# INDEX

**Ex.no.1. STUDIES ON HONEY BEE COLONY: BEE SPECIES AND CAST OF BEES**

**Aim: 1)** To become familiar with different species and sub-species of honey bees found in the world and know their economic importance.

**2)** Differentiating hive bees from wild bees and species from subspecies. There are four well known species of true honey bees (belonging to genus *Apis*) in the world:

**DIFFERENT SPECIES OF HONEY BEES**

i. Rock bee, *Apis dorsata* F. ii. Little bee, *A. florea* F. iii. Asian bee, *A. cerana* F.
iv. European bee, *A. mellifera* L.

**Characteristics of four well known species of honey bees:**

| **Characteristics** | ***Apis dorsata*** | ***Apis florea*** | ***Apis cerana*** | ***Apis mellifera*** |
|---|---|---|---|---|
| Nesting | Open nesting. Builds single large comb (ca 1m2) attached to branches of trees or rocks etc. | Open nesting. Builds single small comb (ca size of palm of hand) fixed to branches of bushes. | Cavity nesting. Builds many parallel combs in cavities of tree trunks, hollows of rocks, poles and other covered places | Cavity nesting and similar in habits to *Apis cerana* and builds parallel combs. |
| Distribution in India | Found in plains as well as hills up to 1600 metres above sea level. Highly migratory. | Found in plains up to 300 metres above sea level. Highly migratory. | Found throughout India having 3 subspecies | Exotic bee to India. Introduced successfully in 1962. It has many subspecies (more than 23)throughout world |
| Size | Biggest honey bee (16-18mm) | Smallest *Apis* bee (9-10mm) | Medium size (14-15mm) | Medium size (14-16mm) |
| Swarming/ Absconding | Strong tendency | Strong tendency | Strong tendency | Strong tendency only in African sub species |
| Temperament | Furious | Mild | Furious | Gentle except African sub species |
| Average honey yield per colony/year | 40 kg (wild bees; cannot be domesticated) | 500 g (wild bees; cannot be domesticated) | 5 kg (Hive bees; can be domesticated) | 15 kg Hive bees; can be |
| of Honey extraction | By squeezing (unhygienic) | By squeezing (unhygienic) | By centrifugal honey extractor from the hived bees (hygienic). | By centrifugal honey extractor from the hived bees (hygienic). |
| Number of cells/10cm comb (worker cells) | 18-19 | 32-36 | 21-25 | 17-19 |

**Species and subspecies of hive bees**: It is important to know difference between a species and subspecies. Species are reproductively isolated from each other and these cannot interbreed where as subspecies are geographically isolated and can interbreed Among the two domestic bee species, each has many subspecies in different parts of the world e.g. *Apis cerana* has three subspecies in India: *A. cerana cerana* in Himachal Pradesh and Jammu and Kashmir (North India) *A. cerana indica* in Kerala, Tamilnadu and Karnataka. (South India) *A. cerana himalaya* in Nagaland, Manipur, Mizoram, Assam and Meghalaya. (Eastern parts of India) In addition to above three subspecies, *A. cerana japonica* has been identified from Japan. *A. mellifera* has many subspecies which can be placed under three groups: 1. Eastern subspecies
2. European subspecies
3. African subspecies

**Eastern subspecies:**

*i. Apis mellifera remipes* (in Iran)
*ii. A. mellifera syriaca* (in Syria, Israel and Lebanon)
These subspecies are not suitable for modern beekeeping **European subspecies:**
*i. A. mellifera mellifera* (Dark Dutch or German bee)
*ii. A. mellifera carnica* (Carniolan bee; in Southern Austria)
*iii. A. mellifera ligustica* (Italian bee; Italy)
*iv. A. mellifera caucasica* (Caucasican bee; USSR)
**African subspecies:** Some of the important subspecies are**:**
*i. A. mellifera intermissa* (Tellian bee; Morocco and Lybia)
*ii. A. mellifera lamarckii* (Egyptian bee; restricted to the Nile Valley)
*iii. A. mellifera capensis* (Cape bee; the only bee which can rear queen from eggs laid by workers
*iv. A. mellifera adansonii* (African bee; also known as killer bee)

In India, all the four bee species are found. *A. mellifera* is an exotic bee which was introduced in India for the first time successfully in 1962 at Nagrota Bagwan, Himachal Pradesh. Honey yield from this species from stationary bee keeping varies from 10-15 kg/colony but through migration yield increases to 45-60 kg/colony. One bee keeper in Himachal has extracted as much as 110kg honey from a single colony of *A. mellifera* which is indicative of its potentials.

**Other species found in different parts of the world:** In addition to the four *Apis* honey bee species, more species have been reported from some parts of the World.
*i. Apis laboriosa* (from Bhutan, Yunnan and Nepal)
*ii. A. breviligula* (from Philippines)
*iii. A. binghami* (from Sulawesi) Above three species resemble *A. dorsata* and are wild
*iv. A. andreniformis* (from China) It resembles *A. florea*.
*v. A. koschevnikovi* (from Malaysia)
*vi. A. nuluensis* (from Malaysia, Indonesia)
*vii. A. nigrocincta* (from Indonesia).

These three species (v - vii) resemble *A. cerana*. **Stingless honey bees:** In addition to honey bees of genus *Apis*, stingless honey bees also provide honey which are:
i) *Melipona* sp.
ii) *Trigona* sp.

These bees are also domesticated, but produce little amount of honey. **Pollen bees:** All the honey bee species are good pollinators besides being honey producers. In addition to these, there are more than 20000 species of other bees which help in pollination. It should be clear that all bees are not honey bees. Batra (1992) has even separated non Apis bees in a separate group of 'pollen bees' that includes all bees except honey bees which help in pollination.

## COLONY ORGANIZATION, DIVISION OF LABOUR AND LIFE CYCLE

**Aim: 1)** To observe organization of a honey bee colony and become familiar with their duties.

**2)** To become familiar with developmental stages and life cycle of different castes of bees.

**Colony organization and division of labour :**

Honey bees are social insects and live in colonies. A normal colony, during active season is composed of 3 kinds of individuals: one queen, thousands of workers (10000 to 30000 or even more) and few hundreds of drones, which vary in size. In addition, each colony has different developmental stages *viz* eggs, larvae and pupae which are collectively known as brood.

**Queen:** Only one queen is found in a colony except under supersedure or swarming instinct . She is the mother of the whole colony producing workers and drones and is the only perfectly developed female member of the colony. Her function is to lay eggs. She does not have motherly instinct or ability to feed the brood. She is fed lavishly by a large number of nurse bees with highly nutritious food known as royal jelly .A good queen can lay 1500-2000 eggs per day

A laying queen is the longest bee in the colony. It has larger thorax than worker and her bdomen gets greatly distended during egg laying .The queen lays both fertilized and unfertilized eggs. Fertilized eggs produce workers (also queens) and unfertilized eggs produce drones (Figure 1)

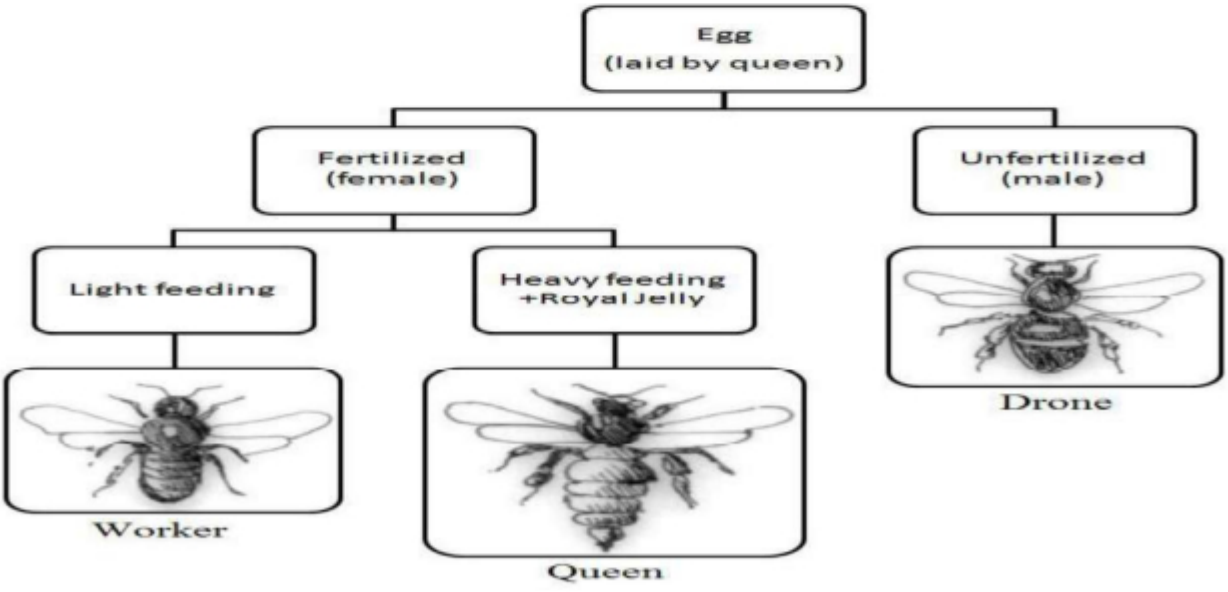



**Figure 1 .Development of different castes of honey bees based on quality and quantity of food and whether fertilized or unfertilized (After Winston)**

A good mated queen may work satisfactorily for 2 or more years, although queens can live eight years or longer. However, in commercial beekeeping, queen is replaced every year to keep high brood rearing in a colony. Queen releases queen substance (**pheromone**) which helps in the colony organization. It acts as worker attractant and inhibits ovary development in worker bees as well as raising new queen. Absence of queen pheromone is detected after about 30 minutes of queen loss and colony may start raising new queen. The pheromones in queen substance stimulate brood rearing, comb building, hoarding and foraging in a colony and thus play important role in normal working of a colony. The virgin queen mates with a number of drones (5-7) within 5-10 days of emergence in the air (**not inside the hive**) and spermatozoa are stored in spermatheca. Stored sperms are utilized to fertilize eggs throughout her life till exhausted.

