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THE NEOTIA UNIVERSITY

ज्ञानम् आत्म प्रदीपाय

Practical Manual
Management of Beneficial Insects
(CC-AGP 648)

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PREFACE

The practical manual for the B. Sc. (Agriculture) course "Management of Beneficial Insects" has been compiled following the prescribed syllabus of the revised ICAR Fifth Dean Committee. The manual would provide basic knowledge about the predators, parasitoids, beekeeping or apiculture, silkworm rearing or sericulture and lac culture to the undergraduate students of Agriculture. I am confident that this practical manual would be helpful as a handy reference to understand the basic principles and methodology of the experiments. It is my prerogative to thank Prof. Swapan Kumar Mandal, former-Head and Professor, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur and Visiting Professor, School of Agriculture and Allied Sciences, The Neotia University (TNU) for his valuable support and guidance during the preparation of this manual.

KOUSHIK SEN

CONTENTS

PRACTICAL 1: HONEY BEE SPECIES AND CASTES OF BEES

Objective: To study the different species of honey bees and castes of bees

Apiculture or **Bee keeping** is the practice of scientific maintenance of honey bee colonies, commonly in hives, by humans in order to collect bee products like honey, beeswax, propolis etc. and marketing them professionally. A bee-keeper is called an **Apiarist**. A location where bee colonies are kept is called an **Apiary** or "**Bee yard**". The scientific study of honey bees is known as **Apiology**. Honey bees are highly organized social insects and their systematic position is as follows –

Phylum: Arthropoda

Class: Insecta

Order: Hymenoptera

Family: Apidae

Genus: Apis

Honeybees are social insects and live in colonies. Their main source of nutrition is flower i.e. nectar and pollen.

Species of Honey bees

Indigenous species: *Apis florea* (Little honey bee), *Apis dorsata* (Giant rock bee), *Apis cerana indica* (Indian honey bee)

Exotic species: *Apis mellifera* (European honey bee or Italian bee)

Important honey bee species and their characters

Sl. No.	Character	Little bee, *Apis florea*	Giant rock bee, *Apis dorsata*	Indian bee, *Apis cerana indica*	Italian bee, *Apis mellifera*
1.	Wild/ domesticated	Wild in nature	Wild in nature	Domesticated	Domesticated
2.	Size	Smallest of all the species	Largest of all the species	Intermediat e	Bigger than *A. cerana* but smaller than *A. dorsata*
3.	Distribution	Found in plains of India upto 300 m above sea level	Present all over India in plains an in hilly areas upto 1600 m above sea level	Present all over India in plains and hilly areas upto 2500 m above sea level	Imported species. Got acclimatized to different climatic conditions all over India

4.	Queen	Bigger and abdomen is golden brown	Darker and much larger than workers and drones	Thorax dark and sparsely hairy. Abdomen and legs coppery brown. Abdomen is big, distended and without black bands.	Brownish body longer than worker and drone
5.	Drone	Black with smoky brown hair on the abdomen	Black and as big as workers	Stout and slightly bigger than workers	Amber/ yellow body with yellowish hair
6.	Worker	Deep black with white strips on the posterior part of the bright orange abdomen	Light brown 16-18 mm in size	Thorax dark coloured with brown hair. Abdomen brown with dark bands	Black with yellowish hairs
7.	Temperament	Very mild, but they do sting when irritated	Ferocious	Gentle	Moderately mild
8.	Type and nature of comb construction	Builds single, small comb (15 cm long and 30 cm height) in open where they get some diffused light	Builds single, big comb in open where they get some diffused light (1-2 m from side to side and 0.5 to 1.25 m from top to bottom	Builds several parallel combs (13-18) i.e., parallel to the direction of the entrance in plains and at right angles to the entrance at high altitude	Builds a series of parallel combs inside some enclosures
9.	Nesting site	Constructs the comb in the files of cotton sticks/bushes/ house chimneys/ house arches and other such places	Suspends its comb to large tree branches/ building projections/water reservoirs/ceilings etc. protecting it from direct sun rays and rain	In nature, constructs combs inside some enclosures such as hollows in the walls/rocks/tree trunks/ inverted baskets etc.	In nature, construct comb in the hollows of walls/rocks/tree trunks/inverted baskets etc.
10.	Honey gathering per year per colony	Poor gathers 0.5 to 1.0 kg	Heavy gathers 37 kg	Fair gather 3-5 kg in plains, but yields are as high as 20-25 kg in Kashmir	15-20 kg. A strong colony can gather upto 50 kg if abundant bee flora is available
11.	Sting	Absent	Present	Present	Absent

Fig. *Apis florea* and its honey comb

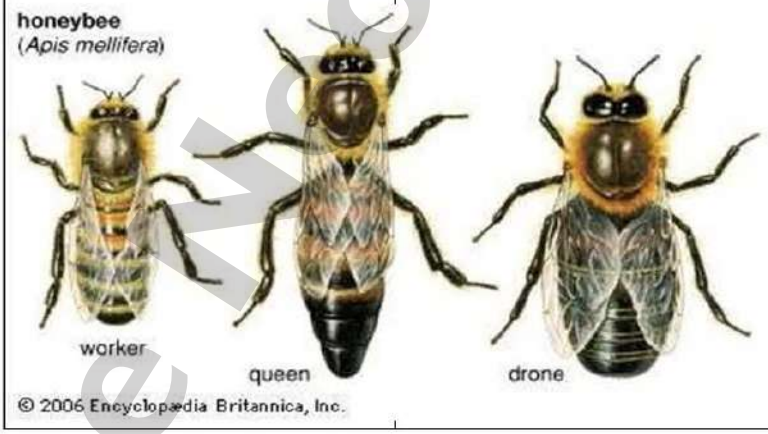

Fig. *Apis dorsata* and its honey comb


Fig. *Apis cerana indica* and its honey comb


Fig. *Apis mellifera* and its honey comb

Castes of bee colony

In a bee colony of an average size, there may be about 20,000 to 30,000 bees consisting normally of a queen, a few hundred drones and the remaining individuals are the workers making up over 90% of the population.

Queen	Drones	Workers
➢ She is the only functional mature female in a colony. ➢ Larger in size than workers. ➢ She has no wax plates and pollen baskets. ➢ May lay eggs at the rate of 1500-3000 per day. ➢ Queens are raised in specially constructed queen cells, which have peanut like shape and structure. ➢ Queen lays both fertilized and unfertilized eggs. ➢ Fertilized eggs produce workers (also queens) and unfertilized eggs produce drones. ➢ Normal life span is 2-3 years.	➢ Drone is the functional male. ➢ Develops from unfertilized egg. ➢ Larger and stouter than workers with powerful wings. ➢ He has no sting, wax glands or pollen baskets. ➢ Drones can live up to about 60 days. ➢ Drones neither perform any duty inside the hive nor do they collect food from flowers. ➢ The sole function of a drone is to mate once with the virgin queen which costs him his life.	➢ Imperfectly developed female (sterile female). ➢ Develops from fertilized egg. ➢ Workers are smaller than the drones and queen and have yellowish-dark brown abdominal stripes. ➢ Have well-developed sting and Hind legs have "pollen basket" for collecting pollen. ➢ The workers perform all the useful work in the colony except egg laying. ➢ Duties of workers include: Cleaning of the hive, feeding of larvae, raising queen cells when required, ventilate hive, guard the hive entrances, secrete bees wax to construct the combs, collect the nectar and convert it into honey, collection of pollen, water and propolis, produce a predigested food of royal jelly for feeding queens and young larvae and scouting for a new nest site during swarming. ➢ Usually live for 5-6 weeks.
		

Video Link:

https://www.youtube.com/watch?v=esJXJS4G3FM

https://www.youtube.com/watch?v=GE9kgegy0EE

QUESTIONS

1. What does "Apis", a Latin word mean literally?

Ans.

2. Write three advantages of bee-keeping.

Ans.

3. What are the wild and domesticated species of honey bees?

Ans.

4. What are the different castes found in a bee colony? What is the major difference between these castes?

Ans.

5. What are the average life span of each castes of bees?

Ans.

6. Write the type and nature of comb constructions of different species of honey bees.

Ans.

PRACTICAL 2: BEE-KEEPING APPLIANCES AND SEASONAL MANAGEMENT

Objective: To acquainted with bee hives and other bee keeping appliances and seasonal management of honey bees

Bee hives

A beehive is a place in which a single colony of honeybee exists containing and performing various functions for their livelihood. Primitive Beekeeping was revolutionized through discovery of Bee space by Rev. L. L. Langstroth and successful use of movable frames which in turn led to designing of modern beehive. L.L. Langstroth discovered the principle of bee space in 1851 in the U.S.A. The "Modern" bee hive is based on understanding of "Bee Space" 1/4″-3/8″. Bee space (passage way) is the space required between any two frames for bees to move about between the combs and too small to build combs and too large to deposit propolis. Bee space for *Apis mellifera* is 5/16″ and for *Apis cerana* is 1/4″.

Different types of bee hives

1. Pot hive
2. Hook hive
3. Madusagar hive
4. House hive
5. Nucleus hive or Jeolikote's hive
6. Marthandam hive for *A. cerana*
7. Dadant's hive (Single walled & Double walled)
8. British standard hive
9. Langstroth's hive (*A. mellifera*)
10. Newton's hive (*A. cerana*)
11. BIS hive (Bureau of Indian Standards) for *A. mellifera* and *A. cerana indica*

Natural beehives (referred to as "nests") are naturally occurring structures occupied by honey bee colonies. The beehive's internal structure is a densely packed matrix of hexagonal cell made of beeswax, called a honeycomb. Bees use cells to store food (honey and pollen) and to house "brood" (eggs, larvae and pupae).

Natural bee nests: Honey bees in subgenus *Apis* use caves, rock cavities and hollow trees as natural nesting sites. Members of other subgenera have exposed aerial combs. Nests composed of multiple honeycombs, parallel to each other, with a relatively uniform bee space, usually with a single entrance.

Artificial bee hives

- Traditional beehives
- Modern beehives

- Skeps are made of baskets with single entry points at the bottom for the bees and no structure inside. It is not feasible to inspect bees inside and harvesting means destroying entire hive by killing or driving away bees.
- Bee Gums – Hives of this type are located exactly on hollowed body part of gum trees. Sticks are attached to honey combs for easier pulling out by the time of harvesting.

Langstroth Hive

- **Stand:** Any four-legged stand 15–25 cm high will do. Its upper dimensions should be such as to support the bottom board properly.
- **Bottom board:** It is floor of the hive having an entrance for bees. On this board brood chamber rests.
- **Brood chamber:** It is a rectangular box without top and bottom and is made of 22 mm thick wood. Chamber used for rearing of brood. Frames are placed in this chamber on which bees raise combs. The dimensions and number of frames vary with the type of hive. A wooden dummy board is used to limit the size of brood chamber and is placed at the end of brood frames.
- **Frame:** Each frame consists of a top bar, two side and a bottom bar. Inner aspect of the top bar has a groove for fixing comb foundation sheet. Side bar has 4 holes for wiring the frame. The frame holds a comb.
- **Super:** The dimensions of the super and the super frames should be the same as those of the brood chamber and the brood chamber frames, respectively. This is the chamber where bees store surplus honey.
- **Inner cover:** This is wooden board to cover the brood chamber or the super as the case may be and the roof.
- **Top cover:** It is made up of 9 mm thick wooden board nailed to a rectangular frame 50 mm high, all covered over with a metallic sheet so as to make it impervious to rainwater. It rests loosely over the hive.

National hive

Widely used hive in the UK. A square hive, with grooves to serve as hand grips. • Frames - smaller than standard Langstroth hive& have longer hand grips (or "lugs").

WBC hive

Invented by and named after William Broughton Carr. A double-walled hive with an external housing that splays out towards the bottom of each frame covering a standard box shape hive inside. Offers extra level of insulation for bees by its double-walled design. Inconvenient to remove external layer before hive can be examined.

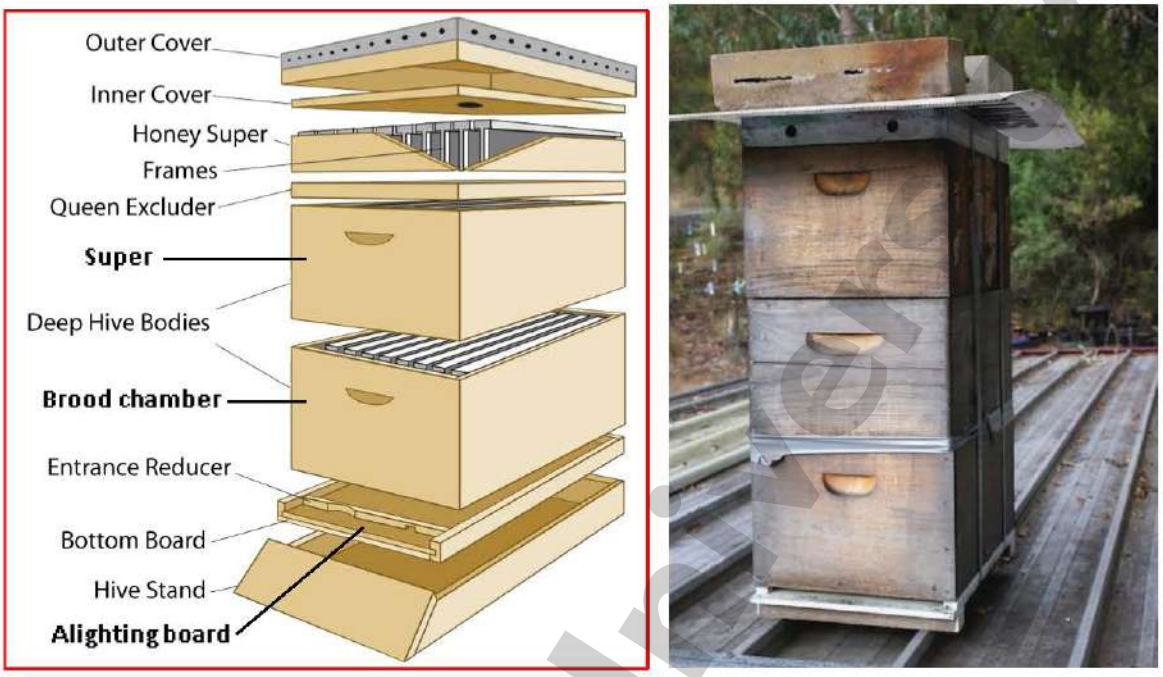


Fig. Langstroth bee hive

Other Beekeeping Equipments or Appliances

Beehive stand	This is made of RCC or wood or iron with provision for water cups to prevent ants from entering beehive. Bee hive is kept on the beehive stand.
Smoker	The smoker is a metal cylinder in which smoke is produced by igniting fire. The smoker is attached with a bellow to blow air into the fire. The regulated smoke that comes out of the nozzle is directed into the hive to make the bees docile and less prone to stinging.
Hive tool	It is made of a thick iron plate to clean the hive, to handle the frames and to remove propolis etc.
Bee veil	This is made of mosquito net type material for being worn to protect the face from being stung by bees while handling.
Gloves	These are used to protect hands from bee sting while handling.
Honey extractor	This is made out of tinned copper, brass or zinc drum with basket cages to hold frames and wheel to rotate them in order to extract honey by centrifugal force generated in it.
Queen gate	This is made out of zinc sheet with perforations to prevent queen from going out or from deserting hive.
Queen excluder	This is made out of zinc sheet with perforations and is placed between broad chamber and super chamber to prevent the movement of queen bee from broad chamber to super chamber.
Drone excluder	This is used to prevent the reentry of drones into the hive after the bees have come out of the hive in evening.
Drone trap	It is useful for fixing in front of the hive entrance when workers and drones come out for play flight. Workers can easily go out through the groove at

	the bottom, but drones are trapped. Drones, thus trapped can be removed and killed, when they are no longer required in the hive.
Comb foundation sheet	This is made of pure wax. It is used to aid the bees to construct straight parallel combs.
Dummy division board	This is useful to reduce the inner area of the broad chamber so that the bees can be confined to a limited space when bee population in the hive is low.
Swarm trap	Basket to catch bee swarm.
Bee brush	A bee brush or a whisk broom is often employed to brush off bees from honeycombs before it is used for honey extraction.
Feeders	Different types of feeders are used for feeding sugar syrup to the bee colonies. These can be (i) slow feeder (friction top pail feeders) in which holes are made in the lid and the feeder is placed inverted inside the hive (ii) fast feeder (division board feeder) which is of the size of a regular frame and the trough contains a wooden float inside the cavity.
Queen cages	Several types of queen cages are available for caging the queens.
Queen cell protector	A spring like structure for protecting queen cells. A queen cell which may have to be introduced from a queen right to a queen less colony is often protected in a queen cell protector until its acceptance by the bees.
Decapping Knife	Large sized knife used to uncap the frames before honey extraction.
Pollen trap	For trapping corbicular pollen of returning bee foragers. For *A. mellifera* pollen trapping screen has holes of 4.7 to 5 mm and for *A. cerana* 3.5 to 3.7 mm.

Fig. Beekeeping equipment



Bee brush Gloves Queen excluder Pollen trap

Fig. Beekeeping equipment

Seasonal management

Pollen and nectar are available only during certain period. When surplus food sources are available it is known as honey flow season. In contrast during dearth period there will be scarcity of food. During extremes in climate like summer, winter and monsoon certain specific management tactics are required.

Honey flow season management

This season coincides with spring. During this season,

- provide more space for honey storage by giving comb foundation sheet or built combs.
- Confine queen to brood chamber using queen excluder.
- Prevent swarming as explained in swarm management.
- Prior to honey flow, provide sugar syrup and build sufficient population.
- Divide strong colonies into 2-3 new colonies, if colony multiplication is needed.
- Queen rearing technique may be followed to produce new queens for new colonies.

Summer management

Bees have to survive intense heat and dearth period by following means.

- Provide sufficient shade, under trees or artificial structure.
- Increase RH and reduce heat by Sprinkling water twice a day on gunny bag or rice straw put on hive.
- Increase ventilation by introducing a splinter between brood and super chamber.
- Provide sugar syrup, pollen supplement, substitute and water.

