SIXTH SEMESTER B.Sc. ZOOLOGY

CALICUT UNIVERSITY

ZOOLOGY ELECTIVE COURSE- I

Code: ZO6B 15(E) 03T

APPLIED ENTOMOLOGY

2017 ADMISSION

Prepared By ,

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SYLLABUS

SIXTH SEMESTER B.Sc. DEGREE PROGRAMME(Theory)
ZOOLOGY ELECTIVE COURSE- I
Code: ZO6B 15(E) 03T
APPLIED ENTOMOLOGY
(54 hours) (3 hours per week) (3 credits)

A. Agricultural Entomology

1. Introduction to Entomology (5 Hrs)

- Mention Agricultural entomology, Forest entomology, Veterinary entomology, Medical entomology, Forensic entomology, Industrial entomology, Nutritional entomology, Cultural entomology.
- Classificaiton of Class Insecta down to orders, General organization of an insect.

2. Insects in Service of Man (2 hrs)

- Useful products, Useful body, Galls, Pollinators, Destroyers of insect pests, Serve as food for animals and even man, Destroyers of weeds, Improve soil fertility, Act as scavengers, Aid in scientific research, Aesthetic and entertainment value, Use in medicine, Pollution indicators, Arrow poisons, Cold light, Insects in forensic science, Utility of insect pheromones and hormones (very brief account)**.**

3. Insects as enemies of Man: **(23 hrs)**

- Definition of pests, kinds of insect pests, causes of pest out break, pests injurious to plants and animals, pests as vectors of diseases,

(a) Pests of Paddy: (Life history , damage and control measures)
1 . *Spodoptera mauritia* (Rice swarming caterpillar)
2. *Leptocorisa acuta* (Rice bug)
3. *Dicladispa armigera* (Rice hispa)

(b) Pests of coconut: (Life history, damage and control measures)
1. *Oryctes rhinoceros* (Rhinoceros beetle)
2. *Opisina arenosella* (Black headed caterpillar)
3. *Aceria guerrerornis* (Coconut mite)

(c) Pests of sugar cane (damage and control measures)
1. *Chilo infuscatellus* (Sugarcane shoot borer)
2. *Scirpophaga nivella* (Sugarcane top shoot borer)
3. *Sacchariococcus sacchari* (Cane mealy bug)

(d) Pests of plantation crops: Coffee, rubber, tea, pepper and cardamom.

(Two examples for each , Damage, control measures)

- Coffee:

1. *Xylotrechus quadripes* (Coffee white stem borer)
2. *Coccus virids* (Coffee green bug)

- Tea :

1. *Helopeltis antonii* (Tea mosquito bug)
2. *Toxoptera aurantii* (Tea aphid)

- Rubber:

1. *Aspidiotus destructor* (Scale insect)
2. *Comocrits pieria* (Bark caterpillar)

- Pepper:

1. *Longitarsus nigripennis* (Pollu beetle)
2. *Laspeyresia hemidoxa* (Shoot borer)

- Cardamom:

1. *Sciothrips cardamomi* (Cardamom thrips)
2. *Eupterote canarica*(Cardamom hairy caterpillar)

(c) Pests of fruits and vegetables (Banana, mango, cashew, lady's finger, chilly, pulses, etc.) Two examples for each, Damage and control measures.

Pests of fruit plants:

- Banana :

1. *Cosmopolites sordidus* (Banana weevil)
2. *Pentalonia nigronervosa* (Banana aphid)

- Mango :

1. *Batocera rufomaculata* (Mango stem borer)
2. *Dacus dorsalis* (Fruit fly)

- Cashew :

1. *Plocoederus ferrugineus* (Cashew stem borer).
2. *Helopeltis antonii* (Cashew mirid).

Pests of vegetables:

- Lady's finger:

1. *Platyedra gossypiella* (Pink ball worm)
2. *Earias vitella* (Spotted ball worm)

- Brinjal :

1. *Leucinodes orbonalis* (Shoot and fruit borer)
2. *Epilachna vigintioctopunctata* (Epilachna beetle)

- Cucurbits :

1. *Dacus cucurbitae* (Melon fly)

2 *Raphidopalpa foveicollis* (Pumpkin beetle)

(d) Pests of stored products. (damage and control measures).

1. *Tribolium castaneum* (Rust red flour beetle)

2.*Callasobruchus chinensis* (Pulse beetle)

(e) Pests of domestic animals: 3 examples.
1. Domestic fowl: *Menopon gallinae* (Shaft louse)
2. Goat : *Oestrus ovis*
3. Cattle : *Tabanus striatus* (Horse fly)

4. Insect Pest Control: (12 hrs)
(a) Natural control
(b) Applied control or Artificial control:

- Prophylactic and Curative methods [cultural, mechanical, legal methods (brief account) biological and chemical methods].

- **Biological control** : History; Ecological, biological and economic dimensions of biological pest control methods
- Mention any 3 important biological control project undertaken in India.
- Merits and demerits.

- **Chemical control**: Classification, Insecticides of plant origin; Insecticides,
- Mention insecticide residue, resistance and resurgence of insect pests;
- Pesticide appliances (Hand compression sprayer, Knapsack sprayer and Rocker sprayer);
- Precautions in handling insecticides (brief account).

- **Modern methods of Pest control**: Autocidal and Pheromonal control (brief account)

- **Integrated Pest Management (IPM)**: Features, advantages (brief account).

B. Industrial Entomology (12 hrs)
Productive Insects

(a) Honey bee:

- Apiculture and its scope
- Different species
- Social organization
- structure of worker bee, life history (brief account) and communication;
- Bee products: Honey and Bee wax, Composition and Uses
- Bee diseases.

(b) Silk moth:

- Different types of silkworms
- life cycle (brief account);
- Sericulture (brief account), moriculture,
- Processing and extraction of silk(brief account
- Diseases of silk worms, composition and uses of silk.

(c) Lac insect:

- Different strains of Lac insect
- cultivation, inoculation and harvesting, propagation of lac ; composition and uses of lac,
- enemies of lac insects.

Seminars / Assignment / Discussion

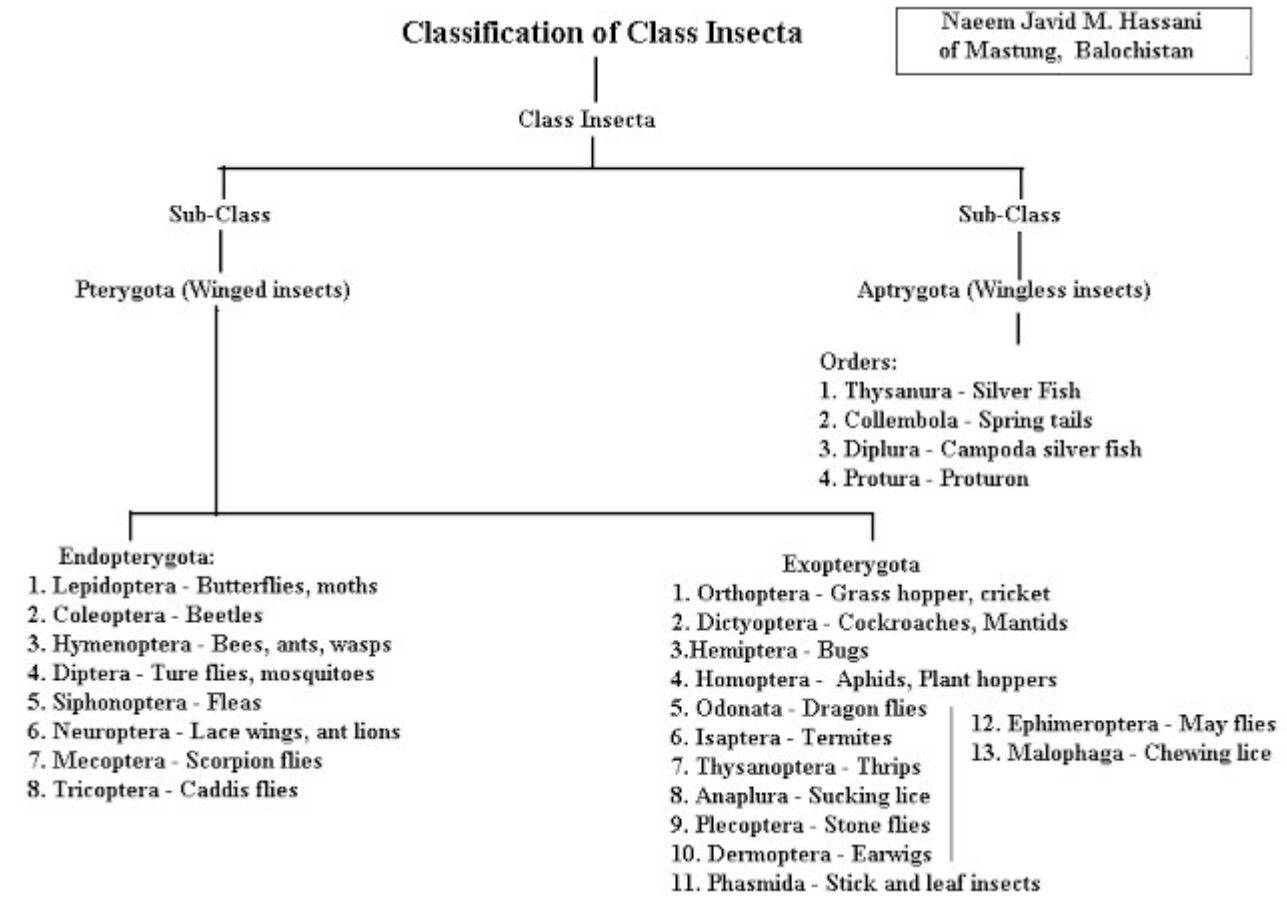
1. Biology of major insect vectors of human diseases, *Anopheles, Culex, Aedes, Xenopsylla, Pediculus, Cimex, Phthirus*.
2. Diseases and its control measures of Filariasis, Yellow fever, Dengue, Typhus fever, Plague and Kala-azar.
3. Collection and Preservation of Insects.
4. Insects as human food for the future.
5. Causes of success of insects.

MODULE : 1 INTRODUCTION

ENTOMOLOGY

- *Entomon :* insect ; *logos :* study
- Scientific study of insects
- Father : William Kirby
- Branch of entomology dealing with the practical importance of insects :*applied or economic entomology*
- Branches :
    1. *Agricultural entomology*
    2. *Medical entomology*
    3. *Veterinary entomology*
    4. *Forensic entomology*
    5. *Forest entomology*
    6. *Industrial entomology*
    7. *Nutritional entomology*
    8. *Cultural entomology*

CLASSIFICATION OF INSECTS



- Insects are tracheate and mostly terrestrial arthropods

- Body is divisible into head thorax and abdomen.
- head bears a pair of antennae, a pair of compound eyes, a pair of mandibles and two pairs of maxillae.
- Mandibles and maxillae form the mouth-parts are variously modified for cutting, sucking, chewing and siphoning the food.
- Thorax has three segments and bears three pairs of legs and one or two pairs of wings.
- Wings may be absent in some.
- Abdomen consists of 1I segments and is without ambulatory appendages.
- Class Insecta includes about 675,000 species.
- lt is divided into two sub-classes:
  - *APTERYGOTA*
  - *PTERYGOTA.*

A. <u>Sub-class Apterygota</u>

- This includes wingless, primitive insects.
- chewing mouthparts
- males have abdominal processes, called *style*
- no metamorphosis.
- Sub-class Apterygota is divided into 4 orders.

1. Order Collembola

- Comprises the springtails, Wingless insects, with 6 abdominal segments and 3 pairs of abdominal appendages
- Compound eyes, tracheal system, Malpighian tubules and anal cerci absent.
- e.g.:*Tomocercus, Podura.*

2. Order Protura

- Small, soft-bodied and wingless insects, without compound eyes,
- anal cerci and antennae.
- Nine abdominal segments in young and 12 in adult.
- First 3 abdominal segments have appendages, called pectines.
- Piercing mouth-parts.
- Little metamorphosis.
- e.g.: *Acerentomun,Campodea*

3. Order Diplura

- The two-pronged bristle-tails.
- Blind, flattened and wingless insects
- biting mouth-parts,
- *moniliform (*beaded) antennae
- a pair of anal cerci.
- No metamorphosis
- e.g*.: Japyx, Anajapyx.*

4. Order Thysanura

- Silver-fishes and three-pronged bristletails.
- Small, soft-bodied,Wingless and scale-covered insects.
- Abdomen has 11 segments.