**Worker:-** Workers are imperfect females. They are unable to mate though they may start egg laying if a colony remains queen less for long period . The workers perform all the useful work in the colony

**Duties of workers include:** Cleaning of the hive, feeding of larvae, raising queen cells when required, ventilate hive, guard the hive entrances, secrete bees wax, construct the combs, collect the nectar and convert it into honey ,collection of pollen, water and propolis, produce a predigested food of royal jelly for feeding queens and young larvae and scouting for a new nest site during swarming. The workers also feed the drones but when not needed, they are thrown out of hive.

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

| **Age of Worker Bee** | **Duties performed** |
|---|---|
| a) Till 3rd day of emergence | Maintain wax cells in sanitary state, cleaning their walls and floors after the emergence of young bees. |
| b) From 4th-6th day of emergence | Feed older larvae with mixture of honey and pollen and making flights around the hive for getting layout of the hive, (play flights or orientation flights)? |
| c) From 7th-11th day of emergence | Hypopharyngeal glands (food glands) get developed and start secreting royal jelly and feed younger larvae. |
| d) From 12th to 18th day | The bees develop wax glands and work on building of comb, construction of cells etc., Receive the nectar, pollen, water, propolis etc., from field gatherers and deposit in the comb cells and help in keeping the brood warm. |
| e) From 19th day onwards | The worker bees take the duty of field i.e. exploring or foraging for nectar and pollen; collect collecting water and propolis. |

Worker bees release alarm pheromone on stinging from lining of sting chamber and it assists in defense of the colony by alerting other colony members of the threat .A worker has an average life of only 40-50 days during honey flow season (active period) and her life may extend up to 6 months during off season.

**Laying workers**: Under queenless conditions for a long duration, ovaries of some of the workers start developing and they can lay even eggs but since these are unfertilized, give rise to only drones. The eggs laid by the laying workers have haphazard pattern and many eggs are laid in each cell of the comb. The colonies with laying workers ultimately perish. ***A. mellifera capensis*** is the exception where even from the eggs of laying workers queen and workers are raised by the bees.

**Drone:** Drones neither perform any duty inside the hive nor do they collect food from flowers. Each drone is fed by 3 to 4 worker bees. A colony rears and tolerates the drones only during breeding season when new queens are being produced and are later driven out of the colony to die of starvation. The sole function of a drone is to mate once which costs him his life. Maximum life of drone honey bee in summer is 59 days.

**Life cycle:** Queen deposits egg at the base of cell and fastens with mucilaginous secretion. After 3 days egg hatches and workers provide pearly white food in which "C" shaped larva floats. Cell is sealed when larva is fully grown. In the sealed cell it turns into pupa from which adult emerges. Larva sheds skin five times during development. The sealed cells containing worker and drone brood and honey can be differentiated on the basis of appearance.

**Development:** The developmental stages of honey bees are: egg, larva, pupa and the adult. Duration of life stages of different castes of honey bee varies which is given in the table and presented through Fig 2 below:

| **Caste** | **Egg period (days)** | | **Larval Stage(days)** | | **Pupal Stage (days)** | | **Total (days)** | |
|---|---|---|---|---|---|---|---|---|
| | ***A. cerana*** | ***A. mellifera*** | ***A. cerana*** | ***A. mellifera*** | ***A. cerana*** | ***A. mellifera*** | ***A. cerana*** | ***A. mellifera*** |
| **Queen** | 3 | 3 | 5 | 5 | 7-8 | 8 | 15-16 | 16 |
| **Worker** | 3 | 3 | 4-5 | 5 | 11-12 | 12-13 | 18-20 | 21 |
| **Drone** | 3 | 3 | 7 | 7 | 14 | 14 | 24 | 24 |

**Ex.no.2. BEE KIPPING APPLIANCES AND SEASONAL MANAGEMENT**

**BEE KEEPING EQUIPMENT**

**Aim: 1)** To become familiar with different equipments used in modern beekeeping for domesticating hive bees.

2) To get detailed information on structure and size of movable frame hives used for domestication of *Apis cerana* and *Apis mellifera.*

1. **Bee hive:** L.L. Langstroth discovered the principle of bee space in 1851 in the U.S.A. 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. We can say that bee space is optimum distance between two surfaces in a bee hive essential for normal movement and functioning of bees. This principle was a big discovery for modern beekeeping. The modern hive has been designed on the bases of principle of bee space in which frames can be easily moved. The bee space measures 9.52 mm for *A. mellifera* and this was modified for *A. cerana* to be between 7 and 9 mm. Different parts of movable frame bee hive are shown in Fig3.

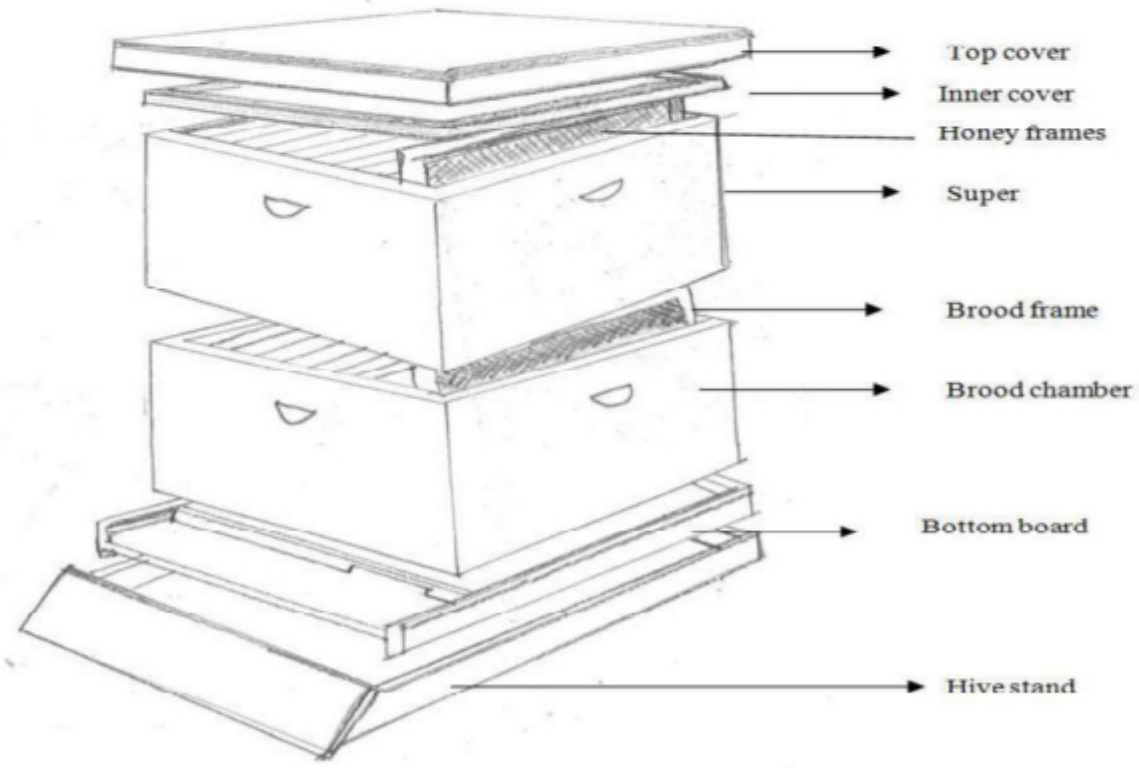



**Figure 3. Parts of a movable frame hive**

**Stand:** To support bottom board.

**Bottom board:** It is floor of the hive having an entrance for bees. On this board brood chamber rests.

**Brood chamber:** Chamber used for rearing of brood. Frames are placed in this chamber on which bees raise combs. The dimensions and number of frames vary with the type of hive. A wooden dummy board is used to limit the size of brood chamber and is placed at the end of brood frames.

**Frame:** Each frame consists of a top bar, two side and a bottom bar. Inner aspect of the top bar has a groove for fixing comb foundation sheet. Side bar has 4 holes for wiring the frame. The frame holds a comb.

**Dimensions of hive:** In general for *A. mellifera* we use Langstroth hive (named after L.L. Langstroth) and for *A. cerana*, BIS (Bureau of Indian Standard) hive A and B type. In 1995, BIS introduced C-type hive based on Langstroth hive, for *A. mellifera*. Well seasoned wood of "Kail, "Toon", teak or rubber can be used for making good quality bee hives. Wood having strong smell is not used. Dimensions of different types of bee hives being used in India are given below:

**Table: Dimensions of bee hives**

| **Hive parameters** | **BIS hive C type for *A. mellifera*** (Langstroth type; Fig. 6.2b)) | **BIS hive A & B type for *A. cerana*** (Modified Newton and Jeolikote types; Fig. 6.2a) |
|---|---|---|
| **Frames** | Contains 10 frames | May contain 4, 8 or 10 frames |
| **Super Chamber** | Generally full super chamber is used. | Half (shallow) super chamber is generally used. |
| **Brood/super frame size** | Outside 448x232mm Inside 428x192mm | **Type A: Modified Newton Type** Outside 230x165mm Inside 210x145mm **Type B: Modified Jeolikote Type** Outside 300x195mm Inside 280x175mm |
| **Bee space** | 10 mm | **Type A** 7 to 9 mm **Type B** 8 or 9 mm |

**Super:** Dimensions may be same as that of brood chamber or half of it (depending on type of bee hive). This is the chamber where bees store surplus honey.