Winter management

It includes the following-

- Maintain strong and disease-free colonies.
- Provide new queen to the hives.
- Provide winter packing in cooler areas hilly regions.

Management during dearth period

- Remove empty combs and store in air tight container.

- Use dummy division board to confine bees to small area.
- Unite weak colonies.
- Provide sugar syrup, pollen supplement and substitute.

Rainy season and monsoon management

- Avoid dampness in apiary site. Provide proper drainage.
- In rain when bees are confined to the hive, provide sugar syrup feeding.

Video Link:

https://www.youtube.com/watch?v=g2Gq5octKkU

https://www.youtube.com/watch?v=gLulI--TdEU

https://www.youtube.com/watch?v=PsSc4HSdU9Y

QUESTION

1. Draw any four honey bee rearing equipment with labelling.

Ans.

2. What do you mean by Bee space?

Ans.

3. Mention the names of artificial hives for rearing *Apis mellifera* and *Apis cerana indica.*

Ans.

4. What is the function of Super in an artificial bee hive?

Ans.

5. Write two practices for summer management of bee colony.

Ans.

PRACTICAL 3: BEE ENEMIES AND DISEASES

Objective: To acquainted with important bee enemies and diseases and their management.

A. Bee Enemies

1. Greater wax moth, *Galleria melonella* **(Lepidoptera: Galleriidae)**

- **Identification:** Adult is brownish grey, 10-18 mm length. The colour and size of adults vary according to food eaten during larval period. Dark brown combs containing pollen give rise to darker and bigger adults. The fore wing of male has a semi lunar notch, while that of females are smooth.
- **Nature of damage:** It is one of the most important enemies of the bee colony causing serious damage particularly to weak colonies where the number of bees are not sufficient enough to cover all the combs. The attack is more prevalent during monsoon. The wax moth larvae tunnel through the mid ribs of the comb and there is presence of small mass of minute wax particles outside the tunnels. In case of severe infestation, further brood rearing is stopped; bees stop field work and colony may abscond.
- **Management**

(i) Maintain the colonies strong to resist wax moth.

(ii) Keep the hives without cracks and crevices.

(iii) Reduce hive entrance size for effective guarding by bees.

(iv) Keep the bottom board neat and clean without debris.

(v) Hold the comb against sun rays to observe the larvae.

(vi) Extra combs stored should be fumigated with sulphur.

2. Lesser wax moth, *Achroia grisella* (Lepidoptera: Pyralidae)

- **Identification:** Lesser wax moth adults are approximately 0.5 inch long and have slender bodies. Their wingspan is approximately 0.5 inch wide. Generally, males are smaller than females. Their coloration ranges from silver-gray to beige and they have a prominent yellow head. The larvae have narrow, white bodies with a brown head and pronotal shield.
- **Nature of damage:** The caterpillars feed mainly on the debris of the combs.
- **Management:** Same as greater wax moth.




3. Ants, *Camponotus compressus* (black ant), *Dorylus labiatus*, *Monomorium indicum* and *M. destructor* (household red ant) (Hymenoptera: Formicidae)

- **Nature of damage:** They attack weak colonies and carry away the honey, pollen and the brood. Strong colonies are able to withstand the ants, but in weak colonies ant attack will result in destruction and end of the colony.
- **Management:** Placing the bee hives on wooden stands with their legs in earthen cups containing water with insecticide. Underground ant nests are eliminated by pouring 0.1% cypermethrin emulsion into them.




4. Predatory wasps, *Vespa velutina*, *Vespa magnifica*, *Vespa cincta*, *Vespa basalis*, *Palarus orientalis* (Hymenoptera: Vespidae)

- **Nature of damage**: The yellow banded hornet, *Vespa cincta*, is a large wasp with a broad transverse yield band on the abdomen. It is a social insect constructing papery nests in hollow spaces. It waits in the area of the entrance of the hive, catches bees as they come out, macerates them for feeding the juice to its young. It captures bee in the field also.
- The bee hunter wasp, *Palarus orientalis*, is black in colour with transverse yellow lines on the abdomen. It catches bees while they are on flight. A wasp can collect about 20 bees a day, stings and carries them to its underground nest and places one in each of the compartments of the nest before laying an egg on the back of each bee. The grub on hatching feeds on the bee.

Vespa cincta

Palarus orientalis

- Most serious damage in hills is caused by *V. magnifica* which cuts down bees in large number while sitting or flying at/near hive entrance.
- Sometimes even *V. basalis* has been found causing severe damage to the colonies.

Vespa velutina

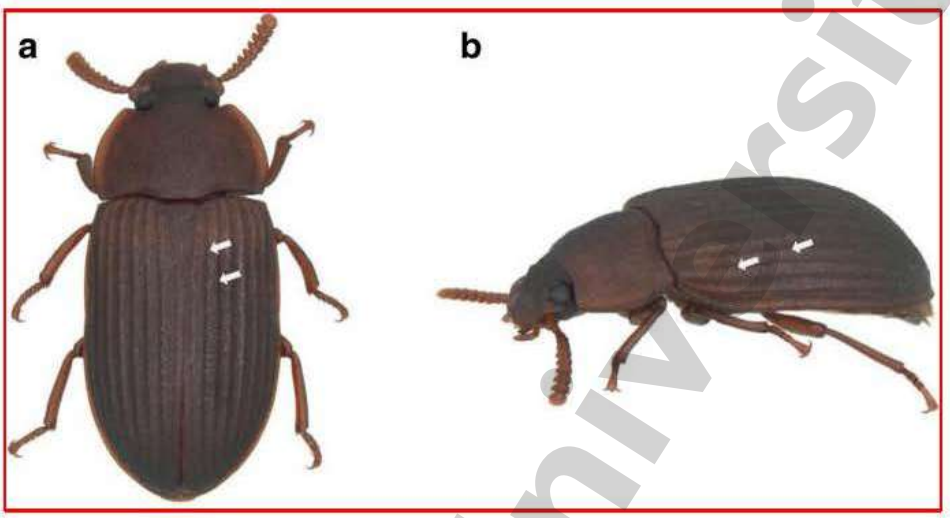
V. magnifica

V. basalis

- **Management:** a) Kill the fecunded females visiting the apiary during spring by flapping. b) Burn the nests during night time. c) In fire prone places destroy the nests by spraying them with strong insecticidal solution. d) Kill the wasps in the apiary by flapping.

5. Wax beetles, *Platybolium alvearium* (Coleoptera: Tenebrionidae)

It is found in the hives under unhygienic conditions feeding on the debris and on old combs in weak colonies. Periodical examination of empty combs and regular cleaning of the bottom boards will control the enemy.



6. Brood mite, *Tropilaelaps clareae* (Acari: Laelapidae)

These mites are serious ectoparasites on brood and adults of *Apis mellifera*. They attack the brood and cause larval death. Perforations are seen on the brood cells. The adult mites are longer than brood.

7. The parasitic mite, *Varroa destructor* (Acari: Varroidae)

These mites are ectoparasitic and attack both Indian and Italian bees. It feeds on early stage of lava and prepupa. The adult mites are broader than long. All the above mites can be managed by dusting micronized sulphur on the frames or by burning Folbex strips (Bromopropylate) as a fumigant inside the hive. The mites can also be controlled by keeping absorbent cotton soaked in 65% formic acid.

8. Other enemies: Birds: bee eater, *Merops orientalis* and king crow, *Dicrurus* sp. eat bees while they are flying. To control the menace, scare them away. Bears and pine martines are the mammals which attack the bees for honey and bees.

Varroa destructor **on an adult bee**

Varroa destructor **on a bee pupa**

B. Bee Diseases

1. Brood diseases: Honey bee brood suffers from a variety of diseases. Adult bees are not affected by brood diseases, but they can spread the causal organism. Brood diseases are more serious than adult diseases.

Bacterial diseases: a) American foul brood (*Bacillus larvae*), b) European foul broad (*Mellissococus pluton*)

Viral diseases: a) Thai sac brood, b) Sac brood

Fungal diseases: a) Chalk brood (*Ascophera apis*), b) Stone brood (*Asperigillus flavus*)

Details of brood diseases

Name of disease	American Foul Brood	European Foul Brood	Sac Brood/Thai sac brood
Causal organism	*Paenibacillus larvae* (bacteria)	*Melissococcus pluton* (bacteria)	Virus (sac brood in *A. mellifera* and Thai sac brood in *A. cerana*
General appearance of brood comb	Brood irregular, intermingling of capped, open and punctured cells. Much dead brood in capped cells, cells with punctured capping and cells uncapped by bees.	Brood irregular. Dead brood mostly in open Cells.	Brood appears as sealed brood and scattered cells with punctured cappings.
Time of death	Late larval or early pupal stage	Coiled larvae in unsealed cell (usually young unsealed larvae sometimes older sealed larvae)	Late larval stage (usuallyolder sealed larvae sometimes young unsealed larvae)
Cell cappings	Sunken and punctured	Dead brood in uncapped stage	Capping removed or punctured often with two holes.

Colour of dead brood	Off white to light cream to brown; coffee brown to dark brown or almost black	Yellowish white to grey or dark brown, dark brown or almost black as compared to glittering white in case of normal brood	Straw coloured, starts darkening from head
Position of dead brood	Lying flat on cell base	Coiled, twisted or collapsed	Extended with head curled upright in cells
Consistency of dead brood	Sticky to ropy	Soft and gummy, rarely sticky or ropy, granular	Sac like with watery content
Odour of dead brood	Glue pot, putrid faint	Slightly sour to penetratingly sour, Putrid fish	None to slightly sour; faint sour
Type of brood affected	Worker, rarely drone or queen	Worker, drone and queen	Worker only
Control	Tetramycin @ 0.25 – 0.40 g in 5 litres of sugar syrup feeding	Feed Tetramycin @ 0.2 g in 500 ml conc. sugar syrup	No effective cure

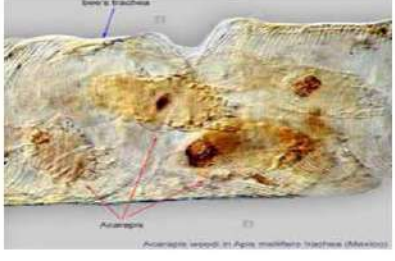
American Foul Brood

European Foul Brood

Thai Sac Brood

Adult Diseases

Name of disease	Nosema disease	Acarine disease
Causal organism	*Nosema apis* and *Nosema ceranae* microsporidian parasites (earlier under Protozoa; now under cluster of fungi)	*Acarapis woodi* (Endoparasitic mite)
Symptoms	Infected bees collect in front of hive, sluggish, crawlers on leaf blades, distended abdomen, dysenteric	Bees gather in front of hive as crawler bees and unable to fly; disjointed wings having typical 'k' wing condition
Control	Feed fumigillin 200 mg in sugar syrup to each colony or 0.5-3.0 mg in 100ml sugar syrup. or Two feedings at weekly interval of Dependel-M @ 0.5g/litre/colony	Fumigate using folbex strips at weekly intervals or with formic acid (85%) @ 10ml/colony and replenish the quantity after every 24 h for 21 days



Video Link:

https://www.youtube.com/watch?v=R-kSY2Q7COw

https://www.youtube.com/watch?v=Fy7NSsmuoPw

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

QUESTION

1. Write the name of bacterial brood diseases of honey bees along with their causal organism.

Ans.

2. Write the name of viral brood diseases of honey bees along with their causal organism.

Ans.

3. Write the name of fungal brood diseases of honey bees along with their causal organism.

Ans.

4. What is the causal organisms and symptoms of Nosema disease of honey bees?

Ans.

5. 'Isle of Wight' disease of honey bees caused by which causative organism?

Ans.

6. Write the damage symptoms caused by greater wax moth to bee hive.

Ans.

7. How a bee hive can be prevented from the attack of different types of ants?

Ans.

8. Honey bees are preyed by how many types of wasps? What are the important practices to be followed to manage these wasps?

Ans.

PRACTICAL 4: BEE PASTURAGE, BEE FORAGING AND COMMUNICATION

Objective: To acquainted with bee flora and forage, foraging behaviour of honey bees and their communication

BEE PASTURAGE

Honey bees gather nectar and pollen from plants as their food. Honey bees collect nectar and pollen from flowering plants. Nectar is a sweet secretion from the floral buds and extra floral nectaries of blossoms is the raw materials for honey. Whereas pollen is a highly proteinaceous food for the bees. The plants that yield these two substances are collectively termed as bee pasturage or bee forage or nectar and pollen plants. As nectar and pollen are basic raw materials for beekeeping, a thorough knowledge of the bee flora of a locality is essential. Efficient beekeeping means managing honey bee colonies in such a way to obtain maximum colony population to coincide with the major honey flow in an area and to utilize the honey production and pollination. Following points should be considered when selecting locality for establishing a new apiary.

1. Are blooming plant species available in abundance within two kilometres radius of the locality?
2. During which period of the year, the bee flora is on bloom?
3. How long is their blooming duration?
4. Whether they are source of nectar, pollen or both?
5. Whether the flora is annual or perennial?
6. Which utility category do they belong to?
7. How long is the duration of nectar and pollen dearth period?

Bee pasturage/Forage: Plants that yield pollen and/or nectar to bees are called bee pasturage/forage. Honey bees collect nectar and pollen from a variety of plants which are known as bee flora or bee forage or bee pasture or nectar and pollen plants.

Honey flow period: The period when a good number of plants providing nectar and pollen are available to bees is called honey flow period.

Major honey flow period: If the nectar yield is copious from a good number of plants of a particular species, it is called major honey flow period.

Minor honey flow period: When the amount of nectar to be collected is small, it is called minor honey flow period.

Dearth period: The day when there is no honey flow is called the dearth period.

Utility of bee flora to honey bees: In general, a honey bee depends on a wide variety of plants for nectar and pollen. These include several species of wild and cultivated plants. For

commercial beekeeping, large crop acreage with good floral qualities is required. A beekeeper must have the details about the availability and suitability of bee flora. Following are the qualities of good bee flora:

- Long flowering period
- High density of flowers per unit of the plants
- Good quality of nectar with high concentration of sugars
- Easy accessibility of the nectaries to the honey bees and ease in collection of nectar
- Availability of flora in the close vicinity of the apiary

SOME EXAMPLES OF IMPORTANT BEE FLORA IN INDIA

Plants which are good source of nectar	
1. Tamarind	6. Moringa
2. Neem	7. *Prosopis juliflora*
3. Soapnut tree	8. *Glyricidia maculata*
4. Eucalyptus	9. *Tribulus terrestris*
5. Pungam	
Plants which are good source of pollen	
1. Sorghum	6. Sweet potato
2. Maize	7. Tobacco
3. Millets like bajra, finger millet	8. Coconut
4. Roses	9. Castor
5. Pomegranate	10. Date palm
Plants which are good source of both Pollen and Nectar	
1. Banana	10. Guava
2. Citrus	11. Sunflower
3. Apple	12. Safflower
4. Berries	13. Mango
5. Pear	14. Sesamum
6. Plum	15. Okra
7. Peach	**16. Cotton**
8. Mustard	17. Cucurbitaceous vegetables
9. Coconut	

BEE FORAGING

Foraging: This refers to collection of nectar and pollen by bees. The field bees get activated in the morning and go out on foraging and collect pollen, nectar, propolis and water, carry them to the hive and make a number of trips till sunset. Based on their foraging activity, honey bees are divided into the following-

i. **Scout Bees:** The bees that go out first to find out new sources of these materials are called searcher bees or scout bees. They return to the hive and communicate the message to young foraging bees by means of definite patterns of dancing.

ii. **Nectar foragers:** These collect nectar from flowers using lapping tongue and pass the nectar to hive bees. Hive bees repeatedly pass the nectar between pre oral cavity and tongue to ripen the honey. Later they drop the ripened honey into cells.

iii. **Pollen foragers:** They collect pollen by passing through different flowers. Pollen sticking to the body is removed by using pollen comb. Then it is packed using pollen press into corbicula or pollen basket. A single bee carries 10 to 30 mg of pollen which is 25 per cent of bee's weight. Then the pollen is dislodged by middle leg into cells. Pollen is mixed with honey and stored.

Duties of forager bees

Collect i) pollen, ii) nectar, iii) water, iv) propolis v) juice of damaged fruits (when bloom is scarce)

Use of pollen: Major food for grubs in combination with honey: also required by adult bees secreting royal jelly.

Use of nectar: Raw material for honey; honey is reserve food for the colony; food for grubs as Well as adults

Use of propolis: Comb repair; protect the colony from large enemies like mouse which enter the hive; water proof the hive

Use of water: hive temperature maintenance (air – conditioning system); and to dilute the honey before catering it.

At any time, bees collect most of the materials from a single or a few plant species but bees in two different colonies located side by side may visit entirely different sources, mainly due to the differences in discoveries by the scout bees. The bees collect materials from a source till they are exhausted when they may go in search of new areas. The honey bees usually forage within about 100 meters distance from the hive but they can go up to 1.5 km. They are capable of flying at a speed of 25-30 km per hour. The bees are most active in foraging within a temperature range of 25-27°C. The bees do not go out for foraging at wind speed of more than 24 km per hour. Nectar is collected by the foragers from the flowers and is stored in the crop where it is mixed with saliva. The **invertase** contained in the saliva acts upon sucrose of the nectar and converts it to **dextrose or levulose**. The bee returns to the hive and regurgitates the contents of the stomach into comb cells which are covered by flat airtight cappings. The weight of nectar load varies from **25 to 40 mg**. On a given trip, a bee visits and exploits 1-500 flowers and makes, on an average, 10-15 trips in a day. During honey flow when there is abundance of food available, bees work to their full capacity and may make upto **150 trips a day**. The workers make about 6,000 trips to collect 0.5-1 g of pollen. The

propolis is also carried in the pollen basket by the worker bees. As soon as the collecting bee returns to the hive, another worker unloads the propolis from the former, carries the same in its mandibles to the place requiring cementing and presses it into the crevices in the comb.

Floral fidelity: A bee visits same species of plant for pollen and nectar collection until the source is exhausted. This is known as floral fidelity. Bees travel 2 to 3 km distance to collect pollen and nectar.

