

# PRACTICAL MANUAL

Course Title : Management of Beneficial Insects

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Course No. : ENTO - 365

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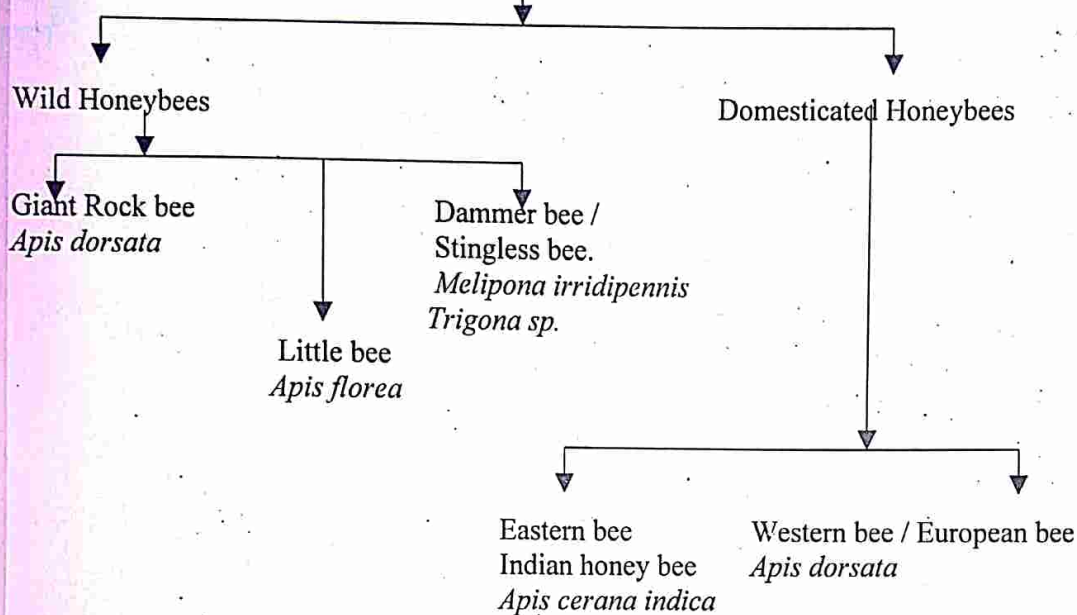
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## Exercise No. 1

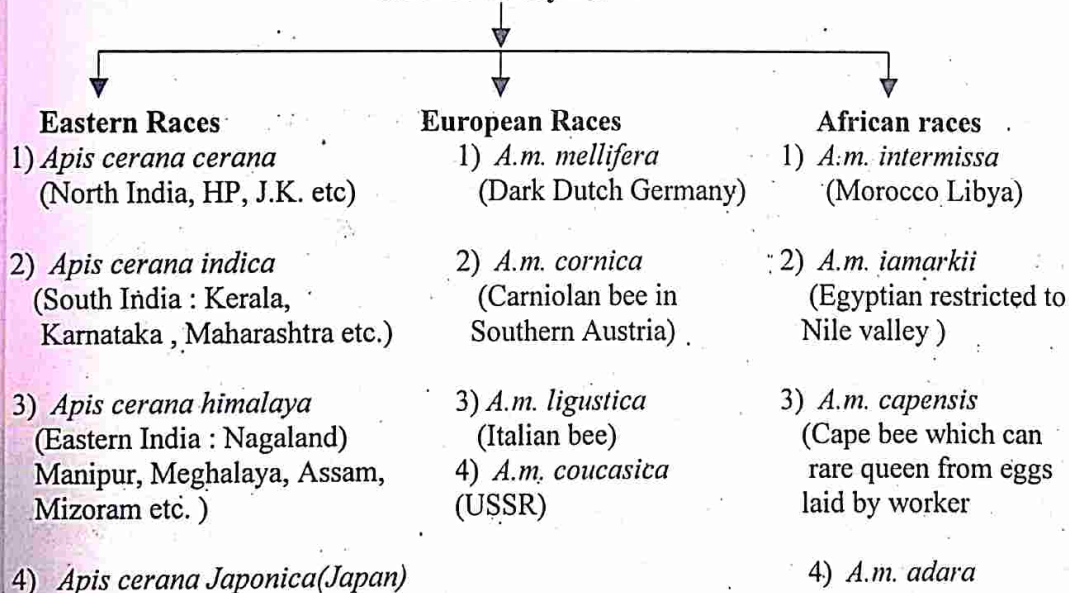
### Studies on Honey Bee Colony : Bee species and castes of bees

#### Bee Species :

There are two types of species of honey bees in the world.



#### Races of Honey bee



In India all the four species are found. *Apis mellifera* is an Exotic bee for India which was introduced in India (Nagrota : HP) for the first time successfully in 1962. In

addition to four true honey bee species, more species have been found in some parts of the world. They are :

- 1) *Apis laboriosa* : (Nepal) resemble to *A. dorsata*.
- 2) *Apis vechti* or *A. Kaschevnikovi* (Malaysia) resemble to *A. cerana*
- 3) *Apis andreniformis* (China) resemble to *A. florea*
- 4) *Apis nuluensis* (Malaysia, Indonesia) resemble to *A. cerana*
- 5) *Apis nigrocincta* (Indonesia) resemble to *A. cerana*

**Species:** Each species is reproductively isolated from the other and these cannot be interbred.

**Races :** Races are geographically isolated and these can be interbred.

#### **Characters of various bee species:**

- 1) **Giant rock bee (*Apis dorsata*) :**
  - 1) Builds a single large comb (5' wide and 2-4 ' long in open on tree branches, caves of high buildings, suspended from rocks, high hedges.
  - 2) Good honey gatherers and produces large quantity of honey. Average honey production is 36.3 kg per colony per year.
  - 3) It can not be domesticated and has ferocious temperament, easily provoked and attack enmasses man or beast often with fatal results.
  - 4) They are industrious, good, efficient pollinators of crops.
- 2) **Little bee (*Apis florea*) :**
  - 1) Builds a small single comb about the size of palm of hand suspended from branches of bushes, hedges, trees, crevices of buildings but in semi dark conditions.
  - 2) Poor honey yielder and produces 0.5 to 1.0 kg of honey per colony per year.
  - 3) Not so prone to stinging. Prone to swarming and have 4-5 swarming.
  - 4) Industrious, good and efficient pollinators.
- 3) **Indian Honey bee (*Apis cerana indica*) :**
  - 1) Widely distributed throughout India, Builds series of parallel combs inside cavities, hollow tree trunks, rocks, wooden boxes, mud receptacles etc are common abodes used by bees.
  - 2) Can easily be domesticated and kept in modern beehive, easy to manage.
  - 3) Good honey yielder and yields 4 to 5 kg of honey per colony per year. Under better management it yields 10 to 15 kg honey / colony / year.
  - 4) Prone to heavy swarming, absconding, robbing and developing large number of laying workers but can be remedied with proper manipulatory practices.
- 4) **Dammer bee (*Melipona irridipennis*) :**
  - 1) Smallest bees and builds their nests in hollow log of trees or rocks or in walls as a sac like comb from a mixture of resins and wax held together by propolis.

- 2) Stingless bees (*Vestigial sting*). Poor honey gatherer and yields only 50 to 170 g of honey per colony per year and difficult to extract.
  - 3) A substance known as 'bee's dammer' or Pivenyet obtained from colonies used as varnish and for caulking boats to make them water proof.
- 5) **European bee (*Apis mellifera*) :**
- 1) Found all over Europe and have well recognized varieties and strains. The Italian variety is considered to be the best.
  - 2) This bee is similar in habits to *Apis cerana* bee and builds several parallel combs in cavities, hollow log of trees etc.
  - 3) It has many desirable traits. Prolific queen, swarm lessness, less absconding habit, gentle temperament, good honey gatherer and amenable to rare in all environmental conditions and modern bee hives. Easy to manage and multiplication,
  - 4) Good honey yielder and yields 45 to 100 kg honey per colony per year under excellent floral conditions. On an average 25 to 40 kg honey is obtained.

**Desirable traits for domestication:**

- 1) Gentle temperament
- 2) Queen must be prolific
- 3) Tendency to swarm less
- 4) Absence of absconding
- 5) Ability to guard against bee enemies
- 6) Industrious ness
- 7) Good honey gathering ability
- 8) Adaptability to modern bee hives.
- 9) Adaptability to modern methods of management i.e. shifting of colonies, eliminating wax moth, migration for pollination etc.

*Apis cerana* and *Apis mellifera* best suited for such modern management methods.

**Colony Organization and Castes of Honeybees**

A normal colony, during active season will be composed of 3 kinds of individual; **one queen, thousands of workers and few hundreds of drones**, which vary in size. Each colony has different developmental stages of bees : eggs, larvae and pupae which are collectively known as brood.

**1. Queen:**

- Normally only one queen is found in a colony except under supersede or swarming instinct.
- She is mother of whole colony producing workers and drones.
- Her function is to lay eggs. She does not have motherly instinct or ability to feed the brood.
- A good queen can lay 1500-2000 eggs per day at the height of her production.
- A laying queen is the longest bee in the colony. It has larger thorax than workers and her abdomen gets greatly distended during egg laying.

- The queen lays fertilized or unfertilized eggs 'at will'. **Fertilized eggs produce worker larvae and unfertilized eggs produce drone.**
- A good mated queen may work satisfactorily for 2 or more years.
- The virgin queen mates in the air and not inside the hive. Within 5 – 10 days after emergence and mates with number of drones (5-7) and spermatozoa received are stored in spermatheca where these are kept alive and used to fertilize the eggs throughout her life or till the supply gets exhausted.

## 2. Workers:

- Workers are imperfect females. They are unable to mate though they may start egg laying in a queen less colony.
- The workers perform all the useful work of the colony except laying of eggs.
- **Duties of workers include :** Cleaning of hive, feeding of larvae, raise queens when required, ventilate hive, guard the hive entrances, secrete bees wax and construct the combs, collect the nectar and convert it into honey, collection of pollen, produce a predigested food of royal jelly for feeding queens and young larvae. The workers also feed the drones but when they are not needed, they are thrown out of hive. The field duties also include scouting for a new nest site during swarming and collecting water and propolis.

### The duties are related to the age of the worker :

- |   |   |   |
|---|---|---|
| a) Till 3 <sup>rd</sup> day of emergence          | : | Maintain waxen cells in sanitary state, cleaning their walls and floors after the emergence of young bees.                                      |
| b) From 4 <sup>th</sup> day of emergence          | : | Feed older larvae with mixture of honey and pollen and making flights around the hive for getting lay out of the hive.                          |
| c) From 7 <sup>th</sup> day of emergence          | : | Maxillary glands get developed and start secreting royal jelly and feed younger larvae.   |
| d) From 12 <sup>th</sup> to 18 <sup>th</sup> days | : | The bees develop wax gland and work on building of comb. These bees also guard the hive, examine the nectar and help in keeping the brood warm. |
| e) From 15 <sup>th</sup> days onwards             | : | The worker bees take the duty of field i.e. exploring or foraging for nectar and pollen. Bees also collect water to meet colony requirements.   |

A worker has an average life on only 40-50 days during honey flow season (active period) and her life may extend up to 6 months during off season.

## 3. Drone:

Drones do not perform any duty inside the hive. The sole function of a drone is to mate with queen only once which costs him his life.

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## Exercise No. 2

### Bee Keeping Appliances

#### 1) Bee hives :

Langstroth discovered the principle of bee space in 1851 in USA. This space permits free passage for worker bees and is too small to build a comb by bees or too large for depositing bee glue i.e. propolis.

This principle was a big discovery for modern beekeeping. The bee space measures 9.525 mm for *A. mellifera* and this was modified for *A. cerana* between 7 to 9 mm. **A complete bee hive has following parts.**

- 1) Stand : To support bottom board.
- 2) Bottom board : It is floor of the hive having an entrance for bees.
- 3) Brood chamber : A box without top and bottom and in this chamber hangs the frames. The dimensions vary with type of chamber.
- 4) Frame : Each frame consists of a top bar, two side and a bottom bar. Top bar has a groove in the middle for fixing comb foundation sheet. Side bar has 4 holes for wiring the frame.
- 5) Super : Dimensions may be same as that of brood chamber of half of it (depending on type of bee hive). **This is a chamber where bees gather surplus honey.**
- 6) Inner cover : A board to cover brood chamber of super.
- 7) Top cover : A type of lid to cover inner cover and brood chamber from the top. In general for *Apis mellifera* we use Langstroth hive and for *A. cerana* I.S.I hive. A wooden dummy board is used to limit the size of brood chamber.

#### Dimensions:

- | <u>Langstroth</u>                       | <u>I.S.I. hive</u>                          |
|---|---|
| 1. Contain 10 frames                    | 1. May contain 8 or 10 frames               |
| 2. Generally full super chamber is used | 2. Half (shallow) super chamber is used.    |
| 3. Brood frame size 440 x 228 mm        | 3. Brood frame size                         |
|   | Type A : Modified Newtons type 230 x 165 mm |
|   | Type B : Modified Geolkote Type 380x195mm   |

Generally in India, wood of 'Kail' or 'Toon' is used for making bee hives. Wood having strong smell e.g. of 'Chil' is not used.

2. **Nucleus hives** : Small bee hive for keeping 4-6 frames. These are used for mating of queens and division of colonies.

3. **Observation hives** : Small hive with glass sides so as to observe movements and behaviour of bees. It is used to observe bee behaviour.
4. **Comb foundation mill** : Used to print cell size of desired comb foundation sheet for *A. mellifera* and *A. cerana*.
5. **Bee veil** : Used for preventing bee stings on face and neck.
6. **Hive tool** : An iron strip used for opening of hive and its cleaning.
7. **Uncapping knife** : Large size knife used to uncapped the frames before honey extraction.
8. **Smoker** : Used to calm down the bees while opening the hive.
9. **Feeders** : For feeding sugar syrup. Two types of feeders are used : (i) Slow feeder (friction top pails) (ii) Fast feeder (Division board feeder).
10. **Swarm basket** : Basket to catch bee swarm.
11. **Queen cage** : Used to introduce a queen to new colony and also to transport the queen.
12. **Queen cell protector** : A spring like structure for protecting queen cells.
13. **Queen excluder** : Perforated zinc sheets or round wires assembled on such a way that workers can pass through them and queen can not (Perforation size is 4.20 mm for *A. mellifera* whereas worker thorax size varies between 3.33 to 3.50 mm).
14. **Honey extractor** : It is machine to centrifuge out the honey from uncapped frames.
15. **Wax melter** : Double walled chamber for melting of bees wax for making comb foundation sheets.
16. **Bee Brush** : To brush the bees from frames.
17. **Bee escape** : To provide one way passage to bees.
18. **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.