**Inner cover:** A board which acts as a partition between brood/super chamber and the roof .

1. **Top cover:** A type of lid acting as roof placed over inner cover.

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

**3. Observation hive:** Small hive with glass sides so as to observe movements and behavior .

**4. Comb foundation mill:** Used to print natural cell size of desired comb foundation sheet. **5.**
**5. Bee veil:** Used for preventing bee stings on face and neck.

**6**. **Smoker:** Used to calm down the bees while opening the hive.

**7**. **Uncapping knife:** Large sized knife used to uncap the frames before honey extraction.

**8**. **Hive tool:** An iron strip used for opening of hive and it's cleaning.

**9. Queen cell protector:** A spring like structure for protecting queen cells.

**10. Queen cage:** Used to introduce a queen to new colony and also to transport the queen.

**11. Bee brush**: To brush the bees from frames.

**12. Feeders:** Different types of feeders are used for feeding sugar syrup to the bee colonies. These can be (i) slow feeder (friction top pail feeders) in which holes are made in the lid and the feeder is placed inverted inside the hive (ii) fast feeder (division board feeder) which is of the size of a regular frame and the trough contains a wooden float inside the cavity.

**13. Swarm basket:** Basket to catch bee swarm.

**14. Queen excluder:** Perforated zinc sheets or round wires assembled in such a way that workers can pass through them and queen cannot (perforation size is 4.20mm for *A. mellifera* whereas worker thorax size varies from 3.33 to 3.50mm). It is used during honey flow season to restrict queen to brood chamber and thereby preventing egg laying in the super. It is also used in maintaining multiple queen system in a colony.

**15. Honey extractor:** It is a machine to centrifuge out the honey from uncapped frames.

**16. Wax melter:** Double walled chamber for melting of bees wax for making comb foundation sheets.

**17. Pollen trap:** For trapping corbicular pollen of returning bee foragers. For *A. mellifera* pollen trapping screen has holes of 4.7 to 5mm. and for *A. cerana* 3.5 to 3.7mm.

**18. Bee escape:** To provide one way passage to bees.

**SEASONAL MANAGEMENT OF HONEY BEE COLONIES (SPRING MANAGEMENT)**

**Aim: 1)** To understand basic principles of honey bee management.
**2)** To understand management practices required for scientific management of honey bee colonies during spring season.

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.

Generally, beekeeping activities start with the onset of spring in cold areas. Therefore, it is appropriate to know the management practices, starting from spring. However, in some parts of the country there are different seasons and the management varies as per season.

**SEASONAL MANAGEMENT**

The climate and vegetation in different areas is different from season to season. Hence, follow specific management tactics as follows:

**Honey Flow Season Management:** Provide more space for honey storage by giving artificial comb foundation sheets. Place queen excluder sheets in between brood and super chamber to confine the queen to brood chamber to prevent egg laying in super chamber as it is meant for honey production. Prevent swarming. Prior to honey flow, use sugar syrup to stimulate the queen to start laying in the spring.

Divide strong colonies into 2-3 new colonies, if colony multiplication is required. Artificial queen grafting technique may be followed to produce new queens for new colonies. By following this technique, queens can be produced throughout the year. In normal case queen cells are constructed only in honey flow season.

**Summer Management :**To reduce the effect of high temp in summer the colonies are kept under shade of trees or shade provided with sheds. Place gunny bags on all sides of beehive except entrance and sprinkle water twice a day. Increase ventilation by introducing a splinter between brood and super chamber .Provide sugar syrup and pollen supplement. A source of fresh water within a short distance of an apiary is essential. Water is required to blend with the food and to lower the temperature of the hives during hot weather.

**Winter Management:** Strong colonies perform well in winter as more bees produce heat. All cracks crevices and holes should be closed. The direction of hives should be in such a way to avoid winds entering. Artificial diet should be given to maintain strong and disease free colonies. Provide new queen to the hives. Winter packing in cooler areas.

**Rainy Season/Monsoon Management:** A regular examination of the colony immediately after rains. Clean the hive to reduce undue water contents inside the hive. While raining when bees are confined to the hive, feed them with sugar syrup.

## Ex.no.4. BEES ENEMIES AND DISEASE AND THEIR MANAGEMENT

PREDATORY WASPS

Honey bee colonies are attacked by a large number of enemies. For efficient management, the colonies require appropriate protection from these enemies. It is important to understand nature and extent of damage caused by the bee enemies and how to prevent and control them? Some of the important enemies requiring regular attention of a beekeeper are described below.

**1. Predatory wasps:**

***Vespa velutina* (*V. auraria*) Nests on tree tops/buildings *Vespa magnifica* Under-ground nest.*Vespa tropica* (*V. cincta*) Underground nest.*Vespa basalis* 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 (Fig. 16.2) - Sometimes even *V. basalis* has been found causing severe damage to the colonies (Fig. 16.3)- The weak colonies may even perish due to its attack.

**Prevention and control:**- Kill the fecunded females visiting the apiary during spring by flapping - Burn the nests during night time - In fire prone places destroy the nests by spraying them with strong insecticidal solution. - Kill the wasps in the apiary by flapping.

**Wax moth (*Galleria mellonella*)**

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

ECTOPARASITIC MITES: In India, ectoparasitic mites *Varroa destructor* and *Tropilaelap sclareae* are causing severe damage to *A. mellifera* colonies. However, no damage in *A. cerana* colonies due to these mites has been reported.

**Nature of damage: i)*Tropilaelapsclareae:*** This mite feeds only on bee brood. In case of severe infestation of this mite dead brood is thrown outside the hive by workers. The bee colonies may even abscond if control measures are not adopted. The diagnostic symptoms are:- irregular brood pattern,- perforated brood capping,- dead or malformed wingless bees at the hive's entrance - fast running small brownish mites can also be seen on the infected brood frame. This mite develops and reproduces in the sealed brood cells of honey bees feeding on haemolymph of bee pupa. Parasitized individual may die or develop into deformed, weak individual incapable of normal functioning,- This mite has caused heavy losses to *A. mellifera* colonies throughout the world as

it reproduces both on drone and worker brood of this species. Although the native host of this mite is *A. cerana*, yet it is causing no serious damage to it. On *A. cerana* this mite reproduces only on drone brood and is unable to complete life cycle on worker brood due to slightly shorter developmental period - In India, Now it is well known that the mite earlier referred to as *Varroajacobsoni* is in fact a species complex consisting of two species *V. jacobsoni* and *V. destructor*, each having several strains. Only two strains of *V. destructor* have become pest of *A. mellifera*

**The symptoms of colony infestation with Varroa are:**- Spotty brood pattern .Mite can be seen on adult bee's body as mature female mite attaches to young adult bee and also feed on haemolyph till further reproduction in the brood cell- Dead brood and malformed adult bees are seen near/around hive entrance- Colonies become weak and wounds inflicted by mites make the bees more susceptible tobacterial and viral diseases.

**Control: i. *Tropilaelapsclareae* :** Sulphur dusting on top bars @ 200mg/frame **ii. *Varroa destructor*:** Formic acid fumigation @ 50ml/hive in sponge pads covered withperforated polythene bags. Level of mite infestation can be kept low by putting sugar (finelypowdered sugar) @ 30g/frame and then sweeping sugar down between the frame spacesusing a bee brush.

**VERTEBRATE PESTS**

**Frogs and Lizards:**The frogs and toads prey upon varieties of insects and occasionally feed on bees at the hive entrance. These are proficient in capturing bees and are less affected by bee stings and bee venom. Lizards are occasional predators of honeybee colonies and eat both brood and adult bees.

**Management:** Place bee colonies on hive stands smeared with grease to prevent the entry of toads and lizards into the hive.Use of beehives free from cracks and crevices and also maintaining colonies with hygienic conditions and would prevent the lizard problem.

**Birds:** Birds are the major predators of honeybees. The beaks of the birds are well adapted to catch bees easily during flight. They are able to manipulate the prey, dislodge the sting and remove the poison sac of the bees. The green bee-eater, *Merops orientalis,* blue bearded bee-eater, *Nyctyornis athertoni* and the drango, *Dicrurus leucophaeus* are the most common bird predators of bee colonies. They catch up bees and are smapped up in the bill, returns to their perch and beat the prey against the perch until they die. Similarly, the oriental honey buzzard, *Pernis ptilorhyncus,* swifts, wood peckers also act as predators of honeybees. Woodpeckers have a strong, sharp pointed bill for excavating insect brood holes in trees and a very long sticky tongue for extracting the bee prey.

**Management:** The methods such as scaring, producing distress voice at a high volume, restricting the flight using reflective tapes, compact discs etc. have been successful to prevent the bird menace in and around apiaries. Covering apiaries with strong mesh would prevent the entry and attack of birds.

**Mammals:** Mice are known to invade bee colonies for shelter and destroy the combs. They feed on bees and hive products such as honey and pollen. Bears usually dismantle the hives to feed on

the honey, pollen, brood and adult bees. They tear the hives into pieces and carry off combs with honey to escape from mass stinging of bees. The monkeys remove the adult bees from the combs and feed on the honey and brood. Monkeys generally in troops jump on to the beehives and carry away both super and brood combs by shooking the bees to fly away.

**Other Bee Enemies: Bee louse, *Braulacoeca*:** 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.

**Other enemies:** Bird, bee eater, *Meropsorientalis* and king crow, *Dicrurus* sp. 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 in pots containing water. Bears and pine martines are the mammals which attack the bees for honey and bees.