BEE COMMUNICATION

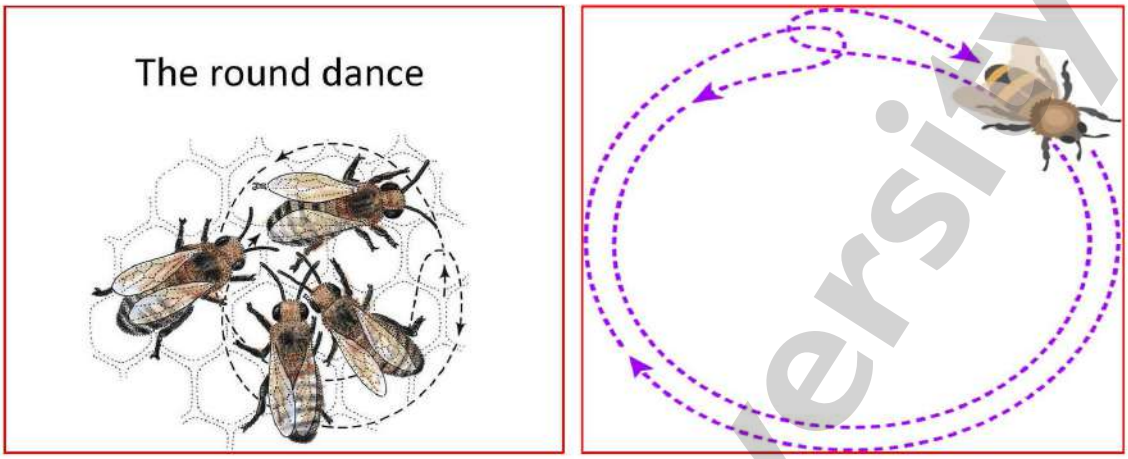
Bees communicate by using various pheromones including the queen's substance, Nasanov gland secretion, alarm pheromone emitted from sting and secretion of tarsal gland. In addition to that the bees also communicate by performing certain dances. Honey bees have a unique and one of the best understood animal languages with which they inform each other the distance and direction of the source of food. When scout bees return to the box after foraging, they communicate to the other forages present in the box about the direction and distance of the food source from the hive by performing dances. Two important types of dances are noticed.

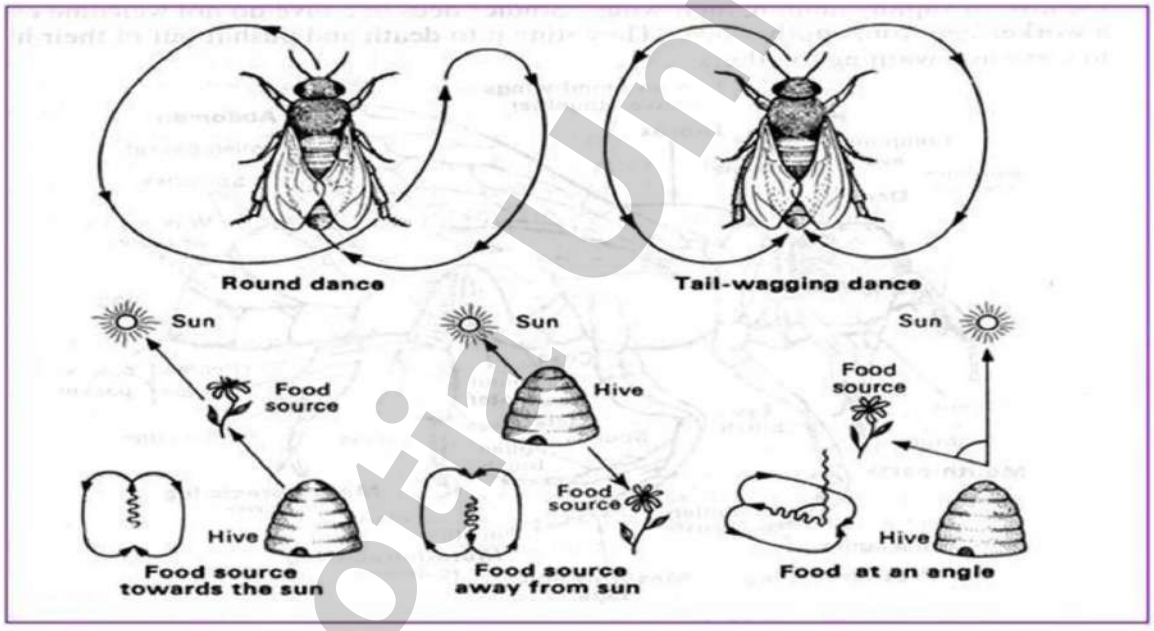
1. **Round dance:** This is used to indicate a short distance (Less than 50 m in case of *A. mellifera*). The bee runs in circles, first in one direction and then in opposite direction, (clockwise and anticlockwise).
2. **Waggle dance or Wag-tail dance:** This is used to indicate long distance (more than 50 m in case of *A. mellifera*). Here the bee makes two half circles in opposite directions with a straight run in between. During the straight run, the bee shakes (wags) its abdomen from side to side, the number of wags per unit time inversely proportional to the distance of the food (more the wags, less the distance.). The direction of food source is conveyed by the angle that the dancing bee makes between its straight run and top of the hive which is the same as between the direction of the food and direction of the sun. The bees, can know the position of the sun even if it is cloudy.

Prof. Karl von Frisch was awarded the Nobel Prize in Physiology and Medicine in 1973 for discovering and interpreting the language of the honey bees in early 1920s. Later on, it was found that honey bees employ both dance and sound in their language.

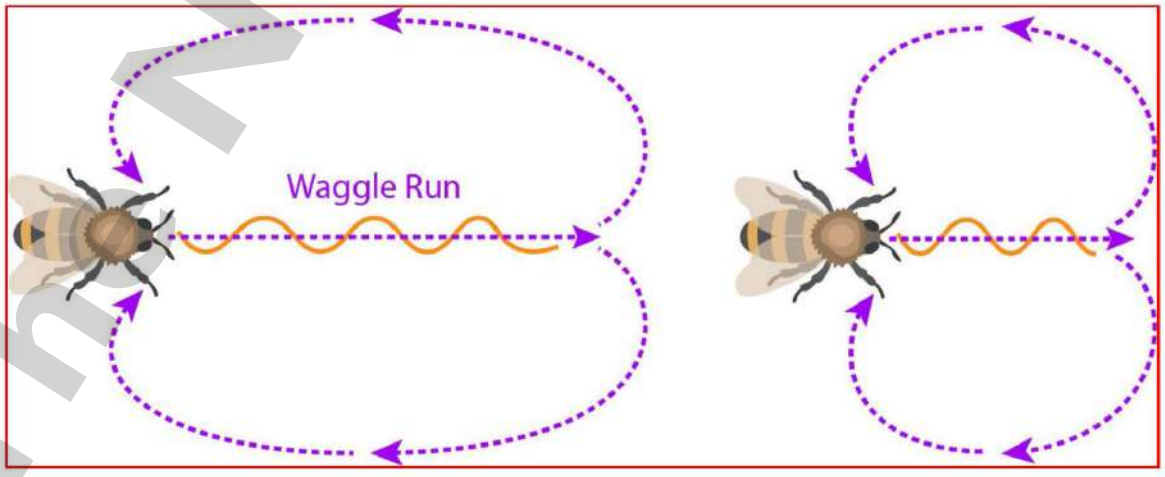
Video Link:

https://www.youtube.com/watch?v=opm0vChwllE ; https://www.youtube.com/watch?v=zsHezbF_F_4
https://www.youtube.com/watch?v=bFDGPgXtK-U ; https://www.youtube.com/watch?v=12Q8FfyLLso
https://www.youtube.com/watch?v=1MX2WN-7Xzc ; https://www.youtube.com/watch?v=GLjCcqIngj4
https://www.youtube.com/watch?v=LA1OTMCJrT8 ; https://www.youtube.com/watch?v=dVUjRiOF3Z8





Bee communication



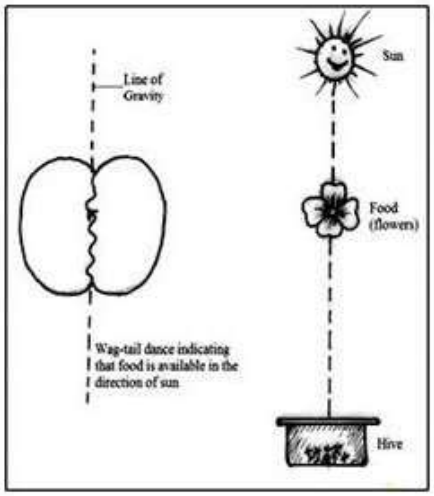


Fig. 1: Direction indication in wag-tail dance when food is in the direction of sun

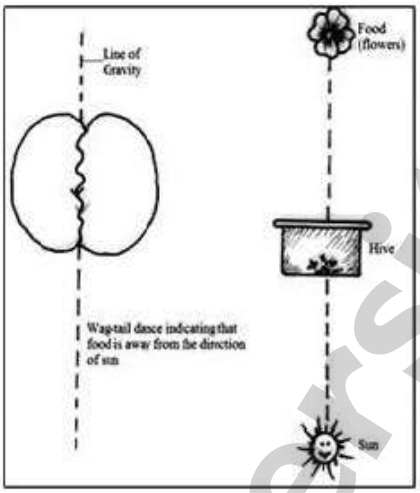


Fig. 2: Dance when food is away from direction of sun

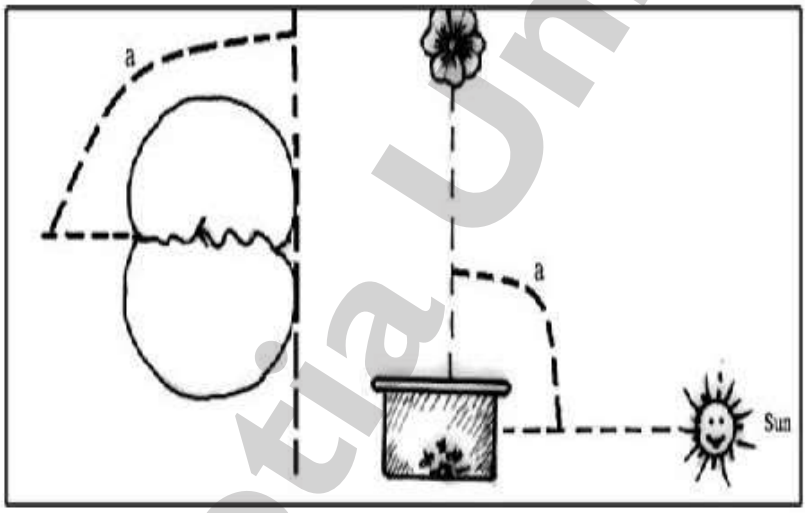


Fig. 3: If food is to the left of the sun, bee dances at an angle counterclockwise to the line of gravity

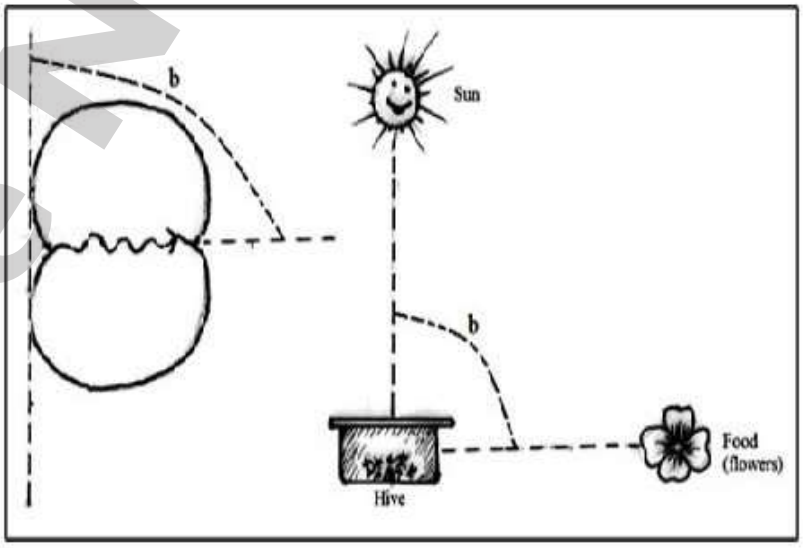


Fig. 4: If food is to the right of the sun, bee dances to the right of the line of gravity

QUESTION

1. Write five names of pollen producing plants. Which is the richest source of pollen?

Ans.

2. Write five names of nectar producing plants. Which is the richest source of nectar?

Ans.

3. Write five names of both pollen and nectar producing plants? Which is the richest source of both nectar and pollen?

Ans.

4. What are the duties of scout bees?

Ans.

5. What are the duties of forger bees?

Ans.

6. What is the temperature range when bees are more active in foraging?

Ans.

7. What is floral fidelity?

Ans.

8. Bees do which type of dance to indicate distance and direction of food?

Ans.

PRACTICAL 5: TYPES OF SILKWORM AND VOLTINISM

Objective: To acquainted with different types and species of silkworm commercially reared and voltinism

Types of Silkworm

There are five major types of natural silk which are commercially produced in the world and obtained from different species of silkworms which feed on a variety of food plants. Among them mulberry silk is the most important and contributes as much as 90 per cent of world production. Other commercially important types fall into the category of non-mulberry silks namely: Eri silk; Tasar silk; Oak Tasar silk and Muga silk. India has the unique distinction of producing all these commercial varieties of silk. There are also other types of non-mulberry silk, which are mostly wild and exploited in Africa and Asia, are Anaphe silk, Fagara silk, Coan silk, Mussel silk and Spider silk.

Silk Type	Colour of Silk	Silkworm	Host Plant	Distribution
Mulberry silk (Domesticated)	Creamy-white	*Bombyx mori* (Lepidoptera: Bombycidae)	*Morus alba, M. indica, M. serrata, M. lattifolia* (Mulberry plants)	Europe, China, USA, India (Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir)
Tropical Tasar silk (Wild)	Copperish colour, coarse silk	*Antheraea mylitta A. paphia* (Saturniidae)	*Terminalia tomentosa* (asan or yen) *T. arjuna* (arjun) *Shorea robusta* (sal)	Tropical forest zone ranging from Bihar, Jharkhand to Karnataka
Temperate Tasar silk or Oak Tasar silk (Wild)	Brown to grayish in colour	*A. proylei A. roylei* (Saturniidae)	*Quercus serrata* (Oak)	Sub Himalayan region and north-eastern India (Manipur, Himachal Pradesh, Uttar Pradesh, Assam, Meghalaya and Jammu & Kashmir)
Muga silk (Semi-domesticated)	Golden yellow	*Antheraea assamensis* (Saturniidae)	*Machilus bombycina* (Som) *Litsaea polyantha* (Soalu)	Assam (Brahmaputra valley)
Eri or Errandi silk (Domesticated)	White	*Philosamia ricini* (Saturniidae)	Castor, *Ricinus communis*	Assam and north-eastern states of India, and also Bihar, West Bengal and Orissa

Mulberry Silk Moth

Tasar Silk Moth

Muga Silk Moth

Eri Silk Moth

Larva of Mulberry Silkworm

Larva of Tasar Silkworm

Larva of Muga Silkworm (yellow morph)

Larva of Eri Silkworm

Voltinism

The number of life cycles per year depends on the silkworm strain and the environmental conditions, particularly the temperature. The characteristic that how many generations the silkworm strains could reproduce per year under natural condition is referred to as voltinism. In other words, voltinism refers to the number of breeds or generations or crops in a year. There is egg hibernation in *Bombyx mori*. Based on voltinism, silkworms are divided into three type of races: univoltines, bivoltines, and poly or multivoltines. The voltinism is regulated at egg stage as the eggs of univoltine and bivoltine races pass through a stage of slow or retarded development known as diapause.

1. **Univoltine:** In temperate zones, with prolonged winter, where the leaf is available for only one season a year, the insect has only one brood per year and such breeds are known as univoltines. The univoltine breeds always lay diapausing eggs.
2. **Bivoltine:** In zones where leaf is available for slightly longer period, the silkworm breeds have two broods and therefore known as bivoltines. Bivoltine races lay both non-diapausing eggs in the first generation and diapause eggs in the second generation.
3. **Multivoltine:** The regions, where the leaf is available throughout the year, there are about 5-6 broods a year and therefore known as multivoltines breeds. Multivoltine races found in tropical areas have the shortest life cycle. Multivoltine breeds always lay non-diapausing eggs which is an adaptation to tropical condition where there is no severe winter.

Artificially, the egg diapause can be broken after storing them at 2.5–5°C in cold storage for a period of 90–110 days. Removal of eggs from cold storage to room temperature (25°C) results in embryonic development in eggs until hatching.

Univoltine	Bivoltine	Multivoltine
Produce only one generation per year during the spring.	Produce two generations per year during spring and summer.	Produce more than three generations (5-6) per year.
Eggs laid remain in a diapausing condition till the next spring.	First generation adults developing from eggs hatched in spring lay non dipausing eggs; second generation of eggs does not hibernate and produce second generation normally during summer.	Do not undergo egg diapause. Adaptation to tropical condition where there is no severe winter.
Larvae are very sensitive to temperature and other environmental conditions.	Larvae are robust and tolerate environmental fluctuations.	Larvae resistant to high temperature and high humidity. Larvae and cocoons are small in size.

Unsuitable for summer and autumn rearing by artificial breaking of egg diapause.	Can be used for Summer and autumn rearing.	-
Larval period is very long.	Larval duration is as long as univoltines.	Larval duration is short.
Cocoons produced are commercially very superior.	Cocoons are commercially superior.	Cocoons are commercially poor quality.

1. Multivoltine Races

Multivoltine races of tropical region generally produce coloured cocoons such as greenish or golden-yellow.

(i) C. Nichi: This was originally a Japanese bivoltine race which was imported and introduced in the state of Mysore. Due to continuous rearing by seed producers, this race has now degenerated to a multivoltine race.

