Lecture no. 1

Introduction and History of Entomology in India

Entomology is a biological science dealing with a specific group of organisms, the insects. Man originated about a million years ago, and insects at least 500 million years ago. Insects constitute the largest Class of the whole living organisms and about 72 per cent of all living animals are insects with 9-15 lakh known species.

- Entomology (from Greek, *entomon* = insect and *logos* = study) is the scientific study of insects, a branch of zoology. It aims at understanding their body organization & functions, their habit and habitat, their classification, development, distribution, origin past history and economic importance.

- Agricultural Entomology divided into two categories
  1. Basic/Fundamental/General Entomology
  2. Applied/Economic Entomology

- **Basic Entomology** deals with Insect morphology, anatomy, physiology, taxonomy & systematics.

- **Applied Entomology** deals with ecology and economic importance and control of insects.

  - There are lot of mentions about insects in our mythological epics, the Ramayana (2550-2150 BC) and Mahabharata (1424-1366 BC). Mentions about silk, honey and lac were found in these epics.

  - The first detailed classification of insects was done by **Umaswati** (0-100 AD). Classification of bees by the Indian physician **Charaka** (1200-1000BC) and classification of ants, flies and mosquitoes by the surgeon **Sushruta** (100-200 AD) are the evidences for our earliest knowledge about insects.
Entomology in modern India must have taken its place in Natural History some time after the 16\textsuperscript{th} century. It is possible to define the modern history of entomology in India under the following two headings.

1. Entomology in India during 1750-1900.
2. Entomology in India during 1900-2000.

**Entomology in India during 1750-1900**

- 1758- The beginning of the modern era of Indian Entomology came with the publication of the tenth edition of Carl Linnaeus’s “Systema Naturae”. This contained the earliest record of 28 species of Indian insects.

- 1767-1779- J.G.Koenig, a medical Officer from Denmark, a student of Carl Linnaeus and friend of Fabricius, for the first time during the 18th century collected number of insects from Coromandel area and Southern Peninsular India and his collections were studied and named by Professor Linnaeus himself. He also published a special account of the termites of Thanjavur District. Fabricius, made Koenig's name remembered for ever by naming the well known and destructive red cotton bug of this country as *Dysdercus koenigi*.

- 1782 - Dr. Kerr published on account of lac insect.

- 1785- Asiatic Society of Bengal started in Calcutta.

- 1791- Dr. J. Anderson issued a monograph on Cochineal scale insects.

- 1875- Foundation of the “Indian Museum” at Calcutta.

- 1883- “Bombay Natural History Society” was started. Numerous contributions of Indian insects were published in the Journal of the Bombay Natural History.

- 1883- Commencement of “Fauna of British India” series under the editorship of W.T. Blandford.

- 1892- Entomological part of the “Fauna of British India” (now Fauna of India) series started with Sir George Hampson contributed first of the four volumes on the moths of India.
1893- Rothney published on Indian Ants (earliest record of biological pest control in India) i.e. White ants attack on stationary items was kept free by red ants.

Entomology in India during 1900-2000

1901- Lionel de Nicevelle was posted as the first entomologist to the Government of India

1903- Professor Maxwell Lefroy succeeded Nicevelle as Government Entomologist.

1905- Establishment of Imperial Agricultural Research Institute at Pusa, Bihar and Professor Lefroy became the first Imperial Entomologist.

1906- ‘Indian Insect Pests' by Professor Lefroy.

1909- "Indian Insect Life"- Professor Lefroy.

Subsequently State Governments also took up entomological work. Madras, Punjab and Uttar Pradesh appointed their first State/ Provincial Government Entomologists in 1912, 1919 and 1922 respectively.

1912- Plant Quarantine Act was enforced.

1914- Destructive Insects and Pests Act was enforced.

1914- T.B. Fletcher, the first Government Entomologist of Madras State, published his book "Some South Indian Insects".

1914- 'Indian Forest Insects of Economic Importance: Coleoptera' was published by the first Imperial Forest Entomologist E.P. Stebbing

1916- Imperial Forest Research Institute was established at Dehra Dun, and E.P. Stebbing was appointed as Forest Zoologist.

1916- The Natural History Section of the Indian Museum was formed as the Zoological Survey of India.

1921- Indian Central Cotton Committee to investigate on pests of cotton.

1925- Indian Lac Research Institute started.

1934- Hem Singh Pruthi who succeeded Fletcher as Imperial Entomologist, made efforts to bring all the entomological workers still closer which resulted into
The foundation of 'Entomological Society of India' in 1938. Afzal Hussain was the first President of the Entomological society of India and the Vice-President were Hem Singh Pruthi and Ramakrishna Ayyar. The official publication of the Society is the 'Indian Journal of Entomology'.