- Biting mouth-parts.
- Many-jointed antennae.
- Three long anal filaments.
- No metamorphosis.
- e.g. *Lepisma (silver fish).*

B. <u>Sub-class Pterygota (metabola)</u>

- Advanced and winged insects.
- Abdomen without appendages.

2 orders :

- *Endopterygota (holometabola) :*complete metamorphosis
- *Exopterygota (hemimetabola):*partial or incomplete metamorphosis

1. Order Ephemeroptera (*ephemeros = lasting for a day)*

- May-flies.
- Small winged insects.
- Undeveloped mouth-parts.
- Well developed compound eyes.
- Membranous wings held vertically over the back.
- Nymphs are aquatic
- Two adult stages : sexually immature *sub-imago* and sexually mature *imago.*
- e.g. *Ephemera vulgata* (mayfly).

2. Order Odonata

- Dragon-flies, damsel-flies.
- Winged insects, with biting mouth-parts.
- Long and slender abdomen.
- Short antennae.
- Large compound eyes.
- Strong mandibles and small antennae.
- Two pairs of wings
- Nymphs are aquatic, found in stagnant fresh waters.
- e.g.*Palaeophlebia* (dragon fly).

3. Order Dictyoptera

- Cockroaches, woodroaches and mantids.
- Head held at right angles to the body axis.
- Biting mouth-parts.
- Leathery anterior wings.
- Posterior wings membranous and used for flight.
- e.g.: *Periplaneta americana* (cockroach)

4. Order Isoptera (*isos = equal, pteron = wing)*

- Termites.
- These are small insects with 2 pairs of membranous Wings
- Large eyes, biting type of mouth-parts.
- Eyes are absent or poorly developed

- E.g.: *Microtermes*

5. ***Order. Zoraptera***
   - These are small wingless or winged insects, with biting mouth parts and nine-segmented antennae.
   - Eyes absent in wingless forms and present in winged forms.
   - e.g., *Zorotypus*
6. ***Order Plecoptera***
   - Stoneflies.
   - These are insects with jointed antennae
   - Biting mouth-parts
   - 2 pairs of wings
   - 11-segmented abdomen
   - Two anal filaments.
   - E.g., *Perlacapitala.*
7. ***Order Notoptera***
   - Wingless insects with biting mouth-parts.
   - Jointed antennae
   - Small compound eyes
   - E.g. : *grylloblata*
8. ***Order Cheleutoptera (Phasmida)***
   - Stick-insects and leaf-insects.
   - Insects with small eyes, biting mouth-parts
   - Leathey forewings
   - E.g., stick insects (*Diapheramera)* and leaf insects *(Phyllium)*
9. ***Order Orthoptera***
   - Crickets. Grasshoppers, locusts, wetas.
   - These are large herbivorous insects.
   - Biting and chewing.
   - Two pairs of wings.
   - Posterior membranous wings are covered over by the anterior leathery wings.
   - E.g*., Poecilocerous, Schistocerca.*
10. ***Order Dermaptera***
    - Earwigs.
    - Simple metamorphosis
    - Biting mouth-parts.
    - Cerci are unsegmented, hairy or smooth, pincer-like.
    - E.g., *Forficula, Adiathelus*
11. ***Order Coleoptera***
    - Beetless and weevils.
    - Insects with tough leathery skin
    - Strong biting and chewing mouth-parts
    - Two pairs of wings.
    - Largest order.
    - E.g., *Dytiscus, Gyrina, Tribolium,Helicorpis.*

12. Order Lepidoptera

- Includes butterflies and moths.
- Both pairs of wings are broad, membranous and covered with minute scales.
- Mouth-parts are siphoning type in the adult for sucking nectar from flowers.
- Metamorphosis is complete.
- Prominent eyes and long antennae.
- E.g*., Bombyx mori* (silk moth).

13. Order Diptera

- Flies and mosquitoes.
- Membranous, transparent fore-wings.
- Hind-wings are modified to short, knobbed structures, called *halters.*
- Mouth-parts are piercing and sucking or sponging type.
- Complete metamorphosis.
- E.g., *culex, anopheles* (mosquitoes), *Tabanus* (cattle fly), *Musca nebula* (horse fly)

14. Order Siphonaptera

- Fleas.
- Wings are absent.
- Piercing and sucking mouth-parts.
- Cerci absent.
- Laterally compressed body.
- No compound eyes, but ocelli present.
- Capable of leaping.
- Ectoparasites
- e.g., Xenopsylla cheopis (rat flea)

15. Order Hymenoptera

- Sawflies, bees, wasps and ants.
- Wings are membranous.
- Complete metamorphosis.
- Biting, chewing, lapping, and sucking mouth-parts
- Hind-wings smaller and interlocked with fore-wings during flight by means of hooks, called hamuli.
- First abdominal segment fused with thorax.
- E.g., apis, vespa, polistes, componotus

16. Order mallophaga

- Bird lice and biting lice
- Small, wingless ectoparasites.
- Biting mouth-parts.
- Poorly developed eyes.
- Ectoparasites on birds and mammals.
- E.g., menopon gallinae (hen louse)

17. Order.Anopleura (Siphunculata)

- These are sucking lice.
- Small, wingless flattened body.
- Ectoparasites.

- Piercing and sucking mouthparts.
- E.g., Pediculus humanus (head louse)

18. Order Psocoptera

- Booklice.
- Small soft-bodied insects, with membranous wings.
- Fore-wings considerably larger than hind-wings.
- Biting mouth-parts, with asymmetrical mandibles.
- Cerci absent.
- Metamorphosis is incomplete.
- E.g., psocus atropos.

19. Order Mecoptera

- Scorpion flies.
- Small to medium-sized insects.
- Wings are similar and membranous, with dark markings.
- Long and filamentous antennae.
- Biting mouth-parts.
- Complete metamorphosis

20. Order. Trichoptera

- Caddis flies.
- Small to medium-sized insects.
- Large, hairy and membranous wings.
- Long and tapering antennae.
- Mandibles, highly reduced or absent.
- Complete metamorphosis

21. Order Neuroptera

- Lacewings and antlions.
- Soft-bodied and predatory insects.
- Long and thread-like antennae.
- Biting mouth-parts
- Complete metamorphosis.

22. Order Thysanoptera

- Includes thrips.
- Small insects, with piercing and sucking mouth-parts.
- Wings small, vestigial or absent.
- Thrips are found on dead or living vegetable matter.
- Many form galls on leaves.
- E.g., thrips fabaci (tobacco thrips)

23. Order Hemiptera

- Cicadas, leaf hoppers, scale insects, mealy bugs, plant bugs and aphids.
- Winged or wingless insects.
- Wings are membranous.
- Mouth-parts are piercing and sucking.
- Head is opisthognathous

GENERAL ORGANISATION OF INSECT

- Exoskeleton : chitin and protein
- Dorsal t*ergum* , ventral s*ternum* and membranous *pleuron*
- Cephalic tagmosis
- Segmented legs
- Compound eyes
- 3 tagma : head , thorax and abdomen)
- Head bears antennae and 3 pairs of gnathal organs : maxillae, mandible and labium
- Mouth parts variously modified
- Thorax bears 3 pairs of legs and wings (may or may not be present)
- metamorphosis
- tracheal respiration
- segmented abdomen

MODULE : 2

INSECTS IN THE SERVICE OF MANKIND

- Beneficial insects are of two main categories :
  - *Helpers* : helps pollination , biological control , scavengers etc
  - *Producers* : produce commercially valuable products
- Services rendered by useful insects to mankind
  - Supply of useful products : honey , wax , silk etc
  - Provide commercially important dead bodies: cactus scale insects used to make carmine – red pigments
  - Gall formation : galls contains tannic acid and dyes
  - Natural pollination
  - Biological control of pest
  - Weed control
  - Improvement of soil fertility : aeration , humus production etc
  - Scavenging
  - Pollution indication : peppered moth : *industrial melanism*
  - Form a source of arrow poison
  - Emission of cold light : fire flies
  - Ideal research material : drosophila
  - Aesthetic and entertainment value : butterfly
  - Use in medicine : honey
  - Use of insect pheromones and hormones for pest control
  - Insects in forensic medicine
  - Serve as a source of food for many animals
  - As human food

ECONOMIC IMPORTANCE OF PESTS

Nature of relation	*Type of activity*	*Major effects*
HARMFUL	1. Pests of crop plants	• Cause qualitative and quantitative reduction in crop yield • Transmit disease
"	2. Pests of domestic animals	• Cause discomfort , damage and injureies • Reduce vitality • Transmit diseases
"	3. Pests of stored food products	• Cause deterioration in quality and nutritional quality
"	4. Pests of timber and wood products	• Damage / affect quality
"	5. Pests of medical importance	• Cause discomfort and ill health • Transmit diseases
"	6. Household pest	• Damage stored food , clothing and

		belongings
BENEFICIAL	1. enemies of pests	• Help biological control of pest and weeds
"	2. Natural pollinators	• Pollination
"	3. Producers	• Produce economically important substances
"	4. Scavengers	• Clean the surroundings and maintain hygiene
NEUTRAL	1. Components of ecosystems	• Maintain stability of ecosystems and ensure human welfare

MODULE 3

INSECTS AS ENEMIES OF MAN

PESTS

- Harmful species whose population size goes beyond the damage threshold level either throughout the year or during specific seasons , adversely affecting the availability , quality and value of useful human resources

KINDS OF INSECT PESTS

1. **Potential pests**

With inherent potential to rise to the pest status though under natural regulations

2. **Key pests**

Major pests of specific crops

3. **Occasional pests**

Occur above the damage threshold level rather infrequently

4. **Regular pests**

Key pests on a crop above damage threshold level most frequently

5. **Persistent pests**

Key pests, which spend whole of their lifetime on specific crops

6. **Sporadic pests**

Occasional pests , rise to pest status unexpectedly

CAUSES OF PEST OUT BREAK

- There is a balance between pest and their natural environment
- Pest outbreak : population size of some species : increases beyond the damage threshold and become pests
- Major causes :
  1. Destruction of forests , conversion of forest areas into farm lands , changes in land use
  2. Destruction of natural enemies
  3. Monoculture
  4. Intensive and extensive cultivation of crops
  5. Introduction of new crops
  6. Improved agronomic practices
  7. Improper plant protection methods
  8. Introduction of new species
  9. Accidental introduction of foreign pests
  10. Resurgence of sucking pests

PESTS INJURIOUS TO PLANTS AND ANIMALS

Different Pests Cause Different Damage :

The signs of damage vary, typically depending on the way that the insect feeds on the plant.

- Damage from insects with **chewing mouthparts** typically appears on leaves or stems as ragged edges, holes, or other missing tissue.

- Insects that often cause chewing damage include caterpillars and Eastern lubber grasshoppers.
- Insects with **piercing-sucking mouthparts** have strong mandibles that they move laterally to often cause yellowing or browning on plants, and possible wilting.
- Examples include aphids, scales, spider mites, and whiteflies.
- Pest insects can also be classified by the types of damage they cause.
- For example, **defoliators** tend to feed voraciously and strip a plant nearly bare.Many caterpillars fall into this category.
- Other insects include l**eafminers**, which burrow into the leaves of plants leaving tell-tale tunnels in the leaves.
- Eg ; leafminer is the citrus leafminer, which is actually a larval stage of a moth.
- **Gall makers** insert all or part of their bodies into plant tissue—typically into leaves, stems, or twigs—and cause the tissue to swell.
- examples include blueberry gall midge larvae that burrow into leaves to feed, and gall wasps that deposit their eggs into plant tissue.
- **Wood/phloem borers** include twig girdlers and powderpost beetles that cause damage by feeding on living wood and wooden structures.

