corn aphid produces 16 nymphs per
female which reaches the adulthood within 16 days. Presence of special types of
reproduction other than oviparity and viviparity like Polyembryony, Parthenogenesis and Paedogenesis

**LECTURE 3. insect external morphology:**

**Head,**
**Antenna**
**HEAD**

The head of an insect is composed of a series of segments, which are specialized for food gathering and manipulation, sensory perception, and neural integration. The head bears the eyes (compound eyes and ocelli), antennae, and mouthparts. The anterior part of the head is the **frons**. The anterior area below the dorsum of the head, between and behind the eyes is the **vertex**. The area below the compound eye, on the side of the head, is the **gena**. The liplike sclerite is the **clypeus**.

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

**1. Hypognathous**: (Hypo-below ; gnathous-jaw)

This type is called orthopteroid type. The long axis of the head is vertical, it is at right angles to the long axis of the body. Mouth parts are ventrally placed and project downwards. E.g. grasshopper, cockroach.

**2. Prognathous**: (Pro-infront ; ganthous-jaw)

This type is also called coleopteroid type. The long axis of the head is horizontal. It is in line with the long axis of the body. Mouth parts are directed forward. e.g. ground beetle.

3. **Opisthognathuos**: (Opistho-benind; gnathuos-jaw)

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

**Structure of insect antenna**: Antennae are also called feelers. They are paired, highly mobile and segmented. Antennae are located between or behind the compound eyes. All insects except protura have a pair of antennae. Antennae are well developed in adults and poorly developed in immature stages. The antenna is set in a socket of the cranium called antennal socket. The base of the antenna is connected to the edge of the socket by an articulatory membrane. This permits free movement of antennae. The basal segment is called **scape**. It is conspicuously larger than succeeding segments. The second antennal segment is called **pedicle** whcih immediately follow the scape. A mass of sence cells called **Johnston's organ** is present in the pedicel, which is used as a chordatonal organ in some of the insects like mosquitoes. Both scape and pedicel are provided with intrinsic muscles. The remaining annuli or flagellomeres are known as **flagellum** or **clavola** which lack individual muscle. Surface of the flagellum is supplied with many sensory receptors that are innervated by the duetocerebrum of brain. Flagellum may very in size and form.

**Function**: Antenna is useful to detect chemicals including food and pheromones (chemicals secreted into air by opposite sex). It perceives smell, humidity changes, variation in temperature, vibration, wind velocity and direction.

Antenna is useful to perceive the forward environment and detect danger. It is useful for hearing in mosquitoes and communication in ants. Rarely it is also useful to clasp the mate (e.g. Flea) and grasp the prey.

Antennae vary greatly among insects, but all follow a basic plan: segments 1 and 2 are termed the scape and pedicel, respectively. The remaining antennal

segments
(flagellomeres) are jointly called the flagellum.
Antennae function almost exclusively in sensory perception. Some of the information that
can be detected by insect antennae includes: **motion and orientation, odor, sound,**
**humidity, and a variety of chemical cues.** Some of the most common types of insect
antennae with which you should be familiar are illustrated below:
(e.g., Odonata) (e.g., Coleoptera)
(e.g., Lepidoptera) (e.g., Diptera)

**Types of antennae:**

**1. Setaceous**: (Bristle like) Size of the segments decreases from base to apex. e.g.
Leafhopper, Dragonfly, Damselfly.

**2. Filiform**: (Thread like) Segments are usually cylindrical. Thickness of segments
remains same throughout. e.g. Grasshopper.

**3. Moniliform**: (Beaded) Segments are either globular or spherical with prominent
constriction in between e.g. Termite.