### Exercise No. 3

### Seasonal Management of Honey bee

All the management practices needed for increased honey production revolve around the following basic principles of bee management:

- i) Ensuring built-up of foraging force of bees at right time for collection of surplus nectar.
- ii) Providing space for storage and ripening of nectar into honey by the bees.
- iii) Removing honey from hive at right time and extracting it.
- iv) Preparing the colonies to withstand any period of dearth and menace of bee enemies.

#### 1) Spring Management :

- Remove the protective covering or lightly packed hives in the early spring. But in those which are heavily packed the packing is removed only when daily maximum temperature has reached 16°C.
- Examine the colonies on a sunny day. Check the food stored and general condition of the colony. The examination should be for short duration to avoid brood chilling and robbing.
- It is a good practice to equalize the strength of normal colonies in an apiary by giving brood frames to the needy colonies.
- The colonies which do not have brood, are likely to be queen less or if queen has failed and has become drone layer, there will be predominance of drone brood. Such colonies if are weak (less than 5 frames), be united with other needy normal colonies. If these are strong, then provide a mated queen and if not available, give a frame of brood with eggs any young larvae for rearing new queen.
- Give stimulatory feeding of sugar syrup (dilute syrup; 30 per cent) to the bee colonies on the onset of spring which is indicated by the start of blooming of spring flowers. Take all the steps to guard against the robbing by bees. Bees will put their whole force during the period for brood rearing.
- Provide raised combs or frames with comb foundation sheets if raised combs are not available so that there is no shortage of space for brood rearing. But be careful not to over expand the brood in the uncertain weather conditions of early spring, which may results in chilling of brood. Once the colony is strong enough to cover the brood, there is no risk of this problem.
- Examine the colonies at least once a week on a sunny day and when conditions permit clean the debris from the bottom boards. Provide empty frames as per need of the colonies. Ensure that each colony always has at least 5 kg of food stores.
- During spring old bees die which are normally replaced by young bees. If mortality of old bees exceeds the rate of emergence of young bees, the colonies show sign of dwindling which is known as spring dwindling. Such colonies

should be provided with adequate stores of pollen and honey and be given 1-2 sealed brood frames from the strong colonies.

If all above mentioned practices are followed, the colonies will be well built up by the time of honey flow when maximum strength is needed. However, increase in strength also induces swarming.

### **What is swarming?**

This is a natural division of colony in which some bees (may be half or more) leave the colony along with old queen and this swarm settles generally in the nearby area of the colony.

### **Period of swarming**

It occurs when queen has reached her peak of brood rearing under the stimulus of incoming pollen and nectar, mainly in late spring or early summer, but can also occur during summer or fall depending upon floral conditions of the area. This is generally during the period before honey flow.

### **What causes swarming?**

Swarming occurs due to:

- Overcrowding and lack of ventilation.
- Presence of old queen is also incentive to swarming.
- Sudden honeyflow.
- Lack of space for egg laying and honey storage.

### **Problems during swarming:**

- Loss of working force due to division of the colony.
- The morale of colony is not favorable for honey collection. The bees direct their efforts towards building queen cells and searching for new home sites.
- Colonies show great variations in respect of swarming. Some colonies do not swarm even after becoming quite populous yet many swarms without any apparent reason indicating genetic variation to the instinct of swarming.

### **Indication of swarming:**

- The colonies start raising large number of queen cells usually along the lower edges of combs.
- Many bees do not go to field creating additional crowding, resulting in clustering of bees outside the hive.

### **Time of swarming:**

Time to issue swarms by the colonies is from 10 AM to 2 PM on sunny days. If weather is not favorable, swarms may be issued even earlier in the morning or late in the evening.

### **Catching and hiving a swarm:**

- A settled swarm can easily be caught using swarm catching basket. This basket is placed above the bee cluster and the cluster is gently pushed upwards so that the

bees start ascending into the basket. Once the queen has entered, the whole swarm will follow the queen.

- The swarm in this basket can be taken to the apiary for hiving.
- To make the swarm settle properly, a hive is prepared by giving one frame each of capped brood, pollen and honey and provided with extra frames as per strength of the swarm. The swarm from the swarm catching basket is then shaken on the top bars of such a prepared hive and immediately covered with burlap cloth, inner cover and top cover.
- Sugar syrup is also fed to such a newly settled swarm (1 part sugar dissolved in 1 part of water).

### **How to prevent and control swarming?**

Depending on the internal and external factors, one colony may issue one to several swarms resulting in loss of population of the parent colony. To prevent swarming do as given below.

- Avoid overcrowding by adding empty combs for egg laying. Sealed brood can be shifted to second hive body.
- Remove the queen cells at regular interval as soon as these are made. Advanced queen cell removal is not much effective.
- Provide shade and ventilation to the colonies.
- Swarming can be prevented by removing old queen (which otherwise provides the supercedure impulse) and the introduce a young laying queen. Requeening the colonies annually is also a good practice.
- Another well know method of swarm control is 'Demaree plan of swarm control' which is described below. :
  - i) Examine the brood of the colony and remove all the queen cells.
  - ii) Remove the brood chamber from the bottom board and place another hive body containing one comb of unsealed brood and put the queen in this part and fill the remaining hive with empty combs.
  - iii) Place queen excluder on this hive and keep the removed brood chamber along with remaining brood and bees over it.
  - iv) Again inspect the top hive body after 10 days and remove all queen cells. In this way swarming can be checked.
- Swarming instinct of the colonies can also be overcome by temporarily dividing the colony and the re-uniting just before honey flow.

## **2) Management during Honey flow :**

### **Indication of honey flow**

- By whitening of honey cells of the comb due to deposition of fresh wax.
- Appearance of large quantities of burr and brace combs (freshly prepared places of combs).

- Increase in weight of the colonies due to incoming nectar (a colony kept on a stage balance in an apiary indicates the sudden increase in weight such a colony is also known as balance colony).

During this period colonies should be quite populous but without swarming instinct and should gather maximum honey instead of only concentrating on brood rearing. Colony morale should be high for honey collection.

### **Supering**

- With the first indication of honey flow, provide supers to the colonies. But before putting supers, examine the colonies for disease; check whether queen is present or not and whether laying satisfactorily because after the honey flow starts the beekeeper becomes too busy in putting and taking off the supers.
- Place queen excluder between brood chamber and super so as to prevent laying in the super by the queen.
- Keep swarming under check by avoiding congestion in the brood chamber. Provide empty combs at all the times until end of honey flow. The space can be provided by removing sealed brood to super chamber.
- Supers should contain drawn combs. If not available provide frames with comb foundation sheets. To attract bees for raising the foundation, super should contain one or two frames of drawn combs.
- Supers can be of half or full depth. But full depth supers are more practical since frames can be exchanged among different chambers.
- When first super is full and there is a need to put the second one, it should be added between brood chamber and first super.
- If there is shortage of drawn combs and rising of new combs is likely to lower honey production, the fully sealed and two thirds sealed honey frames can be taken out for honey extraction. Empty combs can be returned for re-use.
- A strong colony can collect 4.5 to 10 kg of unripe honey in a single day during good honey flow. Therefore keep the supers ready for meeting colony demand. It is better to super at least one super ahead of needs of the colony.

### **Honey extraction:**

Do not extract uncapped honey since it is unripe and due to higher moisture contents, is liable to ferment.

### **Time to remove supers:**

Early in the morning before bees start storing unripe honey in the combs. If combs are well sealed, these can be removed at any time of the day.

### **Process of honey Extraction:**

- To remove honey combs, smoke colonies and brush off bees from the honey combs using soft bee brush or bunch of soft green grass.
- Place the honey combs in bee tight hive bodies and shift to honey extraction room.

- Never rob the colonies of their entire honey stores. Depending on strength, keep with each colony at least 5-15 kg of honey in case of *Apis mellifera* and 3-4 kg with *A. cerana* for summer and monsoon dearth periods.
- Honey extraction room should be bee tight. After bringing the honey frames for extraction, these can be uncapped either with a steam heated double walled uncapping knife or with ordinary uncapping knife by heating in boiling water.
- Keep these uncapped frames in hive bodies with drip trays below, till extraction.
- Put the uncapped frames in honey extractor and work at about 150 revolution per minute for 1 to 2 minutes. Then reverse the sides of the frames and repeat the extraction process.
- Stock the emptied frames in hive bodies and return these to the colonies for cleaning shorten the hive entrance to avoid robbing.
- Since freshly extracted honey is warm and easy to strain, arrangements for straining and packing should be promptly made so as to prevent subsequent heating.
- Clean the appliances and the place where honey is extracted.
- Beeswax collected during uncapping of honey frames should be allowed to drain off its honey. Then purify this beeswax by putting in a muslin bag and boiling in a water bath. On cooling pure beeswax will float over the surface of water and all impurities will remain in the muslin bag.

### 3) Summer Management :

Honey flow in most of the areas is generally followed by summer dearth period. During this period bees throw out drones and colony population also dwindles due to the death or old bees who have worked hard during honey flow season. Attack of bee enemies increases and robbing activity of bees is also more. If colonies are not managed properly, they may even abscond. This tendency is more in *A. cerana* and little in *A. mellifera*. Manage the colonies as described below. :

- Provide the bee colonies with shade by shifting to shady areas or placing them under open straw huts.
- Provide proper ventilation by slightly raising the brood chamber or the super such that bees do not pass through these ventilations. Otherwise robbing may be induced.
- Close all crack and crevices in the hive so as to prevent entry of the enemies and robbers.
- Ensure that colonies do not remain broodless for longer duration. Provide sufficient food stores if the colonies have been stripped heavily of their honey stores during honey extraction.
- Do not examine the colonies very frequently.
- Restrict the number of frames as per colony strength. Remove extra frames and store these safely for later use.

- In areas where summer temperature rises above 40 °C, gunny bags or straw packs moistened twice a day with water should be spread over the top covers of the colonies.
- Since honeybees maintain their hive temperature during summer by collecting water from outside source, spilling it inside hive, evaporating it by fanning, there should be a source of running fresh water. This can easily be arranged in an apiary by hanging an earthen pitcher filled with water having a hole at its bottom and allowing drops of water to fall on sloping stones.

#### 4) Monsoon Managements :

During monsoon high humidity and high temperature cause unfavorable conditions for bees. Sometimes due to continuous rains, bees are confined to their hives for a long period. Honeybees become lethargic and may develop dysentery. Attack of bee's enemies is also more. The colonies need following managements to keep them strong:

- Weak colonies which have become queen less, should be united with queen right colonies, since during the period due to absence of drones new virgin queen can not mate.
- Avoid bloodlessness in colonies : if pollen stores and fresh pollen is not avoidable. Feed the colonies eight pollen substitute of pollen supplement.
- If colonies have poor food stores (below 5kg) provide sugar in the form of candy or dry sugar instead of sugar syrup.
- Keep in check the attack of enemies like wax moth, mites and wasps.

#### 5) Autumn / Fall Management :

Management practices during this period depend on the climatic and floral conditions where bees are kept. In some parts of India, there is a second honey flow season in autumn. The colonies in such, places are managed as described earlier for availing honey flow. Near the end of honey flow, reduce the hive space to the needs of colony for winter. Restrict the food storage space so that bees are forced to store their winter stores in lower hive body, instead of super.

During this period many colonies make preparation for superceding old queens and raise few queen cells. The new queen on emergence replaces the old queen.

For successful over wintering, which is the on – productive season, following managements should be done.

- Ensure that the colony has vigorous and productive queen. An ideal queen is one whose egg laying rate is high and continuous to lay well till late fall and thus provides population of predominantly young bees in sufficient number for wintering.
- Colonies below average population or having scattered or less brood than the average colonies indicate failure of queens. Replace queens of such colonies by early fall so that these colonies produce desirable number of young bees.
- Colonies for wintering should be free from disease.
- Reduce the comb space by removing extra frames to such a level which can be covered by the bees well.

- Under moderate climatic conditions, colonies of bees on 3-5 frames can winter successfully, if the colonies have proper food stores. Unite the weak colonies with a average to strong colonies.
- If colonies have less honey stores, feed them with heavy sugar which is prepared by dissolving 2 parts of sugar in one part of boiling water and to avoid crystallization add 1 table spoon full of tartaric acid to each of 50 kg of sugar. Full this syrup in combs and exchange for empty combs in the hive.

#### **Precaution :**

Sugar should be fed while outside temperature is sufficient for bees to take syrup and store in combs after reducing its moisture. To avoid robbing feeding should be done only in the evening.

#### **6) Winter Management :**

After preparing the colonies in fall for wintering protection should be produced to the colonies from winter by:

- Reducing the hive entrance.
- Plugging all cracks and crevices in the hive.
- Protecting the colonies from direct chilly winds.

#### **Storage and protection of combs :**

Protect the spare combs from attack of wax moth by fumigation in hive stacks frequently till spring when these drawn combs will be needed by the colonies again.

#### **Wintering :**

Honeybees use honey as source of energy for generating heat and to maintain hive temperature of 32-35°C. For wintering, if insulation to hive is provided, it will help in reducing of store consumption and saving energy of bees. The type of insulation depends upon the climatic zones.

#### **Packing of hive :**

- Only good colonies with young bees in large number and enough food stores should be packed.
- For packing colonies straw, sawdust, wood shavings, bean stalks or dry leaves, chopped rice or wheat straw can be used.
- Packing material should be dry since moisture will make it poor insulator.
- Packing can be given in the brood chamber beyond dummy board, as well as between inner and top cover.
- Strong colonies with young bees and good food stores with proper packing need no care during winter and are opened only in spring.