(ii) Nistari: This is one of the indigenous multivoltine race which is continuously being reared not only for producing cross breed hybrids, but also as a commercial indigenous race. It was introduced in 1881 from China and continues to dominate commercial rearing in the entire North India, especially in West Bengal.

(iii) Pure Mysore: It was imported from China in 1895. The main demerit of this race is its long larval period (about 27-28 days).

(iv) Sarupat: This race belongs to the North – Eastern part of India.

(v) Tamil Nadu white: Some multivoltine races of India are able to produce white cocoons. Tamil Nadu Sericulture Department isolated the race called TNW in 1975.

Other races are Kolar Gold, Kollegal Jawan, Mysore princess, Hosa Mysore, MY1, MY2, BL23, BL24 and BL67.

2. Bivoltine Races

(i) Races developed by CSR&TI, Mysore: NB7, NB18, NB4D2, CSR2, CSR3, CSR4, CSR5, CSR6, CSR12, CSR16, CSR17, CSR18, CSR19.

(ii) Races developed by RSRS, Kalimpong: KA (Kalimpong).

(iii) Races developed by KSSRDI, Bangalore: KSO1 and SP2.

3. Multivoltine × Bivoltine (cross breeds)

In India, over 95% of the commercial silk being produced is from multivoltine female x bivoltine male parent (cross breed). i. Pure Mysore (PM) x NB4D2 ii. Pure Mysore x NB18. These races have limitations, especially lower shell weight, high renditta, low cocoon shell ratio and poor fiber quality. To overcome these limitations, new hybrids have been evolved.

Some examples are BL23 x NB4D2, PM x CSR2 (Kolar Gold- most popular cross breed), Swarnaandhra (APM1 x APS8), Cauvery (BL67 x CSR101), Kapila (BL43 x NB4D2) etc.

4. Bivoltine hybrids

Some examples are CSR2 x CSR4, CSR2 x CSR5, CSR3 x CSR6, CSR12 x CSR6, CSR16 x CSR17, CSR18 x CSR19 (sex-limited, all seasons), CSR48 x CSR4 (fine denier hybrid) etc.

Video Link:

https://www.youtube.com/watch?v=2BA7kHynZzM

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

https://www.youtube.com/watch?v=cHdKmIVDK14

QUESTION

1. Write names of mulberry and non-mulberry silkworm species along with their food plants?

Ans.

2. How you can identify the different types of silk produced by silkworm species based on observation?

Ans.

3. Define voltinism.

Ans.

4. Classify the silkworm based on voltinism.

Ans.

5. How egg diapause of silkworm can be artificially broken?

Ans.

6. Differentiate the races of silkworm that lay diapausing as well as non-diapausing eggs.

Ans.

7. Compare the properties of larvae and cocoons of uni-, bi- and multi-voltine races?

Ans.

PRACTICAL 6: BIOLOGY OF SILKWORM

Objective: To acquainted with different life stages of the silkworm species and their important morphological characters

Life History of Mulberry Silkworm

The *Bombyx mori* is a holometabolous insect and undergoes a complete metamorphosis. The insect passes through four distinctive stages *viz.* egg, larva, pupa and adult. The total life history of the moth from egg to adult takes about 50 days. The life cycle of Mulberry silkworm is depicted in a tabular form below.

Stage	Period (days)	Character
Egg Uni & Bi-voltine: 400-500 eggs Multivoltine: 300-350 eggs	9-12	Yellowish-white, semi round, 1 mg weight. The eggs are laid in clusters (closely laid in group) and are covered with gelatinous secretion of the female moth. Newly laid eggs are pale to dark yellow and the diapausing eggs turn to purplish gray often with green or pink tinge in 24 hours. Eggs become darker and darker as embryonic development progresses. Races producing white cocoons lay pale-yellow or creamish-white eggs, and races producing yellow cocoons lay deep yellow eggs. Hibernating eggs of bivoltine and univoltine races are creamish white. These eggs change their colour to dark brown or purple with the deepening of serosal pigment.
Larva	25-30	Newly hatched larvae are brown or reddish brown in colour and look like ants to the naked eye. They measure about 3 mm long. They feed on the mulberry leaves and as they grow, the colour gradually turns into greenish white. Last instar larva is greenish, cylindrical caterpillar, 3-3.5 inches long, bears 3 pairs of thoracic legs, 5 pairs of prolegs, last pair modified to claspers, spiracles- 1 thoracic and 8 abdominal. Each larva feeds on 90 gm of leaves during its larval period (voracious feeders). The males are identified by the presence of milky white pear-shaped **Herold's glands** on the mid-posterior part between the 8^{th} and 9^{th} segment on the ventral side (Fig. 2). The females are identified by the presence of two pairs of milky dotted structures, one pair situated in the lateral side of the 8^{th} segment of the ventral side and the other on the 9^{th} segment. They are called **Ishiwata's fore gland** and **hind gland**, respectively (Fig. 2).
I instar	3-4	
II instar	2-3	
III instar	3-4	
IV instar	5-6	
V instar	7-8	
Pre pupa	4-7	Non feeding stage. The mature silkworm passes through a short transitory stage of prepupa before becoming a
Pupa	10-12	

		pupa. During the prepupal stage, dissolution of the larval organs takes place which is followed by formation of adult organs. Soon after pupation the pupa is white and soft but gradually turns brown to dark brown, and the pupal skin becomes harder. Cocoon spinning within 2-4 days. The female pupa can be identified by its broader abdomen, stout tip and an X- shaped mark on the ventral side of the eighth segment. The male has a narrow abdomen, sharp tip and a dark spot on the ventral side of the ninth segment.
Adult	1-2 weeks	Robust creamy white moth that has a flat body and a wing expanse of about 5 cm, bipectinate antennae, non-feeder, poor flier. The moth is unisexual and shows sexual dimorphism. The female has comparatively smaller antennae. Its body and the abdomen are stouter and larger. The female is generally less active than the male. The male moth possesses a pair of hooks known as harpes at its caudal end. Male moth is smaller in size, active and darker in colour. Male moths copulate with females for about 2–3 hours.

Fig. 1: Life cycle of *Bombyx mori* (Source: Central Silk Board Website)

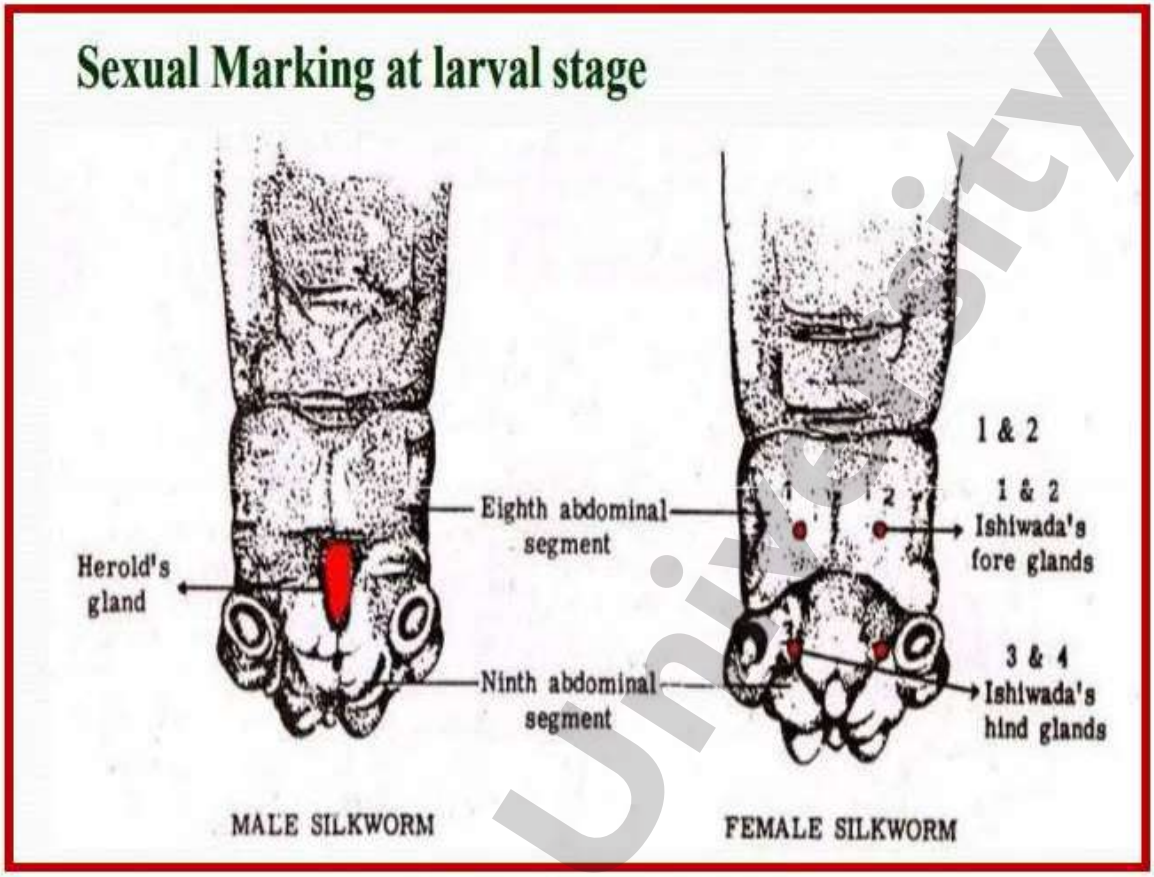


Fig. 2: Sex differences in the larva

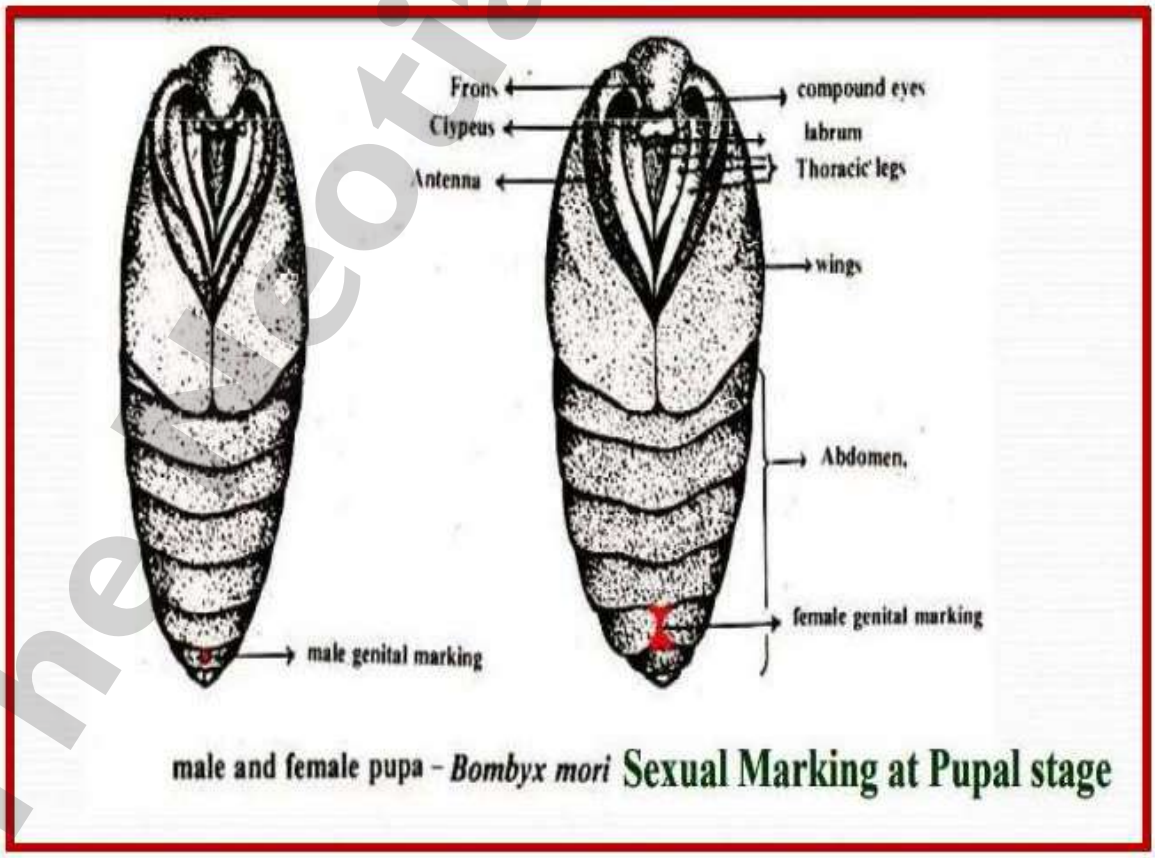


Fig. 3: Sex differences in the pupa

Life History of Tropical Tasar Silkworm

Antheraea mylitta is the tropical Tasar silk insect. It is known as Indian tropical Tasar. The life cycle of *A. mylitta* is depicted in a tabular form below.

Stage	Period (days)	Character
Egg	12	Each female lays about 150-200 eggs. Eggs are oval, dorso-ventrally flattened and bilaterally symmetrical along the anterio-posterior axis. Eggs are about 3 mm long and 2.5 mm in diameter and weighs approximately 10 mg. Freshly laid eggs are dark brown in colour. After washing, it becomes white, light yellow or creamy.
Larva	30-35 (Summer) 50-70 (Winter)	The newly hatched larva is dull brownish yellow with black head, measuring about 7 mm long and 1 mm diameter and weighs about 8 mg. The larvae are brownish in 1st instar and are greenish with violet tubercles in final instar. The Tasar silkworms moult four times and pass through five instars.
Pupa	15-30 (Summer)	The pupa is dark brown, obtect, a dectious with well defined segmental body. The cocoon is single-shelled, yellow or grey pendent, oval, closed and reelable with a hard non-flossy grainy shell. At the anterior end there is a well formed dark brown peduncle with a ring. Female spins larger cocoon than the male.
Adult	5-8	Females are bigger (4.5 cm) with a broad abdomen and narrow bipectinate antennae. Males are smaller (4.0 cm) with a narrow abdomen and broad antennae. The females are gray or yellow, whereas, males are brown or yellow or gray. In male, the wingspan is about 16 cm, while, in female, it is about 18 cm.

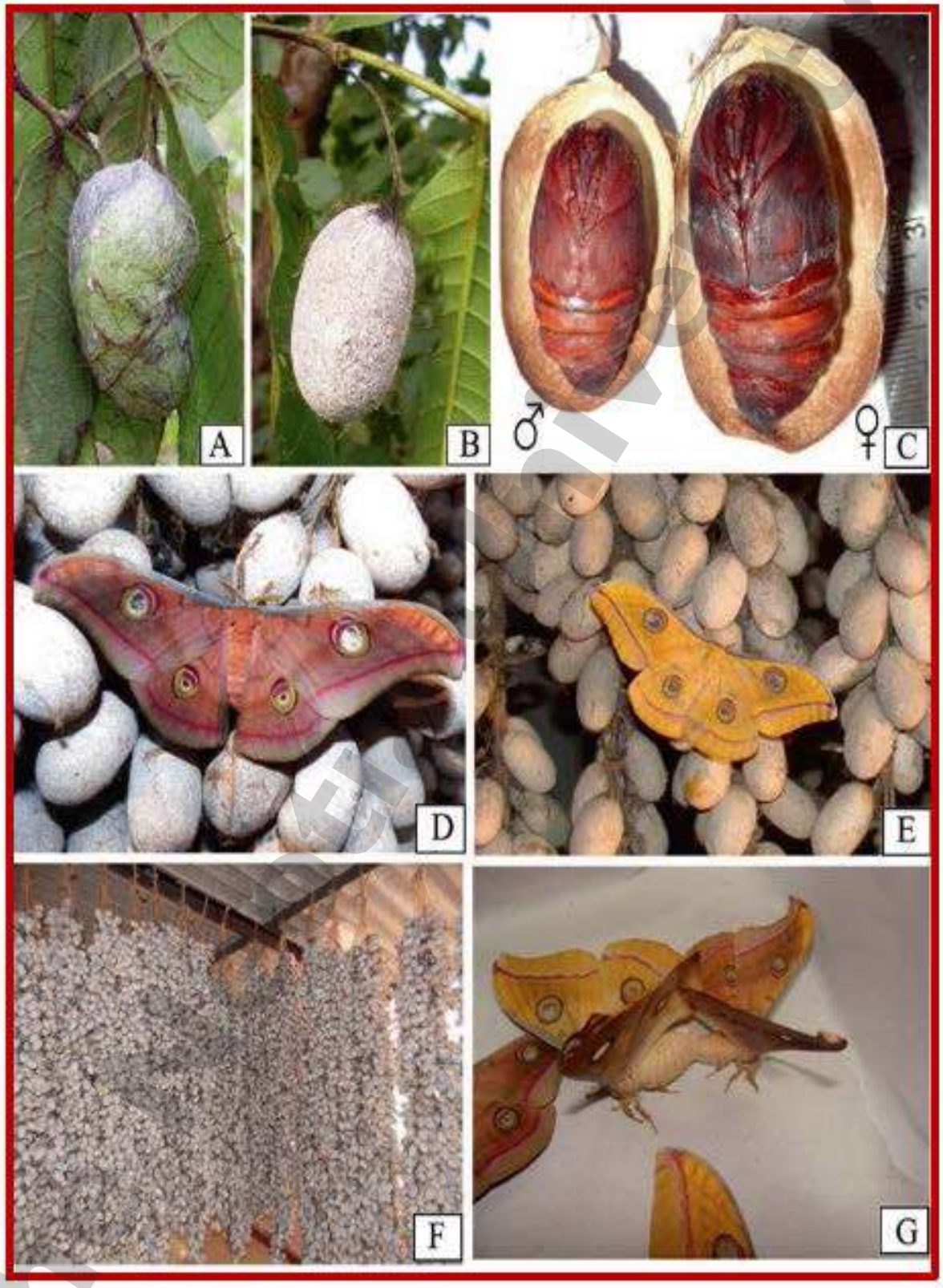


Fig. 4: Life stages of *A. mylitta* (a) Hammock formation, (b) Cocoon, (c) Male and female pupa, (d) Male moth, (e) Female moth, (f) Cocoons in grainage, (g) Coupling of moths (Source: Industrial Entomology, Springer Nature)

Life History of Muga Silkworm

Muga silkworm (*Antheraea assamensis*) produces silk of golden yellow lustre. The popular name 'Muga" is an Assamese word meaning brown colour. It is a multivoltine insect with 5-6 generations a year. Their life cycle is similar to that of mulberry silk insect and completes in about 50 days in summer and 120 days in winter. Like the mulberry silk insect, the Muga silk insect also has four stages in the life cycle - egg, larva, pupa and adult. The life cycle of *A. assamensis* is depicted in a tabular form below.