**4. Serrate**: (Saw like) Segments have short triangular projections on one side. e.g.
Longicorn bettle

**5. Unipectinate**: (Comb like) Segments with long slender processes on one side e.g.
Sawfly

**6. Bipectinate**: (Double comb like) Segments with long slender lateral processes on both
the sides e.g. Silkworm moth

**7. Clavate**: (Clubbed) Antenna enlarges gradually towards the tip. e.g.
Blister beetle

**8.Capitate**: (Knobbed) Terminal segments become enlarged suddenly
e.g. butterfly

**9. Lamellate**: (Plate like) Antennal tip is expanded laterally on one side to form flat
plates e.g. lamellicorn beetle

**10. Aristate**: The terminal segment is enlarged. It bears a conspicuous dorsal bristle
called arista e.g. House fly
**11. Stylate**: Terminal segment bear a style like process eg. Horse fly, Robber fly.
**12. Plumose**: (Feathery) Segments with long whorls of hairs e.g. male mosquito **13.**
**Pilose**: (Hairy) Antenna is less feathery with few hairs at the junction of flagellomeres.
e.g. Female mosquito.
**14. Geniculate:** (Elbowed) Scape is long remaining segments are small and are arranged
at an angle to the first resembling an elbow joint. e.g. Ant, weevil and honey bee.

**LECTURE 4. Insect mouth part and types of mouth parts**
**MOUTHPARTS**
Just as insects take on many different forms, they also possess a variety of different
mouth types, each of which can be grouped under one of two main categories: chewing
(mandibulate) and sucking (haustellate).
***Mandibulate*** mouthparts, like the ones illustrated below, are believed to be the most
primitive. All others, including those categorized as haustellate, are presumed to have
evolved as modifications of this basic type.
The five primary parts of the insect "mouth" are:
1) The clypeus
2) The "upper lip", or labrum
3) Two "jaw-like structures", or mandibles
4) The maxillae (sing. maxilla)
5) The "lower lip", or labium
The maxillae and labium are divided into various substructures, which include the
galea, paraglossa, glossa, and the maxillary and labial palps.

***Haustellate*** mouthparts are primarily used for "sucking up" liquids, and can be broken
down into two subgroups: those that possess stylets and those that do not. **Stylets** are
needle-like projections used to penetrate plant and animal tissue. Examples of insects
with stylets include Hemiptera (true bugs), Diptera (flies), and Siphonaptera (fleas).
Some haustellate mouthparts lack stylets. Unable to pierce tissues, these insects must
rely on easily accessible food sources such as nectar at the base of a flower. One
example of nonstylate mouthparts is the long siphoning proboscis of butterflies and
moths (Order Lepidoptera). Although the method of liquid transport

differs from that of
the butterfly's proboscis, the rasping-sucking rostrum of some flies is also considered to
be haustellate without stylets.

**LECTURE 5**
**ADAPTATIONS OF THE MOUTHPARTS**

**Insect Mouthparts**: Top left, chewing, top right, sponging; center, piercing-sucking;
bottom, siphoning. (F. W. Zettler, Cornell)

**Types of insect mouthparts**

Mouthparts of insects vary to a great extend among insects of different groups
depending upon their feeding habits. They are mainly of two types viz., Mandibulate
(feeding mainly on solid food) and haustellate (feeding mainly on liquid food).

1. **Biting and chewing type**: e.g. Cockroach & grasshopper. It is the primitive type of
mouth part and consists of the following parts.

i. **Labrum** : (Upper lip) It is flap like, bilobed and attached to the clypeus by an articular
membrane. It is movable. It covers the mouth cavity from above. It helps to pull the food
into the mouth. It holds the food in position so that mandibles can act on it. It forms the
roof of the pre oral food cavity.

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

iii. **Mandibles**: There is a pair of mandibles. They are the first pair of jaws. They are also
called as primary jaws or true jaws. Mandibles articulate with the cranium at two points.
They are heavily sclerotised. They are toothed on their inner border.

There are two types of teeth. Distal are sharply pointed and are called incisor or cutting teeth and proximal teeth are called molar or grinding teeth. They act transversely to bite and grind the food into small fragments.