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## Exercise No. 4

### Bee Enemies and Diseases

#### 1) Predatory wasps :

<i>Vespa auraria</i>	Nests on tree tops buildings
<i>Vespa magnifica</i>	Under-ground nest.
<i>Vespa cincta</i>	Underground nest.
<i>Vespa basalis</i>	Nest on tree top/buildings

#### Nature of damage:

- The wasps catch the bees at hive entrance and kill them.
- 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.
- The weak colonies are attacked more than the stronger ones.

#### Prevention and control :

- Kill the fecunded females visiting the apiary during spring by flapping.
- Burn the nests during night time.
- Kill the wasps in the apiary by flapping.

#### 2) Wax moth (*Galleria mellonella*)

##### Nature and extent of damage:

- 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.

##### Prevention and control :

- Close cracks and crevices in the hive. Reduce hive entrance.
- Remove combs not covered by bees. Keep the bottom board clean.

##### Control in storage:

Keep spare combs in empty hive bodies in tiers and close both at bottom and top. Disinfect the stock by burning sulphur @ 180 g/ cubic meter (fumigation by sulphur fumes). After fumigation, put naphthalene flakes in moth proof stacks.

#### 3) Ectoparasitic mites :

In India, *Varroa jacobsoni* is found on *A. cerana* where as *Tropilaelaps clareae* causes severe damage to *A. mellifera* colonies.

**Control :** i) *Tropilaelaps clareae* Sulphur dusting on top bars @ 200 mg frame.

ii) *Varroa jacobsoni* Fumigation by formic and acetic acid in very dilute concentration.

## Exercise No. 4

### Bee Enemies and Diseases

#### 1) Predatory wasps :

<i>Vespa auraria</i>	Nests on tree tops buildings
<i>Vespa magnifica</i>	Under-ground nest.
<i>Vespa cincta</i>	Underground nest.
<i>Vespa basalis</i>	Nest on tree top/buildings

#### Nature of damage:

- The wasps catch the bees at hive entrance and kill them.
- 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.
- The weak colonies are attacked more than the stronger ones.

#### Prevention and control :

- Kill the fecunded females visiting the apiary during spring by flapping.
- Burn the nests during night time.
- Kill the wasps in the apiary by flapping.

#### 2) Wax moth (*Galleria mellonella*)

##### Nature and extent of damage:

- 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.

##### Prevention and control :

- Close cracks and crevices in the hive. Reduce hive entrance.
- Remove combs not covered by bees. Keep the bottom board clean.

##### Control in storage:

Keep spare combs in empty hive bodies in tiers and close both at bottom and top. Disinfect the stock by burning sulphur @ 180 g/ cubic meter (fumigation by sulphur fumes). After fumigation, put naphthalene flakes in moth proof stacks.

#### 3) Ectoparasitic mites :

In India, *Varroa jacobsoni* is found on *A. cerana* where as *Tropilaelaps clareae* causes severe damage to *A. mellifera* colonies.

**Control :** i) *Tropilaelaps clareae* Sulphur dusting on top bars @ 200 mg frame.

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#### 4) Bee louse, *Braula coeca* :

Wingless fly found on, thorax of bee and feeds by coming near mouth close to opening of salivary glands and take the available nourishment. It is not a serious pest.

#### 5) Other enemies :

Birds bee eater *Myropes orientalis* and king crow eat bees while they are flying to control the menace scare them away. Attack of ants can be controlled by making the hive ant proof by putting the legs of hive stand pots containing water. Bears and pine martens are the mammals which attack the bees for honey and bees.

### Bee Diseases :

#### A) Brood diseases :

Sr. No.		<i>American Foul brood</i>	<i>European Foul Brood</i>	<i>Sac Brood/Thai sac</i>
1	Causative Organism	<i>Bacillus larvae</i> (Bacteria)	<i>Melissococcus pluton</i> (Bacteria)	brood (Virus) (Bacteria)
2.	Time of death	Late larval or early Pupal stage	Coiled larvae in unsealed cell	Late larval stage
3.	Cappings	Sunken and punctured	Dead brood in uncapped stage	Capping reoved or punctured
4.	Colour of brood	Off white to light cream to brown.	Yellowish to grey or brown	Snow coloured, stage darkening from head
5.	Position of ddead brood	Extended on cell base	Coiled twisted or collapsed	Extended with head curled up
6.	Consistency	Shows ropiness	Sod and gummy to ropiness	Sac line with watery contents
7.	Odour of dead brood	Glue pot	Worker ond end	Faint
8	Brood affected	Worker, rarely drone or queen	Worker, drone and queen	Worker only
9.	Control	Terramycin 0.25-0.4 g in 5 litres sugar syrup feeding		No effective control

#### Adult Diseases :

	<i>Nosema</i>	<i>Acarine</i>
i) Causative Organism	<i>Nosema apis</i> (protozoan)	<i>Acarapis woodi</i> (Endoparasitic nite)
ii) Symptoms	Infected bees collect in front of hive, sluggish, crawlers on leaf blades, distended of domen	Bees gather in front of hive but unable to fly
iii) Control	Feed fumigating 200 sugar syrup to each colony or Entakon-M45 ppm	Fumigate using folbex strip with formic acid.

## Exercise No. 5 & 6

### Bee Pasturage, Bee foraging and Communication

Honey bees gather nectar and pollen from plants as their food. Nectar is a sweet secretion from the floral buds and extra floral nectaries of blossoms is the raw materials for honey. Pollen is a highly proteinaceous food for the bees. The plants that yield these two substances are collectively termed as 'Bee pasturage', Bee forage or 'Nectar and pollen plants'. The days when a good number of plants have nectar to be foraged by bees is called a '**Honey flow period**'. If the nectar yield is copious from a good number of plants of a particular species it is called a "**major honey flow period**". When the amount of nectar to be collected is small the period is called a minor honey flow. The days when there is no honey flow is called "**dearth period**". As nectar and pollen are the raw materials of the beekeeping industry, a good knowledge that govern production of honey, is of paramount importance.

It is interesting to note that the relationship between honey bees and plants is on a give and take basis. Many plants require visits of insects for cross pollination to attract the insects they secrete nectar and have some highly colored blossom parts (corolla). Insects in search for nectar, so over the flowers thoroughly. In this process pollen grains get stuck among their branched pubescence. Every few minutes bees remove pollen from their bodies with pollen brushes and collect surplus pollen in their pollen baskets.

Where as honey bees help bring male and female parts of flower together and thus arrange fertilization of the ovum, the blossoms give them nectar and pollen to eat. The bees make honey from nectar only and not from pollen.

Not all the blossoms are visited by the bees and some of those which are, may be insignificant. A beekeeper who wants to know the nectar potentialities of a locality must ask him the following questions.

What blossoming plants are found in abundance in one or two mile radius of the locality where he wants to keep honey bees?

- 1) How long are their blossoming periods?
- 2) Are the flowers visited by bees for nectar or pollen or both.
- 3) Are bees able to collect surplus honey from some abundant crops of flowers year after year?

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- 4) What are the nectar secreting and flowering plants besides the major crop of the area?
- 5) How long a dearth period? if any, lasts ?

### Foraging Activities of the Bees:

If Nectar secreting plants are available in large numbers, that is, there are one or two major honey flow periods with minor honey flow periods during other parts of the year and the dearth period is not of a long duration. Beekeeping is successful in that locality. Some plants yield only Nectar, others only pollen and still others both.

### Bee flora of Maharashtra

Sr. No.	Common Name	Botanical Name	Source of Nectar or pollen
A) Fruits :			
1	Banana	<i>Musa paradisiaca</i> L. <i>M. sapientum</i> L.	N* + P*
2	Berries	<i>Rubus spp</i>	N** + P**
3	Citrus	<i>Santra, Mosambi, Nimbu, Malta</i>	N** + P**
4	Coconut	<i>Cocos nucifera</i>	P**
5	Wild date palm	<i>Phoenix sylvestris</i>	P**
6	Guava	<i>Psidium guajava</i> L.	N** + P**
7	Jamoon	<i>Syzygium cuminis</i> S. <i>S. fruticosum</i>	N** + P**
8	Jujuba	<i>Zizyphus mauritianna</i> L.	N* + P*
9	Mango	<i>Mangifera indica</i>	N* + P*
10	Pomegranate	<i>Punica granatum</i> L.	N* + P**
11	Cashew	<i>Anacardium occidentale</i>	N* + P*
12	Grapes	<i>Vitis vinifera</i> L.	N* + P*
13	Papaya	<i>Carica papaya</i> L.	N* + P*
14	Sapota	<i>Achras zapota</i> L.	N* + P*

**B) Vegetable :** Acting as minor sources of pollen and nectar because most of them put forth blossom over prolonged periods. Bees are helpful in pollinating vegetables in seed production condition

15	Coriander	<i>Coriandrum sativum</i> L.	N* + P*
16	Cruciferous	<i>Brassica spp</i>	N* + P*
17	Cucuritaceous		N* + P*
18	Lady's figure	<i>Abelmoschus esculantus</i> L.	N* + P*
19	Onion	<i>Allium cepa</i> L.	N* + P*
20	Garlic	<i>Allium sativum</i> L.	N* + P*
21	Peas	<i>Pisum sativum</i> L.	N* + P*
22	Radish	<i>Raphanus sativum</i>	N* + P*
23	Sweet potato	<i>Ipomea batatas</i> L.	P*
24	Brinjal	<i>Solanum melongena</i> L.	N* + P*
25	Potato	<i>Solanum Tuberosum</i> L.	P*
26	Tomato	<i>Lycopersicon esculentum</i> L.	N* + P*
27	Chillies	<i>Capsicum sp.</i>	N* + P*
<b>C) Ornamental :</b>			
28	Holly hock	<i>Althaea rosea</i> L.	N* + P*
29	Honey suckle	<i>Lonicera sempervirens</i> L.	P*
30	Poinsettia	<i>Euphorbia pulcherrima</i> L.	P*
31	Pride of India	<i>Lagerstroemia indica</i> L.	P*
32	Poppy	<i>Papaver somniferum</i> L.	P*
33	Portulaca	<i>Portulaca grandiflora</i> L.	P*
34	Rangoon creeper	<i>Quisqualis indica</i>	N**
35	Roses	<i>Rosia spp.</i>	P*
36	Sunflower	<i>Heliantum annus</i>	N** + P**
37	Zinnia	<i>Zinnia spp.</i>	P*

## Bees Communication :

The honey bee dance was observed and noted by Aristotle as early as 330 BC. Karl von Frisch, a Professor of zoology in Munich, Germany, earned the Nobel Prize in 1973 for his ground breaking research on this dance language. His book *The Dance Language and Orientation of Bees*, published in 1967, presents fifty years of research on honey bee communication.

### Waggle dance –

Honey bee workers perform a series of movements, to teach other workers the location of food sources more than 150 meters from the hive. Scout bees fly from the colony in search of pollen and nectar. If successful in finding good supplies of food, the scouts return to the hive and "dances" on the honeycomb.

The honey bee first walks straight ahead, vigorously shaking its abdomen and producing a buzzing sound with the beat of its wings. The distance and speed of this movement communicates the distance of the foraging site to the others. Communicating direction becomes more complex, as the dancing bee aligns her body in the direction of the food, relative to the sun. The entire dance pattern is a figure-eight, with the bee repeating the straight portion of the movement each time it circles to the center again.

### Round dance-

A series of narrow circular movements, alerts colony members to the presence of food within 50 meters of the hive. This dance only communicates the direction of the supply, not the distance. The sickle dance, a crescent-shaped pattern of moves, alerts workers to food supplies within 50-150 meters from the hive.

### Jostling Dance :

This dance involves the returning foragers jostling their nest mates by running at them and pushing them aside, advancing information on the dance occurrence.

### Spasmodic Dance :

Spasmodic dance involves food distribution interspersed with short tail wagging movements and may be similar to jostling dance in advancing information about resources.

### Buzzing Run :

This is used for signaling or alerting swarm exit or inducing a swarm to alight by buzzing their wings and running through the colony or swarm in a random but energetic pattern. The movement excites the flight activities of the nest mates.

### Shaking Dance :

This is performed by worker bee shaking her body rapidly from side to side to induce nearby workers to groom her.

### Trembling Dance :

This dance is performed when the colony is disturbed. The worker bees are seen trembling by running around twitching.

### **Honey Bees Communication through odour cues (pheromones) :**

Odor cues also transmit important information to members of the honey bee colony. Pheromones produced by the queen control reproduction in the hive. She emits pheromones that keep female workers disinterested in mating and also uses pheromones to encourage male drones to mate with her. The queen bee produces a unique odor that tells the community she is alive and well. When a beekeeper introduces a new queen to a colony, he must keep the queen in a separate cage within the hive for several days, to familiarize the bees with her smell.

Pheromones play a role in the defense of the hive as well. When a worker honey bee stings, it produces a pheromone that alerts her fellow workers to the threat. That's why a careless intruder may suffer numerous stings if a honey bee colony is disturbed.

In addition to the waggle dance, honey bees use odor cues from food sources to transmit information to other bees.

Some researchers believe the scout bees carry the unique smells of flowers they visit on their bodies, and that these odors must be present for the waggle dance to work. After performing the waggle dance, the scout bees may share some of the foraged food with the following workers, to communicate the quality of the food supply available at the location.

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## Exercise No. 7 and 8

### Types of Silkworms, Voltinism and Biology of Mulberry Silkworm

There are five major types of silk of commercial importance, obtained from different species of silkworms which in turn feed on a number of food plants: Except mulberry, other varieties of silks are generally termed as non-mulberry silks. India has the unique distinction of producing all these commercial varieties of silk.

#### Mulberry :

The bulk of the commercial silk produced in the world comes from this variety and often silk generally refers to mulberry silk. Mulberry silk comes from the silkworm, *Bombyx mori* L. which solely feeds on the leaves of mulberry plant. These silkworms are completely domesticated and reared indoors. In India, the major mulberry silk producing states are Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir which together accounts for 92 % of country's total mulberry raw silk production.