How Insects Injure Plants

- Insects may feed on leaves, stems, roots, and flowers of plants.
- The chewing insects actually consume the infested parts.
- Types of leaf feeding by **chewing insects** include pit feeding on leaves by leaf beetles, flea beetles, and young caterpillars.
- Irregular notches along the edges of leaves are typically caused by various weevils, larger caterpillars, grasshoppers and katydids.
- Perfect semicircular cut portions of leaves indicate the presence of leaf cutter bees.
- Feeding entirely within leaves is called **mining**. Leaf miners can be found among beetles, flies, sawflies, and moths.

- Stem chewing typically is done by **borers,** which feed internally as larvae.
- Important borers include longhorned beetles (roundheaded borers), metallic wood boring beetles (flatheaded borers), engraver beetles, clearwing moths, American plum borer (a moth), and a few less commonly encountered moths.

- Root chewing insects include species that subsist entirely on plant tissue for development, such as root weevils and root maggots, and those that feed on a combination of soil organic matter and roots (most white grubs).

- **Sucking insects** remove cell contents (e.g., thrips) or sap (e.g., aphids, leafhoppers, scales) and thereby weaken the plants. Some of these sucking insects inject salivary fluids into plants. This secretion may
    a) kill plants, as evidenced by armored scale feeding,
    b) cause galls to form, as in the case of gall aphids
    c) kill portions of a leaf, as seen in leafhopper "burn."
- Sucking insects tends to ingest more water and sugars than amino acids.

- Sucking insects balance their nutrition by excreting the excess sugar-water as honeydew, which is objectionably sticky and supports the growth of sooty mold.
- Honeydew can also lure nuisance stinging wasps, and also attracts ants, which protect the sucking aphids from predators and parasites.
- One key to managing populations of honeydew producing insects is to control the ants that protect them.

- Insertion of sucking mouthparts into plants increases potential for the transmission of plant disease organisms.
- Sucking insects, such as leafhoppers moving among plants can transmit mycoplasma-like organisms that cause Peach X-disease and aster yellows.
- Aphids and leafhoppers **transmit virus**es to plants.
- Some insects cause damage by cutting the plants for egg-laying.Conspicuous among these are cicadas, Tree crickets also lay eggs in stems, and while doing so, may transmit disease agents.

❖ PESTS OF PADDY

1 **.** ***Spodoptera mauritia*** **(Rice swarming caterpillar)**

- Leaf eater
- Direct development and complete metamorphosis

Life cycle

- Indirect development and complete metamorphosis
- Female lays eggs on the leaf blades of rice plants
- Eggs are covered by velvety secretion
- In about a week, eggs hatch into very active and voracious larvae
- Larval life : 3-4 weeks
- Larvae moults 5-6 times and pupates in the soil in an earthern cocoons
- After 2-3 weeks , pupa transforms to adult

Damage

- Sporadic pest
- Defoliation
- Larvae cut the seedlings in large scale
- Cattle grazed appearance is found at severely infested fields
- They feed gregariously and march from field to field
- Makes Leafless stumps

Management:

- Drain the water and Spray chlorpyriphos 20 EC 80ml + 20 lit of water for 8 cents
- Physical removal using hand nets
- Allow ducks into the field to feed on the larvae
- Spraying DDT , BHC, endosulphan
- Flood the nursery to expose the hiding larvae to the surface for birds to pick them up.
- Kerosenate water during irrigation to suffocate and kill the larvae.
- Drain water from nursery and spray chlorpyriphos 20 EC 80 ml during late evening

2. *Leptocorisa acuta* (Rice bug / paddy stink bug)

- They are diurnal but most active during morning and evening when they look for the flowering crops. Their presence can be easily detected by the characteristic foul odour that they emit.

Life cytcle

- Life cycle completed in 4/5 weeks, indirect development and incomplete metamorphosis
- Female can lay 200-300 eggs in its lifetime. Eggs are laid in batches of 20-30 in 2-3 rows along the midrib on the upper surface of the leaf blade.
- Nymphs are greenish, slender and similar to the adults in appearance and sucking habit.
- There are 5 nymphal instars and total nymphal period is 25-30 days.
- Nymphs being wingless must stay on the crop till they become adults and grow wings. The bug can complete 4-5 generations in a single season.
- Life span of adult : 3-4 months

Damage :

- Sporadic pest which appears before flowering stage and stays upto milky stage; attacks at milky stage
- Nymphs and adults are destructive
- The pest immigrates in the crop in the flowering stage and feeds on the milky grains and on the sap of the peduncle and leaves.
- Feed on sap of tender stem , peduncle and milky grains
- Some grains on the ear heads appears chaffy
- Yellow spots appear on the leaves due to excessive sucking.
- The empty grains turn whitish and show a puncture mark.
- The characteristic damage is called chaffy grains. Infestation is severe in irrigated and heavy rainfall areas.

Control:

- Collection and destruction of the bugs by netting or in light traps can be done in smaller areas.
- Removal of grasses and other weeds from bunds and surrounding areas reduces population.
- Spraying DDT , BHC
- Light traps
- Dusting of the crop with 5% BHC, Malathion or aldrin @ 15 kg per hectare effectively controls the pest. Application of granules of carbofuran or diazinon has also been found effective.
- Biological control : tiger beetles and robber flies

3. *Dicladispa armigera* (Rice hispa)

Life Cycle

- Indirect development
- The female beetle starts laying eggs only 3- 4 days after emergence and continues to do so for a month. A female lays upto 300 eggs.
- Eggs are pushed inside the leaf tissues singly close to the leaf tips. They hatch in about 5-7 days.
- The grubs start feeding on the mesophyll portion of the leaf and become fully grown in about 15 days.
- Pupation takes place inside the tunnels formed by larvae which lasts for nearly 5 days.

- The total life cycle is completed in about 20-25 days.
- The maximum life span for adults is about 80 days. Generally six life cycles are completed by the insect in one year.
- In the absence of rice the insect keep themselves alive on graminaceous weeds.

Damage:

- The adults as well as the grubs feed upon the leaves of paddy and give rise to white blisters or blotches.
- The adult eats away the green matter resulting in withering and drying of leaves.
- The presence of characteristic parallel white lines on the leaf surface is an indication of the attack of this beetle.
- The average loss by this pest to the paddy crop varies between 5-60%.

Control:

Cultural Method:

- Deep and thorough ploughing of the field.
- Crop rotation
- Grasses around the paddy field should be destroyed before the paddy transplantation.

Chemical Method:

- Dusting the infected crop with 5% BHC, Methylparathione, Fenitrothion or Endosultan.

Mechanical Method:

- Plucking of infected leaves in minor infection and uprooting of the whole plant in case of major infection.

❖ PESTS OF COCONUT

1. *Oryctes rhinoceros* (Rhinoceros beetle)

Life cycle

- Indirect development and complete metamorphosis
- Female lays : upto 140 eggs in dung hills ,manure pits , decaying vegetable matters etc
- In about 8-20 days , sluggish and creamy white larvae emerge
- Larval life : 3-6 months
- Larvae contructs earthern cells and pupate
- Pupal life : 1 month or more
- Pupae transforms to adults and fly to coconut plants

Damage

- Persistent coconut pest
- Damaged leaf : shows holes
- Causes stunted growth
- Bore deep into unopened frond , feed on soft tissues
- Central spindle appears cut or toppled
- Fully opened fronds showing characteristic diamond shaped cuttings
- Holes with chewed fibre sticking out at the base of central spindle.
- Initial - Young palm damage
- Later - Non typical V shaped damage

Management

- Remove and burn all dead coconut trees in the garden (which are likely to serve as breeding ground) to maintain good sanitation.
- Remove decaying organic matter from coconut felds
- Collect and destroy the various bio-stages of the beetle from the manure pits (breeding ground of the pest) whenever manure is lifted from the pits.
- Incorporate the entomopathogen i.e, fungus (Metarrhizium anisopliae) in manure pits to check the perpetuation of the pest.
- Soak castor cake at 1 kg in 5 l of water in small mud pots and keep them in the coconut gardens to attract and kill the adults.
- Treat the longitudinally split tender coconut stem and green petiole of fronds with fresh toddy and keep them in the garden to attract and trap the beetles.
- Examine the crowns of tree at every harvest and hook out and kill the adults.
- For seedlings, apply 3 naphthalene balls/palm weighing 3.5 g each at the base of inter space in leaf sheath in the 3 inner most leaves of the crown once in 45 days.
- Set up light traps
- Apply mixture of either neem seed powder + sand (1:2) @150 g per palm or neem seed kernel powder + sand (1:2) @150 g per palm in the base of the 3 inner most leaves in the crown
- Iron rods use for hooking rhinocerus beetles
- Biological control : ***Sarcophaga fuscicauda*** and ***Pheropsophus hilaris***

2. *Rhynchophorus ferrugineus (*Red palm weevil)

Life cycle

- Indirect and complete metamorphosis
- Female moths lays groups of scaly eggs on the lower surface of coconut leaflets
- In about a week , greenish brown larvae hatch out , feed on leaflets
- After 1-2 months , larvae pupate in thin cocoons
- Pupal life : 1-2 weeks
- Pupae : transforms to adult

Damage

- Holes on trunk with with brownish ooze
- Yellowing of inner leaves
- Gradual wilting of central shoot in the crown
- Brownish oozing
- Central shoots wilting - Later
- Leaf damage - Initial

Management

- Remove and burn all wilting or damaged palms in coconut gardens to prevent further perpetuation of the pest.
- Burn off severely affected palms
- Avoid injuries on stems of palms as the wounds may serve as oviposition sites for the weevil. Fill all holes in the stem with cement.
- Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem.

- Fill the crown and the axils of top most three leaves with a mixture of fine sand and neem seed powder or neem seed kernel powder (2:1)
- Setting up of attractant traps (mud pots)
- Install pheromone trap

3. ***Opisina arenosella (Black headed caterpillar***)

Damage

- Dried up patches on leaflets of the lower leaves
- Galleries of silk and frass on under side of leaflets.
- Burnt appearence

Management

- The parasitoid should be released @3000/ha under the coconut trees when the pest is in the 2nd or 3rd instar larval stage. Parasitoid release trap may be used to release the parasitoid at the site of feeding. Parasitoids should not be released in the crown region since they will be killed by predators like spiders and reduviid bugs.
- Remove and burn all affected leaves/leaflets.
- Spray malathion 50 EC 0.05% (1mi/lit) to cover the undersurface of the leaves thoroughly in case of severe epidemic outbreak of the pest in young palms.
- Root feeding for the control of coconut Black headed caterpillar:

4. Aceria guerreronis (*Coconut Eriophyid mite*)

Life cycle

- Live sin colonies in the tender portion beneath perianth
- Egg,2 nyphs and adult
- Life cycle: 10-12 days
- In about 3 days , egg hatch into nymph
- Very shortly , into 2nd nypnhal stage
- Grow and moults into adults

Damage

- Suck in sap from growing tender nuts and desap
- Initial symptom : Triangular pale or yellow patches close to perianth
- Necrotic tissues
- Brown colour patches, longitudinal fissures and splits on the husk
- Oozing of the gummy exudation from the affected surface
- Reduced size and copra content.
- Malformed nuts with cracks and hardened husk.
- Eriophyid mite damage in young developing buttons

Management

- Biopesticides : neem seed oil and garlic soap emulsion
- Apply urea 1.3 kg, super phosphate 2.0 and muriate of potash 3.5 kg/palm/year
- Neem cake @ 5 kg and organic manure 50 kg/palm/ year
- Borax 50 g + gypsum 1.0kg + Manganese sulphate 0.5 kg/palm/ year
- Biological control : ***Hirsutella thompsonii (***mite attacking fungus)

❖ PESTS OF SUGAR CANE

1. *Chilo infuscatellus* (Sugarcane shoot borer)

Damage

- Shoot borer
- Larva is harmful
- Causes dead heart

Management

- Spiking larvae with sharp iron needle
- Destruction of infested
- Mulching field with trash and earthing up crop 0ne month after planting
- Mixing BHC with soil
- Pre-planting treatment : lindane
- Biological control : ***Trichogramma chilonis***

2. *Scirpophaga nivella* (Sugarcane top shoot borer)

Damage

- Top borer
- Caterpillars attack top portion
- Causes red streaks on the mid rib of leaves
- Holes on blade
- Forms dead heart
- Forms bunchy tops

Management

- Collection and destruction of adult moths and egg clusters
- Removal of affected shoots
- Cutting and destroying cane tops
- Endrin spraying
- Biological; control : ***Gambroides javensis***

3. *Sacchariococcus sacchari* (Cane mealy bug)

Damage

- Nymphs and adults suck the plant sap
- Mealy secretions promotes development of sooty moulds , making the canes black colored
- Suspected : mottling disease is transmitted by these bugs
- Drought affected crop with loose leaf sheaths : severely affected

Control measures

- Spraying malathion 0.05% or diazinon 0.03%

❖ PESTS OF PLANTATION CROPS

PESTS OF COFFEE

Pest of coffee belong to four categories , namely

- leaf –eaters
- stem– borers
- fruit borers
- sap- feeders (*Coccus viridis)*

1. *Xylotrechus quadripes* (coffee white stem borer)

- Commonly called the coffee white stem- borer .
- This is a medium – sized beetle whose larvae
- Are the serious pest arabica variety of coffee plant.