Stage	Period (days)	Character
Egg	7 (Summer) 16 (Winter)	Female moth lays around 150 eggs. The egg is oval in shape, dorsoventrally flattened, bilaterally symmetrical and measures 2.3-2.8 mm × 2.4 mm. Eggs are brownish grey in colour at the time of oviposition and they appear light green or creamy.
Larva	29-38 (Summer) 41-65 (Winter)	-
I instar	3-4 (Summer) 6-8 (Winter)	Newly hatched larva is black in colour with distinct yellow lines at the intersegmental region. The body tubercles are **black** and are provided with setae. The head is small but distinct and black in colour. A newly hatched larva is 0.7–1.2 cm in length and approximately 0.0069–0.007 g in weight.
II instar	3-5 (Summer) 7-10 (Winter	The second instar larva is light yellow in colour and about 1.4–1.8 cm in length and approximately 0.083–0.0912 g in weight. The tubercle colour is **blue**.
III instar	5-7 (Summer) 10-13 (Winter	The third instar larva is green in colour and about 1.8–2.5 cm in length just after moulting. The larvae are approximately 0.442–0.632 g in weight. The tubercle colour is **violet**.
IV instar	7-10 (Summer) 12-15 (Winter	The fourth instar larva is dorsally dark green and ventrally light green in colour, about 2.5–3.5 cm in length and approximately 2–3.5 g in weight. The head is triangular in shape with distinct epicranial sutures and copper colour. Small black eyespots on the lateral side of the head are prominent. The lateral line is distinct and yellow in colour. The clasper is triangular in shape with a copper black margin. The tubercles are **red** in colour.
V instar	10-12 (Summer) 16-19 (Winter	The fifth instar larva is approximately 4–5.5 cm in length and approximately 4.121–5.213 g in weight. The dorsal surface of the body is light green, and ventral surface is deep green in colour. Eyespots are prominent. The body tubercles are **brick red** in colour and with setae. The

		lower portion of the lateral line is yellow and the upper portion is chocolate in colour. Three pairs of thoracic and four pairs of abdominal legs are well developed. Spiracles are black in colour.
Pupa	14 (Summer) 40 (Winter)	The pupa is brown to dark brown in colour with harder skin. Spinning of cocoon takes 3 to 7 days in different seasons. Sex markings are prominent in pupa, which makes it easier to determine the sex in the pupal stage than in the larval stage. The female pupa has a fine longitudinal line on the eighth abdominal segment, whereas such marking is absent in the male pupa.
Adult	7-12	The moths emerge from the cocoons at dusk and continue till dawn. The male and female moths exhibit distinct sexual dimorphism. In male moth, the tips of the forewings have sharp curve, while in female it is not there. The antennae of the male moths are broader than those of females. The abdomen of male moths is narrow and small, whereas in females it is broad, larger and swollen. The colouration of the wings and the body of male moths is brown to dark brown, while in the female it is yellowish light brown. The male moth flies actively and copulates with the stationary female.

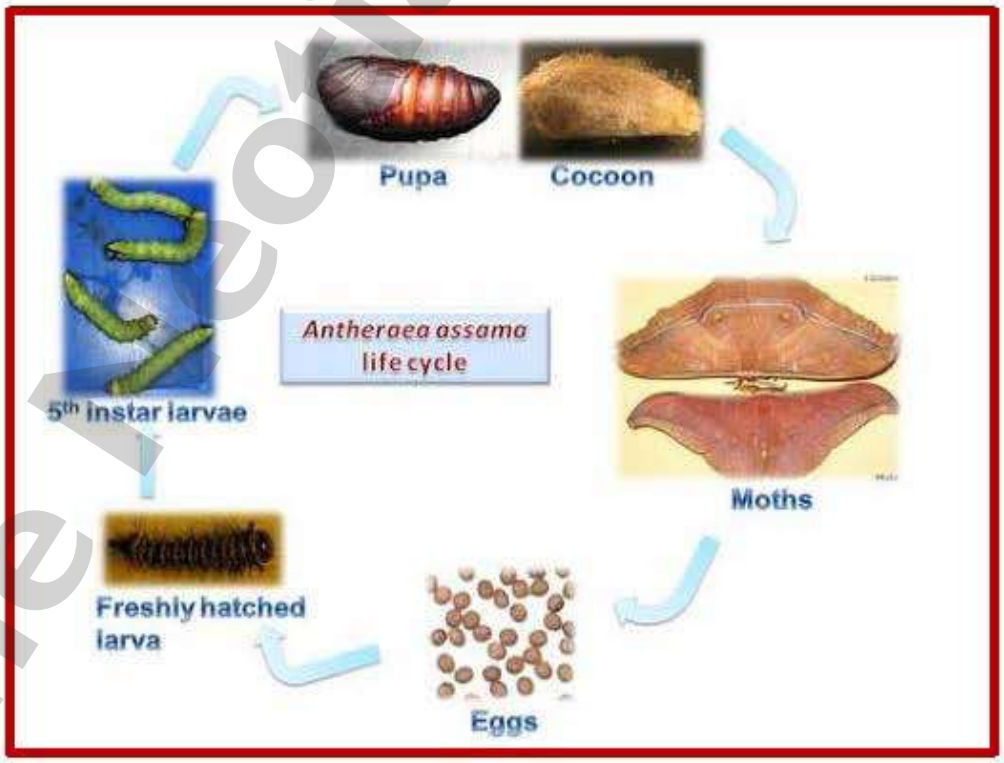


Fig. 5: Male Moth (Muga Silkworm)

Fig. 6: Female Moth (Muga Silkworm)

Life History of Eri Silkworm

This silkworm derives its name 'Eri' from 'Eranda' in Sanskrit or 'Endi' in Assamese languages which means castor, its main food plant. The domesticated species, *Samia ricini* is multivoltine and 5–6 crops can be reared in a year, while, the wild species (*Samia cynthia*) are usually bi- or tri-voltine. Both these moths differ slightly in markings and in the amount of white scales in the abdomen. While the cocoon of *S. ricini* is loose and white or brick red, that of *S. cynthia* is compact and light brown in colour. The complete life cycle takes about 45 days in summer and 90 days in winter. Best quality cocoons are produced during autumn

(October–November) and late spring (May–June). The life cycle of Eri silkworm has four stages – egg, larva, pupa and adult. The life cycle of *S. ricini* is depicted in a tabular form below.

Stage	Period (days)	Character
Egg	9 (Summer) 18 (Winter)	Female lays 120-200 eggs in clusters. Eggs are oval shaped, candid white in colour, measures 1.5 x 1.0 mm and weighs 6 mg.
Larva	17 (Summer) 44 (Winter)	The newly hatched larva is greenish yellow in colour, elongated and cylindrical in shape measuring about 5 × 1 mm. The body colour changes gradually to pure yellow by the end of the third day. From the third instar onwards, the body colour segregates into yellow, cream, green or blue depending upon races. The fully mature larva measures about 90 × 15 mm is translucent and covered with white powdery substances. Different colour and marking patterns, viz. plain, spotted, greenish blue, zebra and semi-zebra larvae, are found in different strains.
Pupa	16 (Summer) 24 (Winter)	Pupae are of obtect adectious type and brown in colour, measuring about 28 × 15 mm in size and weighing about 2.5 g. The cocoons are long, soft and without a peduncle. The cocoon exhibits colour polymorphism being creamy white and brick red.
Adult	3 (Summer) 4 (Winter)	Adult moths are stout, brownish or blackish in colour and covered with white scales. The male moth is smaller than the female. The male measures 25 mm long with 130 mm wing span, while the female measures 30 mm with 150 mm wing span.

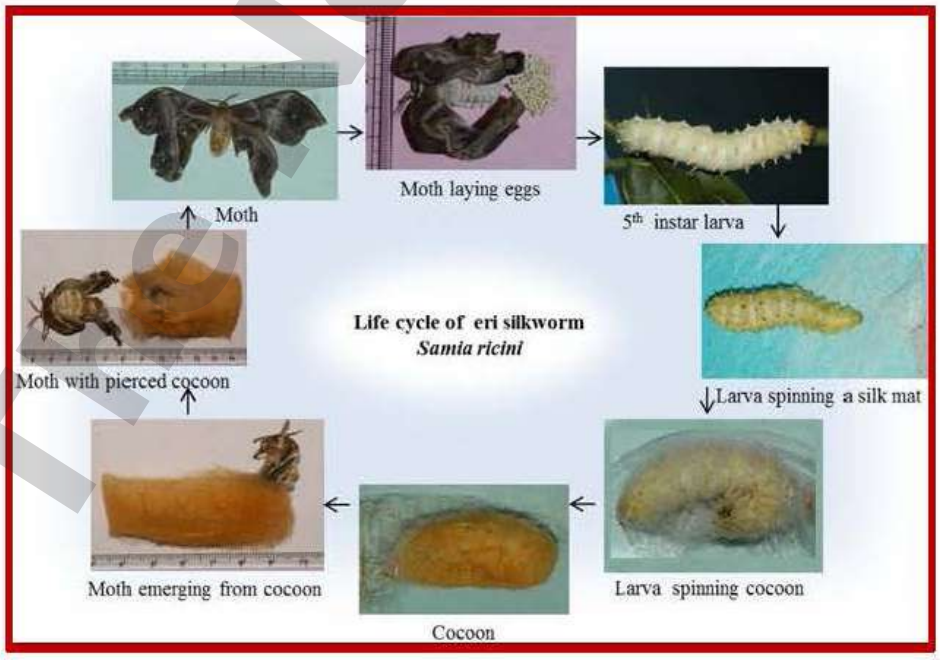


Fig. 7: Male (A) and Female (D) of *S. ricini*

Video Link:

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

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

QUESTION

1. In all the studied silkworm species, how many moults and instars are found?

Ans.

2. How you can differentiate male larva from female ones of mulberry silkworm?

Ans.

3. In mulberry silkworm, how the male and female pupae are different from each other?

Ans.

4. How you can identify the different larval instars of Muga silkworm?

Ans.

5. What are the different colour and marking patterns found in the caterpillars of Eri silkworm?

Ans.

6. How you can identify the male and female adult moths of mulberry silkworm and Tasar silkworm?

Ans.

PRACTICAL 7: MULBERRY CULTIVATION AND ITS VARIETIES

Objective: To acquainted with agronomic practices followed for commercial cultivation of mulberry plants and the common varieties grown

Mulberry Crop Production Technology

Mulberry (*Morus* spp.) is a perennial, deciduous, deep-rooted, fast-growing and high biomass producing plant. Mulberry can be grown in both tropics as well as in temperate regions. It can be cultivated in different soil types and can be raised in both rainfed as well as in irrigated conditions. It is comparatively resistant to environmental fluctuations. There are over 20 species of mulberry, of which four are common and popular species in India, namely, *Morus alba*, *M. indica*, *M. serrata* and *M. latifolia*. They belong to family Moraceae. Cultivation of mulberry plants is called **Moriculture**.

- **Soil:** Mulberry is a deep rooted, perennial, hardy crop. Clayey loam to loam soils are much preferred. Soil pH 6.5 to 7.0 is very ideal. If soil is acidic (below pH 7.0) lime is added. If soil is alkaline (above pH 7.0) gypsum is added.
- **Temperature:** Preparation of nursery beds 20 to 30°C temperature is suitable for mulberry plant growth.
- **Rainfall:** Optimum rainfall required 1000 – 1500 mm.
- **Nursery raising:** Season: June-July and November-December in the year.
- **Varieties:** The most popular and superior mulberry varieties used in India for silkworm rearing are V1, S36, S13, S54, S146, S1635, TR10, S1 and K2 in plain subtropical area and Kosen, Ichinose, Goshoerami and KNG in hill temperate area of Kashmir and parts of Himachal Pradesh.
- **Land Preparation:** Select elevated, flat, well drained light textured, deep loamy or clay loamy soil. Give deep digging/ploughing two times in both the directions. Give a fine tilt after 10-15 days of digging/ploughing. Prepare the bed size of 300 x 120 cm (length and width). Provide drain channels of 25-30 cm width and 15-20 cm deep. Apply 20 kg FYM/ bed.
- **Preparation of cutting:** Mulberry is propagated either by seeds, root- grafts or stem cuttings, the last one being most common. Use eight months old twigs as planting material. Prepare cuttings of 15-20 cm length and 1-1.5 cm diameter having 3-4 active buds Store the cuttings wrapped with wet gunny cloth in shade. Sprinkle water if transplantation is extended/postponed.
- **Planting Techniques:** Provide 20 cm spacing between rows and 8 cm between cuttings. Make holes with a stock in the soil to insert cuttings. Plant the cutting in slant position.

Press the soil firmly around the cuttings. Provide mulching with dried mulberry twigs, thatch etc.

- **Maintenance of mulberry nursery:** Irrigate the nursery once in a week during dry period. Keep the nursery bed weed free.
- **Fertilizer application to nursery:** After 55-60 days of growth, apply 500 g ammonium sulphate or 250 g urea dissolved in the irrigation water for each bed.
- **Disease and pest management in the mulberry nursery:** Spray 0.1% DDVP against Tukra. Spray 0.1% Bavistin against powdery mildew.
- **Transplanting:** After three to four months, saplings become ready for transplanting. Irrigate the nursery beds prior to transplanting. Uproot the saplings with a spade or pick-axe. Sprinkle water in case of preservation for shorter duration. Pack the saplings in wet gunny cloth to avoid desiccation of roots if long distance transportation is required.
- **Plantation in the main field:** Season: June - September (During monsoon).
- **Land preparation:** Prepare the land by ploughing and cross ploughing with power tiller or tractor during pre-monsoon showers to a depth of 30 cm.
- **Preparation for paired row plantation:** Paired rows system of (150 cm + 90 cm) × 60 cm spacing is recommended. In this type of plantation 13,887 plants can be accommodated in one hectare of land. This system of spacing facilitates adoption of mechanization for intercultural operations using tractor/power tiller. Transplant the saplings during monsoon and press the soil firmly around the sapling. Mulch the base of the sapling with dry leaves/ thatch/mulberry twigs. Water the sapling immediately after transplanting.
- **Crop management practices:** Give a light hoeing after one month of plantation to eliminate weeds and for aeration. Give two more weeding and light digging at an interval of one month. Irrigate the plants as and when necessary. Apply FYM @ 25 MT/ha/year. From 2nd year onwards apply NPK @ 350:140:140/ha/year. Five crops can be taken from V1 or S36 variety/year.
- **Pruning:** Certain branches of mulberry are periodically cut to give a proper shape and size to the plant, in order to increase the leaf yield and its feeding value. This is known as pruning.
- **Types of Pruning:** Based on the height of the plant from ground level where it is cut, there are 3 types of pruning.

  i. Bottom pruning or low cut pruning: It is widely practiced in Japan. Plant is cut at a level of 30 cm above ground level during June-July months.

ii. Middle pruning or medium cut pruning: Plant is cut at a height of 0.5 to 1.5 m above ground level during December–January months. Large number of branches grows, but only 3-4 on the upper part are retained.

iii. Top pruning or high cut pruning: Plant is cut at a height of more than 1.5 m above ground level. Leaf quality is poor with low moisture. Harvesting difficult due to more height. Less damage due to floods, but more susceptible to pests, diseases and winds.

Mulberry varieties for various agro-climatic and soil conditions

- **Victory 1:** It is popularly known as V1. Leaves are thick, succulent, large, entire and ovate with truncate base. Leaves are smooth and glossy. It has got good agronomic characters like high rooting ability, fast growth and high yield. Under irrigated conditions, with recommended package of pratices it yields about 60 mt/ha/year. Bioassay and chemoassay tests indicated the superiority of this variety for silkworm rearing.
- **S36:** Leaves heart shaped, thick, light green with glowing nature. Leaves have high moisture and more nutrients. Branches grow straight. It yields 35-45 mt/ha/year under irrigated conditions. Because of its high succulence and nutritive quality, it is recommended for young age silkworm rearing.
- **S13:** Leaves dark green, succulent and good quality. Branches grow bushy and straight. Suitable for chawki and late age worms. It yields 12–15 mt/ha/year under rainfed conditions.
- **S34:** Fast growing has deep and extensive root system and it adopts well under soil moisture stress conditions. Leaves are medium to large, unlobed and dark green in colour with high moisture content and good retention capacity. It yields about 12–15 mt/ha/year under rainfed conditions. The variety is recommended for black cotton soils.
- **Sahana:** Evolved from cross-pollinated hybrids of K2 x Kosen during 2000. It is characterized by medium branching, fast growing, slightly spreading, pinkish-grey branches with short internodes. Leaves are large, unlobed, thick, cordate, glossy and dark green. The variety performs well under limited shade with improved leaf area. As intercrop with coconut plantation the variety can produce 25–30 mt leaf/ha/year under irrigated conditions.
- **AR12 (Alkaline tolerant):** Evolved from cross-pollinated hybrids of S-41 (4x) x Ber. C-776 (2x) during 2000. Leaves are unlobed, large, cordate, thick, dark green with slightly rough surface. The variety is suitable for alkaline soils with pH range of 8.0 – 9.4 with a yield potentiality of about 25 mt/ha/year in alkaline soils under irrigated conditions.

Video Link:

https://www.youtube.com/watch?v=IIq30bgllYw

https://www.youtube.com/watch?v=5n4ANsNPnws

https://www.youtube.com/watch?v=KltyZc7rudw

QUESTION

1. What are the popular and common species of mulberry plant?

Ans.

2. Which mulberry varieties are suitable for growing in the plains of sub-tropical regions?

Ans.