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

**v. Hypopharynx** : It is a tongue like organ. It is located centrally in the preoral cavity. Salivary gland duct opens through it.

vi. **Labium /lower lip:** It is a composite structure formed by the fusion of two primitive segmented appendages. It bounds the mouth cavity from below or behind. It forms the base of the preoral cavity. It consists of three median sclerites *viz*., **submentum** (large basalsclerite), **mentum** (middle sclerite) and **prementum** (apical sclerite). On the lateral side of the prementum there are two small lateral sclerites called **palpiger** bearing three segmented **labial palpi.** Distally prementum bears two pairs of lobes. The

other pair of
lobes is called **paraglossae** and inner pair of lobes, **glossae**. Both pairs when fused are
called **ligula**.

2**. Piercing and sucking / hemipterous / bug type** e.g. Plant bugs.
Labium projects downwards from the anterior part of the head like a beak. Beak is
four segmented and grooved throughout its entire length. At the base of the labium there
is a triangular flap like structure called labrum. Labium is neither involved in piercing nor
sucking. It functions as a protective covering for the four **stylets** (fascicle) found with in
the groove. Both mandibles and maxillae are modified into long slender sclerotized hair
like structure called stylets. They are lying close together and suited for piercing and
sucking. The tips of the stylets may have minute teeth for piercing the plant tissue. The
inner maxillary stylets are doubly grooved on their inner faces. When these are closely
opposed they form two canals viz., food canal and salivary canal through sap and saliva
are conducted respectively. Saliva contains enzymes or toxins that can distort plant cell
wall to permit the stylets to penetrate down and reach phloem for suking the sap. Both
palps are absent.

**3. Piercing and sucking / dipterous / mosquito type** : e.g. Female mosquito
Mouthparts of female mosquito consists of an elongate labium which is grooved
forming a gutter which encloses six stylets. The stylets are composed of labrum -
epipharynx (enclosing the food canal), the hyphophrynx (containing the salivary canal),
two maxillae and two mandibles. Both the ends of maxillary stylets and

mandibular
stylets are saw like and suited piercing flesh. The stylets are inserted into host's skin by a
strong downward and forward thrust of body. Both mandibles and maxillae are reduced
in male and they feed on plant nectar and juices of decaying fruits. Female pierces the
skin of human beings into which it injects saliva containing an anticoagulant (to keep
The blood flowing without clotting) and an anesthetic (to keep the victim unaware
of the bite) and sucks up the blood. Labium does not pierce but folds up or back as stylets
pierce. Maxillary palpi are present.

4. **Chewing and lapping type** : e.g. honey bee.

Labrum and mandibles are as in biting and chewing type of mouth parts. But
mandibles are blunt and not toothed. They are useful to crush and shape wax for comb
building; ingest pollen grains and other manipulative functions. Maxillolabial structures
are modified to form the lapping tongue. The tongue unit consists of two galea of
maxillae, two labial palpi and elongated flexible hairy glossa of labium. The glossa
terminates into a small circular spoon shaped lobe called spoon or bouton or flabellum
which is useful to lick the nectar.

5. **Rasping and sucking** : e.g. Thrips

Mouth cone consists of labrum, labium and maxillae. There are three stylets derived from
two maxillae and left mandible. Right mandible is absent. Stylets are useful to lacerate
the plant tissue and the oozing sap is sucked up by the mouth cone. Both maxillary palpi
and labial palpi are present.