#### Tasar :

Tasar (Tussah) is copperish colour, coarse silk mainly used for furnishings and interiors. It is less lustrous than mulberry silk, but has its own feel and appeal. Tasar silk is generated by the silkworm, *Antheraea mylitta* which mainly thrive on the food plants Asan and Arjun. The rearings are conducted in nature on the trees in the open. In India, tasar silk is mainly produced in the states of Jharkhand, Chattisgarh and Orissa, besides Maharashtra, West Bengal and Andhra Pradesh. Tasar culture is the main stay for many a tribal community in India.

#### Oak Tasar :

It is a finer variety of tasar generated by the silkworm, *Antheraea apreyeli* J. in India which feed on natural food plants of oak, found in abundance in the sub-Himalayan belt of India covering the states of Manipur, Himachal Pradesh, Uttar Pradesh, Assam, Meghalaya and Jammu & Kashmir. China is the major producer of oak tasar in the world and this comes from another silkworm which is known as *Antheraea apernyi*.

#### Eri :

Also known as Endi or Errandi, Eri is a multivoltine silk spun from open-ended cocoons, unlike other varieties of silk. Eri silk is the product of the domesticated silkworm, *Philosamia ricini* that feeds mainly on castor leaves. Eri culture is a household activity practiced mainly for protein rich pupae, a delicacy for the tribal. Resultantly, the eri cocoons are open-mouthed and are spun. The silk is used indigenously for preparation of chaddars (wraps) for own use by these tribals. In India, this culture is practiced mainly in the north-eastern states and Assam. It is also found in Bihar, West Bengal and Orissa.

**Muga :**

This golden yellow colour silk is prerogative of India and the pride of Assam state. It is obtained from semi-domesticated multi voltine silkworm, *Antheraea assamensis*. These silkworms feed on the aromatic leaves of Som and Soalu plants and are reared on trees similar to that of tasar. Muga culture is specific to the state of Assam and an integral part of the tradition and culture of that state. The muga silk, an high value product is used in products like sarees, mekhalas, chaddars, etc

**Voltinism** : It is a term used in biology to indicate the number of broods or generations of an organism in a year. The term is often applied to insects and is particularly use in sericulture.

**Univoltine :**

Organisms having one brood or generation per year. Larval weight is comparatively higher and cocoons are heavy. Not suitable for summer and winter rearings. All European races are univoltines e.g. E 16.

**Bivoltine :**

Organisms having two broods or generations per year. Length of larval stage is short. The quality of cocoons is inferior than univoltine. Most of the temperate races are bivoltines e.g. NB4D2, NB18, KA, NB7.

**Multivoltine :**

Organisms having more than two broods or generations per year. Length of larval duration is short. The length of filament is short. Cocoon filament is fine and clean. The larvae are robust and best suited for tropical climates. e.g. Pure Mysore, *C. nichii*, Hosa Mysore.

**Semivoltine :**

Organisms whose generation time is more than one year

**Partial Voltinism** : It is used to refer to two different situations:

- 1) An organism wherein generations overlap in time, and so are not completely reproductively isolated.
- 2) (More commonly) A population where the voltinism is mixed, because of genetic variation (e.g., in the hybrid zone between a univoltine and a bivoltine area) and/or because environmental stimuli do not induce bivoltinism in all individuals (or across all years).

**Biology of Silkworm :**

The silk moth is dioecious, i.e., the sexes are separate. Fertilization is internal, preceded by copulation. The development includes a complicated metamorphosis.

**Eggs :**

300 to 400 eggs are laid in clusters on the leaves of mulberry tree covered by a gelatinous secretion which glues them to the surface of the leaves. The eggs are small, oval and usually slightly yellowish in colour. The egg contains a good amount of yolk and is covered by a smooth hard chitinous shell.

After laying the eggs the female moth does not take any food and dies within 4-5 days. In the uni voltine they may take months because over-wintering takes place in this stage but the multi voltine broods come out after 10-12 days. From the egg hatches out a larva called the caterpillar.

**Larva :**

**The newly hatched:** larva is about 4.00 to 6.00 mm in length. It has a rough, wrinkled, hairless and yellowish white or greyish worm-like body.

**The full grown larva:** is about 6.00 to 8.00 cm in length. The body is distinguishable into a prominent head, distinctly segmented thorax and an elongated abdomen.

**Head** bears mandibulate mouth and three pairs of ocelli.  
**spinneret**, a distinct hook-like structure present for the extrusion of silk from the inner silk-gland.

**Thorax** forms a hump and consists of three segments. Each segment bears pair of jointed true legs. The tip of each leg has a curved hook for locomotion and ingestion of leaves.

**Abdomen** consists of ten segments of which first nine are clearly marked, while the tenth one is indistinct. The third, fourth, fifth, sixth and ninth abdominal segments bear pro-legs or pseudo-legs. Each leg is retractile and more or less cylindrical. The eighth segment carries a short dorsal anal horn. A series of respiratory spiracles are present on either lateral side of the abdomen.

The larva is a voracious eater and strongly gregarious. In the beginning chopped young mulberry leaves are given as food but with the advancement of age entire and matured leaves are provided as food. The caterpillar moves in a characteristic looping manner. The larval life lasts for 2-3 weeks. During this period the larva moults four times. After each moult, the larva grows rapidly. A full-grown larva is about 8.00 cm long and becomes transparent and golden brown in appearance. A pair of long sac-like silk-glands now develops into the lateral side of the body. These are modified salivary glands.

**Pupa :**

The full-grown larva stops feeding and hides itself in a corner under the leaves and begins to secrete the clear and sticky fluid of its salivary glands through a narrow pore called the spinneret situated on the hypopharynx. The sticky substance turns into a fine, long and solid thread or filament of silk into the air. The thread becomes wrapped around the body of the caterpillar larva forming a complete covering or pupal case called the

cocoon. The cocoon-formation takes about 3-4 days. The cocoon serves a comfortable house for the protection of the caterpillar larva for further development.

**Cocoon :**

It is a white or yellow, thick, oval capsule which is slightly narrow in the middle. It is formed of a single long continuous thread. The outer threads, which are initial filaments of the cocoon, are irregular but the inner ones forming later the actual bed of the pupa, is one long continuous thread about 300 metres in length, wound round in concentric rings by constant motion of the head from one side to the other about 65 times per minute.

The irregular surface threads are secreted first and the inner continuous thread later. The silk thread is secreted at the rate of 150 mm per minute. Within a fortnight the caterpillar larva transforms into a conical brownish creature called the pupa or the chrysalis.

The pupa lies dormant, but undergoes very important active changes which are referred to as metamorphosis. The larval organs are lost and the adult organs develop. The pupa finally metamorphoses into the imago or adult in about 2-3 weeks time.

**Imago or Adult :**

The adult moth emerges out through an opening at the end of the cocoon in about 2 to 3 weeks time, if allowed to live. Immediately before emergence, the pupa secretes an alkaline fluid, that softens one end of the cocoon and after breaking its silk strands, a feeble crumpled adult squeezes its way out. Soon after emergence, the adult silk moths mate, lay eggs and die.

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**Exercise No. 09****Mulberry Cultivation, Mulberry Varieties and Methods of Harvesting Leaves****Sericulture :**

**Sericulture** is the rearing of silkworms for the production of raw silk. The major activities of sericulture comprises of food-plant cultivation to feed the silkworms and reeling the cocoons for unwinding the silk filament for value added benefits such as processing and weaving. Although there are several commercial species of silkworms, *Bombyx mori* is the most widely used. Silk-fiber is a protein produced from the silk-glands of silkworms.

Sericulture is ideally suited for improving the rural economy of the country, as it is practiced as a subsidiary industry to agriculture.

**Mulberry cultivation (*Morus* spp., Family : Moraceae) :**

The cultivation of mulberry for the sericulture is known as Mori culture. The important character of the members of the family Moraceae (especially *Morus* spp.) is the presence of idioblast, an enlarged epidermal cell in the leaf

**Ecological Requirements :****Climate :**

Mulberry can be grown upto	-	800 m MSL.
Mean atmospheric temperature	-	13°C to 37.7 °C.
Ideal or Optimum temperature	-	24 °C and 28 °C
Relative humidity	-	65 to 80 percent
Sun shine duration	-	5 to 12 hours per day.
Rainfall range	-	600mm to 2500mm.

Under low rainfall conditions, the growth is limited and requires supplemental irrigation.

On an average, 50 mm once in 10 days is considered ideal for mulberry.

**Soil :**

Slightly acidic soils (6.2 to 6.8 pH ) free from injurious salts.  
Saline and alkaline soils are not preferred.

**Mulberry Varieties :**

Irrigated	:	Kanva 2, MR 2, S 30, S 36, S 54, DD (Viswa), V1
Semi irrigated	:	Kanva 2, MR 2
Rainfed	:	S 13, S 34, RFS 135, RFS 175, S 1635

**Propagation of Mulberry :**

- i) Mulberry is mostly propagated through cuttings.
- ii) Cuttings may be planted straight away in the main field itself or nursery may be raised and the sprouted and rooted saplings may be planted in the main field.

The latter method is advisable because of its easy establishment in the main field.

**Selection of Planting Material :**

- Generally, the mulberry plants are raised from semi-hardwood cuttings from well established garden of 8-12 months old.
- Only full grown thick main stems, free from insect and disease damages having a diameter of 10-12mm are chosen for preparation of cuttings.
- The cuttings should be of 15-20 cm with 3-4 active buds and should have 45° slanting cut at the bottom end.
- Care should be taken to make a sharp clean cut at both the ends of cuttings without splitting the bark.

Manually/power operated mulberry cutter (stem cutting machine) is available for quick cutting of propagation material.

**Nursery Bed Preparation :**

- i) Select 800 sq.m. area of red loamy soil near water source for raising saplings for planting one hectare of main field.
- ii) Apply 1600 kg of Farm Yard Manure (FYM) @ 20 t/ha and mix well with the soil.
- iii) Raise nursery beds of 4m x 1.5m size. The length may be of convenient size depending upon the slope, irrigation source, etc.
- iv) Provide a drainage channel and avoid shady area.

**Pre-treatment of cuttings :**

Mix one kilogram of *Azospirillum* culture in 40 liters of water. Keep the bottom end of the cuttings for 30 minutes in it before planting. *Azospirillum* is applied for inducement of early rooting.

**Nursery Planting :**

- i) Apply VAM @ 100 g/m<sup>2</sup> of nursery area.
- ii) Irrigate the nursery bed. Plant the cuttings in the nursery at 15cm x 7cm spacing at an angle of 45°.
- iii) Ensure exposure of one active bud in each cutting.

**Nursery Management :**

- i) Irrigate the nursery once in three days.
- ii) Dust one kg of any one of the following chemicals around the nursery bed to avoid termite attack.
  - 1) malathion 5D
  - 2) quinalphos 1.5 D

To avoid root rot and collar rot, drench the soil with carbendazim 50 WP (2 g/l) or apply *Trichoderma viride* 0.5 g/m<sup>2</sup> using rose can.

3. After weeding, apply 100 g of urea/m<sup>2</sup> between 55 and 60 days after planting at the time of weeding.

#### Age of Sapling :

The saplings are ready for transplanting in the main field after 90-120 days of planting.

#### Planting Methods :

##### Paired Row System :

Plant the cuttings/saplings at a spacing of 75 / 105 cm x 90 cm. Raise intercrops in the wider inter row space (amenable for mechanization also).

Planting method	Spacing (cm)	
	Irrigated	Rainfed
Ridges and furrows	60 x 60 / 90x90	90 x 90
Pit system	90 x 90	90 x 90

No. of cuttings/ha. : 27,780 (60 x 60 cm); 12,345 (90 x 90 cm)

#### Time of Planting :

- i) Plant during rainy season
- ii) Avoid planting during winter and summer months

#### Planting of Saplings :

- i) Plant the well rooted and sprouted saplings at a depth of 15-20 cm
- ii) Earth up and level the area around the saplings
- iii) Gap fill during monsoon months.

**Nutrient Management :****A) Irrigated Semi-irrigated (kg/ha)**

	Row system			Pit system		
	N	P	K	N	P	K
Recommendation	300	120	120	280	120	120
<b>Split doses</b>						
First crop	60	60	60	60	60	60
Second crop	60	-	-	40	-	-
Third crop	60	60	60	40	-	-
Fourth crop	60	-	-	60	60	60
Fifth crop	60	-	-	40	-	-
Sixth crop	-	-	-	40	-	-

- For V1, fertilizer schedule is 375 : 140 : 140 kg NPK/ha.
- Apply fertilizers as per soil recommendation wherever possible
- Apply the first dose of fertilizers three months after planting
- Follow subsequent fertilizer application after each leaf harvest and pruning
- Apply straight fertilizers to minimize the cost

**B) Rainfed (Kg/ha) :**

	N	P	K
Recommendation	100	50	50
First dose	50	50	50
Second dose	50	-	-

Apply the first and second doses coinciding with South West and North East monsoons respectively.

**Bio-fertilizers :**

Apply *Azospirillum* @ 20 kg/ha in five split doses. Apply phosphobacterium @ 10 kg/h in two equal splits.

Mix the bio-fertilizers with 50 kg of FYM for uniform distribution

Ensure irrigation after application

Do not mix bio-fertilizers with inorganic fertilizers  
Growing and insitu incorporation of sunhemp.

#### Micro-nutrients :

- i) Apply recommended major/secondary nutrients based on the deficiency symptoms.
- ii) For micro nutrients according to the deficiency symptom expressed, apply micronutrients as foliar spary @ Zinc sulphate 5 g, Ferrous sulphate 10 g, Borax 2.5 g, Copper sulphate 2.5 g, Manganese 2.5 g or Sodium molybdate 100 mg/lit of water using high volume sprayer (spray fluid 500 lit/ha).
- iii) Add wetting agent, Teepol @ 0.5 ml/lit. for better adherence on the foliage.

#### Methods of Irrigation :

##### 1) Ridges and Furrows Method :

- i) Most efficient method of irrigation
- ii) Comparatively requires less amount of water
- iii) The furrows serve as drainage channels during heavy rainfall.