- **1939**- Locust Warning Organisation was established.
- **1940**- Dr. T.V. Ramakrishna Ayyar published the book "Handbook of Economic Entomology for South India".
- **1963**- Text book of Agricultural Entomology by H.S.Pruthi
- **1968**- Dr. M.S. Mani's "General Entomology"
- **1969**- Dr. Pradhan's "Insect Pests of Crops"
- **1946**- 'Directorate of Plant Protection, Quarantine and Storage’ of GOI started.
- **1968**- The Govt. of India enacted ‘Central Insecticide Act’ which came into force from 1st January, 1971.
- **1969**- "The monograph on Indian Thysanoptera" was published by Dr.T. N. Ananthakrishnan.
Lecture no. 2

Major points related to dominance of Insecta in animal kingdom

Reasons for dominance of Insect:

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
4. Presence of exoskeleton
5. Resistance to desiccation
6. Tracheal system of respiration
7. Higher reproductive potential
8. Presence of complete metamorphosis
9. Presence of defense mechanisms
10. Hexapod locomotion

Structural characters

1. **Capacity for flight**: Insects are the only invertebrates that can fly. Flight gave these insects a highly effective mode of escape from predators that roamed the prehistoric landscape. Efficient use of energy allows some insects to travel great distances or remain airborne for long periods of time. More than 200 species, including moths, dragonflies, locusts, flies, and beetles are known to migrate over long distances by air. The migratory locust, *Schistocerca gregaria*, can fly for up to 9 hours without stopping.

   - Monarch butterfly can fly 600 km at time.
2. **More adaptability or universality**: A combination of large and diverse populations, high reproductive potential, and relatively short life cycles, has equipped most insects with the genetic resources to adapt quickly in the face of a changing environment. Adaptation is an ongoing process. Populations must continually change as new resources appear and old ones disappear.

3. **Smaller size**: Majority of insects are small in their size conferring the following physiological and ecological advantages. Most species are between 2 and 20 mm (0.1 - 1.0 inch) in length, although they range in size from giant moths that would nearly cover your computer screen to tiny parasitic wasps. *Dichomorpha echmepterygis* is the smallest of the small. Adult males may be only 0.139 mm (0.00055 inch) in length -- nearly 1/3 smaller than some single-celled protozoa. Advantage of small size is the minimal resources needed for survival and reproduction. Small size is a big advantage to insects that must avoid predation. They can hide in the cracks of a rock, beneath the bark of a tree, behind the petal of a flower, or under a blade of grass.
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.
Developmental characters

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.

8. Presence of complete metamorphosis: More than 82 per cent of insects undergo complete metamorphosis (holometabolous insects) with four stages. As the larval and adult food sources are different, competition for food is less.

Protective adaptations and devices

9. Presence of defense mechanisms: By different defense mechanisms, insects escape from the enemies to increase their survival rate.

Morphological defense
Physiological defense

Behavioral defense

10. **Hexapod locomotion**: Insects uses 3 legs at a time during locomotion, while the remaining 3 legs are static, which gives greater stability.
Lecture no. 3
Classification of phylum Arthropoda upto classes

Insects are invertebrates grouped in the phylum Arthropoda (Arthro-joint, poda-foot) and subphylum Uniramia. Arthropoda (from Greek words arthros = jointed, podos = foot) is the largest phylum in the Animal Kingdom. Arthropods are segmented animals which have jointed appendages. Characters of the Phylum Arthropoda are:

1. Segmented body is divided into head, thorax and abdomen. Sometimes head and thorax are united together to form cephalothorax.
2. Segments grouped into 2 or 3 regions (tagma) known as Tagmosis. Renewable chitinous exoskeleton - a hard protective covering around the outside of the body (divided by sutures into plates called sclerites).
3. Grow by molting.
4. Bilateral symmetry of body.
5. Body cavity filled with blood and called as haemocoel.
6. Tubular alimentary canal with mouth and anus at anterior and posterior ends.
7. Dorsal heart with valve like ostia.
8. Dorsal brain with ventral nerve cord.
9. Striated muscles (with dark and light bands).
10. No cilia (hair like vibratile structure on the surface of the cell).

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. Centipede
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.
Class: Arachnida

Arachnids possess:
- Terrestrial, 2 body segments - cephalothorax and abdomen.
- 4 pairs of legs, simple eyes, respiration is done by gills or lungs no antennae.
- It has 4 sub classes:
  1. Scorpionida: E.g. Scorpion
  2. Phalangida: E.g. Harvest man or Daddy long leg.
  3. Araneida; E.g. Spiders
  4. Acarina: E.g. Ticks and Mites.

Class: Chilopoda

Chilopods are quick moving predators with poison glands which possess:
- Terrestrial in habitat, body is long, flattened and multi-segmented.
- 1 pair of legs per body segment.
- 1 pair of antennae.
- 1st pair of legs modified into venomous “fangs”
- Animals are unisexual.
  E.g. centipedes

Class: Diplopoda

Diplopods are slow moving vegetarians which possess:
- Many body segments, long and cylindrical 2 pair of legs per body segment 1 pair of antennae.
  E.g.: millipedes shrimp, barnacles, sow bugs, etc.