6. **Mandibulosuctorial type** : e.g. grub of antlion

Mandibles are elongate sickle shaped and grooved on the inner surface. Each
maxilla is elongated and fits against the mandibular groove to from a closed food canal.
The body of the insect victim is pierced by the opposing mandibles and fluids are
extracted.
7. **Sponging type** : e.g. House fly
The proboscis is fleshy, elbowed, retractile and projects downwards from head.
The proboscis can be differentiated into basal rostrum and distal haustellum. The
proboscis consists of labium which is grooved on its anterior surface. Within this groove
lie the labrum-epiphraynx (enclosing the food canal) and slender hypopharynx
(containing the salivary canal). Mandibles are absent. Maxillae are represented by single
segmented maxillary palpi. The end of the proboscis is enlarged, sponge like and two
lobed which acts as suction pads.
They are called oral discs or labella. The surfaces of labella are transvered by
capillary canals called pseudotracheae which collect the liquid food and convey it to the
canal. Labella function as sponging organs and are capable of taking exposed fluids.
These insects often spit enzyme containing saliva onto solid foods to liquify them.
8. **Siphoning type** : e.g. Moths and butterflies
Mouth parts consists of elongate sucking tube or proboscis. It is formed by two
greatly elongated galeae of maxillae which are zippered together by interlocking spines
and hooks. Galeae are grooved on their inner surface and when they are fitting together
closely they form a suctorial food canal through which the nectar is

sucked up. The
proboscis is coiled up like watch spring and kept beneath the head when it is not in use.
By pumping of blood into galeae, the proboscis is extended. The other mouth parts are
reduced or absent except the labial palpi and smaller maxillary palpi.

## LECTURE 6. Insect thorax:

## segmentation of thorax. Leg structure and its modifications

### THORAX

The insect thorax is divided into three parts: the prothorax (pro=first), mesothorax
(meso=middle), and metathorax (meta=last). Each segment consists of hardened plates,
or sclerites. Dorsal sclerites are called nota (sing. notum), lateral sclerites are called
pleura (sing. pleuron), and ventral sclerites are called sterna (sing. sternum).
Each of the three thoracic segments contains one pair of legs. Wings are found only on
the meso- and metathoracic segments.

### LEGS

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 to
distal: **coxa** (p1. coxae), **trochanter**, **femur** (p1. femora),**tibia**(p1.tibiae),**tarsus** (p1. tarsi), **pretarsus**.
The femur and tibia may be modified with spines. The tarsus appears to be divided into
one to five "pseudosegments" called **tarsomeres**.

**Structure**:

In almost all insects all the three thoracic segments *viz*., pro-, meso- and metathorax bear
a pair of segmented legs. Each leg consists of five segments viz., coxa,

trochanter, femur,
tibia and tarsus.
**Coxa** : (Pl. coxae) It is the first or proximal leg segment. It articulates with the cup like
depression on the thoracic pleuron. It is generally freely movable.
**Trochanter**: It is the second leg segment. It is usually small and single segmented.
Trochanter seems to be two segmented in dragonfly, dameselfy and ichneumonid wasp.
The apparent second trochanter is in fact a part of femur, which is called trochantellus.
**Femur**: (Pl. femora) It is the largest and stoutest part of the leg and is closely attached to
the trochanter.
**Tibia**: (Pl. tibiae) It is usually long and provided with downward projecting spines which
aid in climbing and footing. Tibia of many insects is armed with large movable spur near
the apex.
**Tarsus**: (Pl. tarsi) It is further sub-divided. The sub segment of the tarsus is called
tarsomere. The number of tarsomeres vary from one to five. The basal tarsal segment is
often larger than others and is named as basitarsus.
**Pretarsus**: Beyound the tarsus there are several structure collectively known as pretarsus.
Tarsus terminates in a pair of strongly curved claws with one or two pads of cushions at
their base between them. A median pad between the claws is usually known as arolium
and a pair of pads, at their base are called pulvilli (Pulvillus-singular). Leg pads are
useful while walking on smooth surface and claws give needed grip while walking on
rough surface. When one structure is used, the other is bent upwards.

**LECTURE 7.**
**LEG TYPES AND FUNCTION**

**Cursorial**: Used for walking/ running.
Some textbooks distinguish the two by calling walking legs ambulatory or gressorial, but the leg structure is basically the same.

**Raptorial**: Fore legs modified for grasping. These are often associated with Preying Mantids.

**Fossorial**: Fore legs and tibiae specialized for digging; common in ground-dwelling insects.

**Saltatorial**: Hind legs adapted for jumping; characterized by an elongated femur and tibia.

**PRONOTUM**

Is the dorsal sclerite of the prothorax, which can be highly modified in various groups such as the Homoptera, Blattaria, and Coleoptera.