##### 2) Flat Bed Method :

- i) Rectangular beds and channels are formed
- ii) Water run off is relatively low
- iii) More land is wasted and requires more labour for field preparation. Most efficient in water use
- iv) Substantial saving in irrigation water
- v) Better crop growth
- vi) Suitable for undulating terrains
- vii) Fertilizers can also be applied along with irrigation water
- viii) Clogging of emitters by physical, chemical and biological impurities
- ix) Initial cost is very high

**Weed Flora :** The common weed flora in the mulberry garden is given below :

Botanical name	English name
<i>Cyperus rotundus</i>	Nut grass
<i>Cynodon dactylon</i>	Bermuda grass
<i>Abutilon indicum</i>	Velvet leaf
<i>Amaranthus viridis</i>	Pig weed
<i>Acalypha indica</i>	Copper leaf
<i>Boerhaavia diffusa</i>	Hog weed
<i>Croton sparsiflorus</i>	Croton

<i>Parthenium hysterophorus</i>	Carrot grass
<i>Trianthema portulacastrum</i>	Carpet grass
<i>Tridax procumbens</i>	Tridax

### Integrated Weed Management :

#### 1) Cultural Method :

- i) Remove the stubbles and roots of weeds while preparing the land
- ii) Use well decomposed manure to avoid dissemination of weeds
- iii) Clean the implements before use

#### 2) Mechanical Method :

- i) Operate country plough after pruning in the inter space
- ii) Remove the weeds by hand hoe

#### 3) Chemical Method

- As post-emergence application, use Paraquat @ 2-3 lit/ha.
- Spray Glycel 7.5 ml with 10 grams of ammonium sulphate per litre of water as post-emergence application. A total of 600 litres of spray fluid is required/ha.
- Use flooding / deflector / fan type nozzle for spraying weedicide. Apply the weedicide immediately after pruning or within 2-3 days after pruning.

### Intercropping

Intercropping with short duration pulse crop enriches the soil, gives additional revenue and also controls the weed growth. Sow the intercrop after pruning and earthing up

### Mulching:

Mulching with pruned mulberry twigs and other materials like straw and dried leaves will have the following advantages

- Controls weed growth
- Conserves soil moisture by reducing run-off
- Increases the infiltration of water
- Reduces the soil temperature

### Pruning Methods :

#### 1)) Bottom Pruning :

The plants are cut at ground level leaving 10-15 cm stump above the ground once in a year

#### 2)) Middle Pruning :

The branches are cut at 40-60 cm above the ground level. After bottom pruning, subsequent cuts are made at 45-50 cm height.

### III) Kolar or Strip System

In closely planted area, this type of pruning is done. The branches are cut at ground level every time. Thus, it receives five prunings every year. This type of severe pruning requires heavy fertilization and irrigation.

**Harvesting :** There are three methods of harvesting of mulberry leaves.

#### 1)) Leaf Picking

Leaves are picked individually from the main stem with petioles. At the same time, the terminal buds are nipped off so that lateral shoots develop rapidly, and sufficient leaves are available for the next crop. Leaf picking starts ten weeks after bottom pruning and subsequent pickings can be done at intervals of about seven to eight weeks. The main advantage of this method is that leaves can be selected to suit the growth stage of the larvae - young ones for the infant and mature ones for the grown-up stages. The main disadvantages are that it requires more labour and further the leaves wither too quickly.

#### 2) Branch Cutting :

This method called 'Batchi' system in Kashmir is also practised in West Bengal and parts of Karnataka in India, and also in Japan and Russia. In this method, the entire branch is harvested and used to feed worms after the III moult directly. Normally, this is used with tree and middling plantations and shoot and floor rearing. This method saves labour in harvesting and also in feeding, spacing and bed-cleaning operations. The hygienic condition of rearing house is easier to be maintained. Leaves of entire branches retain succulency for a longer period and are used to the maximum extent.

#### 3) Whole Shoot Harvest :

This method of harvest consists of cutting the branches to ground level by bottom pruning and feeding the entire shoot to larvae after IV moult. Shoots are harvested at intervals of 10-12 weeks and thus 5-6 harvests are made in a year. As shoots are cut to the ground level, the shoots sprouting reach uniform maturity by next harvest.

This method is popular in Kolar district in Karnataka and Malda district in West Bengal in India. In Japan and Russia, whole shoot harvest is done with mechanical harvesters.

#### Time of Harvest :

It is preferable to harvest the leaves during morning hours.

#### Preservation of leaves :

Use leaf preservation chamber or wet gunny bags to store the leaves or cover the bamboo basket with wet gunny bags to keep it cool and fresh.

**Exercise No. 10****Rearing of Mulberry Silkworm on Artificial Diet /  
Natural Mulberry Leaves****Rearing of Silkworm on Natural Mulberry Leaves :**

Artificial rearing of silk worm on commercial basis for the production of cocoons is known as Sericulture .It requires following infrastructure and equipments .

**Rearing House**

- A separate house is ideal for rearing of silkworm
- The rearing house should have sufficient number of windows to permit cross ventilation.
- Provision should be made to make it air tight for proper disinfection.
- Rearing house has to be built in such a way to provide optimum temperature of 26-28 °C and RH of 60-70% for the growth of silkworm at minimum operational cost

**Important Principles :**

The most important principles to be remembered in silkworm rearing house are :

**Avoid**

- \* Damp condition
- \* Stagnation of air
- \* Direct and strong drift of air
- \* Exposure to bright sun light and radiation

**Ensure**

- \* An equable temperature and humidity
- \* Good ventilation.

**Features :**

- Rearing house should be built depending on the brusing capacity and the method of rearing. The rearing area of 2 sq.ft/ dfl for floor rearing and 3 sq. ft/ dfl for shoot rearing is the general criteria.
- Rearing house should have a main rearing hall, an ante room (8 x 8 ft) and leaf preservation room. Maintaining a separate chawki room (a must for two- plot rearing system; rearing room of size 10' x 14' with a height of 9-10 ft for an acre of garden) ideal.
- Rearing house should face east-west direction.
- Rearing house should have facilities to maintain the required environmental conditions.
- Growing trees around rearing house helps to maintain favourable environment
- Rearing house should be constructed taking consideration the following points such as effective disinfection, washable floor, etc.
- 480 sq.ft area is required for rearing 100 dfls.

**Preparation of Rearing House :**

- Rearing room is to be kept ready after disinfection atleast 3-4 days in advance of commencement of rearing.
- Preconditioning of the rearing house is essential *ie*, arrangement of rearing appliances and provision of essential environmental conditions one day in advance.

**Preparation for Brushing :**

- Before commencement of each rearing, the rearing equipments and rearing houses must be thoroughly washed and disinfected with chlorine dioxide.
- Chlorine dioxide is sprayed on equipments, walls, roof and floor uniformly to destroy the disease causing organisms.
- The rooms should be kept closed for about 24 hours after disinfection.
- The doors and windows should be kept open at least for 24 hours before commencement of rearing to avoid traces of disinfectants.
- To disinfect rearing room and rearing appliances, chlorine dioxide can be used. 500 ml of chlorine dioxide is mixed with 50 g of activator and this is dissolved in 20 litres of water. To this, 100 g of lime powder has to be mixed.

**Rearing Appliances Non-Recurring (General) :**

Disinfection mask and protective gum shoes, Sprayer for disinfection, Room heater, Water air cooler, Kerosene blow lap, Wet and dry thermometer and 6" forceps

**Non Recurring (Specific) :**

Egg transportation box, Egg incubation chamber, Loose egg incubation frame, Black box, Chawki rearing trays, Rearing bottom stand, Feeding Stand, Ant wells, Leaf chopping board, Leaf chopping knife, Leaf mat, Bed cleaning nets, Earthen pot, Litter basket, Late age rearing trays, Rearing stand, Shoot rearing rack, Chandrike, Plastic basin, Buckets, Mug, Plastic box, Foam pads, Foot rugs, Leaf chamber for late age, Leaf basket and Cleaning nets

**Recurring :**

Paraffin paper, Formalin, Bleaching powder, Lime powder, Bed disinfectants, Slides and cover slips, Gunny cloth and Cora cloth

**Disinfection :**

- Spray 2 % formalin with 0.3% slaked lime or 2.5 % chlorine dioxide with 0.5 % slaked lime @ 2 l/m<sup>2</sup> area for disinfecting the rearing house immediately after completion of rearing and three days before brushing.
- Dip the rearing equipments in 2 % bleaching powder solution and sun dry before use.
- Dust 5% bleaching powder with slaked lime powder @ 200 g/m<sup>2</sup> around the rearing house and passages and sprinkle water @ 1 lit / m<sup>2</sup> floor area.

**Incubation of Egg and Hatching :**

- The egg sheets should be spread out as a single layer in a chawki tray.

- Temperature of 25°C and humidity of 80 per cent are maintained. For this, paraffin papers and wet foam pads may be used.
- When the eggs come to head pigmentation stage (about 48 hours before hatching), they should be kept in dark condition by wrapping them in black paper or by keeping them in a box (black boxing). On the expected day of hatching, eggs are exposed to light, early in the morning to ensure uniform hatching. This facilitates uniform development of embryo.
- Most of the eggs (90 to 95 per cent) will hatch in about 2 to 3 hours.

#### **Low cost Method of Preservation of Eggs :**

- The eggs can be kept in an earthen incubation chamber.
- Draw the diagram and observe how humidity is maintained in the chamber.

#### **Brushing :**

- The hatched larvae should not be starved and they must be brushed on a paraffin paper in a rearing tray or blue polythene sheet (Rearing bed).
- This is done by sprinkling chopped tender mulberry leaves of size 0.5 to 1 cm<sup>2</sup> over the hatched larvae. The larvae crawl on to the leaves.
- After 8 to 10 minutes, the egg sheet is inverted over rearing tray and gently tapped.
- Worms that are still attached to the egg sheets should be gently removed to the tray with a feather.
- A rearing bed is prepared and some more chopped leaves, if necessary, are sprinkled.
- To prevent drying of leaves and to maintain the required humidity in the rearing bed, wet foam pads and paraffin paper covering are provided.

#### **Young Age silkworm (Chawki) Rearing :**

- In a tray of 120 cm x 90 cm x 105 cm size, 20 dfls are brushed and reared upto second stage.

#### **Selection of Leaves :**

- From brushing to the end of second age, the larvae are fed with tender leaves.
- The leaves are selected from the largest glossy leaf, 3rd or 4th from the top.
- The next 6 to 8 leaves are used to rear the young age worms upto II moult.
- The size of the chopped leaf is around 0.5 to 1.0 sq.cm. during 2nd age.
- Illustrate with the help of a figure, the selection of leaves from a fully grown branch.

#### **Leaf Preservation :**

- Silkworm grows best when fed with succulent leaves which are rich in nutrients and moisture.
- The leaves, if not preserved properly, dry up and become unsuitable for feeding.
- The harvested leaves must be preserved in fresh condition in a wet gunny cloth.
- If the climate is too hot and dry, the leaves are preserved in a leaf chamber which is lined with gunny cloth.
- The cloth is kept wet by spraying water at frequent intervals.

**Cleaning :**

- It is the process of removing the silkworm excreta and left over leaves in the rearing bed
- In the first age, one cleaning is given just a day before the worms settle for moulting.
- In the second age, two cleanings are given, one after resuming feeding and the other before second moult.
- A net with mesh size of 0.5 x 0.5 cm is spread over the rearing bed and feeding is given.
- The worms crawl through the net and come to fresh leaves.
- The net along with the worms and leaves are transferred to another tray.
- The left over leaves and litter are discarded.

**Moulting :**

- At the time of moulting, care should be taken not to disturb the worms.
- Correct detection of moult and stopping or resuming feeds are very important for uniform growth of silkworms.
- During moult, the rearing bed should be kept thin and dry by applying lime @ 30 – 50 g/m<sup>2</sup> and should have proper aeration.

**Late Age silkworm rearing :**

- The third, fourth and fifth instar larvae are considered as late age worms. They are reared in bamboo trays. Newspapers are spread over the trays to absorb excess moisture in leaves and faecal pellets.
- The temperature and humidity requirement gradually comes down as the stage advances.
- Leaves of medium maturity (6<sup>th</sup> leaf onwards) are fed in the third and fourth age and coarse leaves are fed in the fifth age.
- Over matured and yellow leaves should be rejected, since they may induce disease outbreak.

**Bed Disinfectants :** Apply bed disinfectants like TNAU Seridust, ReshamJyothi, Vijetha or Sajeevini @ 4 kgs/100 dfls.

Stage (before feeding)	Bed disinfectant (Qty/100 dfls) (g)
After 1st moult	50
After 2nd moult	150
After 3rd moult	800
After 4th moult	1000
On fourth day of final instar	2000
<b>Total</b>	<b>4000</b>

**Moulting :**

- Remove the paraffin papers
- Evenly spread the larvae in the rearing bed 6-8 h before settling for moult.
- Provide air circulation to avoid excess humidity inside the room.

- Provide charcoal stove/heaters to raise the room temperature during winter.
- Apply lime powder at 60 minutes before resumption of feeding daily during rainy/winter seasons to reduce the dampness in bamboo trays.

#### **Mouthing :**

- Apply Sampoorna @ 20 ml (dissolved in 4 l of water) per 100 dfls over the leaves for early and uniform spinning of cocoons.
- After attaining full growth in the final instar, the worms cease to feed and are ready to spin.
- Such worms are slightly translucent and raise their heads to find a place for spinning.
- These worms have to be picked up and transferred to a mountage for spinning cocoons.
- Mounting of worms should not be delayed as the ripened worms will waste silk.
- About 800-900 worms per m<sup>2</sup> are to be kept on a mountage. For 100 dfls, about 30 to 40 chandrikas are required.
- Mountages should be kept under shade in well ventilated place.

#### **Care during spinning :** Quality of silk depends on the care taken at the time of spinning.

- Mature worms are sensitive to temperature, humidity, light, etc., at the time of spinning.
- The ripe worm requires space equal in area to square of the length of its body for spinning.
- Proper spacing avoids wastage of silk for forming preliminary web and avoids double cocoons.
- To prevent staining of cocoons, keep mountage in an inclined position so that the urine may drop to the ground.