3. Mention the soil, temperature and rainfall requirement for mulberry cultivation?

Ans.

4. What are the different mode of mulberry propagation? Which one is most popular?

Ans.

5. Write the main characteristic features of mulberry variety 'V1'?

Ans.

PRACTICAL 8: METHOD OF HARVESTING AND PRESERVATION OF MULBERRY LEAVES

Objective: To acquainted with proper methods of harvesting of mulberry leaves and its preservation process

Leaf Harvesting

Leaf harvested during afternoon contain less water and more of carbohydrates due to active photosynthesis and transpiration taking place in day time and such leaves wither very quickly. Hence, mulberry leaves should be harvested during cooler hours in the early morning hours is recommended to avoid moisture loss in leaves during harvest and transportation.

1. **Leaf picking:** Leaves are picked individually from main stem with petioles. At the same time, terminal buds are nipped off so that lateral shoots develop rapidly. It requires more labour and leaves wither quickly.
2. **Branch cutting (Batchi system in Kashmir):** The entire branch is harvested and used to feed worms after third moult directly. It requires less labour and leaves retain succulence for longer period.
3. **Whole shoot harvest:** The branches are cut to ground level by bottom pruning. The entire shoot is fed to leaves. Shoots are harvested at 10-12 weeks interval and 5-6 harvests are made per year. Shoots of 4–5 ft height are cut with the help of sharp sickle and bundled with 10–12 kg weight, convenient to carry them to shoot preservation room.

Preservation of Harvested Leaves and Shoots

- **Leaf preservation:** The harvested leaves should be collected in wet gunny cloth-covered baskets and transported to a leaf chamber/room carefully in well-ventilated condition. Leaf should be preserved in a separate room or leaf chamber made up of wood with sufficient number of ventilators and covered with wet gunny cloth. This helps in maintaining leaf quality and moisture in leaves. Leaves can also be stored in a separate ventilated room with well-disinfected floor. Leaves should never be preserved on heaps. This will increase the humidity. Leaves scattered on floor should be frequently sprinkled with water and tilted up and down in summer. Always fresh leaves are recommended to feed the worms. Longer the preservation, lesser the moisture and the nutrition, hence temperature, humidity and moisture contents in the storage place should be 20°C and 90% of relative humidity and cool, clean with frequent watering. Chawki mulberry leaves can be stored in a mud pot, which is placed in the moist sand and mouth of the pot must be covered with wet

cloth. Also, chawki mulberry leaves can be stored on a flat moist sand bed covered with wet and clean white cloth.

- **Shoot preservation:** Shoots are properly wrapped with wet gunny cloth and preserved vertically in upward direction. Floor of rearing room should be washed with 1% bleaching solution daily before preservation of shoots. Separate footwear can be used for leaf chamber, which is disinfected daily with soap solution. While transporting from mulberry garden to preservation room, shoots should be covered with wet gunny cloth or polythene sheet to avoid water loss in leaves.

Fig. 1: Harvesting of mulberry shoots (Source: Industrial Entomology, Springer Nature)

Video Link:

https://www.youtube.com/watch?v=OlTpzhj-sBI

QUESTION

1. What are the prerequisite for harvesting of mulberry leaves?

Ans.

2. How harvested mulberry leaves should be preserved carefully?

Ans.

PRACTICAL 9: SPECIES OF LAC INSECT

Objective: To acquainted with different species of lac insect with their morphology and biology

Lac culture is an economically important vocation practiced by millions of farmers particularly tribals in Jharkhand, Odisha, Chattisgarh and West Bengal. The products of lac insects namely lac, dye and wax having many useful industrial applications. These products, being natural are ecofriendly and least detrimental to the ecosystem.

What is lac?

Lac is a non-toxic, valuable resin of commerce secreted by tiny gregarious lac insects.

Lac insect species

Lac insects are placed under the order Hemiptera, superfamily Coccoidea and family Tachardiidae. The first scientific account of the lac insect was given by J. Kerr in 1782. Lac insects (family Tachardiidae) of the world are now represented by 87 species under nine genera distributed in two subfamilies: (i) Tachardiinae, including true lac insects of resinous cell, and (ii) Tachardininae, including pseudo-lac insects of non-resinous cell. In India, 16 species under the genus *Kerria* and 6 under the genus *Paratachardina* have been recorded so far and most common Indian lac insect of commercial importance is *Kerria lacca* (Kerr). The lac insect is a soft bodied insect.

Strains of lac insect

Two strains of lac insects are commonly known in India. These are *Rangeeni* and *Kusmi*. Each of these produce two crops in a year (bivoltine). In coastal region of Odisha and West Bengal, however, three crops in a year are produced by *Kerria sharda* (trivoltine). Species belonging to *Paratachardina* produce a hard, horny substance which is insoluble in alcohol. These are univoltine and are generally treated as parasites of economically important plants like tea and sandal and are biocontrol agents on weeds.

Specific host

Lac insects thrive on 400 plant species. *Kusmi* strain grows well mainly on kusum (*Schleichera oleosa*) and also on a few other trees but not on palash (*Butea monosperma*). Whereas *Rangeeni* strain grows well mainly on palash and also on a few other trees but not on kusum. The *Kerria sharda* grows on kusum, ber and raintree.

Maturity

Rangeeni insect – October-November and then June-July

Kusmi insect- January-February and then June-July

Kerria sharda matures in March-April, June-July and October-November.

Table 1: Lac crops from *Rangeeni* and *Kusmi* strains of *Kerria sp.*

Strain/Insect	Name of crop	Season	Period		Approx. duration
			Raised in	Harvested in	
Rangeeni	Katki	Rainy	June/July	Oct./Nov.	4 months
	Baisakhi	Summer	Oct./Nov.	June/July	8 months
Kusmi	Aghani	Winter	June/July	Jan./Feb.	6 months
	Jethwi	Summer	Jan./Feb.	June/July	6 months
Trivoltine		Rainy	June/July	Sept./Oct.	3 months
		Winter	Sept./Oct.	Feb./March	5 moths
		Summer	Feb./March	June/July	4 months

Mature *kusmi* lac in Kusum

Stick lac

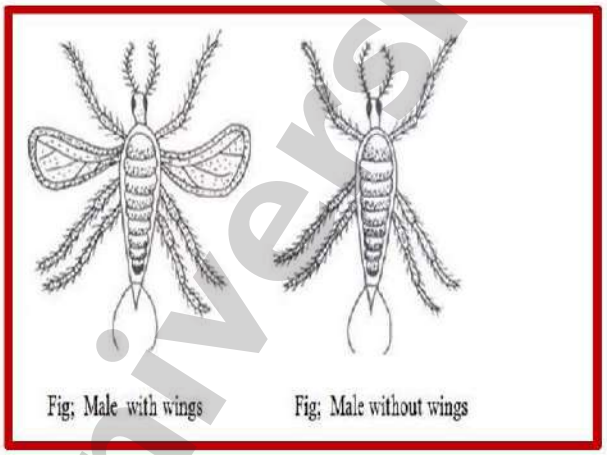
Morphology of lac insects

The adult lac insect shows a marked phenomenon of sexual dimorphism. The male and female insect varies in shape, size and also in presence or absence of certain body parts.

Structure of Male Lac insect: It is larger in size and red in colour. The body is typically divided into head, thorax and abdomen. The head bears a pair of antennae and a pair of eyes. Mouth parts are absent so a male adult insect is unable to feed. Thorax bears three pairs of legs. Wings may or may not be found. Abdomen is the largest part of the body bearing a pair of caudal setae and sheath containing penis at the posterior end.

Structure of Female lac-insect: It is smaller in size. Head bears a pair of antennae and a single proboscis. Eyes are absent. Thorax is devoid of wings and legs. The loss of eyes, wings, and legs are due to the fact that the female larvae after settling down once never move again

and thus these parts become useless and ultimately atrophy. Abdomen bears a pair of caudal setae. It is female lac insect which secretes the bulk of lac for commerce.



Fig; Male with wings Fig; Male without wings

Male lac insect

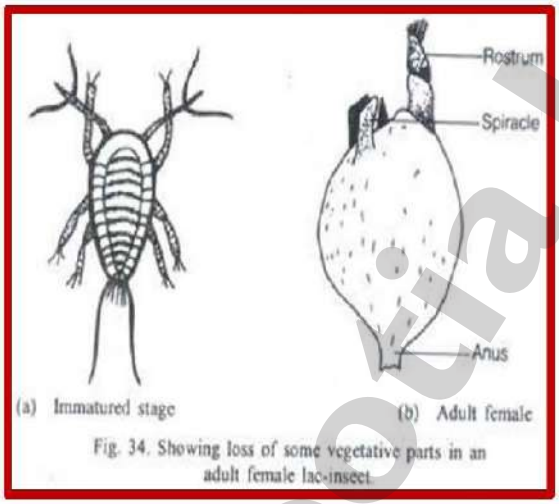
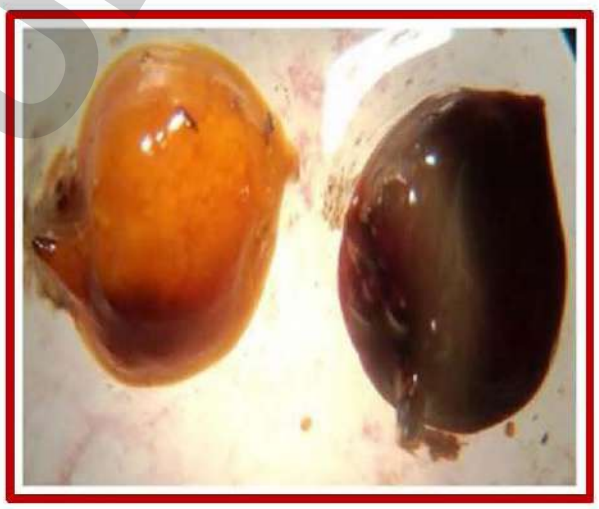


Fig. 34. Showing loss of some vegetative parts in an adult female lac-insect



Female lac insect

Lac encrustations on Palash

Fertilization

- ❑ After attaining the maturity, males emerge out from their cells and walk over the lac encrustations. The male enters the female cell through anal tubular opening and inside female cell it fertilizes the female.
- ❑ After copulation, the male dies. One male is capable of fertilizing several females. Females develop very rapidly after fertilization. They take more sap from plants and exude more resin and wax.

Life cycle

- ➢ Female insect is ovoviviparous, producing about 1000 nymphs, deep red in colour with black eyes, soft bodied, 0.6 mm long, 3 pairs of leg and a pair of antennae.
- ➢ The crawlers emerge from the female cells moves on host tree in search of food they settle the place. The larvae settle down on a suitable place of the host plant. A day or two after settlement, the larvae start secreting lac all around the body except on the rostrum, spiracles and on the tip of abdomen.
- ➢ Thus, it gets encased in a cell of lac which gradually increases in size along with the increase in size of the insect.
- ➢ The nymphs moult thrice, after the first moult both male and female loose their legs, antennae and eyes and become degenerate. During the second moult males regenerate the appendages. The female nymph never regains appendages and continue to remain under the lac cell, become adults and reproduce.
- ➢ As the lac insects remain close together, lac secretion from adjacent cells coalesces with each other and forms a continuous encrustation on the tree branch.
- ➢ Males walk over the lac encrustation, fertilize the females present inside cell through anal tubercular opening.
- ➢ Female after maturity grow very fast, secrets lack abundantly. Size of the female cell is several times larger than male cell. As they grow become globular when they are about to lay eggs they shrink in size providing a space for eggs.
- ➢ At that time the two yellow spots appear at the rear end of the cell. The spot enlarges and become orange coloured. When this happens the females oviposited large number of eggs in the space called ovisac under their tail ends.
- ➢ It is the appropriate time that the twigs (brood lack) are cut from the trees for the purpose of inoculation to new trees.
- ➢ It takes 4 to 8 months to complete its life cycle. Females are the major contributors of lac production.

Video Link:

https://www.youtube.com/watch?v=7lawOa6QJo8

QUESTION

1. What is the scientific name and family of the Indian lac insect?

Ans.

2. What are the different strains found in Indian lac insect?

Ans.

3. What are the specific hosts of lac insect strains?

Ans.

4. What is the inoculation and maturity time of *Rangeeni* and *Kusmi* strains?

Ans.

5. How you differentiate male lac insect from female lac insect?

Ans.

6. What is the mode of reproduction of lac insect? Specify.

Ans.

PRACTICAL 10: HOST PLANT IDENTIFICATION OF LAC INSECT

Objective: To acquainted with different host plants of lac insect and their identification

Lac insects thrive on twigs of certain plant species, suck the plant sap, and grow all the while secreting lac resin from their bodies. These plants are called host plants. Although lac insect is natural pest on host plant, these insects enjoy the privileged position not being treated as pest. This is because: i) they yield a useful product, ii) the host plants are economically not so important, and iii) the insects cause only temporary and recoverable damage to the host plants. Presently, the number of host plants of the Indian lac insect, *Kerria lacca* is 129 in the Indian region, of which 19 are good-quality lac host plants of commercial and other specific importance. The common or major hosts include 14 species in which three, namely, palash, kusum and ber are of all-India importance since these are excellent hosts wherever they occur in the country. These host plants contribute about 90% of total national lac production whereas other species are of regional importance. Among these host plants, *Flemingia semialata* and *F. macrophylla* are found to be more suitable and economical.

Table 1: Major host plants of lac insect

Commercial importance				
Sl. No.	**Common name**	**Botanical name**	**Suitable for strain**	**Distribution**
1.	Kusum	*Schleichera oleosa*	*Kusmi*	All major lac growing states
2.	Palash	*Butea monosperma*	*Rangeeni*	
3.	Ber	*Zizyphus mauritiana*	*Kusmi/Rangeeni*	
Regional importance				
4.	Babool	*Acacia arabica*	*Rangeeni*	West Bengal, Jharkhand, Punjab, Uttar Pradesh, Maharashtra, Gujarat, Tamil Nadu
5.	Ghont	*Zizyphus xylopyra*	*Rangeeni*	Madhya Pradesh, Chattisgarh
6.	Galwang	*Albizia lucida*	*Kusmi*	Gujarat
7.	Banchlata	*Leea crispa*	*Rangeeni*	Assam
8.	Akashmani	*Acacia auriculiformis*	*Kusmi*	West Bengal, Jharkhand
9.	**Semilata**	***Flemingia semialata***	***Kusmi***	All major lac growing states
10.	**Bhalia**	***Flemingia macrophylla***	***Kusmi***	
11.	Arhar	*Cajanus cajan*	*Rangeeni*	Assam
12.	Khair	*Acacia catechu*	*Kusmi*	Jammu & Kashmir
13.	Jalari	*Shorea talura*	*Rangeeni*	Tamil Nadu, Karnataka
14.	Fig	*Ficus* species	*Rangeeni*	West Bengal, Jharkhand, Punjab, Karnataka

Palash (*Butea monosperma*)

Kusum (*Schleichera oleosa*)

Ber (*Zizyphus mauritiana*)

Lac cultivation on plantation scale on *Flemingia semialata*. (a) Plantation of *F. semialata* for intensive lac cultivation and (b) lac crop on *F. semialata* (Source: Industrial Entomology, Springer Nature)

Video Link:

https://www.youtube.com/watch?v=9h-TYhW5NjM
https://www.youtube.com/watch?v=k8WQJNtg1yM

QUESTION

1. What are the major host plants of lac insect of commercial importance?

Ans.

2. Write common names along with botanical names of three host plants of regional importance of *Kusmi* and *Rangeeni* lac strains?

Ans.

3. In West Bengal, how many host plants of lac insects are found? Mention their common and scientific names.

Ans.

PRACTICAL 11: IDENTIFICATION OF IMPORTANT POLLINATORS

Objective: To acquainted with different insect species associated with pollination of crop plants

Pollination refers to the transfer of anther to stigma in flowering plants for sexual reproduction. Pollinators are animals especially insects that transfer pollen from the anthers to the stigma of a flower, enabling the flower to set seed and fruit (fertilization) and, through cross- fertilization, they play an important role in maintaining plant diversity. Insects aid in cross pollination in fruits, vegetables, ornamentals, cotton, tobacco, sunflower and many other crops. Insect pollination helps in uniform seed set, improvement in quality and increase in crop yield. Entomophily refers to cross pollination aided by insects.

Crop Pollination by Different Groups of Insects

Pollination classes	Type of insects	Pollination classes	Type of insects
Melittophily	Bees	Psychophily	Butterflies
Cantharophily	Beetles	Phalaenophily	Small moths
Myophily	Syrphid and Bombyliid flies	Myrmecophily	Ants
Sphingophily	Hawk moths		

Bees are well-known insect pollinators providing pollination services. Among bees, social bees (honey bee, stingless bee and bumble bee) and solitary bees (leafcutter bee, mason bee, carpenter bee, alkali bee, digger bee and blue-banded bee) are important and effective pollinators of many crops; besides bees, syrphid fly, butterfly, wasp and some beetles are potential pollinators in agriculture and horticulture ecosystem.

1. Honey bees

The honey bees (genus *Apis*) being social in nature require ample food (pollen and nectar) to nourish the brood and other nest mates. For this, they need to make frequent visits to the flowering plants. As such, the honey bees have a wide foraging range, and by doing this they perform pollination in diverse plant species including cross-pollinated crop plants in agriculture, horticulture and other ecosystems. In India, *A. mellifera* and *A. cerana* are being commercially used for pollination services in fruits (apple, litchi, pear, peach, plum, etc.) and vegetables (radish, cabbage, cauliflower, etc.). The dwarf honey bee, *A. florea* and the giant rock bee, *A. dorsata* are the major pollinator of onion and coffee, respectively.

2. Stingless Bees

It is often stated that stingless bees are important pollinators of crops in tropical and subtropical parts of the world. Stingless bees make an important contribution to pollination in crops such as coconut, mango, coffee, avocado, strawberry, sweet pepper, tomato, cucumber

etc. In India, the stingless bee, *Tetragonula iridipennis* (Smith), is used by the farmers for pollination in coconut plantations. Among different species of stingless bees, *T. iridipennis* and *T. laeviceps* were most commonly available species in all selected zone of India.