**Types of legs**

Insects are six legged arthropods and hence the class is also called Hexapoda. In insects legs perform varied functions and are modified accordingly.

1. Digging or Fossorial type: The forelegs are greatly expanded, tibia is digitate with three segmented tarsus beneath. The legs are used for digging soil. E.g. Mole cricket
2. Jumping or Saltatorial type: The hindlegs are modified for leaping or jumping. Femur is greatly enlarged, tibia is very long e.g. Grasshopper

**Natatorial:** fore or hind legs adapted for swimming; charachterized by elongated setae on tarsi

3. Walking or running type: All three pairs of legs are equal in size and comparatively long. Trochanter is two segmented. E.g. Cockroach
4. Grasping or Raptorial type: The forelegs are modified for catching prey. The coxae are elongate and moveable, the femora are spiny and grooved along

the
lower side, the tibiae are also spiny and fit into the groove along the femur. The
prey is held between the femur and tibia. Tarsus is five segmented. E.g. Preying
mantids.

5. Swimming or Natatorial type: Usually the hind legs are modified for swimming.
Hind coxae are flat and fixed to the body. Numerous long stiff hairs are present
on the lateral aspects of the tibia and tarsus. E.g. diving beetles.

6. Pollen carrying type: The hind legs of honey bees are modified for carrying
pollen. At the junction of tibia and basitarsus, a cavity guarded by hairs is present
which is used for carrying pollen. This structure is also called carbiculum. E.g.
Worker honeybee.

7. Antenna cleaner: the forelegs of honey bees are modified for cleaning antenna.
The first segment of tarsus has a notch, which can be closed by the flat tibial spur.
The notch has an inner lining of fine hairs. The antenna is placed in the notch,
closed by the spur and then drawn out to clean. E.g. Worker honeybees

8. clinging type: The legs are strong and adapted for maintaining a strong and firm
hold on the host. Tarsi are single segmented and terminate in a single sickle
shaped claw which works against a tibial process. E.g. Head louse and body
louse.

9. Climbing type: The terminal segment of the leg, pretarsus, bears two claws and
beneath the claws are two lobes ccalled pulvulii. Between the pulvulii is an
elongate spine called empodium. The empodium and pulvulii help the

insect to
climb smooth surfaces. E.g. housefly.

**LECTURE 8. Insect wing:**

**structure and its modifications**

**WINGS**

Insects have evolved many variations of the wing. Wing venation is a commonly used taxonomic character, especially at the family and species level.

Membranous wings are thin and more or less transparent. This type of wings is found among the Odonata and Neuroptera.

**Halteres** are an extreme modification among the order Diptera (true flies), in which the hind wings are reduced to mere nubs used for balance and direction during flight.

HALTERE

**Elytra** (sing. elytron) are the hardened, heavily sclerotized forewings of beetles (Order Coleoptera) and are modified to protect the hind wings when at rest.

A variation of the elytra is the **hemelytra**. The forewings of Hemipterans are said to be hemelytrous because they are hardened throughout the proximal two-thirds (approximately), while the distal portion is membranous. Unlike elytra, hemelytra function primarily as flight wings. In both cases, the membranous hind wings (when present) are used in flight and are folded beneath the forewings when at rest.

ELYTRA

HEMELYTRA

Membranous
hind wing

The wings of butterflies and moths are covered with scales, and mosquitoes possess scales along wing veins.

**NEOPTEROUS VS PALEOPTEROUS WING CONDITIONS**

In most living insects (the Neoptera), there are three axillary sclerites that articulate with various parts of the wing. In the Neoptera, a muscle on the third axillary causes it to pivot about the posterior notal wing process and thereby to fold the wing over the back of the insect. (In some groups of Neoptera, such as butterflies, the ability to fold the wings over the back has been lost.) Two Orders of winged insects, the Ephemeroptera and Odonata, have not evolved this wing-flexing mechanism, and their axillary sclerites are arranged in a pattern different from that of the Neoptera; these two orders (together with a number of extinct orders) form the Paleoptera.