#### **Maintenance of Humidity :**

- Fluctuation of humidity causes abrupt thinning and thickening of silk filament.
- A relative humidity of 60-70% is ideal for spinning.
- Provide proper ventilation and straw mats below the mountage to quid excreta.
- Provide even and moderate lighting. Improper lighting (bright light or dark shadow) causes crowding of larvae to shaded area leading to double cocoons.
- Remove dead worms and non-spinners on the 2nd day of spinning.
- To protect the silkworm from predatory ants, apply malathion 5% dust/lakshmanrekha at the base of mountage stand.

#### **Harvesting :**

- The silk worms complete spinning in 2 to 3 days but the cocoons should not be harvested at this time as the worms inside are still in the prepupal stage.
- Harvesting should be done on the fifth day (7th day for bivoltine hybrids) when pupae are fully formed and hard.
- Do not harvest when the pupa is in amber colour.
- Dead and diseased worms on the mountages should be removed before harvest.

- Marketing of cocoons should be done on the sixth day (8th day for bivoltine hybrids).

**Shoot rearing for Late age worms :** Silkworm larvae consume 85% of their food requirement during fifth instar. Fifty per cent of the labour input is utilized during the last seven days of rearing.

**Rearing House :**

- Provide separate rearing house for shoot rearing in shady areas. Separate room should be provided for young age worm rearing, leaf storing and hall for late age worm rearing.

**Shoot Rearing Rack :**

- A rearing rack of 1.2m x 11m size is sufficient to rear 50 dfls.
- Provide 15 cm border on all sides of the shelf to prevent the migration of the larvae.
- Arrange the shelves in three tier system with 50 cm space between the tiers.
- Fabricate the rack stand with wood, or steel and the rearing seat with wire mesh/bamboo mat.

**Shoot Harvesting :**

- Harvest the shoots at 1 m height from ground level at 60 to 70 days after pruning.
- Store the shoots vertically upwards in dark cooler room.
- Provide thin layer of water (3 cm) in one corner of storage room and place the cut of shoots in the water for moisture retention.

**Feeding :**

- Provide a layer of newspaper in rearing shelf.
- Disinfect the bed, spread the shoot in perpendicular to width of the bed.
- Place top and bottom ends of the shoots alternatively to ensure equal mixing of different qualities of leaves.
- Transfer the third instar larvae to shoots immediately after moulting.
- Watch for feeding rate from 4th day of fourth instar. If 90% of larvae have not settled for moulting, provide one or two extra feedings.
- Provide 3 feedings during rainy/winter months and 4 feedings during summer rearing.

**Spacing :** 18-36 m<sup>2</sup>/100 dfls.

**Bed Cleaning :**

- Bed cleaning is done once during second day of fifth instar following rope (or) net method.
- In rope method, spread 2 m length of rope (two numbers) at parallel row leaving 0.5 m on other side.
- After 2 to 3 feedings, ends of the ropes are pulled to the centre to make it into a bundle.
- In net cleaning method, spread 1.5 m<sup>2</sup> size net across the bed.

- After 2 or 3 feedings, the nets are lifted and the old bed is cleaned and disinfected.
- Transfer the net to newer shelf, spread the net over the shoots; larvae will migrate to lower layer.

#### Advantages :

1. Labour saving upto 70% when compared on hour to hour basis with leaf feeding method.
2. Leaf saving upto 15-20%. Hence, leaf cocoon ratio is less by 2-3 kg and extra cocoon production.
3. Better cocoon characters and effective rate of rearing (ERR).
4. Better preservation of leaf quality both during storing and on the bed.
5. More organic matter production (upto 18 tonnes per ha per year).
6. Better hygienic conditions can be maintained.
7. Handling of silkworms minimised. Hence, contamination and spreading of disease reduced.
8. Bed cleaning only once after IV moult.
9. Worms and leaves are kept away from the litter. Hence, chances of secondary contamination are minimised.
10. Labour dependent risk is reduced.

#### Disadvantages :

1. Required rearing room floor area is more (by 30%)
2. Bed refusals will not be available as a cattle feed.
3. Planting materials (cuttings) will not be available.

## Exercise No. 11

### Studies on Strains / Species of Lac Insects, Host Plant and their identification

Lac is a resinous exudation from the body of female scale insect. Since Vedic period, it has been in use in India. Its earliest reference is found in Atherva Veda.

The English word lac synonyms Lakh in Hindi which is derivative of Sanskrit word Laksh meaning a lakh or hundred thousand. Lac is Nature's gift to mankind and the only known commercial resin of animal origin.

The first scientific name given to it was *Tachardia lacca* following the name of French Missionary Father 'Tachardia'. It was later changed to *Laccifer lacca* Kerr. The other name given to it has been *Kerria Lac* Kerr.

Phylum	-	Arthropoda
Class	-	Insecta
Order	-	Hemiptera
Suborder	-	Homoptera
Super family	-	Coccoidea
Family	-	Lacciferidae
Genus	-	<i>Laccifer lacca</i>

Lac Insect belongs to super family Coccoidea which includes all scale insects. Scale insects range from almost microscopic size to more than 2.5 cm. These insects attach themselves in great numbers to plants. The mouth part of these insects is piercing and sucking type. They can be very destructive to tree-stunting or killing twigs and branches by draining the sap.

There are six genera of lac insects, out of which only five secrete lac, and only one, i.e. *Laccifera* secretes recoverable or commercial lac.

The commonest and most widely occurring species of lac insect in India is *Laccifera lacca* (Kerr) which produces the bulk of commercial lac.

Lac insect of South East Asia is *Kerria chinensis*.

#### Distribution :

It is found distributed in South-East Asian countries. Lac is currently produced in India, Myanmar, Thailand, Malaya, Lao and Yuan province of China. India and Thailand are main areas in the world, while India has prime position in relation to lac production.

Lac cultivation is introduced into Thailand from India.

Over 90% of Indian lac produced comes from the states of Bihar, Jharkhand, West Bengal, Madhya Pradesh, Chattisgarh, Eastern Maharashtra and northern Orissa. Some pockets of lac cultivation also exist in Andhra Pradesh, Punjab, Rajasthan, Mysore, Gujarat, and Mirzapur and Sonbhadra districts of Uttar Pradesh.

#### Life Cycle :

Lac insect is a minute crawling scale insect which inserts its suctorial proboscis into plant tissue, sucks juices, grows and secretes resinous lac from the body. Its own body ultimately gets covered with lac in the so called 'CELL'. Lac is secreted by insects for

protection from predators.

**Male :** are red in colour and measures 1.2 - 1.5mm in length. It has reduced eyes and antennae. Thorax bears a pair of hyaline wings.

**Female :** are larger than male, measures 4-5 mm in length and has a pyriform body. The head, thorax and abdomen are not clearly distinct. The antennae and legs are in degenerated form, and wings are absent.

**The life cycle :** about six months

**Life Stages :** egg, nymph instars, pupa and adult.

**Mode of Reproduction :** ovoviviparous.

Female lays 200-500 ready to hatch eggs, (the embryos are already fully developed in eggs when these are laid). Eggs hatch within a few hours of laying, and a crimson-red first instar nymph called crawlers come out.

**Crawler :** measures 0.6 x .25 mm in size.

**Nymphal Period :** 5 weeks

The emergence of nymph is called swarming. The nymphs crawl about on branches. On reaching soft succulent twigs, the nymphs settle down close together at rate of 200-300 insects per square inch. At this stage, both male and female nymphs live on the sap of the trees. After a day or so of settling, the nymphs start secreting resin from the glands distributed under the cuticle throughout the body (except mouth parts, breathing spiracles and anus).

The resin secreted is semi-solid which hardens on exposure to air into a protective covering. The nymphs molt thrice inside the cells before reaching maturity. The duration of each instar is dependent on several factors, viz. temperature, humidity and host plant. After the first moult, both male and female nymphs lose their appendages, eye and become degenerate. While still inside their cells, the nymphs cast off their second and third moult and mature into adult.

**Adult Maturity :** Both the male and female larvae become sexually mature in about eight weeks.

**Male :** Only the male one undergoes a complete metamorphosis or transformation into another form; it loses its proboscis and develops antennae, legs and a single pair of wings. It is contained in a brood cell somewhat slipper like with a round trap door (operculum) through which it emerges. The adult male is winged and walks over the females to fertilize them.

**Female :** The female brood cell is larger and globular in shape and remains fixed to the twig. The female retains her mouth parts but fails to develop any wings, eyes or appendages. While developing, it really becomes an immobile organism with little resemblance to an insect. Females become little more than egg producing organisms. The

female increases in size to accommodate her growing number of eggs. Lac resin is secreted at a faster rate, and a continuous layer coalesces or grows into one body.

After fourteen weeks, the female shrinks in size allowing light to pass into the cell and the space for the eggs. About this time, two yellow spots appear at the rear end of the cell. The spots enlarge and become orange coloured. When this happens, the female has oviposited a large number of eggs in the space called 'Ovisac'.

The ovisac appears orange due to crimson fluid called lac dye which resembles cochineal. It indicates that the eggs will hatch in a week time.

When the eggs hatch, larvae emerge and the whole process begins all over again. After the cycle has been completed and around the time when the next generation begin to emerge, the resin encrusted branches are harvested. They are scraped off, dried and processed for various lac products. A portion of brood lac is retained from the previous crop for the purpose of inoculation to new trees.

### Host Plants:

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. Lac insects have 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.

About 113 varieties of host plants are mentioned as lac host plant. Out of which the followings are very common in India:

- 1) *Butea monosperma* (Vern. Palas)
- 2) *Zizyphus spp* (vern. Ber)
- 3) *Schleichera oleosa* (Vern. Kusum)
- 4) *Acacia catechu* (Vern. Khair)
- 5) *Acacia arabica* (Vern. Babul)
- 6) *Acacia auriculiformis* (Vern. Akashmani)
- 7) *Zizyphus xylopyrus* (Vern. Khatber- grown in part of M.P. & U.P.)
- 8) *Shorea talura* (Vern. Sal grown in mysore)
- 9) *Cajanus cajan* (Vern. Pigeon-pea or Arhar)
- 10) *Grewia teliaefolia* (Vern. Dhaman preferred in Assam)
- 11) *Albizia lebbek* (Vern. Siris/Gulwang)
- 12) *Flemingia macrophylla* (Vern. Bholia)
- 13) *Ficus benghalensis* (Vern. Bargad)
- 14) *Ficus religiosa* (Vern. Peepal)

**Strains of Lac Insects :** In India, Lac insect is known to have two distinct strains: Kusumi and Rangeeni.

**Kusumi Strain :** grown on kusum or on other host plants using kusumi brood.

**Rangeeni Strain :** thrives on host plants other than kusum. The life cycle of lac insects take about six months, hence, two crops a year can be obtained. In case of kusumi strain, two

crops are: i) Jethwi (June / July) and (ii) Aghani (Jan. Feb.)

In case of rangeeni, two crops are:

- i) Kartiki (Oct. / Nov.) and
- ii) Baisakhi (May / June).

The crops have been named after Hindi months during which these are harvested.

The lac of rangeeni crops is harvested while it is still immature. Aghani and baisakhi of rangeeni strain are the main crops contributing about 90% of lac production, remaining 10% is contributed by kusumi crops. The kusumi crop lac is considered superior resin, because of the lighter colour of resin, and it fetches better price.

#### **Lac Cultivation :**

Lac cultivation is done by putting brood lac on suitably prepared specific host plants. The brood lac contains gravid females which are about to lay eggs to give birth to young larvae. After emergence from mother cells, the young larvae settle on fresh twigs of host plants, suck the plant sap and grow to form encrustations.

#### **Disadvantages in Local practices of Lac cultivation :**

- i) The same host plants are continuously exploited without giving rest for recoupment.
- ii) Only natural inoculation occurs.
- iii) Partial harvest is done leaving few branches untouched for auto inoculation of next crop and no pruning is done.

As a result of the defective local practices, host trees loss the vigour and unable to throw out new succulent shoots, and in course of time, the trees become weak and die. The self inoculation leads to need of artificial inoculation

#### **Artificial inoculation :**

Artificial inoculation is brought about by the agency of man. The main idea behind the artificial inoculation is to check the drawbacks of natural inoculation. In this method, the host plants are first of all pruned in Jan. or June.

**Pruning :** means cutting away old, weak and diseased twigs. It induces host plants to throw out new succulent twigs.

- i) Pruning should be done with a sharp instrument (secator, pruning Saw and pruning knife) to give a sharp and neat cut.
- ii) Only light pruning should be carried out.
- iii) In artificial inoculation, brood twigs are cut in size 20 - 30 cm in length.
- iv) the cut pieces of brood twig are tied to fresh tree twigs in such a way that each stick touches the tender branches of trees at several places.
- v) The nymphs swarm from brood and migrate to tender and succulent twigs and infest them.
- vi) Following swarming, the brood twigs should be removed from the host plant, as this would decrease the chance of pest infestation.

### Precautions to be taken during Artificial inoculation :

- i) Fully mature and healthy brood pest infestation free brood should be taken.
- ii) Brood should not be kept for long and used immediately after crop cutting.
- iii) Tying of the brood lac stick should be done securely on the upper surface of branches. This will prevent falling of twigs and provide full contact for quick and easy crawling of the nymphs.
- iv) Some times due to bad weather, swarming of nymphs from brood is prevented. Hence, the room storing brood lac sticks is moderately heated to 20°C to induce swarming, and then sticks are tied.
- v) Generally, cultivation of kusumi in rangeeni area and vice versa should be avoided. Brood lac from a particular host used year after year is likely to deteriorate in quality. Therefore, alternation of brood and host should be done to improve the quality.

### Inoculation Period :

Strains	Crops	Inoculation period	Harvesting period
Kusumi	Jethwi	Jan. /Feb.	June/July
	Aghani	June/July	Jan/Feb
Rangeeni	Kartiki	June/July	Oct. /Nov
	Baisakhi	Oct. /Nov	May/June

## Exercise No. 12

### Identification of Other Important Pollinators and Scavengers

Pollination refers to the transfer of anther to stigma in flowering plants for sexual reproduction.

Insect 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.