BEE DISEASES:Brood diseases: **European Foul Brood Sac Brood/Thai sac brood**

Causative Organism *Paenibacillus larvae*(bacteria)*Melissococcus pluton*(bacteria)Virus (sac brood in *A. mellifera* and Thai sac brood in *A. cerana* Time of death Late larval or early pupal stage Coiled larvae in unsealed cell (usually young unsealed larvae sometime older sealed larvae) Late larval stage; (usually older sealed larvae sometimes young unsealed larvae) Cappings Sunken and punctured Dead brood in uncapped stage Capping removed or punctured often with two holes. Colour of dead brood Off white to light cream to brown; coffee brown to dark brown or almost black Yellowish white to grey or dark brown, dark brown or almost black as compared to glittering white in case of normal brood Straw coloured, starts darkening from head Position of dead brood Lying flat on cell base Coiled, twisted or collapsed Extended with head curled upright in cells Consistency of dead brood Sticky to ropy Soft and gummy ; rarely sticky or ropy, granular Sac like with watery content Odour of dead brood Glue pot, putrid faint Slightly sour to penetratingly sour, Putrid fish None to slightly sour; faint sour Type of brood affected Worker, rarely drone or queen Worker, drone and queen Worker only

**Management**: Terramycin @ 0.250 0.400g in 5lt sugar syrup feeding Feed Terramycin @ 0.2g in500ml conc. Sugar syrup No effective cure

**Adult diseases: Nosema disease Acarine disease** Causative organism: *Nosemaapis*(protozoan*) Acarapiswoodi* (Endoparasiticmite)

**Symptoms** :Infected bees collect in front of hive, sluggish, crawlers on leaf blades, distended abdomen, dysentric Bees gather in front of hive as crawler bees and unable to fly; disjointed wings having typical ‘k’ wing condition

**Management**: : Feed fumigillin 200 mg in sugar syrup to each colony or 0.5-3.0 mg in 100ml sugar syrup. Or Two feedings at weekly interval of Dependel-M @0.5g/litre/colony, Fumigate using folbex strips at weekly intervals or with formic acid (85%) @ 10ml/colony and replenish the quantity after every 24 h for 21 days

**Viral Diseases:** Viruses are microscopic entities causing diseases in honeybees. About 18 viruses have been identified in honeybees and most of them cause sub-lethal infections. Only a few have been reported in *A.cerana indica* in contrast to many viruses from *A. mellifera.* Though a few viruses infect brood, most of the viruses infect both brood as well as adult bees. The major viral diseases of honeybees are Thai sac brood, Sac brood, Kashmir bee virus, paralysis and *Apis* iridescent virus. Filamentous virus, black queen cell virus, Arkansas virus, Egypt bee virus, viruses X and Y, cloudy wing virus, deformed wing virus are other viruses infecting honeybee colonies.

**Disease Causal organism Susceptible Honeybee Species**

**A. Thai Sac Brood Disease:** Thai sac brood disease is one of the deadly diseases of *Apis cerana indica* colonies. It was originated for first time in Thailand during 1976 and caused greater losses to beekeeping industry by killing over 80 to 90% bee colonies during 1980s. Thai sac brood virus is confined to the brood and quite evidently the larvae exhibit disease symptoms. Its prevalence is quite evident in brood rearing seasons in honeybee colonies.

**Symptoms:** The symptoms are seen in early larval stages and death occurs either in late larval or in the pre-pupal stage. The dead larvae usually lie at the bottom of the cell with the head typically turned up. Such larvae become scale like and adhere to one side of the cell at the bottom. Infected pupae are irregularly scattered on combs with perforations on the capping. Adult bees become sluggish with extremely low foraging activity.

**Diagnosis:** The disease can be diagnosed by lifting infected larva with a pointed needle which shows a sac like appearance. Examination of ultra thin sections of midgut of infected adult bees reveals bundles of virions accumulated next to the peritrophic membranes in the gut lumen.

**Sac Brood:**Sac brood virus (SBV) is one of the foremost viruses reported from *A.mellifera* colonies. It infects and multiplies in the tissues of young larvae. Such larvae generally fail to pupatebut remain stretched on their back by extruding their head towards cell capping. The larval cuticle looks like a transparent sac accumulated with a fluid between the epidermal layers. The infected larvae changes from pearly white to pale yellow followed by dark brown in colour.

**Kashmir Bee Virus:**Kashmir bee virus is a pathogen of *A. cerana* that killed thousands of colonies in Kashmir.The major symptoms of its infection are gradual weakening of bee colonies with large numbers of dead and dying bees near the hive. The infected bees are partly or completely hairless with dark upper thoracic surface and exhibit trembling uncoordinated movements.

**Paralysis Viruses:**Four types of viruses' *viz.* chronic paralysis, chronic paralysis associate, acute paralysis and slow paralysis are known to cause paralyses in adults of *A.mellifera.* The infected bees become hairless, shiny and have bloated abdomen with partially spread dislocated wings.

They show an abnormal trembling motion of the wings and body. They fail to fly out often crawling on the ground and cluster on top of the hive.

***Apis* Iridescent Virus:***Apis* iridescent virus multiplies in the tissues of fat body, alimentary canal, hypopharyngeal glands and ovaries of adult honeybees. The tissues of the diseased bees become blue-violet to green on illumination with bright white light. It is known to reduce the egg-laying capacity of the queen and the worker bees become sluggish and form clusters at the hive entrance.

**Management of Viral Diseases:**The adult population of diseased colonies may be transferred to a new or disinfected hive provided with comb foundation. They are fed most frequently with sugar syrup and pollen supplements. During severe infection, the combs containing diseased larvae may be burnt to prevent further contamination. A break in brood rearing either by de-queening or by caging the queen encourage bees to remove infected dead brood efficiently and thereby keeping the infection under control. Avoid exchange of infected combs and use only sterilized beekeeping equipment in the bee colonies. The control measures followed to prevent the transmission of viruses through bee mites, protozoan parasites and other vectors would reduce the problem of viral diseases.

**Bacterial Diseases:** Bacteria cause many diseases in honeybee colonies. They are classified into two broad categories such as non spore- forming bacteria and spore-forming bacteria. American foul brood and European foul brood are highly destructive and widely distributed bacterial diseases of honeybees.

**A. American Foul Brood:** American foul brood (AFB) is one of the most destructive infectious brood diseaseskilling millions of *A.mellifera* colonies throughout the world. It is highly contagious and occurs in all seasons on bee brood. *Paenibacillus (*formerly *Bacillus) larvae subsp. Larva* causes the disease.

**Symptoms:**The diseased brood is irregularly intermingled with healthy brood with uncapped, punctured or sunken capping in the form of 'pepper box'. The diseased brood is initially dull white in colour and gradually changes to light brown or dark brown.Death of an infected larva usually takes place after the cell is sealed and the cocoonhas been spun.The segmentation of the larva is well marked and gives off fish-glue like foul odour.

**Diagnosis:**The spores of the pathogen exhibit Brownian movement in the regions of the smear where pockets of water are formed in the oil. This movement is an extremely valuable diagnostic tool as the spores of other pathogens of honeybees are usually remained fixed. Stretch test is followed where the dead larval contents are easily adhering to the tip of the pointed stick on dipped into the larval extract by stretching in an elastic way when lifted. Microscopic examination of infected larval scales stained with nigrosin show a mass of bacterial spores. Holst test essentially consists of placing the suspected material such as dried scales into dilute warm milk. The spores turn the milk curdled and cleared within few minutes. The immuno

fluorescence and immuno diffusion and use of monoclonal antibody in enzyme linked immuno sorbent assay (ELISA) are the other diagnostic techniques followed in detection of AFB.

**Management:**Honeybee colonies could be placed in the areas rich with plenty of nectar and pollen flow during active season. Artificial swarming or shook swarm technique is followed in AFB infected colonies during post honey flow seasons. This technique involves transferring of adult bees to a disease free hive followed by destroying diseased brood combs. Depleting adult bees supplied with comb foundation leads to break in survival of the pathogen in absence of the brood. The combs and equipment may be sterilized by fumigation with formaldehyde. Sodium sulphathiozole (1.5g/15*l*) and oxytetracyclin hydrochloride (0.4g in 5 *l*) suppress the disease when fed with strong sugar syrup.

**B. European Foul Brood:**European foul brood is caused by *Melissococcus plutonius*, a non-spore formingbacterium. It is an infectious and contagious disease primarily infecting 2-3 days old young larvae. The virulence of the pathogen is common in high brood rearing season.

**Symptoms:**A slight yellow or grey discolouration of the larvae. Most of the bee larvae die at coiled stage on the bottom of the cells. The dead larvae appear like collapsed mass giving melted appearance.The larvae undergo decaying often giving off a foul odour and are sour in taste. An infected larva may spins cocoon with poorly developed silk glands but become flaccid and the tracheal system becomes quite visible. The diseased larva dries up into rubbery scales in the cell.

**Diagnosis:**Exposing the smears of diseased larvae stained with carbol fuschin under a microscope before appearance of secondary bacteria shows bacteria.The Enzyme Linked Immuno Sorbent Assay (ELISA) Polymerase Chain Reactions (PCR) are efficient in detection of the pathogen in the larvae and beehive products.

**Management:**The severely infected colonies may be destroyed. Sodium sulphathiazole 1.5g/15 *l*) suppress the disease on feeding in strong sugar syrup. Oxytetracycline hydrochloride (Terramycin®) may be fed or sprinkled with sugar syrup over the bees cluster in the hive in warm weather.

**C. Para Foul Brood:** The bacterium, *Bacillus paraalvei* causes Para foul brood disease in honeybees. The worker, queen and drone larvae and sometimes pupae are affected by Para foul brood disease.

**Symptoms and Management:**The larvae infected are slightly less plumpy and change in colour from glistening white to a dull white. The cell capping are dark, sunken and greasy in nature. The infected brood produces a sour odour. A large number of larvae are coiled or irregularly twisted in the cells, although many larvae die in an extended position. The larvae in later stages turn reddish brown and form dark coloured scales. Since the epidemiology of Para foul brood is almost similar to that of EFB, similar control measures would also be effective.