Class: Crustacea

Crustaceans possess:
- Mostly aquatic, free living parasites.
- Two body regions – Cephalothorax and abdomen.
- Pairs of antennae.
- Varied number of legs (usually five).
- Respiration is done by skin or by gills.
- Excretion is done by green glands.
Mostly unisexual.

**Class: Insecta**

- Body divided into 3 segments: head, thorax, and abdomen.
- Possess three pairs of legs, hence the name Hexapoda.
- Presence of one or two pairs of wings.
- A pair of antennae.
- Respiration by means of internal air tubes known as trachea.
- Genital opening situated at the posterior end of the body.
- Presence of metamorphosis (incomplete/complete) during development.
- Possess exoskeleton made up of hard cuticle which plays an important role for survival.
- Excretion is mainly by malpighian tubules which help in maintaining ionic balance.
<table>
<thead>
<tr>
<th>Characters</th>
<th>Onychophora</th>
<th>Crustacea</th>
<th>Arachnida</th>
<th>Chilopoda</th>
<th>Diplopoda</th>
<th>Insecta/ Hexapoda</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Habit</td>
<td>Terrestrial</td>
<td>Aquatic and few terrestrial</td>
<td>Terrestrial</td>
<td>Terrestrial</td>
<td>Terrestrial</td>
<td>Many terrestrial and very few aquatic</td>
</tr>
<tr>
<td>2. Body regions</td>
<td>Not distinct</td>
<td>Two- Cephalothorax and abdomen</td>
<td>Three-Pro, Meso and Metasoma eg. Scorpion. Two-Pro and Opisthosoma eg. Spider</td>
<td>Two-Head and multisegmented trunk</td>
<td>Two-Head and multisegmented trunk</td>
<td>Three-Head, thorax and abdomen</td>
</tr>
<tr>
<td>3. Antenna</td>
<td>I pair</td>
<td>2 pair - Antennule and Antenna</td>
<td>No antenna</td>
<td>One pair</td>
<td>One pair</td>
<td>One pair</td>
</tr>
<tr>
<td>4. Visual organs</td>
<td>Not distinct</td>
<td>One pair - Stalked compound eyes</td>
<td>One pair - simple eyes</td>
<td>One pair-simple eyes</td>
<td>One pair-simple eyes</td>
<td>Both simple eyes and compound eyes (one pair)</td>
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<tr>
<td>5. Locomotor organs</td>
<td>Many pairs of unjointed legs</td>
<td>Minimum five pairs of biramous legs</td>
<td>Four pairs</td>
<td>One pair per segment (First pair of legs modified as poison claw)</td>
<td>Two pair per segment (No poison claws)</td>
<td>3 pairs of legs on 3 thoracic segments and 2 pairs of wings on meso and metathorax</td>
</tr>
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<td>6. Mouth Parts</td>
<td>Non mandibulate</td>
<td>Mandibulate (1 pair)</td>
<td>No mandibulate, but possess chelicerae</td>
<td>Mandibulate (1 pair)</td>
<td>Mandibulate (1 pair)</td>
<td>Mandibulate (1 pair)</td>
</tr>
<tr>
<td>7. Respiration</td>
<td>Cutaneous</td>
<td>Gill breathing</td>
<td>(Scorpion) and tracheal.</td>
<td>Tracheal</td>
<td>Tracheal</td>
<td>Tracheal</td>
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<tr>
<td>8. Body fluid</td>
<td>Haemolymph</td>
<td>Haemolymph</td>
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<td>9. Circulatory system</td>
<td>Heart with ostia</td>
<td>Heart with ostia</td>
<td>Heart With ostia</td>
<td>Heart With ostia</td>
<td>Heart With ostia</td>
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<td>10. Development</td>
<td>Anamorphosis</td>
<td>Anamorphosis</td>
<td>Metamorphosis absent scorpion; Metamorphosis present-mites</td>
<td>Metamorphosis</td>
<td>Metamorphosis</td>
<td>Metamorphosis</td>
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<tr>
<td>11. Habit</td>
<td>Feed on organic matter</td>
<td>Herbivorous and Carnivorous</td>
<td>Phytophagous and predators</td>
<td>Carnivorous</td>
<td>Herbivorous</td>
<td>Phytophagous, predators and parasitoids</td>
</tr>
<tr>
<td>12. Special features</td>
<td>Link between Annelida and Arthropoda</td>
<td>Classification strengthens exoskeleton</td>
<td>Life cycle; Egg-larva-nymph-adult. Larva With 3 pairs of legs and Nymph with 4</td>
<td>Opisthogenital- in the terminal segment</td>
<td>Progogenital- segment</td>
<td>Genital structures on 8th and 9th abdominal segments. Brain with proto, deuto and tritocerebrum</td>
</tr>
</tbody>
</table>