## LECTURE 9. NEOPTEROUS VS PALEOPTEROUS WING CONDITIONS

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**Types of insect wings**

Among invertebrate animals, only insects posses wings. Wings are present only in

adult stage. Number of wings vary from two pairs to none. Certain primitive insects like
silverfish and spring tail have no wings (apterous). Ectoparasites like head louse, poultry
louse and flea are secondarily wingless. Wings are deciduous in ants and termites. There
is only one pair of wings in the true flies. Normally, two pairs of wings are present in
insects and they are borne on pterothoracic segments viz., mesothorax and metathorax.
Wings are moved by thoacic flight muscles attached to their bases.
Wing is a flattened double - layered expansion of body wall with a dorsal and
ventral lamina having the same structure as the integument. Both dorsal and ventral
Paleopterous
laminane grow, meet and fuse except along certain lines. Thus a series of channels is
formed. These channels serve for the passage of tracheae, nerves and blood. Wing is
nourished by blood circulating through veins. Later the walls of these channels become
thickened to form veins or nervures. The arrangement of veins on the wings is called
venation which is extensively used in insect classification. The principal longitudinal
veins arranged in order from the anterior margin are costa (C), sub costa (Sc), radius (R),
median (M), cubitus (Cu) and anal veins (A). Small veins often found inter connecting
the longitudinal veins are called cross veins. Due to the presence of longitudinal veins
and cross veins, the wing surface gets divided into a number of enclosed spaces termed
cells. In insects like dragonfly and damesefly, there is an opaque spot near the coastal
margin of the wing called pterotigma.

**Margins and angles**: The wing is triangular in shape and has therefore three sides and
three angles. The anterior margin strengthened by the costa is called coastal margin and
the lateral margin is called apical margin and the posterior margin is called anal margin.
The angle by which the wing is attached to the thorax is called humeral angle. The angle
between the coastal and apical margins is called apical angle. The angle between apical
and anal margins is anal angle.
**Wing regions**: The anterior area of the wing supported by veins is usually called
remigium. The flexible posterior area is termed vannus. The two regions are separated by
vannal fold. The proximal part of vannus is called jugum, when well developed is
separated by a jugal fold. The area containing wing articulation sclerites, pteralia is called
axilla.

**LECTURE 10**.**Wing regions**:

The anterior area of the wing supported by veins is usually called
remigium. The flexible posterior area is termed vannus. The two regions are separated by
vannal fold. The proximal part of vannus is called jugum, when well developed is
separated by a jugal fold. The area containing wing articulation sclerites, pteralia is called
axilla.
**Wing types:**
**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** : (Sigular : Elytron) The wing is heavily sclerotised. Wing

venation is lost.
Wing is tough and it is protective in function. It protects hind wings and abdomen. It is
not used during flight. But during flight they are kept at an angle allowing free movement
of hind wings. e.g. Fore wings of beetles and weevils.
**3. Hemelytra** : (Singular : Hemelytron) The basal half of the wing is thick and leathery
and distal half is membranous. They are not involved in flight and are protective in
function. e.g. Fore wing of heteropteran bugs.
**4. Halteres**: (Singular : Haltere) In true flies the hind wings are modified into small
knobbed vibrating organs called haltere. Each haltere is a slender rod clubbed at the free
end (capitellum) and enlarged at the base (scabellum). On the basal part two large group
of sensory bodies forming the smaller hick's papillae and the large set of scapel plate.
They act as balancing organs and provide the needed stability during flight. e.g. true flies,
mosquito, male scale insect.
**5. Fringed wings**: Wings are usually reduced in size. Wing margins are fringed with long
setae. These insects literally swim through the air. e.g. Thrips.
**6. 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**: They are thin, transparent wings and supported by a system of
tubular veins. In many insects either forewings (true flies) or hind wings (grass hopper,

cockroach, beetles and earwig) or both fore wings and hind wings (wasp, bees, dragonfly
and damselfly) are membranous. They are useful in flight.