**Septicemia:** Septicemia is a disease associated with adult honeybees and is caused by a bacterium, *Pseudomonas apiseptica*. It is most prevalent in the bee colonies placed near moist soil.

**Symptoms and Management:**A change in the colour of the haemolymph of infected bees from apple brown to chalky white followed by rapid regeneration of muscles. Severe infection causes the haemolymph to become turbid and milky.

**PESTS AND DISEASES IN BEEHIVE**

Dead or dying bees emit a putrid odour.Placing bee colonies in well-drained apiary sites and exposing them to the sunlightfor at least a part of the day would minimize the disease.

**Fungal Diseases:** Fungi infect brood, adult bees and combs containing stored products in honeybeecolonies. The most common fungal diseases of honeybees are chalk brood and stone brood.

**A. Chalk Brood:** The fungus, *Ascosphaera apis* causes chalk brood disease. It infects larval and pre-pupal stages of the bee brood. The chalk brood causes severe damage to bee colonies most frequently in spring and early summer seasons.

**Symptoms:** The fungus infects younger larvae and pre-pupae usually located in outer fringes. The infected larvae die after cell capping and turn white followed by grey and black colour on formation of fruiting bodies.Larva is over grown by fluffy like mycelia and swells. he infected larva dries into hard, shrunken white chalk mummies.

**Diagnosis:**Presence of stained mummies containing spore cysts under the microscope. Identification of the pathogen by a polymerase chain reaction technique.

**Management:**Strengthening of weak colonies by uniting adult bees and brood combs. Periodic renewal of old combs with new ones. Fumigation of hive equipment and combs with Ethylene oxide and methyl bromide. Trichloro isocyanouric acid (TCA) dissolved water is effective in control of chalk brood.

**B. Stone Brood:**Stone brood disease is generally caused by the fungus, *Asperigillus flavus* and occasionally by *Aspergillus fumigatus*. It is more prevalent in beehives under damp conditions with poor ventilation.

**Symptoms and Management:**The spores are found abundant near the head of the infected larvae and pupae and form green stone like solid mummies.The infected larva becomes hardened and quite difficult to crush after its death hence the name stone brood. The management practices followed in control of chalk brood disease are also effective against stone brood.

**Protozoan Diseases:**Protozoans are either parasitic or symbiotic on honeybees and cause greater losses to the beekeeping industry throughout the world. The microsporadian and protozoan diseases of honeybees are nosemosis and amoeba disease respectively.

**A. Nosemosis:**Nosemosis is one of the most widespread adult honeybee diseases caused by the microsporadian parasite, *Nosema apis*. It is distributed worldwide and has also been reported from many parts of India on *A.cerana* colonies. It is an obligate parasite which develops in the gut tissues of adult bees and has been known to shorten the life span of honeybees.

**Symptoms:**The bees of diseased colonies show restlessness and are unable to fly but drop loose excreta on the combs and hive parts. The hind wings of infected bees may get unlocked from the fore wings and held at unusual angles. The infected nurse bees do not produce sufficient royal jelly due to deterioration of food glands. The hypopharyngeal glands of the newly emerged adult bees with the pathogen fail to develop completely and eventually undergo atrophy.

**Diagnosis:**Nosemosis can be diagnosed by microscopic examination of ventriculus of the infected bees. The ventriculus, which is normally brown in colour becomes white and fragile on infection Giemsa (10% 0.02 M phosphate buffer) stained air-dried ethanol fixed smears of infected tissues shows spores with thick unstained walls without visible nuclei.

**Management:**Maintenance of bee colonies strong with a prolific queen and sufficient food stores. Old combs which are constant source of pathogen may be replaced with new combs. Fumes of cetic acid (60 per cent) would inactivate the *Nosema* spores. The antibiotic, fumagillin suppresses *Nosema* infection when fed to bees at the concentrations of 0.5 to 3 mg/100 ml sugar syrup.

**B. Amoeba Disease:**Amoeba disease is caused by the protozoan, *Malpighamoeba mellificae*. It is widely distributed in temperate regions. The *M. mellificae* cysts ingested by the adult bees germinate possibly at the posterior end of the ventriculus of bees where solid food particles are accumulated.

**Symptoms:**Gradual decline in adult bee population.Infected Malpighian tubules are slightly distended, glassy in appearance and easilybroken. The infection causes the epithelium of malpighian tubules to undergo atrophy.

**Diagnosis and Management:**Presence of cysts in the abdominal suspension of the suspected bees examined undermicroscope. Phenyl salicylate, quinosol, fumagillin, furazolodone and dichloroxyquinaldine areeffective against the amoeba disease.

## Ex.no.5&6 . BEE PASTURE, BEE FORAGING AND COMMUNICATION

**Bee pasturage or bee forage:** Plants that yield pollen and nectar are collectively called bee pasturage or bee forage. Plants which are good source of nectar are tamarind, moringa, neem, *Prosopis juliflora, Soapnut tree, Glyricidia maculata, eucalyptus, Tribulus terrestris* and pungam. Plants which are good source of pollen are sorghum, sweet potato, maize, tobacco, millets like cumbu, tenai, varagu, ragi, coconut, roses, castor, pomegranate and date palm. Plants which are good source of both pollen and nectar are banana, peach, citrus, guava, apple, Sunflower, berries, safflower, pear, mango and plum.

**Foraging:** This refers to collection of nectar and pollen by bees.

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

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

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

Honey bee foragers specialize on collecting pollen and nectar. Pollen foraging behavior is modulated by at least two stimuli within the nest: the presence of brood pheromone and young larvae and the quantity of stored pollen. Honey bees collect distinct nutrient sources in the form of nectar (energy) and pollen (nitrogen).

**Nectar:** Perhaps the most obvious reason for bees to leave the hive is to collect nectar. Nectar is the raw material for honey, pending "processing" back at the hive. When nectar is processed, converted into honey and stored, it becomes a vital resource to the colony, not just for day-to-day purposes but particularly to help survive the winter months.

Honey provides essential nutritional benefits to the colony. It is a rich source of carbohydrates, providing fuel for all aspects of a bee's lifetime. Bees need energy for everything they do, particularly for flying and foraging. **The need to flap their wings thousands of time per minute creates a huge energy deficit and the only way to keep up is to have "on-board energy" at all times**.Honey provides this, with nectar as the starting point in its production.

**Pollen:** Pollen is perhaps the most visible of the commodities bees bring back to the hive**.** As a beekeeper, the sight of many workers returning with heavy and resplendent pollen baskets is beautiful and reassuring**.** While the layman considers pollination the primary reason why bees

have pollen stuck to their bodies, that process is an incidental and accidental by-product of their flight between flowers, albeit one with enormous implications. But bees don't collect pollen because they like the idea of helping with the reproduction of flowers! Rather, they need pollen back-at-base.

Pollen provides a wide range of nutritional components and is the principal source of protein for bees. The amount of protein is dependent on the flowers visited from which pollen is collected. This can be highly variable, with the protein component ranging from less than 10% to around 30% of the dry weight of the pollen. Pollen also provides important minerals such as calcium, potassium, sodium and others.

**Protein includes key amino acids and 10 of these are considered essential to honey bees**, including threonine, valine, methionine, isoleucine, leucine, phenylalanine, histidine, lysine, arginine, and tryptophan. The quantity of amino acids present in pollen is also highly dependent on the floral source of the pollen.

**Propolis:** To some extent, propolis is a hidden resource, but still essential to bees. To be strictly accurate, bees don't collect propolis, they create it. They visit trees and other sources that release sap, bringing the exudate back to the hive**.** Then they mix in saliva and beeswax to produce an extremely sticky resin, which eventually hardens. The result is typically an unmistakable red, easily visible throughout the hive. Propolis, when "set", is extremely strong and an important foundational element of any hive**.**

**Water**: All living things need water and bees are no different. The assessment of water needs for the hive is a highly dynamic process and the number of bees waiting to receive water sends a message to foraging bees. If there are many bees waiting then the returning bees will fly back to a water source to collect still more. The speed with which the receiving bees collect the incoming water is also a part of the messaging – fast, urgent collection equals "we need more, now!". Thus, the number of bees waiting for water and their urgency regulates the flow of water into the hive.

**For cooling**: Bees have quite the challenge to keep the inside of the hive cool in the heat of summer. They use a number of techniques, including an organized fanning of their wings to increase air flow, but water is an essential tool. They place a thin layer of water on top of capped brood (unborn bees in their cells, capped off with a layer of wax), which has the benefit of lowering temperatures when bees fan the water, creating evaporation.

**For nurse bees:** Worker bees acting as nurse bees create large volumes of food for larvae and need water to help with that process

**For re-hydrating honey:** When honey is stored it has a tendency to crystallize. When bees need to consume the honey, they apply water to dilute the crystals.

**COMMUNICATION IN BEES**

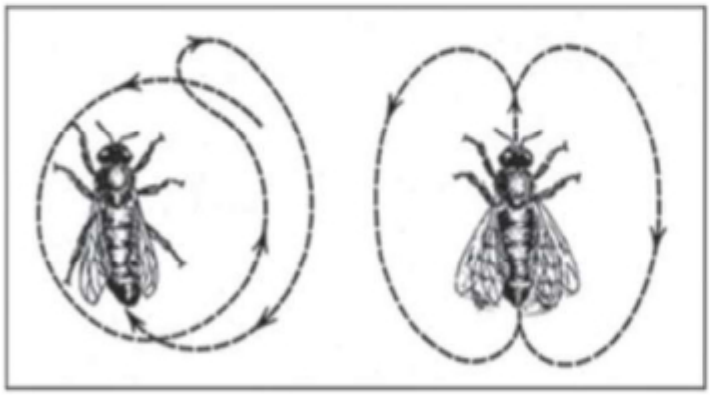
It was Father Spitzner in 1788 who for the first time described bee dances as method of communication among inmates of the hive about volume of honey flow and place of source of nectar. These observations remained unnoticed till Frisch (1920) published his observations. Karl

von Frisch got noble prize in 1973 (under physiology & medicine, who shared it with two other animal behaviourists) on the basis of his work published in 1946.