Apis cerana

Apis melllifera

Apis florea

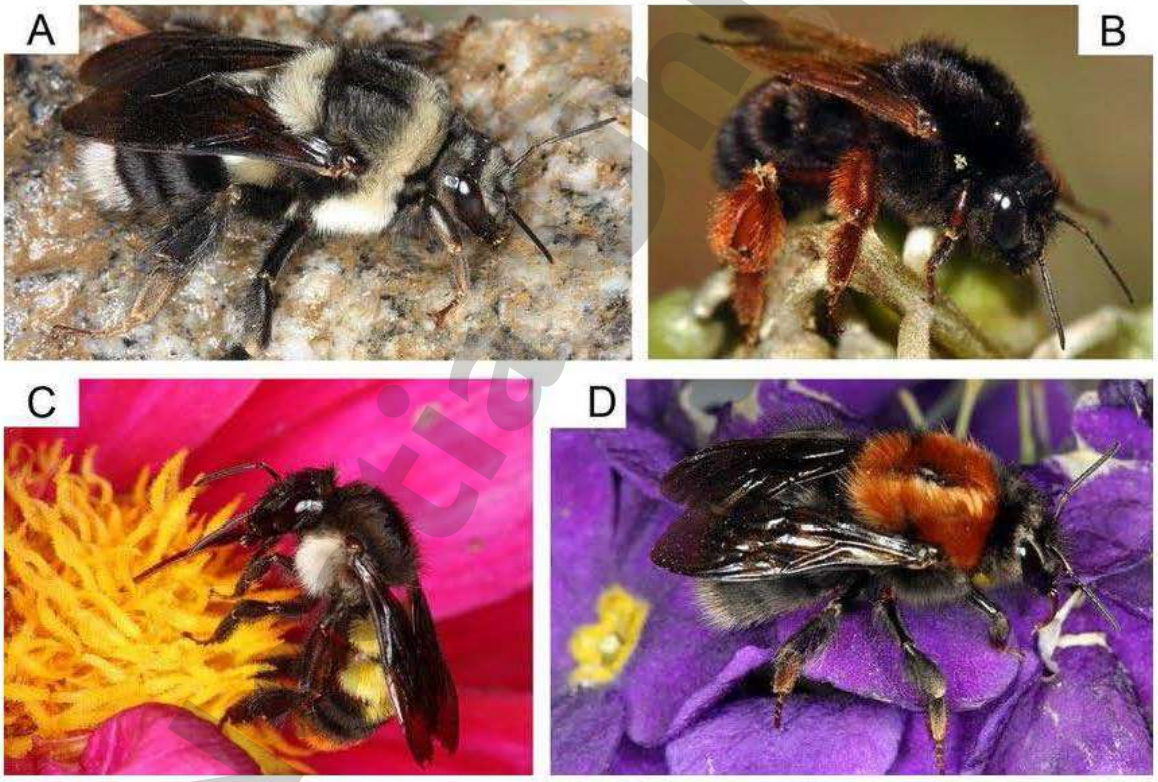
Apis dorsata

Tetragonula iridipennis

Tetragonula laeviceps

3. Bumble Bees

India is home to 48 of the 250 known species of bumble bees, the only pollinators of vegetation in high-altitude regions. Mostly characterized by black, yellow and reddish body hair, and often striped, bumble bees are generally found on altitudes of 2,000-15,000 feet along the entire Himalayas, from Jammu & Kashmir to Nagaland. They pollinate vegetables (tomato, cabbage, cauliflower, brinjal, radish etc.), fruit trees, cash crops and even ornamental and medicinal plants high in the Himalayas. The Indian species of *Bombus* has generally been restricted to higher elevations especially Himalayan ranges. *Bombus miniatus* is an Oriental species and is widely distributed in Kashmir, Himachal Pradesh, Uttarakhand and Sikkim with a long seasonal activity period.



(A) *Bombus miniatus* (queen), (B) *Bombus genalis* (worker), (C) *Bombus albopleuralis* (worker), (D) *Bombus abnormis* (queen)

4. Carpenter bee, *Xylocopa* sp. (Xylocopinae: Anthophoridae: Hymenoptera)

Robust dark bluish bees with hairy body. Dorsum of abdomen bare, pollen basket absent. Adults are good pollinators. Construct galleries in wood and store honey and pollen. Important species are found in India are *Xylocopa latipes*, *Xylocopa confusa*, *Xylocopa tenuiscapa* etc.

5. Digger bees, *Anthophora* sp. (Anthophoridae: Hymenoptera)

Stout, hairy, pollen collecting bees. Abdomen with black and blue bands.

6. Leafcutter bees, *Megachile* species (Megachilidae: Hymenoptera)

The 'cutter' in their names comes from the apparatus these bees have on their bodies to cut leaves. Leaf-cutter bees have mandibles (mouthparts) with cutting edges, something unique to this group of bees. They usually cut leaves for building their nests. In general, leaf cutter bees were found to be more abundant during June, July, September and October and moderately abundant during May, August, November and December and lowest during January to April. Some important species are *Megachile lanata, M. lerma, M. disjuncta, M. anthracina, M. bicolor* etc.

Xylocopa latipes

Megachile lanata

***Anthophora* sp.**

7. Hover flies, *Syrphus* sp. (Syrphidae: Diptera)

Brightly coloured flies. Body is striped or banded with yellow or blue and resemble bees and wasps. Larval stage predatory, adults are pollinators. Crops pollinated - carrot, cotton, pulses.

8. Fig wasp, *Blastophaga psenes* (Agaonitae: Hymenoptera)

Fig is pollinated by fig wasp only. There is no other mode of pollination.

Hover flies

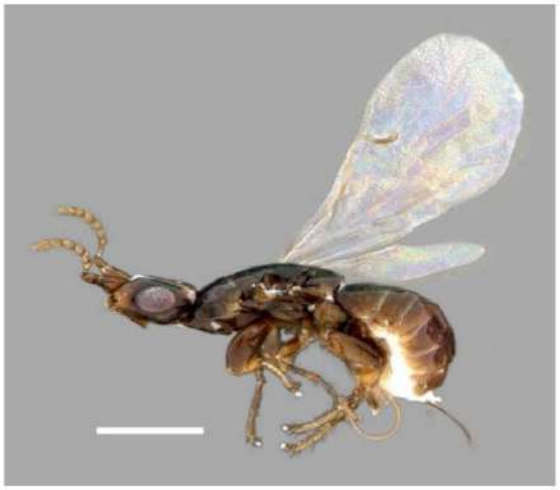


Fig wasp

Video Link:

https://www.youtube.com/watch?v=ZBVVLTz4xuQ

https://www.youtube.com/watch?v=fOMbAegJ1wQ

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

QUESTION

1. What are the different types of bees plays role in crop pollination?

Ans.

2. Which stingless bee species are commercially used for coconut pollination by farmers? Name some other crop plants which are pollinated by stingless bees.

Ans.

3. How many bumble bee species are found in India and which crop plants are pollinated by them? Name one species of bumble bee found in India.

Ans.

4. How you identify carpenter bees? Write some important species of carpenter bees found in India.

Ans.

5. During which months leafcutter bees are more abundantly found?

Ans.

PRACTICAL 12: IDENTIFICATION OF WEED KILLERS AND SCAVANGERS

Objective: To acquainted with different insect species of weed killers and scavengers

Weed Killers

Insect which help in controlling weeds by feeding on them are called weed killers. A successful weed killer has following qualities-

- Should not be a pest of cultivated plants - at present or in future.
- Effective in damaging and controlling the weed.
- Should be a borer or internal feeder of the weed.
- Should not be affected by parasitoids/predators.

1. ***Dactylopius tomentosus***, the cochineal insect to control prickly pear, *Opuntia dillenii*. This insect was introduced into India in 1925. Within 5-10 years it controlled the weed.

2. Aristalochia butterfly, *Papilio aristolochiae* (Papilionidae: Lepidoptera) feeds on Aristalochia which is a weed.

3. Calotropis butterfly - *Danaus chrysippus* (Nymphalidae: Lepidoptera) - feeds on Calotropis.

4. AK Grasshopper - *Poekilocerus pictus* (Actididae: Orthoptera)-feeds on Calotropis and controls it.

5. Water hyacinth weevil, *Neochetina eichhorniae* and *N. bruchi*- The larvae tunnel and feed inside the petioles. Ten pairs of adults and progeny controls plant growth in 0.58 m^2.

6. Water hyacinth (*Eichhornia crassipes*) was also successfully controlled with mite ***Orthogalumna terebrantis*** (Curculionidae) in Kerala and Karnataka.

7. Parthenium weed killer, *Zygogramma bicolorata* (Chrysomelidae: Coleoptera)- Adults and grubs feed on leaves and flowers. 2 beetles controls and destroys one plant in 45 days.

8. Water fern, *Salvinia molesta* was successfully controlled with ***Cryptobagus singularis*** (Curculionidae) in India.

Dactylopius tomentosus **feeding on** ***Opuntia dilleniid***

***Zygogramma bicolorata* feeding on Parthenium**

Neochetina eichhorniae

Neochetina bruchi

Papilio aristolochiae

Danaus chrysippus

Orthogalumna terebrantis

Poekilocerus pictus

Scavengers

Insects which feed on dead and decaying plant and animal matter are called scavengers. They remove decomposing material and prevents health hazard by converting complex material into simple substances. Examples-

(i) Rove beetles (Staphylinidae: Coleoptera): Adults and larvae feed on decaying matter

(ii) Chafer beetles (Scarabaeidae: Coleoptera)

(iii) Darkling beetles (Tenebrionidae: Coleoptera)

(iv) Nitidulids (Nitidulidae: Coleoptera)

(v) Water scavenger beetle (Hydrophilidae: Coleoptera)

(vi) Daddy long legs (Tipulidae: Diptera)

(vii) Muscid flies (Muscidae: Diptera)

(viii) Termites (Isoptera)

(ix) Ants (Hymenoptera)

Rove beetle

European chafer beetle

Insects as Scavengers (Source: ICRISAT)

Video Link:

https://www.youtube.com/watch?v=apkIjw0g4Q8

https://www.youtube.com/watch?v=53F8e8Mnddc

QUESTION

1. What are the attributes of an ideal insect weed killer?

Ans.

2. Which species of scale insect feeds on Opuntia dillenii?

Ans.

3. Write the insect agents which is used for the management of water hyacinth along with their systematic position.

Ans.

4. Write one name of insect species each associated for the control of parthenium, water fern and Calotropis.

Ans.

5. Write five species of insects which acts as scavengers?

Ans.

PRACTICAL 13: IDENTIFICATION OF NATURAL ENEMIES

Objective: To acquainted with identification of some common predators and parasitoids

1. Ladybird beetle: *Cheilomenes sexmaculata* **(Coccinellidae: Coleoptera)**

Cheilomenes sexmaculata is a very important, polyphagous predator of aphids and other soft bodied insects. It has been recorded in most crop ecosystems, particularly where aphids are serious pests. It has been produced in the laboratory and used for the suppression of *A. craccivora* on groundnut.

2. Ladybird beetle: *Cryptolaemus montouzeri* **(Coccinellidae: Coleoptera)**

The adults and larvae of these insects eat scale insects, especially mealybugs. Females lay their eggs among the egg sack of mealybugs. Larvae feed on mealybug eggs, young crawlers and their honeydew. They become adults in 24 days, after three larval stages and a pupal stage. The life span lasts two months.

3. Green lace wing: *Chrysoperla carnea* **(Chrysopidae: Neuroptera)**

Larvae are important predators of insect pests viz., aphids, mealy bugs, eggs and smaller larvae of various insects of agricultural importance and mites. Each larva has potential to feed on average 12 aphids/day or about 120 aphids during the entire developmental period.

4. Syrphid (Hover) fly (Syrphidae: Diptera)

Hover fly larvae are flattened, legless maggots with no distinct head and a tapered body. They are variously coloured (yellow, green to brown). Adults frequent flowers over which they hover before landing to feed on nectar and pollen (their only food source). They are often mistaken for bees or wasps which they mimic in colouration. Hover fly eggs are white, elongate, with fine sculpturing and are visible in aphid colonies. They mainly feed on aphids, scales, thrips and other small soft-bodied insects.



5. Praying mantids

Adults are 5-10 cm long and green, brown or yellow in colour. Mantids have an elongated thorax and grasping forelegs, which they use to hold their prey while they eat. They attacked many insect pests including aphids, flies, beetles. Feeds on pests as well as beneficial insects.



6. Mirid bug: *Cyrtorhinus lividipennis* (Miridae: Hemiptera)

The green mirid bug is the most promising predator for the control of brown plant hopper, *Nilaparvata lugens* in paddy. Both the nymphs and adults are important predators of hopper eggs, nymphs and adults. They sucks out the liquid contents of hopper eggs, which causes the eggs to collapse.


Video Link:

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

https://www.youtube.com/watch?v=u-XoU4uZo-Y

https://www.youtube.com/watch?v=2ucifNxMtn0

https://www.youtube.com/watch?v=YYJpNLWlp8U

QUESTION

1. Go to fields and observe for predators and fill the table with following information.

Sl. No.	Crop	Common name of predator	Scientific name with order and family	Prey insect's name	Identifying characters
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

2. Mention three names of egg parasitoids, larval parasitoids and pupal parasitoids along with their host insects.

Ans.

PRACTICAL 14: MASS MULTIPLICATION TECHNIQUES OF NATURAL ENEMIES (PREDATORS)

Objective: To acquainted with mass multiplication techniques of important predators- *Cheilomenes*, *Cryptolaemus* and *Chrysoperla*

Mass multiplication of *Cheilomenes sexmaculata*

The ladybird beetle, *Cheilomenes sexmaculata* is a potential biocontrol agent for use in augmentative release programmes. Adults and larvae of C. sexmaculata voraciously feed on a wide range of prey including aphids, coccids, diaspids and aleyrodids etc.

Mass production technique

- The initial culture is started by collecting unparasitized pupae of *C. sexmaculata* from the field. The parasitized pupae look dark black to brown and are brittle to touch, whereas, healthy pupae are bright yellow coloured with black markings and are soft to touch.
- The freshly emerged adults are fed with groundnut aphid (*Aphis craccivora*) for ten days in which period mating may occur.
- The days old, pre-fed beetles are released on pumpkins bearing colonies of 25 days old striped mealybugs, *Ferrisia virgata.*
- Dry leaves of *Bauhinia purpurea* are arranged on the periphery of the pumpkins in a slanting position. Any other plant's leaves can also be used as an oviposition substrate. The leaves should be broad and should remain stiff after drying. These leaves act as oviposition substrate and also help the beetles to climb over the pumpkin.
- Honey (50%) soaked in absorbent cotton swab is provided as an additional carbohydrate source.
- The beetles are allowed to feed on *F. virgata* in the same cage for 25 days. The pumpkin is replaced with another infested pumpkin if necessary. Dead adults are removed regularly and replaced with fresh ones to ensure regular supply of eggs.
- The honey swabs are changed on alternate days. The eggs deposited on the leaves are collected and used for further multiplication.
- Eggs thus collected are kept separately in glass vials, as the grubs are highly cannibalistic.
- The grubs are released on cowpea seedlings infested with *A. craccivora*, grown either in plastic cups or glass jars.
- 25 grubs can be reared for 8-9 days in one jar containing more than 6500 aphids. Four jars are required for rearing 100 grubs up to the pupal stage.

- The adults emerging in 5-6 days from pupae are used either for further multiplication or for field release.
- The adult beetles survive for 50-70 days on mealy bugs. A regular decline in fecundity is observed 3-4 weeks after emergence and the beetles stop laying eggs during the last week of their life. Hence, the beetles should be discarded after the fourth week as they become less productive and rearing becomes uneconomical.

Mass multiplication of *Cryptolaemus montouzieri*

C. montrouzieri has been introduced from Australia for the control of *Coccus viridis* on coffee. But the predator has established on many species of mealybugs and green shield scale. In the field its practical use for the suppression of mealybugs *viz*., pink mealy bug (*Maconellicoccus hirsutus*), citrus mealy bug (*Planococcus citri*), tailed mealy bug (*Ferrisia virgate*) and scale (*Pulvinaria maxima*) on citrus, coffee, grapes and several other fruit crops and ornamentals has been demonstrated. Equipments like wooden boxes/cages, iron rack, buckets etc. are needed for mass multiplication of ladybird beetles.

Mass production technique

- After 15 days of infestation of pumpkins with mealy bugs (*Planococcus citri*), they are exposed to a set of 100 beetles for 24 hrs. After exposing the pumpkin is kept back in a cage.
- The beetles during the period of exposure feed on mealybugs as well as deposit their egg singly or in groups of 4-12. The young grubs feed on eggs and small mealybugs but as they grow they become voracious and feed on all stages of mealybugs.
- For facilitating the pupation of grubs, dried guava leaves or pieces of papers are kept at the base of each of the eggs.
- The first beetle from the cages start emerging on 30th day of exposure to beetle adults. The beetles are collected daily and kept in separate cages for about 10-15 days to facilitate completion of mating and pre-oviposition.
- The beetles are also fed on diet containing agar powder (1 g), sugar (20 g), honey (40 g) and water (100 ml).
- The adult beetle diet is prepared by boiling sugar in 70 ml of water, adding 1 g agar, diluting 40 g honey in 30 ml of water and adding to the sugar and agar mixture when it comes to boiling point. The hot liquid diet is kept on small white plastic cards in the form of droplets which get solidified on cooling. Such cards containing diet can be fed not only

to *C. montrouzieri* but also to many other species of coccinellids. From each cage about 175 beetles are obtained. The emergence of the beetles is completed within 10 days.

Mass multiplication of green lacewing, *Chrysoperla carnea*

Chrysoperla carnea is neuropteran, very voracious predator of eggs of variety of insects and soft-bodied insects like aphids, whiteflies, mealy bugs, scales, leafhoppers, spider mites, neonate larvae, etc. The larva devours about 11,000 spider mites or 300–400 aphids to complete its development.