**Wing coupling:** Among the insects with two pairs of wings, the wings may work
separately as in the dragonflies and damselflies. But in higher pterygote insects, fore and
hind wings are coupled together as a unit, so that both pairs move synchronously. By
coupling the wings the insects become functionally two winged.

**Types of wing coupling**

1. **Hamulate** : A row of small hooks is present on the coastal margin of the hind wing
which is known as hamuli. These engage the folded posterior edge of fore wing. e.g.
bees.

2. **Amplexiform** : It is the simplest form of wing coupling. A linking structure is absent.
Coupling is achieved by broad overlapping of adjacent margins. e.g. butterflies.

3. **Frenate** : There are two sub types. e.g. Fruit sucking moth.

i. Male frenate : Hindwing bears near the base of the coastal margin a stout bristle
called frenulum which is normally held by a curved process, retinaculum arising
from the subcostal vein found on the surface of the forewing.

ii. Female frenate : Hindwing bears near the base of the costal margin a group of
stout bristle (frenulum) which lies beneath extended forewing and engages there
in a retinaculum formed by a patch of hairs near cubitus.

4. **Jugate :** Jugam of the forewings are lobe like and it is locked to the coastalmargin of
the hindwings. e.g. Hepialid moths.

**LECTURE 11**. **Insect abdomen:**

**structure and its modifications**

## ABDOMEN

The dorsal and ventral abdominal segments are termed terga (singular tergum) and sterna
(singular sternum), respectively. Spiracles usually can be found in the conjunctive tissue
between the terga and sterna of abdominal segments 1-8. Reproductive structures are
located on the 9th segment in males (including the aedeagus, or penis, and often a pair of
claspers) and on the 8th and 9th abdominal segments in females (female external genitalia
copulatory openings and ovipositor).

## MODIFICATIONS OF THE OVIPOSITOR

## SEXUAL DIMORPHISM

**Female** (note the long ovipositor **Male** (two cerci at the end of
Between the cerci) the abdomen)

## Abdominal structures in insects

### Basic structures

Segmentation is more evident in abdomen. The basic number of abdominal
segments in insect is eleven plus a telson which bears anus. Abdominal segments are
called uromeres. On eighth and nineth segment of female and nineth segment of male, the
appendages are modified as external organs of reproduction or genitalia. These segments
are known as genital segments. Usually eight pairs of small lateral openings (spiracles)
are present on the first eight abdominal segments. In grasshoppers, a pair of tympanum is

CERCI

OVIPOSITOR

found one on either side of the first abdominal segment. It is an auditory organ. It is
obliquely placed and connected to the metathoracic ganglia through auditory nerve.

**Modifications:**
Reduction in number of abdominal segments has taken place in many insects. In
spring tail only six segments are present. In house fly only segments 2 to 5 are visible and
segments 6 to 9 are telescoped within others. In ants, bees and wasps, the first abdominal
segment is fused with the metathorax and is called propodeum. Often the second segment
forms a narrow petiole. The rest of the abdomen is called gaster. In queen termite after
mating the abdomen becomes gradually swollen due to the enlargement of ovaries. The
abdomen becomes bloated and as a result sclerites are eventually isolated as small
islands. Obesity of abdomen of queen termite is called physogastry.