They communicate with each other and pass their information using various pheromones. However, worker bees communicate information through their peculiar 'dance'. The following types of dances are noticed:

(a) **Round dance**: It is used to indicate a short distance of food source. The bee runs in circles, first in one direction and then in opposite direction (clockwise andante clockwise). For example. If the source of the food is less than 100m away, thenthe bees perform 'round dance' making small circles. The number of circles formed by them indicates the distance of beehive from the food source. Workers dance vigorously, if the quantity of food is more and of superior quality. If the food is inferior and the quality is less, then the dance is slow and shorter.

(b) **Tail wagging dance or Wag-tail dance:** This is used to indicate long distance offood source (more than 100m). Here the bee makes two half circles in oppositedirections with a straight run in between. During the straight run, the bee shakes(wags) its abdomen from side to side, the number of wags per unit time inverselyproportional to the distance of the food (more the wags, less the distance). Honeybees also make a buzzing sound 'ZZZZZ' during the dance, which possibly alertthe other bees that then attempt to 'read' dancer's message.

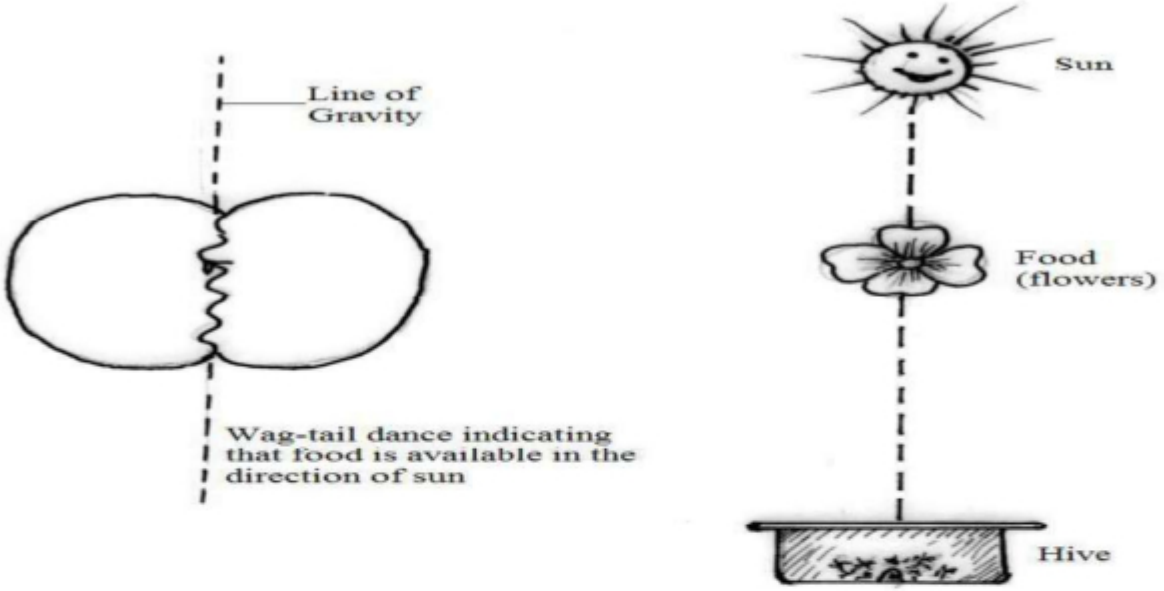


*A bee can fly @35km/hr. They go as far as 5km from the hives for collecting nector.*

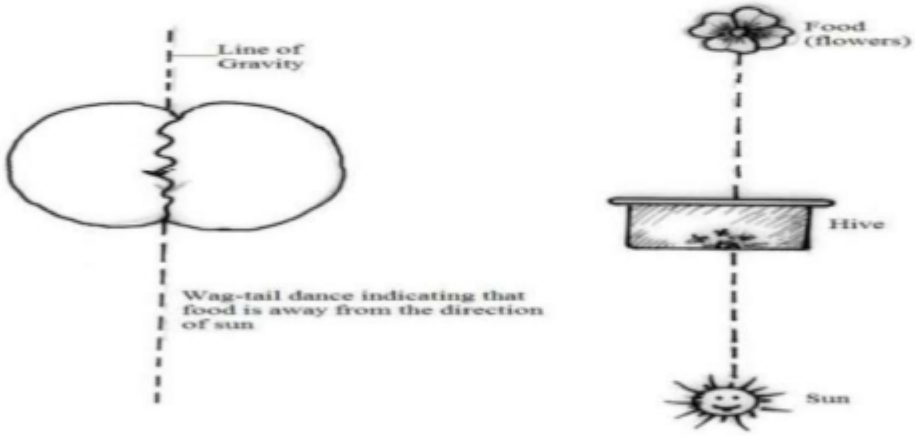
**Social behavior:**Honey bees are among the fully social insects having overlap of many generations in thesame nest. The colony is a well organized social group having division of labour in terms oflaying of eggs, nursing, comb building, guarding, food collection and its storage. They havewell developed communication system through different types of dances as well astrophallaxis.

**Biological communication** can be defined as an action on the part of one organism that alters the probability pattern of behavior in another organism in an adaptive fashion. Adaptive means that he signaling or the response or both which have been genetically programmed to some extent by natural selection. **Trophallaxis** is food transmission (exchange of food) which is common between workers and also from workers to queen and drones. It is a sort of

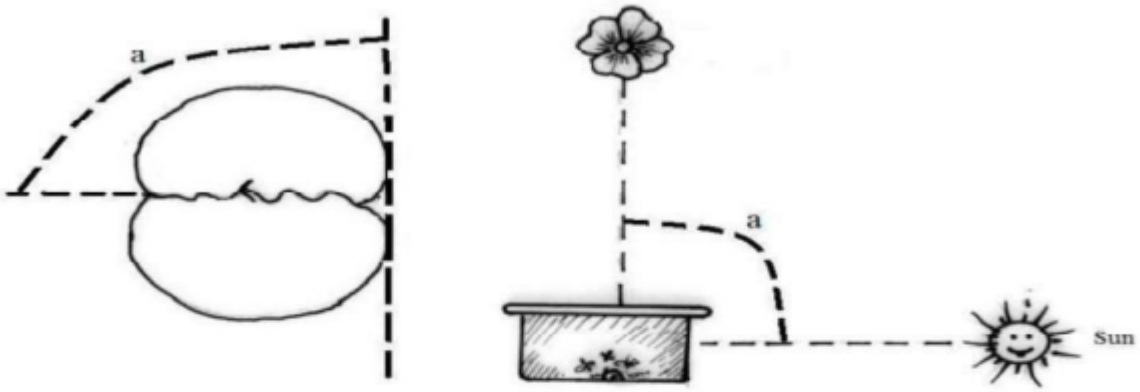
communication regarding availability of food and water and also a medium for transfer of pheromone. In honey bees, recruit communication is very important mode of communication which is defined as a communication that brings nest mates to some point in space where work is required. Dances of honey bees are important recruit communication.



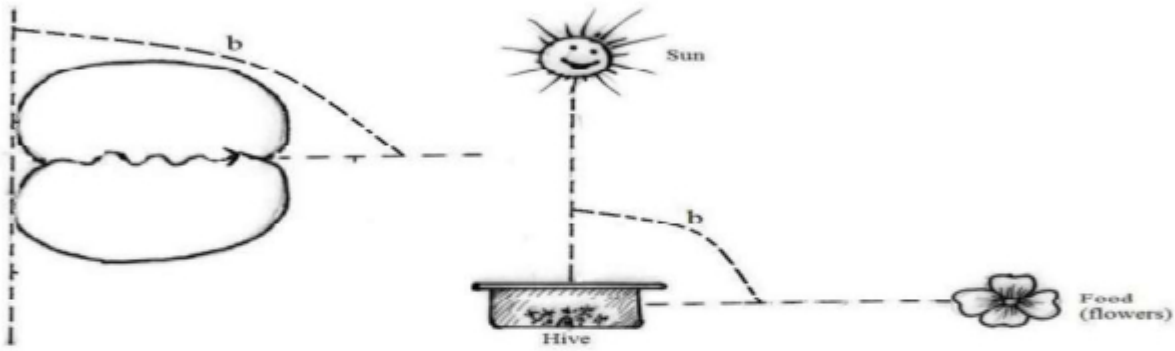

**a. Direction indication in wag-tail dance when food is in the direction of sun**




**b. Dance when food is away from direction of sun**




**c. If food is to the left of the sun, bee dances at an angle counterclockwise to the line of gravity**




d. If food is to the right of the sun, bee dances to the right of the line of gravity

**Figure .Wag-tail dance in relation to direction of sun**

The distance is indicated by the number of straight runs per 15 seconds as given below: Distance of food from hive(metres)Number of straight runs/15 sec.100 9-10,600 71000 4,6000 2

As a social unit a bee colony maintains its hive temperature between 32-35$_o$C in the brood area. Queen substance 9-oxo-2-decenoic acid (9-ODA) from the queen bee, alarm pheromone and alarm odour from worker bees play important role in the welfare of the colony and help in the social organize

## EX.7 &8. TYPES OF SILKWORM, VOLTINISM AND BIOLOGY OF MULBERRY SILKWORM

Silk is a fibrous protein of animal origin. A number of organisms secrete silk, which is used by them for anchorage (mussels), entangling their prey (spiders), or forming a protective sheath with or without other materials (Lepidopteron cocoons). Nearly 400 - 500 species are known to produce silk but only very few are commercially exploited. Based on the organism producing it, silk is classified into Insect silk and Non- insect silk. Insect silk is commercially more important. The majority of silk producing insects belong to the order : Lepidoptera, Super family. Bombycoidea and Families. Bombycidae and Saturniidae.