Damage

- The grubs of xylotrechus are the most harmful pests of coffee plant .
- They first bore into bark then to interior ;make extensive tunnels and feed on tissues.
- This causes death of young plant.

Control measures

- Removal and burning of infested part.
- Killing of adult beetle found in plantation field.
- Smearing of BHC suspension over stem and main branches three times in a year.
- Dislodging of eggs and young beetle with help of tough brushes.
- Biological control.

2. *Coccus virids* (coffee green bug)

- Commonly called mealy bug .
- it is a sap feeding pest of coffee.
- Body is soft, green coloured.it feed on tender shoot ,leave.

Damage

- Nymphs and adult remain crowded in large numbers on the under surface leaves,fruit , suck in sap.
- This seriously affected health of plant and quality , quantity of yield.

Control measures

- Spray application of malathion 0.1 per cent ,methyl preparation 0.05 per cent.
- Biological control by release big some ants ,fungi.

PESTS OF TEA

***1. Helopeltis antonii (*Tea mosquito bug)**

Damage

- Nymphs and adults suck sap from tender parts
- Toxic saliva injected during sucking causes necrosis and appearance of black / brown patches
- Leaves curl , dry and drop
- Shoot dries ; and plant becomes broom like

Control measures

- Chemical control : spraying malathion ,parathion and other contact insecticides
- Physical : collecting and killingnymphs and adults using hand nets

***2. Toxoptera aurantii* (Tea aphid)**

Damage

- Colonies infest tender stem , leaves and buds
- Leaf curl and crinkle
- Seedlings and young plants : severely affected

Control measures

- Spraying endosulphan

PESTS OF RUBBER

1. *Aspidiotus destructor* (scale insect)

Damages

- This is a scale insect whose larvae and adult females are sap feeding pests of rubber.
- Adult males are harmless.
- Females lay eggs on tender twigs. Within a few days, active larvae pierce mouth parts into the interior of leaf or bark and suck in plant sap.
- The insect produces a sweet nourishing secretion to feed ants. Consequently, it is often called the ant-cow. Ants feed on this secretion and also carry the insect to other locations. Massive infestation causes great loss of sap, leading to premature leaf fall

Control measures

- Biological control : *Aphytis melinus :* parasitoid
- Cultural control : pruning ; proper disposal of infested leaves , twigs and branches
- Chemical control : only affective on the crawler stage of pest : spraying diazinon , dimethoate, malathion and nicotine

2. *Comocrits Pieria* (Bark caterpillar)

Damages

- They construct flat canopies and galleries of fine silk and comminuted fragments of bark on the stems of *Hevea brasiliensis*, feeding on lichens and algae growing on the stem.
- Pupation takes place in a flattened cocoon or case, formed in a shallow depression beneath the silken canopy

PESTS OF PEPPER

***1. Longitarsus nigripennis (*pollu beetle)**

- It is monophagous specific pest of pepper, commonly called pepper beetle or pollu beetle.
- Adult beetle is a bluish-yellow shining insect, with thick hind- legs.
- It feeds on tender leaves, severely destroying the plant.

Damage

- Adults and grubs of pepper beetle cause serious damage to pepper plants.
- Adult voraciously feed on tender leaves and make holes in them.
- Grubs bore into the berries and eat away their contents As a result, the attacked berries become hollow, wrinkle and dried.
- Quite often, the grubs may feed on spikes also, leading to the drying of the terminal part.

Control measures

- Spraying of insecticides, such as lindine, in pepper plantations at least once in every month.
- Raking the soil just around the plant and mixing it with insecticide powder to expose and kill pupae.

2. *Laspeyresia hemidoxa* (Shoot borer)

Damages

- The pepper stem-borers a highly destructive pepper pest.
- Adult insect is small-sized. Its wings are coloured red and yellow.
- Female makes holes at the tender tips of the stem and lays eggs in them.
- Embryos hatch out into larvae, which penetrate to the interior of the stem, feed on the sap and pupate there.
- This damages the growing tips of the plant.
- Fully grown pupae transform to adults and then come out.
- The attack of *Laspeyresia is* severe during the August-September season.

Control measures

- Removal of the damaged parts, together with the larvae or pupae in them.
- Frequent spraying of insecticides.
- Periodic raking of the soil around the base of the vines to bring pupae to the surface to be preyed by birds, or for heat-killing .

PESTS OF CARDAMOM

***1. Sciothrips cardamomi* (Cardamom thrips)**

- Commonly called the cardamom thrips
- Sciothrips is very small, greyish brown, sap-feeding insect whose larvae and adults inhabit the inflorescence, seeds, tender leaves, swollen leaf bases and the aerial stem of cardamom plant in large groups

Damage

- Both the nymph and adults are harmful.
- They suck in plant sap from blossoms, pods and other parts, leading to the shedding of flowers and pods,shrivelling and malformations of pods, damages to seeds etc…

Control measures

- Dusting with quinalphos 1.5 per cent once in a month
- praying of phosalone ,quinalphos and profenofos during flowering and seeding seasons are found effective.

***2. Eupterote canarica*(Cardamom hairy caterpillar)**

- The larvae of nearly seven species of insects are cardamom pest.
- The most harmful among them are the larvae *of Eupterote cardamomi , ,E.fabia and E.canarica*.
- Adult females of these insects lay eggs on the leaves of the tall shade trees of cardamom plantations.

Damages

- Feeding on tender leaves of the cardamom plants
- Two or three larvae can completely damage a plant
- They heavily damages cardamom plants and reduces them to leafless stumps
- When full growth is attained, larvae come to land and pupate in underground soil.

Control measures

- Mechanical collection and killing of larvea
- Spraying of highly toxic phosphatic pesticides, etc..

❖ PESTS OF FRUIT PLANTS

PESTS OF BANANA

1. *Cosmopolites sordidus* (Banana weevil)

Damage

- Grubs are destructive
- Bore into rhizome , make tunnels inside , feed on the tissues
- Makes plant weak
- Causes death of unopened leaves , decoloration and premature withering of leaves
- Decaying of heart and ultimate death of plant

Control measures

- Uprooting and destroying of infested plants
- Addition of BHC , aldrin , etc into plantation pits
- Selective use of pest free suckers for planting

2. *Pentalonia nigronervosa* (Banana aphid)

Damage

- Sucks in plant saps in large numbers
- Serves as carrier of virus causing bunchy top disease

Control measures

- Addition of disulfoton to the pits
- Spraying organophosphates
- Cultural control : banana fruit infestation can be controlled by covering with polythene bags

PESTS OF MANGO

1. *Batocera rufomaculata* (Mango stem borer)

- Mango boring beetle
- They are serious pests of mango,fig,jack, rubber..etc
- Adult are large sized,well built and pale grey longicorn beetles,with long legs tip of the body on each side.
- Two concentric orenge yellow spots on prothorax,and several yellow spots on the fore wings

Damages

- Caused by grubs
- Bore into the stem
- Cut tunnels or galleries and feed on the Woody tissues.
- Kill branches and causes the wilting and sometimes the death of the tree.

Control measures

- Closing of the bore holes with cotton plugs, soaked in kerosene or petroleum and then plastering them with mud
- Injection of chloroform, carbondisulphid ,endrin, methyl parathion etc. to kill the grubs
- Removal and destruction of the affected part

2. *Dacus dorsalis* (Fruit fly)

- Commonly called mango fruit fly or oriental fruit fly.

Damage

- Maggots alone cause damage to fruit.
- They feed on fruit pulp, making the fruit unsuitable for human consumption.
- The infected fruit may be crowded with maggots

Control measures

- Frequent spraying of the plant with a mixture of malathion and molasses or dimethoate during the fruiting period

PESTS OF CASHEW

1. ***Plocoederus ferrugineus (*Cashew stem borer)**

Damage

- Grubs are highly destructive
- Grubs Make holes on the stem , bore deep into interior , cut tunnels and feed on woody tissue
- Fully grown larvae tunnel their way down to the root region where they form thick calcareous shells / cocoons for pupation
- Grubs bore inward and damage cambial tissue , disrupting flow of sap ; which causes wilting and weakening of trees
- Massive destruction: death of plant

Control measures

- Mechanical removal of grubs
- Swabbing and drenching of basal trunk and root region with BHC , coaltar , kerosene etc
- Injection of pyrocone into bore hole sand closing
- Removal and destruction of infested parts

2. ***Helopeltis antonii* (Cashew mirid)**

Damages

- Causes '*blossom blight*'

Control measures

- Biological control : *crematogaster*
- Chemical control : endosulphan and phosphamidon

- **PESTS OF VEGETABLES**

PEST OF LADY'S FINGER

1. ***Platyedra gossypiella* (Pink ball worm)**
   - Popularly known as the pink bollworm.
   - It is most destructive pest of cotton and lady's finger.
   - Adult moths are small and deep brown, with irregular black markings on fore-wings and deeply fringed margins on hind-wings.
   - They active at night, hide during day time.

Damage

- They live inside the flower buds, panicles and bolls of cotton.

- The damage they cause include permanent shading of buds and bolls, premature opening of infested bolls in some cases exposing them to bacterial and fungal attack and boll rot, failure of boll to open, defective development of seeds with poor power for germination.

Control measures

- Deep ploughing of the field to kill pupae and hibernating larvae
- Collection and burning of infested and fallen bolls, leaves and sticks.
- Sundrying or mechanical heating of seeds for 2-4 hours to kill larvae
- Spraying the crop with BHC, DDT, endrin, carbyl, endosulfan, etc. with 15 days interval during August-September. This is the most effective measure to control boll worms.
- Fumigation of cotton seeds with methyl bromide or aluminium phosphide is also effective.
- Destruction of attacked parts, off-season cotton sprouts and plant debris.

2. ***Earias vitella*** **(Spotted ball worm)**

- It is fruit- boring pests of lady's finger cotton.
- Adult insects are creamy white in colour, with silvery abdomen. Fore wings have a wedge-shaped band.

Damage

- The caterpillars of Earias are the most harmfull pests of lady's finger.
- They bore into the tender shoot tip and fruits in large number and feed on the tissue.
- This causes the wilting and death of the growing part and inflicts heavy destruction on fruits.
- This damage the fruit and makes them unsuitable for human consumption.

Control measures

- Removal and destruction of affected plant parts and fruits to kill the larvae.
- Spraying of DDT, eldrin, sevin, etc. once in three weeks.