Equipment and facilities required: Black muslin cloth, cotton rolls, plastic jars (20 x 15 cm), *Chrysopa* cage, glass tubes (10 x 2.5 cm), camel hair brush, honey, pollen, laboratory host, *Corcyra*, refrigerator etc.

Biology (When reared on *Corcyra*): Larval period: 6.50 days; Pupal period: 7.50 days; Adult longevity (male): 27.50 days; Adult longevity (female): 27.50 days; Fecundity: 34.28; Incubation period: 3.00 days.

Oviposition Cage

Adults are kept in the oviposition cage. It is rectangular wooden box and its interior is lined with net cloth. The top of the cage is provided with a sliding lid lined with black cloth. The lid has free sliding movement on both sides breadthwise. The females prefer to lay eggs on the black cloth; net cloth deters egg laying on it. Such an arrangement induces egg laying on the ceiling of black cloth. One of the edges of breadth of cage is provided with a comb with tooth upside, positioned in such a way that when the lid is slid over the comb, the eggs laid on the cloth pass in between the teeth of the comb and do not get injured, while the comb teeth prevent escape of adults. Every day the lid laden with eggs is replaced by pushing it with another lid, thereby replacing an egg laden lid with a new lid. Eggs are scrapped from the cloth using razor.

Mass production technique

- *Chrysoperla* predators are mass multiplied in laboratory at 27 ± 10°C and 70% RH on the eggs of *Corcyra cephalonica*, a laboratory host. On an average for rearing 5-6 larvae of the predator, 1 cc eggs of *C. cephalonica* are required.
- Three days old 120 chrysopid eggs are mixed with 0.75 ml *Corcyra* eggs (the embryo of *Corcyra* eggs is inactivated by keeping them at 2 feet distance from 30 watt ultraviolet tube light for 45 minutes) in a plastic container.
- On hatching, the larvae feed on the contents of eggs. The second and subsequent instars are reared individually in cells of louvers on the eggs of *C. cephalonica*.

- Host eggs are provided twice during the course of larval rearing. First feeding of 1.75 ml for 100 larvae and second feeding of 2 ml for 100 larvae with a gap of 3 to 4 days is provided.
- Cocoons formed in the cells are collected after 24 hours. The cocoons are placed in oviposition cage for adult emergence.
- In each oviposition box roughly 20 pairs can be accommodated and inside portion of the container is covered with black paper on which adults lay eggs.
- The adults in the oviposition boxes are provided with castor pollen, protinex mixture (equal volume of protinex, fructose, honey and powdered yeast dissolved in small quantity of water), 50% honey and drinking water in cotton swab.
- Adults lay eggs on the under surface of the top lid which is removed by sliding a clean lid.
- After 24 hours of hardening the eggs are gently brushed with a brush to dislodge on to a paper, eggs are collected and either reused for mass multiplication or sent to farmers for field release. Only first instar larvae are released on to the recommended crop plants.

Precautions

- Always wear larvae either in individual vials or hexagonal cells of the *Chrysopa* cage due to cannibalistic habit.
- Flowers containing pollen grains of castor or maize enhances it's fecundity by many folds, hence may be offered to the adults along with prey.
- If viability of eggs of the predator starts deteriorating through generations on laboratory host. Shift at least for one generation of larval rearing on natural prey (aphids).
- Freeze laboratory hosts at least for 6 hours at –4°C to –6°C in order to kill its' embryo.
- Handle adults preferably with the aspirator.

Video Link:

https://www.youtube.com/watch?v=M4eflDcndRI

https://www.youtube.com/watch?v=bZ7nB1LEopM

QUESTION

1. Collect different predators and arrange them with labels in the insect box given.

2. Observe and record the identification marks of different insect predators reared in the laboratory and draw neat labeled diagrams of the specimens.

PRACTICAL 15: MASS MULTIPLICATION TECHNIQUES OF NATURAL ENEMIES (PARASITOIDS)

Objective: To acquainted with mass multiplication techniques of important parasitoids- *Trichogramma*, *Bracon* and *Tetrastichus*

Mass multiplication of egg parasitoid, *Trichogramma* species

The genus *Trichogramma* is cosmopolitan in distribution and present in all terrestrial habitats and is one of 80 genera in the family Trichogrammatidae. *Trichogramma* primarily parasitize eggs of Lepidoptera, but parasitism also occurs in eggs of other orders such as Coleoptera, Diptera, Hemiptera, Hymenoptera and Neuroptera. In India it is commercially available for the pest suppression of sugarcane, cotton, sorghum, maize and paddy borers.

(a) Biology

Fecundity: 20-200 eggs

Egg period: 1-2 days

Larval period: 3-4 days

Pupal period: 4-5 days

Adult longevity

Male: 5-7 days

Female: 5-20 days

(b) Materials required

Corcyra cephalonica eggs, Nucleus culture of *Trichogramma*, Polythene bags, Rubber bands, Scissors, Gum, Tea strainer, Brush, Mesh sieve (40 mesh size), Tricho cards, 50% honey solution, Stapler, Refrigerator/fridge, B.O.D. incubators and UV lamp/LED light.

(c) Rearing

In India, *Trichogramma* sp. are reared on the eggs of rice meal moth. Freshly collected eggs of Corcyra are cleaned of the scales, mites and other foreign matter associated with these and are glued on the Trichocard with uniformly thin layer using 2 per cent gum Arabic in distilled water (W/V). The sprinkling of the eggs is done either with camel hair brush or a fine sieve which does not allow more than one or two eggs to pass through its hole at a time. Thus 18000-72000 (1 ml) frozen host eggs are glued on a tricho card (15 x 7.5 cm). If the eggs were not frozen the trichocard should be exposed to UV lamp for about 10 minutes. The card is further divided through punching into 6 strips each of 7.5 x 2.5 cm size which can be easily pressed and separated. A strip containing glued eggs on it was inserted into a glass tube (10 x 2.5 cm) having newly emerged adults. The adult parasitoids are

provided with honey streaks (50% honey dissolved in water) drawn on inner side of the tube and secured tightly with muslin cloth and rubber bands. The card is changed after 24 hours and replaced with fresh card. Thus, continuity of changeover is maintained for 3 to 4 days or till female survive and remain productive. The host eggs oviposited by female turns black after 3 days of parasitization. The parasitoid completes its life cycle in 7-9 days at 27 ± 2°C and 75 ± 5% RH.

Precautions

1) If host eggs are not frozen/treated with UV rays to kill the embryo, the moth's larvae may hatch out from the unparasitized eggs. These larvae should be brushed out gently since they eat away the unparasitized eggs.
2) Avoid super parasitism either by exposing host eggs upto 8 hours or providing 6 eggs for one parasitoid.
3) Maintain pure species of different species of Trichogrammatids through proper handling and regular examination.
4) Do not offer frozen eggs to *T. japonicum* as it does not develop well on such eggs.
5) Do not rear *T. brasiliensis* at the temperature exceeding 26°C where undesired male formation is more.
6) Do not cold store parasitized eggs at 5-10°C for more than 15-20 days as beyond this storage biological attributes of the parasitoids are affected.
7) Use healthy eggs of host for healthy parasitoid.
8) Do not put excess gum while sprinkling the host eggs.
9) Do not rely on super parasitized parasitoids as they are normally weak and unfit for the production of healthy progeny.

Mass multiplication of larva parasitoid, *Bracon hebetor*

Bracon hebetor and *B. brevicornis* are highly polyphagous, gregarious, and ecto-larval parasitoids of several species of Lepidopteran larvae. They parasitize a variety of important Lepidopteran pests of stored product and field crops. Among the common insect pests that are hosts of *Bracon* are rice moth (*Corcyra cephalonica*), angoumois grain moth (*Sitotroga cerealella*), wax moth (*Galleria mellonella*), Indian meal moth (*Plodia interpunctella*), castor shoot and capsule borer (*Conogethes punctiferalis*), castor semilooper (*Achaea janata*), cabbage head borer (*Hellula undalis*), gram pod borer (*Helicoverpa armigera)*, spotted pod borer (*Maruca testulalis*), spotted bollworm (*Earias vittella*), tobacco caterpillar (*Spodoptera litura*), cabbage leaf webber (*Crocidolomia binotalis*), sorghum/maize stem borer (*Chilo*

partellus), pink bollworm (*Pectinophora gossypiella*) and coconut black headed caterpillar (*Opisina arenosella*).

(a) Biology: Egg period: 24-36 hrs; Larval period: 4-6 days; Pupal period: 3-7 days; Adult longevity: 15-25 days; Average fecundity: 130-200 eggs.

(b) Materials required: B.O.D. incubator or air-conditioned room, larvae of rice meal moth, room humidifier with humidistat, oviposition cages, glass plates, rubber bands, forceps etc.

(c) Rearing

The adult parasitoids soon after emergence are ready for mating and hence are held in a glass jar (10 x7.5 cm) and fed with honey (5%) as food. The female parasitoid lays 8 to 12 eggs on the ventral surface of the host larvae after paralyzing it through stinging. The mouth of the jar containing the parasitoids is covered by a marking cloth over which 80-100 full grown larvae of *Corcyra* are kept in position with the help of rubber bands. After one day, the parasitized larvae are removed gently with the help of forceps and kept on paper plates (3 x 8 cm) as to avoid falling of the eggs from the host body and left undisturbed till cocoon formation. After cocoon formation, the remains of dead host larvae are removed. The cocoons are placed in glass jar (19 x 19 cm) for emergence. The optimum rearing conditions are 27 ± 2°C and 60 ± 5% RH with a photoperiod of 12-14 hours.

Precautions

1. Provide sufficient light and high RH (60-80%) to adult parasitoids to ensure proper mating.
2. Avoid infestation of mite, *Pediculoides ventricosus* in the culture.
3. Sterilize all equipment and cloths in hot air at 110°C for 1 hour and also remove the dead larvae regularly.
4. Do not cold store parasitoid cocoons for more than one month at 5-10°C as beyond this period the biological attributes of the parasitoid are adversely affected.

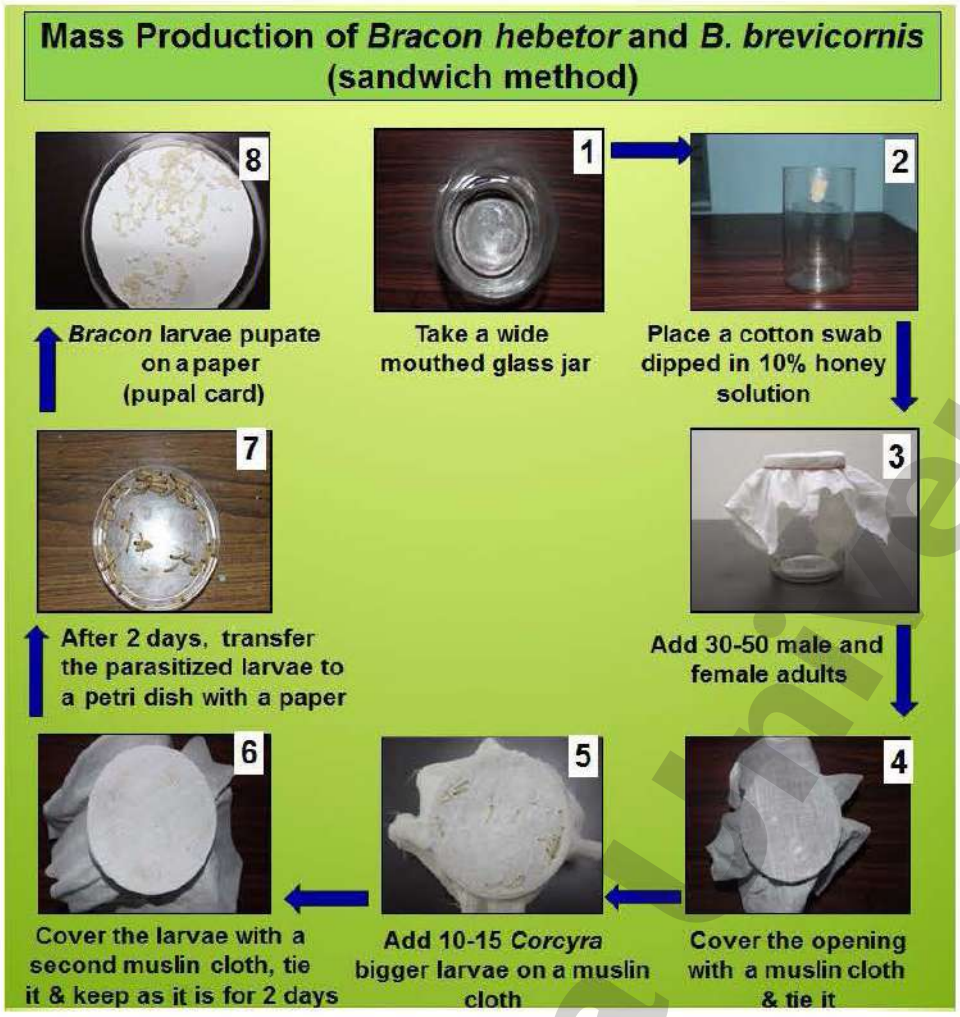

Adult

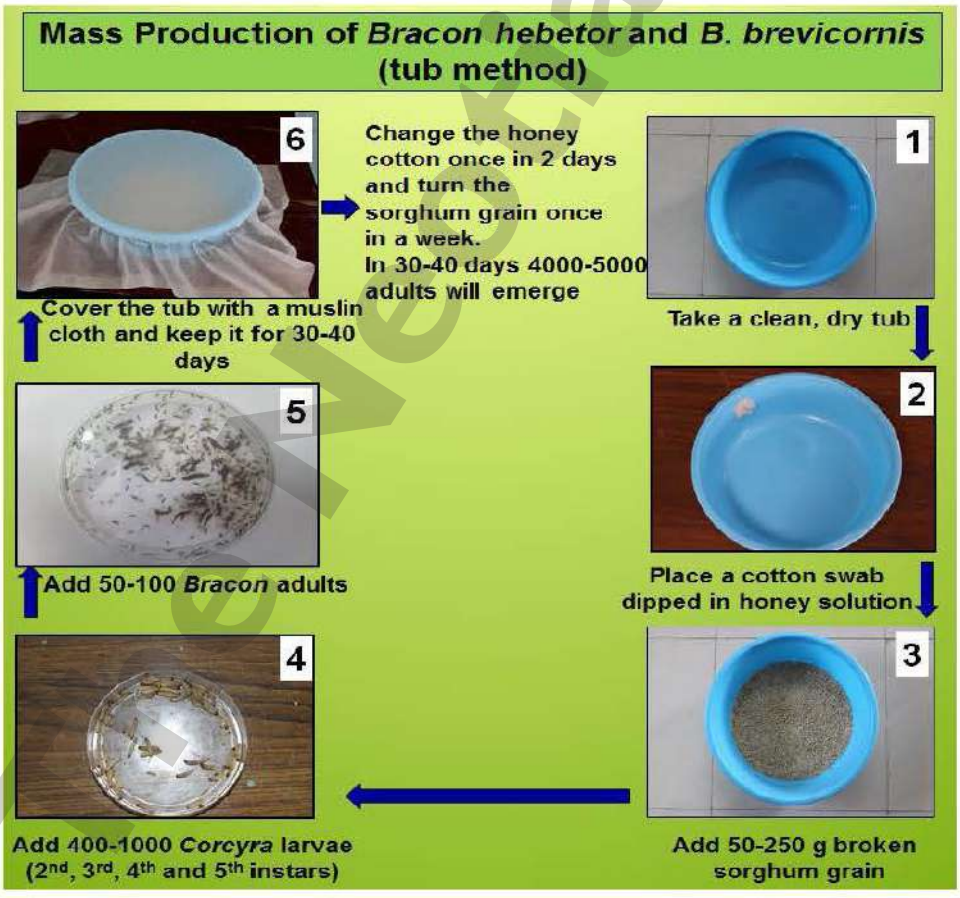

Larva


Pupa


Egg laying by *Bracon*

(Source: NIPHM)





(Source: NIPHM)

Mass multiplication of pupal parasitoid, *Tetrastichus israeli*

(a) Biology: Egg period: 20-24 hrs; Larval period: 4-6 days; Pupal period: 6-10 days; Longivity: 10-15 days; Fecundity: 50-150.

(b) Materials required: B.O.D. incubator, A.C. room, glass tubes, fresh pupae of hosts, honey, rubber bands, markin cloth etc.

(c) Rearing

This pupal parasitoid can reared on pupa of coconut black headed caterpillar (*Opisina arenosella*), chickpea pod borer, tobacco caterpillar, *Euproctis lunata* and *Ergolis merione*, etc. Fresh pupae of host insect (coconut black headed caterpillar) are transferred at the rate of 5/tube size of 15 x 2.5 cm. Adult food purpose every tube fill up 50% honey solution and transfer 30 females after mating in tube. The newly appeared adult parasitoid consumed small drop of honey on a wax containing paper kept in vials. Newly converted pupae are provided for parasitization to the parasitoids. In succeeding 2 days, parasitized pupae are shifted in the test tubes for arrival of parasitoid, having gregarious natures which finish life stages in pupa of the target pests. Immature as well as resting stage completed within 6 and 8–10 days, respectively; field transfer occurred at the rate of 20 adults/tree for coconut (BHC).

Precautions

1. Provide fresh host pupae.
2. Sometimes it may realize breaking the outer shell of host pupa for easy emergence of parasitoids.
3. Maintain cleanliness.

Video Link:

https://www.youtube.com/watch?v=M4eflDcndRI

https://www.youtube.com/watch?v=bZ7nB1LEopM

QUESTION

1. Collect different parasitoids and arrange them with labels in the insect box given.

2. Observe and record the identification marks of different parasitoids reared in the laboratory and draw neat labeled diagrams of the specimens.

PRACTICAL 16: VISIT TO RESEARCH AND TRAINING INSTITUTIONS DEVOTED TO BEEKEEPING, SERICULTURE, LAC CULTURE AND NATURAL ENEMIES

Objective: To visit nearest research and training institutions related to apiculture, sericulture, lac culture and biocontrol agents

Date of visit: ……………………………

Observations: ……………………………………………………………………

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