Nearly 95% of commercial insect silk comes from the mulberry silkworm *Bombyx mori* and is known as mulberry silk. The commercial silk from all other sources is collectively called Non-mulberry silk. Hence, the major insect species producing silk are,

**SILK WORM – TYPES::** 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.

1. **Mulberry:** Mulberry silkworm : *Bombyx mori* . 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

2. **Tasar silkworm**: 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.i) Tropical tasar - *Antheraea mylitta* ii) Temperate tasar - *Antheraea proylei* iii) Chinese tasar - *Antheraea pernyi* iv) Japanese tasar – *Antheraea yamamai*

3. **Eri silkworm** – *Samia ricini:* 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. Ericulture 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

**4. Muga silkworm** – *Antheraea assamensis :* This golden yellow colour silk is prerogative of India and the pride of Assam state. It is obtained from semi-domesticated multivoltine 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.

**A. Classification :1. Based on voltinism :** Based on the number of generations, it is classified as Uni, Bi and multivoltines. Diapause can be broken artificially in bivoltines but not in univoltines. In case of univoltines larval period is long and rearing is unsuitable during unfavourable seasons.

**Univoltines:**Only one generation per year; Diapauses during eggs; Unsuitable for rearing in summer and autumn; larval period is long; Cocoons are of superior quality. Eg. European races.

**Bivoltines:** Two generations in a year; White cocoons; Larvae are robust; tolerant to environmental conditions; Diapause can be artificially broken. Eg. Japanese and Chinese races
**Multivoltines:**More than three generations per year; Golden yellow coloured cocoons; Larvae can withstand high temperature and humidity; well adapted to tropical conditions; comparatively the cocoons are of poor quality.Eg. Indian and Chinese races.

**Silkworm Biology**

**Egg** :Egg is round and white. The weight of newly laid 2,000 eggs is about 1.0 g. It measures 1-1.3 mm in length and 0.9-1.2 mm in width. With time, eggs become darker and darker. Races producing white cocoons lay pale yellow eggs; while races producing yellow cocoons lay deep yellow eggs. In case of hibernating eggs laid by bi-voltine and univoltine races, the egg colour changes to dark brown or purple with the deepening of colour of the serosal pigments. The eggs may be of diapause or non-diapause type. The diapause type of eggs are laid by the silkworms inhabiting in temperate regions; whereas silkworms belonging to subtropical regions like India lay non-diapause type of eggs. During diapause all vital activities of the eggs cease.

**Larva** : After 10 days of incubation, the eggs hatch into larva called caterpillar. Newly hatched caterpillar is about 0.3 cm in length and pale yellowish white. The larval body in densely covered with bristles. As the larva grows, it becomes smoother and lighter in 5 colour due to rapid stretching of the cuticular skin during different instars of the larval stage. The prementum is also chitinized, and its distal part carries a median process known as spinneret through which silk is extruded out from the silk gland. The sensory labial palpi are found on both sides of the spinneret.. In females, the sexual marking appear as a pair of milky white spot in each of the eighth and ninth segments and are referred to as Ishiwata's Fore Gland and Ishiwata's Hind

Gland respectively. In males a small milky white body known as Herold's Gland appears ventrally in the centre between eighth and ninth segments. The larval growth is marked by four moultings and five instar stages. The full-grown caterpillar develops a pair of sericteries or silk glands. Sericteries or silk glands are modified labial glands. These glands are cylindrical and divided into three segments: Anterior-, middle- and posterior-segments. The inner lining cells are characterized by the presence of large and branched nucleus. These glands secrete silk which consists of an inner tough protein, fibroin, enclosed by a water soluble gelatinous protein, sericin. In Bombyx, the fibrinogen which on extrusion is denatured to fibroin is secreted in the posterior segment of the gland and form the core of the silk filament in the form of two very thin fibres called brins. The sericin, a hot water soluble protein, secreted by middle segment of the gland, holds the brins together and covers them. The duct from another small gland called Lyonnet's gland, that lubricates the tube through which the silk passes, joins the ducts of the silk glands. Finally, the silk is moulded to a thread as it passes through the silk press or spinneret.

**Pupa** :Pupa is the inactive resting stage of silkworm. It is a transitional period during which definite changes take place.. Sex markings are prominent and it is much easier to determine the sex of pupa. The female has a fine longitudinal line on the eighth abdominal segment, where as such marking is absent in case of male. The pupa is covered within a thick, oval, white or yellow silken case called cocoon. The pupal period may last for 8-14 days after which the adult moth emerges slitting through the pupal skin and piercing the fibrous cocoon shell with the aid of the alkaline salivary secretion that softens the tough cocoon shell.

**Adult:** The adult of Bombyx mori is about 2.5 cm in length and pale creamy white. After emergence the adult is incapable of flight because of its feeble wings and heavy body. It does not feed during its short adult life. The moth is unisexual and shows sexual dimorphism. In male eight abdominal segments are visible; while in female, seven. The female has comparatively smaller antennae. Its body and the abdomen are stouter and larger, and it is generally less active than male. The male moth possesses a pair of hooks known as harpes at its caudal end; while the female has a knob like projection with sensory hair. Just after emergence, male moths copulate with female for about 2-3 hours, and die after that. The female starts laying eggs just after copulation, which is completed within 24 hours. A female lays 400-500 eggs. The eggs are laid in clusters and are covered with gelatinous secretion of the female moth.

**Life cycle :** Egg : 7 -8 days; Larvae: 20 – 22 days; Pupa: 10 days; Adult : 7 days

**Sexual dimorphism in adult**

Male & Female moths can be distinguished using morphological characters

| Characters | Female | Male |
|---|---|---|
| Colour | Pale | Darker |
| Activity | Less active | More active |

| | | |
|---|---|---|
| Antennae | Small | Large |
| Body size | Large | Small |
| Abdomen | Large and flat | Long and narrow |
| External genitalia | Caudal end has a median knob like projection with sensory hairs. This knob is protruded and retracted to expel the pheromone | Caudal end has a pair of hooks known as harps helping in copulation |

## EX.NO.9 MULBERY CULTIVATION , MULBERRY VARITIES AND METHODS OF HARVESTING OF LEAVES

**Mulberry:Origin :** Mulberry, *Morus* spp. is believed to be a native of the lower slopes of the Himalayas either in India or China. Towards the year 2800 BC, Chin-Nong, one of the successors of Emperor Fo-Hi taught cultivation of mulberry in China. Mulberry is cultivated in 29 countries.

Moriculture: Cultivation of mulberry plants for rearing the silkworm called as moriculture.

**Species :** There is no unanimity in the classification of the genus *Morus* into species. There are four common species of the genus that occur throughout India.

1. *Morus alba 2.Morus nigra 3.Morus latifolia 4.Morus laevigata*

Apart from these,

*5.Morus indica* and 6.*Morus serrata* also occur in Himalayan ranges

**Ecological requirements for mulberry cultivation**

**Climate :** The optimum elevation for mulberry growth is about 700 m above MSL. For cultivation purposes, an elevation of 300 to 900 m above MSL is the optimum range. The ideal temperature is 24 to 28$^{o}$ C, relative humidity is 65 to 80% and sunshine duration 5 to 12 hours per day. Mulberry cannot sprout below 13$^{o}$C or above 38$^{o}$C.

**Rainfall :** A rainfall range from 600 m to 2500 mm per year is considered ideal. During the growth period, mulberry requires about 280 – 400 ml of water to synthesize one gram of dry matter.

**Soil :** As mulberry is a perennial, deep -rooted plant, soil structure must be sufficiently porous to supply air and water to the root zone. Soil should be deep, fertile, porous, well drained and with good water holding capacity. Loamy, clayey- loamy or sandy - loamy soils are the best. Slightly acidic soils (6.2 to 6.8pH) free from injurious salts are ideal.

**2. Mulberry varieties**

Irrigated : Kanva 2 (M5) , MR 2, S 30, S36, S 54, DD (Viswa), V1.

Semi irrigated : Kanva 2, MR 2.

Rainfed : S 13, S 34, RFS, 135, RFS, 175, S 1635.

| Variety | Yield (ton/ha/year) |
|---|---|
| Local | 25 |
| Kanva2, MR2, S 30 | 35 |
| S 36, DD | 40 |
| S 54 | 45 |
| V1 | 60 |
| Rainfed conditions | 17-18 |

**Planting methods:** Pit system; Row system; Paired row system; Kolar system

**1. Pit system:** This system is followed for rainfed crop. Instead of ploughing the entire field, pits of standard size (45 x 45 x 45 cm) are dug. Equal quantities of organic manure, red soil and sand are placed in each pit after mixing and a sapling is planted. Spacing is 90 x 90 cm.

**2. Row system:**Row system is followed for irrigated mulberry. Ridges and furrows are formed. Spacing is 60 x 60 cm (rainfed - 90 x 0 cm). This method is suited to high yielding varieties likes V1.

**3. Paired row system:**The spacing is 75/105 x 90 cm. Inter crops can be raised in the wider spacing. The advantages are less weeds, additional income, mechanization is possible and water saving. Inter crop should not compete with mulberry. Space created should be effectively utilized. Incompatible crop invites pest and disease problem.