PESTSOFBRINJAL

1. *Leucinodes orbonalis* (Shoot and fruit borer)

Damages

- The larvae are highly destructive to the shoot, flower, and fruits of brinjal.
- It bore in to the petioles and midribs of leaves, young tender shoots, flower buds and fruits and feed on soft tissues.
- The affected leaves dry and fall off.
- The growing points of the shoot may be killed – leading to "*dead -heart"*.
- It cause wilting and drooping of the shoot.
- The damaged flower buds are shed without blossoming.
- Fruits become porous, excreta-filled and unfit for human consumption.
- In fruits-there would be more than 60% reduction in vitamin C content.

Control measures

- Avoidance of continuous cropping of brinjal in the same field.
- Burning of the affected shoots and fruits.
- Spraying of endrin, endosulfan, etc.
- Biological control- The caterpillars of leucinodes are parasitised by some other species. Eg: peristomerustestaceus, phanerotoma species, etc.

- Such species can be artificially employed for the control of leucinodes.

2. *Epilachna vigintioctopunctata* (Epilachna beetle)

Damages

- Adults and grubs are phytophagous pests.
- It feed voraciously on leaves by scraping the green matter.
- As a result, the leaves become skeletonized and they eventually dry out and fall off.
- Also defoliating the plant.
- It is very seriously affectesthe photosynthetic activity and adversely influences the growth, flowering and fruiting of the plants.
- Severe infection may kill young plants.

Control measures

- Avoidance of continuous cropping.
- Collection and mechanical destruction of the affected leaves, which harbour eggs and adults.
- Spraying of malathion, diazinon, endosulfan or dichlorvos.

PESTS OF CUCURBITS

1. *Dacus cucurbitae* (Melon fly)

Damages

- Phytophagous
- Female flies puncture holes in the soft and tender fruits and deposit eggs
- As the larval life completes , fruits fall off and larvae pupate in the sub-soil
- Larvae inside fruits feed on the pulp of the fruits and damage
- Punctures made during oviposition , serve as passages for entry of bacteria and fungi
- Infested fruit become malformed , distorted and rotten , leading to premature fall

Control measures

- Selection of resistant or early maturing varieties
- Harvesting fruit before ripening to check damage
- Collection and destruction of the fallen infested fruits
- Frequent raking /ploughing of the soil below plant to kill pupae
- Poison baiting/ bait –spraying at the early stage of fruiting

2. *Raphidopalpa foveicollis* (Pumpkin beetle)

Damages

- Adult beetles and grubs are destructive
- Adults bites holes on leaves and voraciously feed on tender leaves
- Feed on flowers , affecting fruit setting
- Grubs feed on roots and underground portions and fruits touching ground
- Infested fruit start rotting and unripe fruits dry up

Control measures

- Early sowing and use of resustant varieties
- Deep ploughing after harvesting

- Collection and destruction
- Chemical control : BHC, endrin , carbaryl , endosulphan

❖ **PEST OF STORED PRODUCTS**

1. ***Tribolium castaneum*** **(Rust red flour beetle)**

Damage

- The adult and larvae are highly destructive to the grains and flours, stored grocery stores, godowns, flourmills etc..
- And also to stored rice and wheat giving them and unpleasant and offensive smell.
- In severe infestation, the flour may turn greyish

Control measures

- Thoroughly dry grains and other food products before storage.
- Clean and disinfect godowns, flour mills, storage bins, bags etc before storing food products.
- Destroy infested food products.
- Treat food products with mild insecticide before storage.
- Periodic fumigation with methyl bromide, ethylene dibromide to kill larvea and adults.

2. ***Callasobruchus chinensis*** **(Pulse beetle)**

Damage

- Adult and larvae causes damage to pulses and grains.
- They bore in to pulses and grains and feed in said them making tunnels
- This severally hollows out and damages pulses and grains.
- In heavy infestation, a considerable amount of frass is formed, which form the food for young larvae. Often, the pest attack leguminous pods of in the field, before they are carried to storage godowns.

Control measures

- Thoroughly dry grains and other food products before storage.
- Clean and disinfect godowns,flourmills, storage bins…before storing food products.
- Destroy infested food products.
- Treat food products with mild insecticide before storage.
- Periodic fumigation with methyl bromide, ethylene dibromide etc to kill larvea and adults.

❖ **PESTS OF DOMESTIC ANIMALS**

PESTS OF DOMESTIC FOWL

1. ***Menopon gallinae*** **(Shaft louse)**

- Commonly called the chicken louse or shaft louse.
- It occurs on the shafts of feathers, and hence the name shaft louse.
- It attaches itself to the host by nibbling on the dry skin and chewing the feather.

Damage

- Chicken louse is not usually a serious parasite, though it is very common and feeds on feathers.
- heavily infested fowls may become very much annoyed and restless and they may stop feeding.
- they respond by feather plucking and rubbing their body in the soil or in ash pits.

- Severe infestation may impede their growth, reduce their body weight and adversely affect their egg production.
- In rare instances the fowls may ultimately succumb to death.

Control

- Dusting on the fowls with malathion, carbaryl, dichlorvos, etc., once in two weeks is an effective control measure.

PESTS OF GOAT

1. *Oestrus ovis* (sheep bot-fly)

- Commonly called the "sheep bot-fly" or "sheep nasal bot-fly".
- They may be found on the flesh of cattle, horse, sheep, goat, elephant, etc.

Damage

- In the nasal cavities and frontal sinuses of the sheep, the larvae do not cause appreciable harm , in moderate numbers
- However, heavy infestation may cause constant nasal discharge, sneezing and blockage of the nasal passage. In extreme cases, the sheep may succumb to death.
- Very often, the larvae attack open wounds and sores on the skin and feed on decaying tissues and also on sub-cutaneous tumours.
- Sometimes, they may bore into the flesh and cause hypodermal rash and cutaneous myiasis.

Control

- Injection of 2 ml of carbondisulphide and liquid paraffin in the ratio 1:1, or 5 ml of tetrachloroethylene emulsion, into the affected part
- Application of invermectin at the dose rate of 0.2 mg per 1 kg body weight
- Spraying of crufomate, dichlorvos, or fenthion directly into the nostrils.

PESTS OF CATTLE

1. *Tabanus striatus* (horse fly)

- Commonly called the tabanid flies, cattle-flies, horse-flies, deer-flies, green-headed flies, or gad-flies.

Damage

- Female tabanid flies are primarily blood suckers.
- They are suspected to transmit anthrax, surra and swamp fever among horses and a kind of filariasis among human beings

Control

- Draining and drying of the breeding grounds to kill eggs, larvae and pupae.
- Collection and destruction of egg masses.
- Spraying of DDT in the breeding grounds to kill larvae and pupae.
- Mist spray of dichlorvos in stables to repel the flies.

INSECT PEST CONTROL

NATURAL PEST CONTROL

- Natural pest control involves the operation of natural factors, without significant influence of human activities.
- Factors include *climatic, topographic* and *biological factors.*

1. Pest control by climatic factors

- Climatic factors which control insect pest populations include the influence of temperature, humidity, rainfall, wind, air currents, etc.
- Temperature- every insect requires an optimum range of temperature for each stage of its life cycle. If the temperature goes above or below the optimum range it will have damaging effect on the insect population and sometimes it may even kill the insects.
- Rainfall- Too much or too little of rainfall can kill the insects.
- Eg-life of red hairy caterpillars of cutworms.
- Humidity-it helps the development of entomophagous fungi which turn, check the insect population.
- Eg-growth of *Cephalosporiumlecanii.*

2. Pest control by topographic factors

- Geographical barriers, such as mountain ranges, large water bodies, vast deserts, dense forests, etc.,limit or restrict the dispersal of insects.
- These factors influence considerably the climate of an area and thus interfere with the growth of insect populations.

3. Pest control by biological enemies

- There are natural enemies for every insect. They may be parasites(mites,disease - causing viruses, bacteria and fungi),pathogens, or predators(spiders,birds, reptiles, fishes and mammals).
- Predators pathogens and parasites keep the insect population in dynamic equilibrium at its optimum size.
- But any change in the size of the insect population, or in the population of the natural enemies, will disturb the equilibrium.

APPLIED CONTROL OR ARTIFICIAL CONTROL

Prophylactic methods

- Prior protection of crop from pest attack
- It includes,
  - Field and plant sanitation
  - Scientific agricultural methods
  - Use of pest-resistant varieties of plants and seeds
  - Time adjustment

Curative methods

- Direct destruction of pest after infestation
- It includes,

- **Cultural methods** : deliberate modification of the agricultural practices to the disadvantage of pest populations either to destroy insect pests or to prevent them from destroying the crop.It includes , crop rotation ,trap cropping , mixed cropping , tillage operation

- **Mechanical methods** :procedure in which members of the pest species are trapped or killed by mechanical means or are prevented from gaining access to the crop plants by making barriers. It includes , killing of eggs, larvae ; trapping of pests ; sieving and winnowing (stored products pests) ; flooding etc.

- **Physical methods** : deliberate modification of some physical factors to slow down the growth of the pest populations or to minimize or prevent pest infestation .It includes , use drie-die , use of lethal temperatures , ionizing radiations , light traps etc.

- **Legal methods** : control of pest through the enactment of laws and regulations and enforcement of legal restrictions . It includes foreign quarantine , domestic quarantine etc

- **Biological methods** : eradication or suppression of a pest species using natural enemies like predators , parasites , or pathogens. It involves 3 main steps : inoculation , augmentation and conservation of natural enemies

- **Chemical methods** : controlling pest using toxic chemicals called pesticides

BIOLOGICAL CONTROL

The four approaches are:

- **Natural biological control,** i.e., the natural suppression of potential insect pests by resident natural enemies that requires no human facilitation
- **Importation biological control**, i.e., the deliberate importation and establishment of specialized natural enemies from the region of origin of an exotic invasive insect pest to provide long-term suppression over broad geographic regions
- **Conservation biological control**, i.e., the localized manipulation of the crop environment to protect or enhance the activity of resident natural enemies for short-to longer-term suppression of insect pests
- **Augmentative biological control**, i.e., the mass production and localized release of resident natural enemies to augment their abundance for either immediate (inundation) or season-long (inoculation) suppression of insect pests.

Merits:

- Harmless to beneficial and non-target organisms
- Highly specific
- Development resistance is slow
- Self sustaining system and brings down expenditure
- No residual effect
- No environment problem
- Does not cause ecological imbalance
- Adds to stability of ecosystem

- Maintain dynamic balance of nature
- Promotes adaptation

Demerits :

- Needs very high initial expenditure
- Needs full scale ecological evaluation
- Slow and time consuming
- Heavy economic loss
- Unpredictable climatic changes : affects
- Degree of biological control by natural enemies is rarely adequate

Three important biological control project undertaken in India

1. ***Opisina arenosella***
   - Coconut pest .larva called black headed coconut caterpillar is harmful
   - Parasitoids ***Goniozus nephantidis*** **,** ***Bracon brevicornis*** are the natural enemies
2. ***Icerya purchase*****(colony cushion scale)**
   - Polyphagous pest, affects fruit trees
   - **Rodolia cardinalis** : natural enemy
3. ***Chilo infuscatellus (shoot borer of sugarcane)***
   - Parasitoid ***Trichogramma chilonis*** attacks egg of *Chilo*
   - *Trichogramma* is released into the field through parasitized egg at *Corcyra cephalonica*

CHEMICAL PEST CONTROL

- Chemical pest control is the controlling of pest populations using toxic chemicals, called pesticides, which can kill, deter, attract, or influence pests to check their ravages
- The pesticides used to control insect pests are called insecticides.
- Chemicals are often used in both preventive and curative methods of pest control.
- These chemicals kill pests by their toxic and lethal effects.
- But their other effects they alter the behaviour of pests, induce sterility in them, interfere with their metabolism, impair their normal activities, or disrupt and distort their development.
- A broad-spectrum pesticide, that can kill many species of organisms : ***biocide***.
- Generally, narrow-spectrum pesticides, that attack only specific types of pests, are preferred in agricultural pest control.