Sr. No.	Pollination classes	Type of insects
1)	Melitophily	Bees
2)	Cantharophily	Beetles
3)	Myophily	Syrphid and Bombyid flies
4)	Sphigophily	Hawk moths
5)	Psychophily	Butterflies
6)	Phalaeophily	Small moths

#### A) Insect Pollinators :

Insect pollinators include bees, (honey bees, solitary species, bumblebees); pollen wasps (Masarinae); ants; flies including bee flies, hoverflies and mosquitoes; lepidopterans, both butterflies and moths; and flower beetles. Vertebrates, mainly bats and birds, but also some non-bat mammals (monkeys, lemurs, possums, rodents) and some lizards pollinate certain plants. Among the pollinating birds are hummingbirds, honeyeaters and sunbirds with long beaks; they pollinate a number of deep-throated flowers. Humans may also carry out artificial pollination.

Many insects other than bees accomplish pollination by visiting flowers for nectar or pollen, or commonly both. Males of many species of Hymenoptera, including many hunting wasps, rely on freely flowering plants as sources of flowers.

Prominent examples are predatory wasps (especially Sphecidae, Vespidae, and Pompilidae). The term pollen wasps, in particular, is widely applied to the Masarinae, a subfamily of the Vespidae; they are remarkable among solitary wasps in that they specialise in gathering pollen for feeding their larvae, carried internally and regurgitated into a mud chamber prior to oviposition.

Many bee flies, and some Tabanidae and Nemestrinidae are particularly adapted to pollinating fynbos and Karoo plants with narrow, deep corolla tubes, such as *Lupeirousia* species.

Lepidoptera (butterflies and moths) also pollinate plants to various degrees. They are not major pollinators of food crops, but various moths are important pollinators of other commercial crops such as tobacco.

Various midges and thrips are comparatively minor opportunist pollinators. Ants also pollinate some kinds of flowers, but for the most part they are parasites, robbing nectar without conveying useful amounts of pollen to a stigma.

Hoverflies are important pollinators of flowering plant worldwide. Often hoverflies are considered to be the second most important pollinators after wild bees.

Adult mosquitoes act as pollinators while they feed on nectar. *Aedes communis*, a species found in North America, is known to be pollinating the *Platanthera obtusata*, commonly referred as the blunt-leaved orchid.

Some Diptera (flies) may be the main pollinators at higher elevations of mountains. Whereas *Bombus* species are the only pollinators among Apoidea in alpine regions at timberline and beyond.

Bats are important pollinators of some tropical flowers, visiting to take nectar. Birds, particularly hummingbirds, honeyeaters and sunbirds also accomplish much pollination, especially of deep-throated flowers. Other vertebrates, such as kinkajous, monkeys, lemurs, possums, rodents and lizards have been recorded pollinating some plants.

## B) Scavengers :

Animals that feed on dead flesh or carrion are called Scavengers. This feeding behaviour is common to some vertebrates, such as vultures and coyotes, but also happens among invertebrates, such as insects. Scavenger insects are essential to the ecosystems in which they exist, as they clear away rotting flesh and vegetation. Scavengers are typically omnivorous, feeding opportunistically. Many animal orders include scavengers from the largest big cats to the smallest insects. Blow flies, flesh flies, harvester ants, some species of yellow-jacket wasps and several species of beetles feed on dead flesh.

### 1) Beetles :

Beetles of the families Siphidae or carrion beetles, Staphylinidae or rove beetles, and Scarabaeidae or dung beetles feed on a variety of decaying organic material, including dead flesh. Common carrion beetles in North America include the small American carrion beetle (*Necrophila Americana*), the giant carrion beetle (*Nicrophorus americanus*) and the gold-necked carrion beetle (*Nicrophorus tomentosus*). The devil's coach-horse beetle (*Ocypus olens*) is a species of rove beetle while giant Amazonian carrion scarab beetle (*Coprophanaeus lancifer*) is among the largest dung beetles that also eat carrion.

### 2) Flesh Flies :

Flesh flies are members of the family Sarcophagidae, which feed on carrion throughout their development stages, from maggot to adult. Flesh flies can carry several pathogens, including the *Leprosy bacilli*, which is transmitted to people who eat meat contaminated with eggs or larvae. Common genera of flies include *Blaesoxipha*, *Gymnopsidia* and *Opsidia*.

### 3) Ants and Wasps :

Although most ant species feed on plants, some species of harvester ants also eat carrion, thus playing an important role in the recycling of organic matter in forest ecosystems. Closely related to ants and also part of the order Hymenoptera, some wasps such as the North American Western yellow-jacket (*Vespula pensylvanica*), also eat dead animals.

**Exercise No. 13****Mass Production Technique of Factitious host  
*Corcyra cephalonica* Staint.**

In India *Corcyra cephalonica* is said as a laboratory host for mass production of *Trichogrammatid* \ *Chrysopids*, *Chelonus blackburni*, Mirid bugs, *Copidosoma*, Anthocorid bugs and entomophagus nematodes etc. The *Corcyra* larvae are also used to multiply larval or larvo-pupal parasitoids. Enough care is taken to avoid excess of direct sunlight to rearing room. A temperature of  $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$  with relative humidity (R.H.) 60 to 80% and Moderate light are to be maintained for good production of Rice grain moth.

**Rice meal moth**

Botanical name	:	<i>Corcyra cephalonica</i> ,
Family	:	Pyralidae
Order	:	Lepidoptera.

**Facilities and Materials required :**

One rearing room (rat proof) of size 15' x 12' x 8' size with Air Conditioner  
Installation round plastic trays of 12" diameter x 7" height with cover fitted with fine iron net 100 Numbers, slotted angle iron-racks 10 Numbers, working tables 2 Numbers  
oviposition drums transparent buckets 6 Numbers, coarsely ground grains of sorghum (as per requirement) 250 kg, granular yeast 500 gms, crushed groundnut 10 kg, hot air oven, UV chamber, Refrigerator, Micronized sulphur 80%, scissors, brushes, measuring cylinder, cotton, honey, rectangular plastic trays, petri-plates, sieves, fresh eggs of *Corcyra* for infestation, streptomycin sulphate, mosquito net, muslin cloth, room heater (for winter season), plastic tubes, sodium hypochloride, formalin.

**Procedure / step involved in production of Laboratory- host *Corcyra cephalonica***

1. Procure sorghum grains suitable for human consumption, Sorghum grains should not be treated with insecticides.
2. Sorghum is milledly crushed to make 3 pieces of each grain.
3. Heat crushed sorghum grains in oven at  $100^{\circ}\text{C}$  for 30 minutes to sterilize.
4. After sterilizing, these grain should be sprayed with 0.1% formalin which helps to prevent the growth of moulds as well as increase in the moisture in the grains to the optimum 13% which was lost due to heat sterilization.
5. Pour 2.5 Kg crushed sorghum along with other ingredients per plastic tray.

**Ingredients:**

1. Crushed sorghum grains - 2.5 kg.
2. Crushed groundnut seed -100 gms.
3. Granular yeast - 5 gms.
4. Micronised 80% wettable Sulphur - 5 gms.
5. Streptomycin Sulphate - 0.05% solution ( 25 to 30 ml. per box /tray).
6. Fresh & live corcyra eggs, half (C.C.) cubic centimetre per tray, then mix corcyra eggs in the mixture of tray and secure the cover of the box Keep the boxes on the racks. Maintain the temp of the rearing room about 27° to 30 °C.
7. Collect the moths by placing the trays in mosquito net after 40 days, daily and transfer into oviposition drum batchwise, put about 1000 moth per drum.
8. Corcyra moths are fed with 10% honey solution in water, with soaked cotton swab. Keep swab in hanging position in the oviposition chamber.
9. Daily collection of eggs up to 4 to 5 days . After 5th day the Oviposition chamber is cleaned.
10. The collected *Corcyra* eggs be passed through 15, 30 and 40 mesh sieve and run over a slope of paper to eliminate the dust particles and scales of the moths.
11. Peak period of *Corcyra* moth emergence between 60 to 75 days, it reduces after 100 days , thereafter this culture is discarded , boxes should be cleaned and reused again.
12. Use of UV Lamp :-The eggs are treated with UV rays 15 Watt Ultra violet tube for 45 minutes at a distance of 20 cms to prevent hatching.

**Yield:** About 4-5 thousand moths per box could be obtained and as such from one cc of *Corcyra* eggs reared in each wooden box ie about 10cc eggs, 200 *Corcyra* moths give 1cc eggs per day, 1cc = 16000 *Corcyra* eggs.

**Problems in *Corcyra* culture :**

1. *Bracon hebetor* is a larval parasitoid of *Corcyra* which may suppress the *Corcyra* culture to a maximum extent and can be controlled by water and light traps , secondly by using sticky material on glass window pan and spraying of DDVP or malathion followed by 1% formalin solution.

2. Red rust flour beetle *Tribolium castenium* can be controlled by heating crushed grains at 100°C for 30 minutes and separation of fine flour by sieving.
3. Store grain mites *Pediculoides ventrococcus* may contaminate the *Corcyra* culture and affect egg laying and larval development. If mites are observed, the racks, cages, boxes etc. should be disinfected with and placed in the sun for several hours, boxes should be dusted with sulphur.
4. If infestation is severe, treat with the acaricide dicofol (Kelthane). muslin cloths are dipped in a 0.05% of dicofol and for a couple of hours. These sheets are spread over the crushed sorghum grains in boxes. Mites coming in contact with Kelthane treated cloth are killed rapidly.
5. For control the bacterial diseases to *Corcyra* culture Streptomycine sulphate is added to the sorghum @ 20 to 50 milligrams per tray and mix thoroughly.

#### Precautions:

1. Use low heighted room of *Corcyra*, as the escaped moths resting on the walls & roof ceiling can be collected easily.
2. Use separate room for mass rearing of *Corcyra* to avoid the adult ration of the culture.
3. Each box should be kept for 3 to 4 months only and then clean them with 2% formalin.
4. Conceal only 1000 adults *Corcyra* moths per oviposition drum to avoid overcrowding.
5. Moths should be fed with Vitamin E capsules to enhance fecundity.

## Exercise No. 14

### Mass Multiplication of Parasitoids - *Trichogramma chilonis*, *Chelonus blackburni*, *Goniozus nephantidis*

#### A) *Trichogramma chilonis* :

Trichogrammatids (Family- Trichogrammatidae, Order- Hymenoptera) are one of the most important groups of biotic agents for the suppression of several lepidopterous pests all over India and widely distributed species of egg parasitoid in India and abroad. Over 200 insect species are parasitized by various strains of Trichogrammatids. Out of 26 *Trichogramma* species recorded in India *T. chilonis*, *T. japonium*, *T. achaeae* are key mortality factors for many crop pest. In India, this egg parasitoid is mostly used against pest like Sugar cane borer, *Chilo* spp., paddy stem borer *Scirpophaga incertulas*, tomato fruit borer *Helicoverpa armigera*, cotton bollworm *Pectinophora gossypiella* and *Earias* spp. Maize stem borer *Chilo partellus* and cut worms *Agrotis* spp. etc. Trichogrammatids are minute parasitic wasp having 0.4 to 0.7 mm size.

#### Biology:-

Egg period	-	16-24 hours.
Larval period	-	23 days.
Pupal period	-	2 to 3 days.
Adult period	-	2 to 3 days.
Total Period	-	7 to 10 days.

In rainy and summer season 9 to 12 days in winter season, only adults of *Trichogramma* are visible and other stages are internally developed. For mass production of Trichogrammatids laboratory host used in India - Rice grain moth - *Corcyra cephalonica* USA, USSR-Angoumois grain moth - *Sitotroga cerealella*, China : Oak silk moth - *Antherea pernyi*.

#### Techniques for preparation of Trichocards

##### Material required:

Working tables, Table lamp, Scissors and brushes, *Corcyra* eggs, Printed Tricho cards, Polythene bag, Rubber bands, Sieve, Camel gum, Absorptive cotton, Glass tubes (15x3cm), Petri-plates, Black century paper, Tea strainer, Wall thermometer and Hygrometer etc., Room temperature  $27^{\circ} \pm 2^{\circ} \text{C}$  with R.H.  $80 \pm 5\%$ .

##### Steps involved in production (preparation of Trichocards)

- 1) Apply 5-6 drops of gum and smear with the puf of absorbant cotton, under table lamp, on the marked portion on the Trichocards .

- 2) On this, spread the UV treated *Corcyra* eggs uniformly with the help of sieve on the card, by pouring the eggs from glass tube tapping with the fingers through sieve. 1.25cc. eggs (Approximately 20,000 eggs) one trichocard.
- 3) Allow this card to dry under table lamp and fan for 15 – 20 minutes.
- 4) A nucleus strip of *Trichogramma* parasitized eggs (2.5 x 5.0cm) by keeping host parasitoid ratio 6:1 and is kept one day earlier in polythene bag ( 45 x 30 cm ) tightly closed with rubber bands .
- 5) In this polythene bag, place above Trichocard and again close with rubber bands .
- 6) Keep this ballooned polythene bag as such for 3 – 4 days in the rack or on the working table.
- 7) Observe the blackening of cards after 3 – 4 days indicating the completion of parasitism.
- 8) This parasitized card should be removed on 5th day and put it in fresh packing polythene bag.
- 9) A group of such 10 poly covered cards be put in large polythene bag to store in the refrigerator at 6° to 10° C temp. for 20 to 30 days .

#### Utility of Trichocards or Field release:

**Note:** Read the instructions on the backside of card for release of *Trichogramma* in the field.

#### Releases:

Five cards i.e. 1 to 1.5 lakh parasitized eggs of *Trichogramma*/ha against crop pests on cotton, sunflower, paddy, sugarcane, tomato, brinjal, jawar, maize etc.

#### Precautions:

It is advisable to observe following precautions during packaging and release for better results.

- 1) Trichocards should be packed keeping parasitized eggs surface on inner side.
- 2) Emergence date should be specified on cards for guidance of the user.
- 3) Cut pieces of Tricho cards should be stapled on the inner-side of the leaf to avoid direct sunlight.
- 4) Card pieces should be stapled in morning hours and just before emergence to avoid predation.

- 5) In case adult *Trichogramma* is released, the farmers should open the bag after days from the date of egg parasitism, move along the rows and go on tapping the bag.
- 6) Do not use pesticides in the field where *Trichogramma* are released. If need arise use selective/ safer pesticides. Ensure that pesticides are used 15 day before or after *Trichogramma* release.