**LECTURE 12. Abdominal appendages**
**i . Pregenital abdominal appendages in wingless insects**:
1) **Styli** : (Stylus : Singular) Varying number of paired tube like outgrowths are found on
the ventral side of the abdomen of silverfish. These are reduced abdominal legs which
help in locomotion.
2). **Collophore or ventral tube or glue peg**: It is located on the ventral side of the first
abdominal segment of spring tail. It is cylindrical. It is protruded out by the hydrostatic
pressure of haemolymph. It might serve as an organ of adhesion. It aids in water
absorption from the substratum and also in respiration.
3). **Retinaculum or tenaculum or catch**: It is present on the ventral side of the third
abdominal segment. It is useful to hold the springing organ when not in use.
4). **Furcula or Furca**: This is a 'Y' shaped organ. It is present on the venter of fourth

abdominal segment. When it is released from the catch, it exerts a force against the
substratum and the insect is propelled in the air.

ii) **Abdominal appendages in immature insects**:

1) **Tracheal gills**: Gills are lateral outgrowths of body wall which are richly supplied
with tracheae to obtain oxygen from water in naiads (aquatic immature stages of
hemimetabolous insects). Seven pairs of filamentous gills are present in the first seven
abdominal segments of naiads of may flyand are called as lateral gills. Three or two leaf
like gills (lamellate) are found at the end of adbomen of naiad of damselfly and are called
as caudal gills. In dragonfly the gills are retained within the abdomen in a pouch like
rectum and are called as rectal gills.

2) **Anal papillae**: A group of four papillae surrounds the anus in mosquito larvae. These
papillae are concerned with salt regulation.

3) **Dolichasters**: These structures are found on the abdomen of antlion grub. Each
dolichaster is a segmental protuberance fringed with setae.

4) **Proloegs**: These are present in the larvae of moth, butterfly and sawfly. Two to five
pairs are normally present. They are unsegmented, thick and fleshy. The tip of the proleg
is called planta upon which are borne heavily sclerotised hooks called crochets. They aid
in crawling and clinging to surface.

iii) **Abdominal appendages in winged adults** :

1) **Cornicles**: Aphids have a pair of short tubes known as cornicles or siphonculi
projecting from dorsum of fifth or sixth abdominal segment. They permit the escape of
waxy fluid which perhaps serves for protection against predators.

2) **Caudal breathing tube**: It consists of two grooved filaments closely

applied to each
other forming a hollow tube at the apex of abdomen. e.g. water scorpion.
3) **Cerci** : (Cercus - Singular) They are the most conspicuous appendages associated
normally with the eleventh abdominal segment. They are sensory in function. They
exhibit wide diversity and form.
Long and many segmented :- e.g. Mayfly
Long and unsegmented :- e.g. Cricket
Short and many segmented :- e.g. Cockroach
Short and unsegmented :- e.g. Grasshopper
Sclerotised and forceps like : e.g. Earwig. Cerci are useful in defense, prey
capture, unfolding wings and courtship.
Asymmetrical cerci :- Male embiid. Left cercus is longer than right and functions
as clasping organ during copulation.
4) **Median caudal filament**: In mayfly (and also in a wingless insect silverfish) the
epiproct is elongated into cercus like median caudal filament.
5) **Pygostyles**: A pair of unsegmented cerci like structures are found in the last abdominal
segment of scoliid wasp.
6) **Anal styli**: A pair of short unsegmented structure found at the end of the abdomen of
male cockroach. They are used to hold the female during copulation.
7) **Ovipositor**: The egg laying organ found in female insect is called ovipositor. It is
suited to lay eggs in precise microhabitats. It exhibits wide diversity and form. Short and
horny : e.g. Short horned grasshopper
Long and sword like : e.g. Katydid, long horned grasshopper
Needle like : e.g. Cricket
Ovipositor modified into sting : e.g. Worker honey bee.
**Pseudoovipositor**: An appendicular ovipositor is lacking in fruit flies and house flies. In
fruit flies, the elongated abdomen terminates into a sharp point with

which the fly pierces
the rind of the fruit before depositing the eggs. In the house fly the terminal abdominal
segments are telescopic and these telescopic segments aid in oviposition. The ovipositor
of house fly is called pseudoovipositor or ovitubus or oviscapt.

**Male genitalia**: External sexual organs of male insects are confined to ninth abdominal
segment. In damselfly, the functional copulatory organ is present on the venter of second
abdominal segment