Classification based on application

1. Attractants

- Attractants are the chemical substances towards which insects make preferential and oriented movements.
- Use of insect attractants :
- Synthetic chemical attractants, specific for insect pests, are important in insect pest control. Insects respond to them either for feeding purpose, or egg-laying, in the former, both males and females are attracted, while in the latter only mature females are attracted.
- Chemical insect attractants are used as an ingredient of insecticides, as a constituent of poison baits, or as a part of mechanical trapping devices.

2. Repellents

- Repellents are offensive chemicals which repel insects away from them.
- Use of insect repellents :
- Chemical repellents are effective for the protection of man and domestic animals from blood-sucking insects. However, they have never been successful for controlling the pests of plants. This is because their continuous emission is essential for effective protection.

3. Synthetic pheromones

two major kinds of synthetic pheromones are used in pest control

- **Alarm pheromones** : alarm pheromones are sometimes used against sap-feeding aphid pests. They cause the insects to drop from the plant,
- **Sex attractant pheromones** : sex attractant pheromones are mostly male-attractants. They are highly species-specific. Their high potency and extreme selectivity and specificity are of great significance for the manipulation of selected pests.

Classification of insecticides based on chemical nature :

Their major active groups include

- Organochloride
- Organophosphates
- Carbamates
- Synthetic pyrethroids
- insect growth regulators
- plant derivatives, oils etc.

A. Inorganic insecticides

Inorganic insecticides are mainly made up of elemental sulphur and mineral compounds.

a) Arsenic compounds

- These are the major inorganic insecticides. T
- heir insecticidal property depends mainly on their total arsenic content and the proportion of water-insoluble arsenic

eg, Lead arsenate , Calcium arsenate

b) Fluorine compounds

- They are primarily stomach poisons.

Eg,Sodium fuoride (NaF)

c) Sulphur

- Sulphur is used in inorganic insecticides, always mixed with other insecticidal dusts. It prevents that balling of the dust.

d) Lime sulphur

This is the solution of calcium polysulphide in water.

e) sodium tetra borate or borax

B. Organic insecticides

a) Hydrocarbon oils

These are the insecticides, formed of hydrogen and carbon, Mineral (petroleum)oils and coal-tar are examples. Mineral oils are obtained from sedimentary rocks.

b) Organic insecticides of animal origin

there are only very few insecticides of animal origin.

c) Organic insecticides of plant origin

Organic insecticides of plant origin are generally called "**botanicals"**

- **Nicotine**

- Nicotine, the main alkaloid present in tobacco, is well known for its insecticidal property.
- There are about 12 alkaloids in tobacco of which nicotine amounts to 97% .
- Nicotine is a neurotoxin and it can enter into the body of insect pests through cuticle, spiracles and ingested food.
- It can be sprayed as a solution with soap, lime, or ammonium hydroxide, The solution can be prepared by boiling 1 kg of tobacco waste in 10 litres of water for 30 minutes and then by diluting it into 30 litres and adding 90 gm of soap

- **Pyrethroids**

- Pyrethroids are the extracts of the plants Chrysanthemum coccineum and C.canneum.
- The insecticidal property of pyrethroids is due to the presence of esters.

- **Rotenoids**

- Rotenone (C23H22O6) is a compound present in the roots of the plants Derris and Lonchocarpus (the root of Derrris elliptica is used as a fish poison).

d) Synthetic organic insecticides

These include organochlorines, organophosphorus compounds, carbamates, synthetic pyrethroids, insect growth regulators, organic thiocyanates and dinitrophenols.

- **Organochlorines**

Also called chlorinated hydrocarbons. As the name suggests, they consist of aliphatic or aromatic hydrocarbon nucleus and varying numbers of chlorine atoms attached to it.

- **Organophosphorus compounds** (organophosphates)

These are organic pesticides, with an invarible phosphorus - containing central core in each molecule.

- **Carbamates or urethanes**
- **Synthetic pyrethroids**
- **Insect growth regulators(IGRs)**

Classification of insecticides based on the mode of entry

- Contact Insecticides :oral / dermal .Eg. DDT
- Stomach poisons : Oral .Eg. arsenic
- Fumigants : volatile .Eg. Hydrogen cyanide
- Systemic insecticides :get absorbed to the sap stream of plants from leaves , fruits , stem and roots and moves along vascular system

Mechanism of action of insecticides

The mechanism of action of insecticides is highly variable.In general, they may act as physical poisons, protoplasmic poisons, never poisons, respiratory poisons, or as asphyxiating agents.

Spectrum of insecticide activity

The range of the pest species, affected by an insecticide, is known as its spectrum of action.

Insecticide resistance

Some populations or strains of insects may exhibit a natural tolerance to particular insecticide.

Pesticide hazards

- In Modern times, pesticides are considered as major pollutants, contaminating air soil and water.

- The pollution problem, associated with the use of pesticides, started with the extensive use of DDT and other organochlorines.
- Kills natural enemies
- Causes sec outbreak of pest
- Pesticide poisoning of top soil kill soil microorganisms
- Aquatic environment pollution : affects primary productivity , ecological energetic and dynamics of ecosystem
- Destroy insect pollinators
- Increases susceptibility of organisms to diseases
- Biological magnification
- Interfere with enzyme action , metabolic processes and behavior of animals
- Pesticides, in general, seriously affect human health.
- Their effects include *short-term effects and long-term effect.*

Pesticide residue

- *Pesticide deposit*: quantity of an insecticide remaining attached to the plant surface or other surfaces soon after the application
- *Pesticide residue* : Pesticide deposit progressively decreases due to chemical breakdown , volatalization and other weathering processes . The amount still remaining at crop maturity
- Expressed in parts per million (*ppm)* fresh weight of produce
- *Tolerance level*: max permissible insecticide residue level in harvested produce
- Insecticide residues can be maintained by *waiting period*
- Factors affecting :
    - Nature and method of application
    - Environmental factors
    - Agricultural practices
    - Plant characters

PESTICIDE APPLIANCES

2 methods :

- Dusting : duster : dry pesticides application: manually operated and power operated
- Spraying : sprayer : wet application : may be space sprays or residual sprays

Sprayer

- Consists of ,
    - Tank
    - Agitator
    - Filters
    - Pump
- May be manually operated or power operated

Hand compression sprayer :

- Residual effect insecticides, larvicides, and molluscicides can be applied by hand compression sprayers.
- consists of a cylindrical tank with a capacity of 8-10 litres, in which the insecticide solution is compressed by an air pump and projected evenly through a lance, on the end of which is a slit nozzle.

- A pressure-gauge on the tank indicates whether the correct pressure is being used during spraying. A harness attached to the tank allows it to be carried on a person's back
- Tank pressure drops during spraying, resulting in a decrease in flow, a wider angle of spray, and an increase in the size of the droplets. When this happens, the tank needs to be pumped again. The pumps should be calibrated periodically to ensure the correct flow-volume of liquid per minute.
- The hand compression sprayer is the basic item of equipment in a vector control programme.
- Stainless steel models are better than plastic ones; if well maintained, they can last several years.

Knapsack sprayer :

- Carried by operator on his back
- The tank is flat and made of plastic or galvanized iron
- Operated by lever handle

Rocker sprayer :

- Consists of pump-assembly , rocking lever , pressure chamber , suction hose with strainer , delivery hose , cut off valve and nozzled spray lance
- Built-in tank is absent
- Rocking movement of the lever produces a suction pressure in the pressure chamber and it forces out the liquid through nozzle
- Used for spraying on trees and tall field crops

PRECAUTIONS IN HANDLING INSECTICIDES

Insecticide Resistance Action Committee : recommends guidelines *:*

- Judicious use of chemical pesticides.
- Use of synergists, which will enhance the toxicity of insecticides.
- Use of insecticides, containing more than one type of compounds which differ from each other in chemical composition and mode of action.
- Strictly follow the stipulated dose of insecticide and time of application.
- Use of pest-resistant crop varieties.
- Use of biological pest control.

Precautions in handling pesticides :

- Pesticides should be stored most safely, away from food stuffs and medicines.
- Pesticides must be kept in their original containers, out of reach of children
- The containers and bags of pesticides should be cut open by a separate knife, not with the one that is used in kitchen.
- While using the pesticides, the instructions given on the container should be read carefully.
- While preparing the solution, hand gloves should be used.
- Smoking, eating or drinking while handling pesticides should be avoided.
- If accidentally a drop of pesticide falls into the eye,eye should be washed immediately with a large quantity of clean water.
- Should never be done against direction of wind
- Body should be washed and clothing should be changed after application
- Containers , sprayers or dusters should not be washed in river , ponds or lakes
- Empty containers : destroyed
- Should undergo regular medical check up

MODERN METHODS OF PEST CONTROL

1. **Autocidal control or sterility method**
   - Controlling insect pests by reducing their capacity to produce viable or fertile offspring
   - Sterility principle is now best applied in pest control.
   - Initialy,only males were sterilized.
   - But at present, both males and females are sterilized.
   - Sterilization does not prevent an individual from infesting its host, but only destroys its reproductive potential.
   - Advantages :
     - A sterile individual can neutralize the reproductive capacity of other individuals of the same species by mating with them
     - The rearing and release of sterilized individual will have significant effects on the species concerned.
   - Sexual sterility can be produced by :
     - Chemical sterilants
     - Radiation
2. **Pheromonal control**
   - Pheromone : chemical substances secreted to the external environment
   - Ectohormones
   - 2 types :
     - Alarm pheromones
     - Sex attractant pheromones (male confusion technique)

INTEGRATED PEST MANAGEMENT (IPM)

- Ecologically based pest-control strategy
- Advocates application of a combination of techniques and relies more on natural enemies , weather , cultural control and restricted use of pesticides
- Specific times-specific pest- specific crop

Features :

- 2 or more techniques in an integrated manner
- Max use of mortality rates
- Based on ecological principles
- Applies specific control measures only when they become unavoidable

Advantages :

- Reduces chemical pesticide usage – reduces environmental pollution-no pesticide residue
- Least possibility of developing resistance by pests
- Reliable because it considers ecological aspects and population dynamics of pests

INDUSTRIAL ENTOMOLOGY

Productive Insects

- ✓ **HONEY BEE**:

Apiculture and its scope

- Scientific method of rearing honey bees
- Caring and management of honey bees for honey and wax
- Bees are bred commercially in apiaries
- The word 'apiculture' comes from the Latin word 'apis' meaning bee.

Products obtained

- Bees are mainly reared for their honey. Bees produce honey from the sugary secretions of plants. Although honey is an important ingredient in many food dishes, beeswax holds a lot of commercial significance too. It is used in the cosmetic and medical industry, as well as a coating for cheese, and as a food additive. It is also used as the main component for making candles, preparing polishes for the shoe, furniture, etc
- beeswax..

Importance of Beekeeping

- Provides honey, which is the most valuable nutritional food.
- Provides bee wax which is used in many industries, including cosmetics industries, polishing industries, pharmaceutical industries, etc.
- Plays an excellent role in pollination. Honey bees are the best pollinating agents which help in increasing the yield of several crops.
- According to the recent studies, the honey bee's venom contains a mixture of proteins which can potentially be used as a prophylactic to destroy HIV that causes AIDS in humans.

Life history of honey bees :

- In a colony, there are 10,000 to 60,000 bees! But all of them do not collect nectar- there is a strict division of labour.
- The queen bee and female bees lay thousands of eggs.
- Indirect development and complete metamorphosis
- Larva : pupa: adult
- unfertilized egg : drones
- Fertilized egg : workers and queen
- Larvae that hatch are fed royal jelly and the duration that they are fed will decide their role as a worker or queen.
- The drone bees are male and their job is only to help in fertilizing the eggs laid by the queen, and the worker bees do the actual work of collecting nectar.
- The true social organization (*eusociality)* of honey-bees is well understood in the study of *Apis mellifera.* They live in colonies in hives and each bee-colony includes several thousands of bees which consist of one queen, several hundred drones and tens of thou-sands of worker bees (50,000-80,000 or more).
- Both queen and workers are female and diploid. Drones are males and haploid.
- A strong or healthy colony is called when the maximum number of workers is found in the colony

Hive or Comb:

- The worker bees construct hive with the help of wax secreted from the wax-secreting glands of the abdomen.
- They repair the cracks of the walls of hive with propolis (resinous substance collected by bees from different parts of plants for use as glue) and balm collected from the plants and is used in the construction of comb.
- The propolis is used as a glue to bind broken parts, and balm is taken for polishing inner walls. Each bee hive contains thousands of hexagonal cells arranged in two vertical rows.