### Use of Trichocards

- 1) Use trichocards just before date of emergence.
- 2) First cut the card breadth-wise along middle cross line in to equal big strips Then make small segments along marking as per requirement. One card gives 20 segments.
- 3) Staple one segment /plant in cotton and other crops under middle leaf of plant at 10m x 10m distance.
- 4)

Sr. No.	Crops & pest	Cards/ha Per release	Crop Age at 1st release (days)	No. of releases	Release interval (days)	Most effective spp.
1.	Sugarcane borers	3 to 4	21	4 to 6	10	<i>T.minutum</i> & <i>T.chilonis</i>
						<i>T.japonicum</i> <i>T.chilonis</i>
2.	Cotton bollworms	5	45	10	7	<i>T.achae</i> ,
3.	Tomato/ okra/ brinjal Fruit Cabbage DBM borer	3 to 4	45	4 to 5	7	<i>T.pretiosum</i> & <i>T.chilonis</i>
4.	Maize stem /cob borer	3 to 4	45	3 to 4	10	<i>T.chilonis</i>
5.	Paddy stem borer	3 to 4	30	3 to 4	10	<i>T.japonicum</i>

A private firm, Pest Control of India (PCI) Ltd., BCRL Biological Control Research Laboratory and P.D.B.C. Bangalore and TNAU, Coimbatore, S.8.1. Coimbatore such other several private personnels have started the mass production of *Trichogramma*, at present in India. Such egg cards are available for sale @ Rs. 35/- per card, containing 20,000 parasitized eggs.

### B) *Chelonus blackburni* :

Cotton bollworms cause severe losses (40%) in yield of seed cotton. *Chelonus blackburni* is highly potent egg-larval parasitoid of the bollworms. Method of mass multiplication of the parasitoid is given below :

- 1) Rearing unit of *Corcyra cephalonica* staint which include wooden boxes, crushed grains of sorghum, egg cards, gum arabic *Corcyra* eggs, etc.
- 2) Rearing unit of potato tuber moth, which includes potato tubers, plastic baskets, sterilized soil, puncturing brush, egg-sheet of Potato tuber moth etc.
- 3) Breeding glass jars, muslin cloth, rubber bands, scissor, wide mouth plastic jars etc.
- 4) Nucleus culture of *C. blackburni* adults.

#### Laboratory host :

- a) Rice moth, *Corcyra cephalonica* staint.
- b) Potato tuber moth, *Phthorimaea operculella* Z.

#### Target pest :

- a) Pink bollworm, *Pectinophora gossypiella* S.
- b) Spotted bollworm, *Earias* spp.
- c) Potato tuber moth, *Phthorimaea operculella* Z.

#### Method :

*C. blackburni* is an exotic internal solitary egg larval parasitoid and is uniparental in nature. One adult parasitoid parasitizes 70-100 eggs and on *Corcyra* culture, it completes the life cycle within 30-35 days. Whereas on Potato tuber moth culture, life cycle of the parasitoid is completed in 26 days.

Following steps are involved in mass rearing of *C. blackburni* on *C. cephalonica* culture.

- 1) Paste 1 cc of *Corcyra* eggs. For this purpose, use only freshly laid 0-24 hours old eggs of the host. Do not kill the egg embryo.
- 2) Expose the egg card for 24 hours in a glass jar containing the freshly emerged adult parasitoids of *C. blackburni*. During parasitization, adult parasitoids may be provided with 50 per cent honey solution on wax paper on in cotton wicks. About 100 adult parasitoids can be used to parasitize 0.25 cc of the host eggs with the live embryo.
- 3) Remove parasitized eggs card and with the live embryo.

- 4) Place the convenient sized pieces of parasitized egg on the 1 inch thick layer of the crushed sorghum gains filled in wooden box or jar, cover the top of the wooden box with its lid or jar with muslin cloth or rubber band. The parasitized eggs hatch and the larvae carrying the parasite start feeding on broken grains. The parasite development continues by feeding on internal part of the larvae.
- 5) After a period of 1 month, the parasitoid, completes its life cycle and adult emergence starts, which can be collected with aspirator and used for further multiplication. Beside this, after about 25 days of parasitization of eggs, the pupae of the parasitoid which are silvery white in colour may be collected from larval grain webbing. Such pupae, as per requirement, could be stored for 17 days at 10°C temperature. In case mass culturing of *C. blackburni* on PTM, follow same procedure as given for *C. koehleri* parasitoid. Here eggs sheet of PTM may be exposed to adults of *C. blackburni* and parasitized egg sheet after 24 hours of exposure, may be introduced into plastic basket with the punctured potato tubers placed on soil layer. The pupae of parasitoid could be collected by sieving the soil or collect emerging adults with aspirator.

#### Use of *C. blackburni* for field release :

**Dose :** The parasitoids could directly be released in the field crops or even in stored potatoes (Arnies).

1) **Potato :** Release 50,000 adults per week / release and such 2 releases in the field crop. In case of stored potatoes 2 adults/kg tubers week against PTM.

2) **Cotton :** Release 50,000 adult parasitoids / ha / week for bollworm.

#### Precautions :

- 1) Do not keep the height of broken grains more than 1 inch in the jar/box. Otherwise parasitoid emergence may be affected.
- 2) Plant flowering shrubs along the field margin to provide food to parasitoids in off season.
- 3) Avoid use of pesticides before and after 15 days of release and follows strip or staggered spray technique for pesticide use and release the parasitoid on alternate untreated strip.

### Exercise No. 15

## Mass multiplication of Predators : *Chrysoperla* spp. and Australian Lady Beetle - *Cryptoleamus montrouzieri*

### A) Mass Production Technique of *Chrysoperla* spp.

Green lace wing (Aphid lio), *Chrysoperla* spp. is a potent predator of many sucking pests viz. Aphids, white flies, jassids, eggs and early stages of lepidopterous caterpillars. *Chrysoperla* spp. belongs to family Chrysopidae and order Neuroptera.

In India, 67 species belonging to 21 genera have been recorded from various crop ecosystems. Among them, *Chrysoperla carnea*, *C. scelesters*, *Mallada boninensis*, *M. Astus* and *Aptertochrysa crassinervis* are the most common. The green lace wing is being mass produced primarily on the eggs of rice moth, *Corcyra cephalonica*.

#### Adult Food

- 1) Water (Clean) - 50 ml.
- 2) Honey - 2.5 g.
- 3) Protinex - 5 gm.
- 4) Granular yeast -100 mg.
- 5) Fructose - 1 g.

A piece of sponge soaked in above mixture should be kept on the netted nylon cloth at the top of the chamber.

#### Note :

- 1) Fresh food be provided daily.
- 2) Eggs be collected daily along with century paper.

#### Rearing of Chrysopid Larvae:

- 1) The century paper having eggs be cut into small pieces in 2 x 2 cm. size and placed in gogglets.
- 2) In this gogglet, the irradiated (UV treated) eggs of *Corcyra* be poured (2 to 3 cc.).
- 3) Cover this gogglet with fine muslin cloth with rubber band.
- 4) After 2 to 3 days, the larvae of chrysopa be kept separately in each glass vial or plastic container to avoid cannibalism.
- 5) Provide sufficient quantity of irradiated (800 - 1000) *corcyra* eggs as a host.
- 6) Observe the pupation after 6 days.
- 7) Remove the unused eggs.
- 8) Observe the adult emergence after 5 - 6 days daily from this.
- 9) Transfer the newly emerged adults in the oviposition chamber.

### Utilization of Chrysopids :

Normally chrysopids are recommended 10,000 eggs per ha. against different Crop pests, sucking pests like aphids, jassids thrips, whiteflies, mealy bugs psyllids, mites and eggs and early larval stages of bollworms, *Spodoptera*, *Helicoverpa* attacking crops viz., cotton, sunflower, tobacco, ground nut Sugar cane woolly aphids, fruit crops - oranges etc.

### *Mallada boninensis*

#### Method of release :

Cut the small pieces of *Chrysopa* card in which single card strip contain 3 eggs. Such one piece is to be stapled to the leaf of each plant where the infestation of the host insect is available. After release, on the next day, hatching of the *Chrysoperla* eggs takes place and larvae may start feeding on available stage the insects.

Note: For 10 to 12 days do not use pesticides.

## B) Mass Production Technique of Australian Lady Bird Beetle

*Cryptolaemus montrouzieri* Mulsant,  
(Coccinellidae :Coleoptera)

Mealy bugs, *Planococcus citri* is potential pests of guava, citrus, custard apple, pomogranate, grape etc. fruit crops. Waxy mealy secretion of pest protects it from chemical pesticides and the pest problem is aggravated. Australian lady bird beetle, *Cryptolaemus montrouzieri* was proved to be a potential predator of the mealy bugs on fruit crops. There is increasing demand to the predator from grape growers in the country.

Other species of lady bird beetle are :

- 1) *Coccinella septempunctata* (septum=seven & punctata =spots).
- 2) *Cheilomenes sexmaculata* (serrated black margin like design or line on wings) The mass production technique of the lady bird beetle is given below.

#### Material:

1. Nucleus culture of *C.montrouzieri* predatory beetle and Mealy bug.
2. Red pumpkin, sprouted potatoes.
3. Rearing cages, plastic trays, plastic jars and slotted angle iron racks.
4. Burlaps strips and paper strips, scissors, muslin cloth, rub 0.1% solution, brush, etc.
5. Honey – agar diet prepared with honey 10 ml, sugar 5 gm, agar-agar 250 mg water 25 ml mixture.

**Laboratory host :** Mealybugs, *Planococcus citri* -Eggs, Nymphs and adults.

**Target host :** bugs on grape vine and other fruit crops.

**Method :**

The predatory beetle, *C. montrouzieri* needs to be reared on its host species of mealy bugs under laboratory conditions. Hence, the development of culture of mealy bugs is a pre-requisite factor. The mass production of mealy bugs could be done on ripened red pumpkins as well as on potato sprouts. But its rearing on red pumpkins is more practical and economical.

**Rearing of mealy bugs on potato sprouts:**

Fill wooden trays of 45 x 45 x 10 cm. sized with sandy silt soil up to 2 to 3 cm. depth or planting potatoes. Place 25 to 36 whole potato tubers about 2 cm. apart in the tray and cover slightly with moist soil. Fill such trays frequently. Maintain the temperature in a rearing room between 20 to 30 °C. Put ovi-sacks of mealy bugs over the potato sprouts. Within 20- 25 days, mass culture of mealy bugs could be obtained in such trays.

**Rearing of mealy bugs on red pumpkins:**

To facilitate easy handling, medium sized pumpkins with ridges and furrows, and grooves with small stalk and of medium sized may be selected for the mealy bug rearing. Clean the pumpkins with water to remove dust particles on it and treat with 0.1% Bavistin solution (1 gm. / lit water) to prevent its rotting during rearing process. The wounds, if any on the pumpkins may be plugged with paraffin wax. Then keep such pumpkins in a plastic trays, introduce the ovi-sacks of mealy bugs on the pumpkins. After 2 days, such infested pumpkins may be kept in wooden cages provided with sliding glass at front and wire gauge or cloth on other sides. These cages may be placed on working tables/racks in rearing room. The mealy bugs will be developed fully within 30-40 days.

**Biology of mealy bugs:**

A female lays	-	300 - 500 eggs in its ovi-sac
Incubation period	-	5 days,
Nymphal period	-	3 weeks.( nymph undergoes 2 instars each one of a week period),
Adult period	-	5 - 7 days,
A life cycle	-	30 - 40 days.

**Rearing of predator, *C. montrouzieri***

The method adopted by Fisher (1963) may be followed for rearing of the predator. When mealy bugs are of 8-10 days old, a stock of 15-20 females of *C. montrouzieri* could be placed in the rearing cages, containing infested red Pumpkins or potato sprout at the temperature of 20 - 30 °C. The released mated females of the predator feed on eggs (preferably), nymphs and adults mealy bugs. Later on these females deposit their eggs on

potato sprouts / pumpkins in wooden tray. Remove the ovipositing adults from the trays after 12 days. On hatching, larvae feed on stages of mealy bugs. Attach paper strips to the front of the trays to accommodate pupating larvae of the predator. During this period keep darkness in the room. Put paper strips & put fully developed larvae with mealy bugs as food in plastic jars and provide paper strips for its pupation. The emerging adults may be collected in a plastic bowls and fed with honey-agar diet as well as mealy bugs (eggs). Pair the newly emerged male and female of predator and confine them in petri plate or plastic jar with lid and use for further mass production.

#### Biology of *C. montrouzieri*

Pre-oviposition period	:	7-12 days,
Oviposition period	:	39 - 63 days,
Egg period	:	4 - 8 days,
Grub period	:	14 days,
1st instar	:	2 - 4 days, with
2nd instar	:	3- 5 days
3rd instar	:	2- 4 days,
Pre-pupal period	:	1-2 days,
Pupal period	:	7-11 days.

#### Utilization of *C. montrouzieri* for field release:

For field release, both larvae as well as a beetles could be utilized. Adult beetles are released by opening the lid of jar containing beetles, which will fly away where as larvae could be kept in mealy bug colony with the help of brush.

Dose : Release 2 - 3 larvae per bug colony, Release 1500 adults/ha.

The mealy bugs are reported on 29 plant species including grape, custard apple, guava, pomogranate, ber, mango, okra, glaricidia, acalypha, croton, mulberry etc.

#### Precautions:

1. Do not feed adult predatory beetles only on honey-agar diet, but supplement it with mealy bug eggs as it affects fecundity of the predator.
2. Avoid insecticide application in the field where predatory beetles are released. If insecticide spray is necessary keep 7-10 days distance between release of predator and insecticide spray and follow staggered spray technique. For this 1st spray alternate tree and release predator on remaining untreated (alternate) trees after 4 to 5 days. Next time after 15 days on pre sprayed trees for faster control of pest by chemical + biological method and conservation of the released predators.

**Exercise No. 16, 17 and 18**  
**Visit to Research and Training Institution / Unit of Bee**  
**Keeping, Sericulture, Lac Culture and Bio-agent Production**  
**Unit**

Lined area for writing answers, consisting of multiple horizontal dashed lines.