These cells are of 5 types:

1. ***Queen cells***: These are a very few in number in a hive. They are larger than the other cells and vase-shaped, and are situated at the margin of the comb. These cells are used for queen rearing.
2. ***Drone cells:***There are about 200 drone cells in each hive and are smaller than the queen cells. The drones are reared in these cells.
3. ***Worker cells***: Majority number of cells is worker cells and each cell is about 5 mm across. The workers are reared in these cells.
4. ***Brood cells:*** The larvae of the honey bee are reared in these cells.
5. ***Storage cells***: These cells are meant for the storage of honey and pollen.

Common varieties of bees

1. ***Apis dorsata***: It is also referred to as the rock bee. It is a giant bee and produces about 38 to 40 kg of honey per colony.
2. ***Apis indica***: It is also referred to as the Indian bee. It can be easily domesticated and is most commonly used for honey production. The annual yield of honey is 2 to 5 kg per colony.
3. ***Apis florea***: It is also referred to as the little bee. It rarely stings and thus honey extraction from its hive is easy. It produces about 1 kg of honey per colony per year.
4. ***Apis mellifera***: It is also referred to as the Italian bee. This species has a very typical dance routine to indicate food availability, and like the little bee, stings less. As the common name suggests, this species is not local. However, because of the high amount of honey produced, it is often reared by beekeepers.

Social organization

- The social organization of the honey-bees is established by the living of all individuals within the colony and they show the mutual cooperation among the members of the colony, and exhibit the overlapping generations.
- there is a division of labour among the different types of honey-bees in the colony or hive.
- The different forms or types of insects having a particular function live in the colony, called the castes.
- **Caste System:**

Thousands of bees (50,000 to 1,00,000 or more) which live in a hive are of three different forms:

1. **Workers (infer-tile females),**
2. **Drones (males) and**
3. **Queens (fertile females)**

- The phenomenon of existence of several morphological forms with separate functions in a species is known as *polymorphism*. So honey-bees are well known as social and polymorphic insects

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Queen bee:

- Generally a single matured queen is present in each hive.
- The size of the queen is nearly 2.5 times longer than that of a worker bee.
- characterized by the long tapering abdomen, well-proportioned body, short and golden coloured wings and colour of the legs.
- The queen possesses a curved sting at the tip of the abdomen which is known as ovipositor.
- The function of the queen is reproduction and lays about 1000- 2000 eggs every day depending upon seasonal variation and seasonal factors.
- The eggs may be either fertilized or unfertilized.
- Depending on the type of food supplied to the newly developed larvae by the nursing workers the eggs may develop either queen or workers.
- **The drones or males are produced by the laying of unfertilized eggs (i.e. *parthenogenetically*).**
- The queen deposits each egg in a cell prepared by the worker bees
- After three days the eggs hatch into small larvae.
- The larva which is fed with a special food called '***royal jelly'*** develops into queen.
- The royal jelly is a high proteinous substance produced by the hypopharyngeal glands of the workers.
- The larva which is selected to become queen is taken before the third day of development in a special chamber, called *queen's chamber*.
- The queen lives five to eight years on aver-age and her fertility decreases with the in-crease of age.
- The sting of the queen serves an ovipositor for lying of eggs and is also used for defence.
- The queen secretes a kind of chemical substance with hormonal properties from the mandibular glands, called ***pheromone or queen substance*** which inhibits the growth of ovaries of workers and control the activi-ties of all bees within the hive.
- She can attract the workers towards the queen and stimulates the workers to build wax cells for worker bees and drones but prevents in the building of queen cells.
- When the queen becomes matured she leaves the hive with some drones and takes several nuptial flights and mates with a drone.
- After copulation the drone dies soon after and the queen stores enough sperm in the spermatheca to last her lifetime.
- The queen after copulation returns in her old hive and is looked after by nurse workers, known as her retinue.
- With the increase of the age the egg laying capacity of the queen loses, the workers choose a three day old egg.
- This egg after hatching into larva is fed with royal jelly and it develops a new queen in about 16 days. At that time the old queen leaves the hive along with some workers to establish a new colony.
- Nuptial Flight and Copulation: About a week after emergence from her chamber, the new queen flies in air with many drones. The copulation takes place in the air with a drone and the queen receives the spermatophores from the drone. After copulation, the genital parts of the drone are forced out and the drone dies immediately.
- The flight of one queen with several drones in air for copulation is called ***nuptial flight.***
- Role of Hormone for Social Organization: The mandibular glands of queens are situated in the head and open at the base of mandible. The queen secretes a kind of chemical substance that inhibits the development of ovaries of worker bees.

Drones:

- The drones are the male mem-bers of the bee colony and are haploid each genetically.
- The drones take 24 days to develop from the egg to adult.
- They have no food (pollen and nectar) collecting organs. So the drones are totally dependent on worker bees for food.
- They feed on the honey during spring and summer months provided by worker bees and are driven out in autumn from the hive.
- Function: The main function is to fertilize the queens. They also help to maintain the warmth of the hive which is necessary for the hatching of the eggs.

Workers:

- The size of worker bee is small but they constitute the majority in a hive.
- Called *neuters*: degenerated gonads:no instinct to mating and reproductive powers
- They are produced by the fertilized eggs laid by the queen. It takes 20 days from egg to adult and life span is about 6 weeks.
- 2 categories : ***house bees and foragers***
- Foragers : 2 types : *searchers and collectors*
- Duties :
    - Builders
    - Repairers
    - Cleaners
    - Fanners
    - Store keepers
    - Nurses
    - Waiters
    - Brewers
    - soldiers

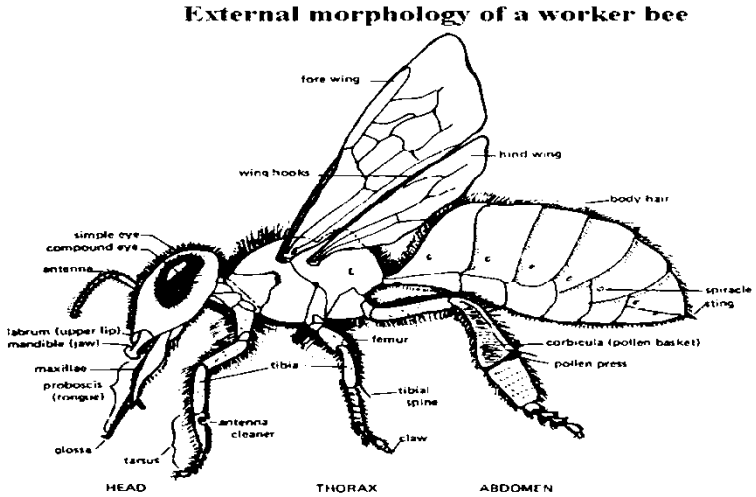
<u>Communication of Honey Bee:</u>

- They perform certain rythmic movements and emit odours that are easily received by other bees.
- When the source is nearer to hive (within 100 metres), reporter bee or forager or worker bee performs a ***round dance,*** turning in a circle, once to left then to right and repeating the same movement for 1½ min-utes in one place.
- Round dance informs the distance of source of food which is less than 100 metres but cannot give the indication of direction.
- If the source is further away, the reporter bee performs a tail ***wagging dance*** .
- It runs towards the direction straight ahead for a short distance, wagging the abdomen, makes a 360° turn towards left, runs ahead once again and turns right. This is repeated for several times.
- These dances are closely watched by other bees in the hive and then immediately they come out in search of the source.
- The wagging dance informs their sisters of the hive both direction and distance of the source of food (nectar or pollen) discovered by the worker bees and is considered as language of bee.
- The direction of straight run indicates the direction of source of food and tempo of the dance also indicates distance.

- ***Odours*** play a vital role in their commu-nication. Sudden death of queen bee is relayed to 60,000 or more bees of the hive in less than an hour.
- Healthy queen secretes an aromatic substance called 'queen substance' which is licked off by her nurse bees. When the queen dies the secretion stops and the absence of the queen substance is immediately relayed to all the members of the colony. The message being conveyed to all members of the colony; they at once set about the vital task of rearing a new queen.

Structure of worker bee

1. Head
2. Thorax
3. Abdomen



Head

- Triangular
- Bears :
  - Antennae: tactile / olfactory
  - Compound eyes (2) : formed of 5,000 ommatida , perceive moving objects and distinguish only blue , yellow and white colors and UV rays,
  - 3 ocelli : photoreceptors
  - Mouth parts

Mouth parts

- chewing and lapping
- consists of ,
  - *labrum* : upper lip
  - *epipharynx* : organ of taste
  - a pair of *mandibles* : large , toothless and spatulate : used for kneading pollen , moulding wax , removing wastes , cleaning cells
  - *1st maxillae* : has cardo and stipes (has *maxillary palp , palea and lacinia)*
  - enlarged *labium* : has *sub-mentum , mentum and pre–mentum* (has *labial palps , paraglossae and glossae*)
  - glossae forms flexible hairy proboscis or tongue with terminally expanded *labellum*

Thorax

- *prothorax :* pair of legs

- *mesothorax and metathorax* : both bears a pair of legs and wings
- *wings* : membranous with hamuli
- *legs* : specialized for gathering , storing and carrying pollen . 5 regions : *coxa , trochanter, femur tibia and trasus*
  - *prothoracic legs* : contains eye brush , pollen brush , tarsal notch ,antenna comb and , tibial spine.Antenna comb and spine form antennae cleaner
  - *mesothoracic legs* : provided with tibial spur (used to remove wax plates) and pollen brush
  - *metathoracic legs* : has *pollen basket , pollen brush ,wax pincher & pollen packer* (auricle and pecten) , *pollen combs*

Abdomen

- Ten segmented
- 2 parts : propodeum (1st seg)and gaster (6 in females , 7 in males)
- Propodeum and gaster unites by *petiole*
- Bears 4 pairs of *wax glands , scent gland and a sting* (sting is absent in drones)

Wax glands

- 4 pairs
- Lower side of last 4 abdominal segments
- *Wax mirrors* has openings from which wax secreted from wax glands reaches sternite and forms *wax pockets*

Scent glands

- Beneath tergite of 7th abdominal segment
- Pheromone

Sting apparatus

- Only in female bees and absent in drones
- Consists of :
  - Venom glands
  - Venom duct
  - Alkaline gland
  - Venom receptacle
  - Chitinized sting

Specialised glands

- *Salivary glands* : one pair cephalic and thoracic . Contains *invertase :* for honey modification(sucrose to levulose and dextrose) and for comb building
- *Food glands* : in head for royal jelly production
- *Mandibular glands* : in head ; produces enzymes for cocoon softening
- *Honey sac:* crop , specialized for storing honey and water

Bee products

1. Honey

Composition and Uses of honey

- Water -17%
- Pollen grains
- Fructose :40%
- Dextrose : 35%
- Sucrose: 1.8%

- Dextrins : 1.5%
- Minerals salts : 2% : calcium, magnesium , phosphorus , sulphur , chlorine and iodine
- Organic acids : citric ,tartaric , formic acids
- Gums,enzyme s: *amylases, invertases, saccharases , lipases , peroxidases*
- Vitamins :A,C,E & K ,vitamin B complex

Uses:

- Food
- Medicine
- Beverage making
- Laboratory plants : growth
- Rooting of plants : promotes
- Bacterial culture preparation

2. Bee wax

- Wax Paints , Candles , Cosmetics , Insulation, Pharmaceutical , Polish etc

3. **Bee venom** : apitoxin
    - Mellitin lowers BP, therapeutic and prophylactic remedy
    - Antibiotic
    - Control haemolysis
    - Raise immunity
    - Remedy for rheumatism , neuritis , eye disease etc

Bee diseases

Adult diseases

1. Nosema
2. Amoebic disease
3. Acarine disease
4. Septicaemia
5. Fungal diseases

Brood diseases

1. Bacterial : foul brood
2. Fungal

✓ **SILK MOTH**

Different types of silkworms

1. **Mulberry silk moth (*Bombyx spp.)*** : feed on tender mulberry leaves ;both domesticated and wild species are included;produce finest natural silk
2. **Eri silk moth**: feed on castor leaves ;fully domesticated; produce eri silk
3. **Tussar silk moth** : feed on leaves of oak, fig etc ; partially domesticated; produce tasar silk
4. **Muga silk moth** : feed on several trees ;produces muga silk

Life cycle

- Indirect development
- Holometabolous (complete metamorphosis)
- 4 stages : egg,larva,pupa and adult
- Female lays 400-500 brownish white eggs

- Adults die after mating
- 2 kinds of eggs : diapauses (hibernating) and non diapauses (non-hibernating)
- After 8-12 days of embryonic development , a pale , yellowish white worm like larva hatches: silkworm
- Silkworm moults 4/5 times and fully grown
- Body of silkworm : head , thorax and abdomen , with legs , salivary glands , silk glands , spinneret
- By thy end of 30-40 days : larva stops feeding- rest –cocoon
- Cocoon making takes 3-5 days
- Pupal life : lasts 2-3 weeks
- Pupa transforms to : winged adult moth

SERICULTURE

- Rearing of domesticated silk moths and silk worms for commercial silk production
- **Requirements** : superior races of ***Bombyx mori*** and **high quality mulberry plants**
- Rearing Equipments:
  - Rearing house: The rearing house should meet certain specification, as the silk worms are very sensitive to weather conditions like humidity and temperature. The rearing room should have proper ventilation optimum temperature and proper humidity. It should be ensured that dampness, stagnation of air, exposure to bright sunlight and strong wind should be avoided.
  - Rearing stand: Rearing stands are made up of wood or bamboo and are portable. These are the frames at which rearing trays are kept.. The trays are arranged on the shelves, and each stand can accommodate 10 rearing trays.
  - Ant well: Ant wells are provided to stop ants from crawling on to trays
  - Rearing tray: These are made of bamboo or wood so that they are light and easy to handle.
  - Paraffin paper: It is used for rearing early stages of silk worms and prevents withering of the chopped leaves and also help to maintain proper humidity in the rearing bed.
  - Foam rubber strips
  - Chopsticks: These are tapering bamboo rods (1cm in diameter) and meant for picking younger stages of larvae to ensure the hygienic handling.
  - Feathers: These are used for brushing newly hatched worms to prevent injuries.
  - Chopping board and Knife
  - Leaf chambers: These are used for storing harvested leaves.
  - Cleaning net: These are cotton or nylon nets of different mesh size to suit the size variations of different instars of the silk worm. These are used for cleaning the rearing beds, and at least two nets are required for each rearing tray.
  - Mountages: These are used to support silkworm for spinning cocoons.
  - Hygrometers and Thermometers: These are used to record humidity and temperature of the rearing room.
  - Feeding stands: These are small wooden stands (0.9 m height) used for holding the trays during feeding and bed cleaning.
  - Other equipments like feeding basins, sprayer, and leaf baskets may also be required.

Steps:

- Selection of silk moth : disease resistant, adaptability , silk production potential etc
- Growing mulberry plantations : moriculture
- Rearing of silk worms

- Processing of cocoons : 10% of pupae are allowed to grow to raise nest generations and remaining are used for silk production : involves ;
  - *Stifling* : killing of pupae inside cocoons :by hot air , sun or fumigation
  - *cooking :* soaking in hot water : it softens the sericin that glues coils of fibroin thread: helps loosening and separation
  - *reeling*: separation and uncoiling of silk threads : produces raw silk / reeled silk / spools of silk
- raw silk : boiled , steamed , stretched , purified , washed and cleaned : combed and untangled
- can be used directly or bleached and colored

Stages of production

The stages of production are as follows:

1. The female silkmoth lays 300 to 500 eggs.
2. The silkmoth eggs hatch to form larvae or caterpillars, known as silkworms.
3. The larvae feed on mulberry leaves.
4. Having grown and moulted several times, the silkworm extrudes a silk fibre and forms a net to hold itself.
5. It swings itself from side to side in a figure '8', distributing the saliva that will form silk.
6. The silk solidifies when it contacts the air.
7. The silkworm spins approximately one mile of filament and completely encloses itself in a cocoon in about two or three days. The amount of usable quality silk in each cocoon is small. As a result, about 2,500 silkworms are required to produce a pound of raw silk.
8. The intact cocoons are boiled, killing the silkworm pupa.
9. The silk is obtained by brushing the undamaged cocoon to find the outside end of the filament.
10. The silk filaments are then wound on a reel. One cocoon contains approximately 1,000 yards of silk filament. The silk at this stage is known as raw silk. One thread comprises up to 48 individual silk filaments.

MORICULTURE : Mulberry Cultivation

- Cultivation of mulberry plants is called moriculture.
- There are over 20 species of mulberry, of which four are common: *Morus alba, M. indica, M. serrata* and *M latifolia.*
- Mulberry is propagated either by seeds, root- grafts or stem cuttings, the last one being most common.
- Cuttings, 22-23 cm long with 3-4 buds each and pencil thick, are obtained from mature stem.
- These are planted directly in the field or first in nurseries to be transplanted later.
- After the plants have grown, pruning is carried out routinely which serves two purposes, induction of growth and sprouting of new shoots.
- Harvesting of leaves for feeding larva is done in three ways:
  - Leaf picking: individual leaves are handpicked. In branch cutting method, entire branch with leaves are cut and offered to 3rd instar larva
  - Branch cutting.
  - top shoot harvesting: the tops of shoots are clipped and given to the 4th & 5th instars.
- The yield and quality of leaf depend upon the agronomic practices for cultivation of mulberry trees, namely irrigation, application of fertilizers etc.

- It is estimated that 20,000 to 25,000 kg of leaves can be harvested per hectare per year under optimum conditions.

Diseases of silkworms

Diseases

1. ***Pebrine***:
   - Pebrine is also known as pepper disease or corpuscle disease.
   - The disease is caused by a sporozoan, *Nosema bombycis* (family Nosematidae).
   - The main source of infection is food contaminated with spores.
   - Infection can be carried from one larva to another by the spores contained in faeces or liberated in other ways by the moths carrying infection.
   - Pebrinized eggs easily get detached from the egg cards.
   - They may be laid in lumps. The eggs may die before hatching. The larva shows black spots.
   - They may become sluggish and dull, and the cuticle gets wrinkled.
   - Pupa may show dark spots.
   - Moths emerging from pebrinized cocoons have deformed wings and distorted antennae. The egg laying capacity of the moth becomes poor.
2. ***Flacherie:***
   - Flacherie is a common term to denote bacterial and viral diseases.
   - Symptoms : digestion impaired : void foul smelling and semi solid excreta: lethargic
   - It has been classified into following types:-
     - Bacterial diseases of digestive organs: Due to the poor supply of quality mulberry leaves, the digestive physiology of the silkworm is disturbed, and multiplication of bacteria occurs in the gastric cavity. Bacteria like Streptococci, Coli, etc. have been found associated with this disease. Symptoms, like diarrhoea, vomiting, shrinkage of larval body may be seen.
     - Septicemia: Penetration and multiplication of certain kinds of bacteria in haemolymph cause septicemia. The principal pathogenic bacteria are large and small Bacilli, Streptococci, and Staphylococci etc. Symptoms like diarrhoea, vomiting, shrinkage of larval body may be seen. Appearance of foul odor is also a common symptom.
     - Sotto disease: It is caused by toxin of *Bacillus thuringensis*. The larvae become unconscious, soft, and darkish and rot off.
     - Infectious Flacherie: It is caused by a virus called Morator Virus which does not form polyhedra in the body of silkworm larvae. The infection occurs mainly through oral cavity. The virus multiplies in the midgut and is released into the gastric juice and is excreted in faeces.
     - Cytoplasmic polyhedrosis: It is caused by a virus called Smithia which form Polyhedra are formed in the cytoplasm of the cylindrical cells of the midgut. The larva loses appetite. The head may become disproportionately large. Infection occurs through the oral cavity.
3. ***Grasserie***:
   - The disease is also known as Jaundice or Nuclear Polyhedrosis
   - It is caused by a virus called Borrelina, which form polyhedra in the nuclei of the cells of fatty tissues , dermal tissues, muscles, tracheal membrane ,basement membrane , epithelial cells of midgut and blood corpuscles.
   - Viral

- Symptoms: caterpillar becomes swollen like bag of granules ; body fluid becomes thick and cloudy , ;leading to death
- The infected larvae lose appetite,become inactive, membranes become swollen, skin becomes tender and pus leaks out from skin. The larvae finally die.

4. *Muscardine or Calcino:*

- Fungal : *Beauveria bassiana*
- Spread by wind dispersal of its spores
- Affected larvae becomes yellow or green colored
- Body softens , then hardens and finally after death
- Massive destruction of worms

Composition of silk

- 75% ***fibroin*** : forms the inner core : alanine, serine, glycine , and tyrosine
- 25% ***sericin***:forms gummy coating alanine , leucine and serine
- Traces of carotenoid pigments and wax

✓ **LAC INSECT**

- Lac producing scale insects
- Host plants : mango,fig,peepal,oak ets
- Insert proboscis on to bark and feed on sap
- Abdominal glands secrete protective resinous substance called lac that encases and protects them
- Lac insects are not domesticated
- Adult lac insects : small orange –red organisms with piercing and sucking mouth parts
- Reside inside resinous coverings : *lac cells/lac scales*
- Adult females : wingless and inactive . adult male s:m active and winged
- After mating , male dies
- Eggs : 200-500
- Larvae feed on plant sap : dermal glands secretes lac
- Larvae : becomes adult inside lac cells

Different strains of lac insects

1. *Kusumi :* superior in color and quality
2. *Rangeeni*

Lac cultivation

- 3 steps :
  - Selection and preparation of host plants
- Common in India : mango, peepal, oak , fig etc
- 4/5 months after Pruning , lac insects are introduced to tender branches
  - Inoculation of lac insects
- Young ones of lac insects are introduced into host tree and properly asscociated with succulent branches
- May be natural or artificial(lac-encrusted twigs or brood lac are tied to succulent branches of pruned host tree
  - Harvesting of lac

- 2 kinds : immature harvesting (harvested before larval swarming; ari lac)and mature harvesting (mature lac)
- Stick lac $\xrightarrow{\text{washed and powdered}}$ grain lac/seed lac $\xrightarrow{\text{melted with arsenic sulphate\& filtered}}$ kirri lac $\xrightarrow{\text{cooled and solidified}}$ pure lac $\xrightarrow{\text{sheet}}$ sheet lac $\xrightarrow{\text{chemically processed}}$ shellac

Composition of lac

- Resin:70-80%
- Water:2-3%
- Sugar
- Protein
- Soluble salts
- Wax:5-6%
- Coloring pigments :2-10%: like *laccaic acid , erythrolaccin*

Properties of lac

- Water-insoluble ,readily soluble in alcohol and ammonia
- Bad conductor of heat
- High adhesive power
- Forms binding material , when mixed with alcohol

Uses of lac

- Resinous material
- Paints , polishes , varnishes, finishers , electrical insulation, metal coating etc
- Thermoplastic moulding material
- Crayons
- Optical frames

Enemies of lac insects

- *Eublema anabilis and Holocera pulverea* : caterpillars of these moth tunnel through the stick lac and eat away the lac encrustation as well as the eggs, larvae and adults of lac insects
- *Chrysopa* : larvae of different species of this lacewing penetrate into lac cells and suck body fluid of lac insects
- *Parasitic wasps*
- Ants, birds , monkeys , rats etc

BIBLIOGRAPHY

1. *ELEMENTS OF APPLIED ENTOMOLOGY* ; K.K. BHASKARAN ,C.F.FRANZY ; MANJUSHA PUBLICATIONS
2. WIKIPEDIA