**4.Kolar system:** This is similar to the row system except that the distance between the plants is very much less. Spacing between row is 30 - 45 cm and the distance between plants is 10 -15 cm. This is followed in Kolar district of Karnataka and so is called the Kolar system.

**Inorganic manures**

The nutrient requirement of mulberry / ha/y is the highest compared to any other field crops. Nearly 30-40% of total cost of cocoon production goes to Fertilizers and manures alone. Recommended schedule is 300: 120 : 120 NPK kg/ha/y. N is applied in 5 split doses and P and K in two split doses.

**Micro nutrients: Fe, Zn, Cu, Mn, Cu, Mo and B**

Apply foliar spray of micro nutrients when deficiency symptoms are exhibited

Spray micronutrient nutrient mixture containing $FeSO_4$ 10 g , $ZnSO_4$ 5g, Borax 2.5 g, $CuSO_4$- 2.5 g, $MnSO_4$ – 2.5 g and Sodium molybdate–100 g @ 600 litres of spray fluid /ha.

**Water management :**Water requirement of mulberry is 1100 mm /1200 mm/ha/year. To produce 1.0 kg of mulberry leaves, 320 liters of water is required irrigation can be better regulated through ridges furrows. **Frequency :** 8 -10 days for sandy soils , 15 days for clayey soils **Methods of irrigation**: Surface and drip irrigation, Drip irrigation can save up to 40% of water. Fertigation through drip system can provide better nutrition to crops.

**Methods of harvesting of leaves**: the nutritive value of leaves changes according to to photosynthesis activity and respiratory activities of the leaf. leaf harvested in noon contain less water and more carbohydrate. so harvesting can be done in morning.

**Leaf picking**: Leaf picking can be done ten weeks after bottom cutting or pruning and subsequent picking can be done after seven to eight weeks. Leaves are picked from the main stem with petiole and terminal buds are nipped off so that lateral shoot develops rapidly. The main advantage of this method is that leaves can be selected to suit the growth stages of larvae .it required more labour.

**Branch cutting**: this method is called Batchi system in Kashmir. In this method entire branch is harvested and used to feed worms after III moult directly. this method saves labour for harvesting easy to cleaning. leaves of branches retain for longer period.

**Whole shoot harvest**: in this method of harvest cutting of the branches to ground level by bottom pruning and feeding entire shoot to larva after IV moult. Harvesting of shoot can be done at intervals of 10-12 weeks and 5-6 harvests can br done in a year. this method is popular in kolhar Karnataka ,malda in WB.

**Preservation of leaves**: The leaves can be kept in small leaf preservation bags of 2'x3; size, having a capacity for holding -4 kg leaves. these bags of gunny or polythene they should be double layered. They are god than traditional method of storing in heaps and covering them with wet gunny cloth.

## Ex.no.10 REARING OF MULBERRY SILKWORM ON ARTIFICIAL DIET/NATURAL MULBERRY LEAVES

REARING on MULBERRY LEAVES: **Rearing Equipments :**

i) **Rearing house**: The rearing house should meet certain specification, as the silk worms are very sensitive to weather conditions like humidity and temperature. The rearing room should have proper ventilation optimum temperature and proper humidity. It should be ensured that dampness, stagnation of air, exposure to bright sunlight and strong wind should be avoided.

ii) **Rearing stand:** Rearing stands are made up of wood or bamboo and are portable. These are the frames at which rearing trays are kept. A rearing stand should be 2.5 m high, 1.5 m long and 1.0 m wide and should have 10 shelves with a space of 20 cm between the shelves. The trays are arranged on the shelves, and each stand can accommodate 10 rearing trays.

iii) **Ant well:** Ant wells are provided to stop ants from crawling on to trays, as ants are serious menace to silk worms. They are made of concrete or stone blocks 20 cm square and 7.5 cm high with a deep groove of 2.5 cm running all round the top. The legs of the rearing stands rest on the centre of well filled with water.

iv) **Rearing tray:** These are made of bamboo or wood so that they are light and easy to handle. These are either round or rectangular.

v) **Paraffin paper:** This is a thick craft paper coated with paraffin wax with a melting point of $55^{o}$ C. It is used for rearing early stages of silk worms and prevents withering of the chopped leaves and also help to maintain proper humidity in the rearing bed.

vi) **Foam rubber strips:** Long foam rubber strips 2.5 cm wide and 2.5 cm thick dipped in water are kept around the silkworm rearing bed during first two instar stages to maintain optimum humidity. Newspaper strips may also be used as a substitute.

vii) **Chopsticks:** These are tapering bamboo rods (1cm in diameter) and meant for picking younger stages of larvae to ensure the hygienic handling.

viii) **Feathers:** Bird feathers preferably white and large are important items of silkworm rearing room. These are used for brushing newly hatched worms to prevent injuries.

ix) **Chopping board and Knife:** The chopping board is made up of soft wood it is used as a base for cutting leaves with knife to the suitable size required for feeding the worms in different instar stages.

**x) Leaf chambers:** These are used for storing harvested leaves. The sidewalls and bottom are made of wooden strips. The chamber is covered on all sides with a wet gunny cloth.

xi) **Cleaning net:** These are cotton or nylon nets of different mesh size to suit the size variations of different instars of the silk worm. These are used for cleaning the rearing beds, and at least two nets are required for each rearing tray.

xii) **Mountages:** These are used to support silkworm for spinning cocoons. These are made up of bamboo, usually 1.8 m long and 1.2 m wide. Over a mat base, tapes (woven out of

bamboo and 5-6 cm wide) are fixed in the form of spirals leaving a gap of 5-6 cm. They are also called **chandrikes**. Other types of mountage such as **centipede rope mountage**, **straw cocooning frames** etc. are also used.

*xiii)* **Hygrometers and Thermometers:** These are used to record humidity and temperature of the rearing room.

xiv) **Feeding stands:** These are small wooden stands (0.9 m height) used for holding the trays during feeding and bed cleaning.

Other equipments like feeding basins, sprayer, and leaf baskets may also be required.

Rearing Practices 1

Silkworms must be reared with utmost care since they are susceptible to diseases. Therefore, to prevent diseases, good sanitation methods and hygienic rearing techniques must be followed. The appliances and the rearing room should be thoroughly cleaned and disinfected with 2-4% formaldehyde solution. Room temperature should be maintained around $25^0$ C.

**Procurement of quality seeds :**The most important step in silkworm rearing is the procurement of quality seeds free from diseases. Seeds are obtained from grainages, which are the centers for production of disease free seeds of pure and hybrid races in large quantities. These centers purchase cocoons from the certified seed cocoon producers. These cocoons are placed in well-ventilated rooms with proper temperature (23-$25^{\circ}$ C) and humidity (70-80 %), and emergence of moth is allowed. Grainage rooms may be kept dark, and light may be supplied suddenly on the expected day of emergence to bring uniform emergence. Emerging moths are sexed and used for breeding purposes to produce seed eggs. Three hours of mating secures maximum fertilized eggs. The females are then made to lay eggs on paper sheets or cardboard coated with a gummy substance. Egg sheets are disinfected with 2% formalin, and then washed with water to remove traces of formalin and then dried up in shades. The eggs are transported in the form of egg sheet. However, it is easy to transport loose eggs. To loosen the eggs, the sheets are soaked in water. The loose eggs are washed in salt solution of 1.06-1.10 specific gravity to separate out unfertilized eggs and dead eggs floating on surface. Prior to the final washing, the eggs are disinfected with 2% formalin solution. Eggs are dried, weighed to the required standard and packed in small flat boxes with muslin covers and dispatched to buyers.

**Brushing :**The process of transferring the silkworm to rearing trays is called brushing. Suitable time for brushing is about 10.00 am. Eggs at the blue egg stage are kept in black boxes on the days prior to hatching. The next day they are exposed to diffused light so that the larvae hatch uniformly in response to photic stimuli. About 90% hatching can be obtained in one day by this method. In case of eggs prepared on egg cards, the cards with the newly hatched worms are placed in the rearing trays or boxes and tender mulberry leaves are chopped into pieces and sprinkled over egg cards. In case of loose eggs a net with small holes is spread over the box containing the hatched larvae and mulberry leaves cut into small pieces are scattered over the

net. Worms start crawling over the leaves on the net; the net with worms is transferred to rearing tray.

**Preparation of feed bed and feeding :**After brushing, the bed is prepared by collecting the worms and the mulberry leaves together by using a feather. The bed is spread uniformly using chopsticks. The first feeding is given after two hours of brushing. Feed bed is a layer of chopped leaves spread on a tray or over a large area. The first and second instar larvae are commonly known as **chawki worms**. For chawki worms, paraffin paper sheet is spread on the rearing tray. Chopped mulberry leaves are sprinkled on the sheet and hatched larvae are brushed on to the leaves. A second paraffin paper sheet is spread over the first bed. In between two sheets water soaked foam rubber strips are placed to maintain humidity.

The 4th and $5^{th}$ instars are reared in wooden or bamboo trays by any of the three methods: viz., shelf-rearing, floor-rearing and shoot-rearing. In shelf rearing, the rearing trays are arranged one above the other in tiers on a rearing stand which can accommodate 10 -11 trays. This method provides enough space for rearing, but it is uneconomical as it requires large number of laborers to handle the trays. Chopped leaves are given as feed in this method. In floor rearing, fixed rearing sheets of 5-7x1-1.5m size are constructed out of wooden or bamboo strips in two tiers one meter apart. These sheets are used for rearing. Chopped leaves are given as feed. This method is economical than the first one because it does not involve much labour in handling of trays. Shoot-rearing is most economical of the three methods. The rearing sheet used is one meter wide and any length long in single tier and the larvae are offered fresh shoot or twigs bearing leaves. This method can be practiced both outdoors and indoors depending upon the weather.

Each age of the silk worms could be conveniently divided into seven stages. First feeding stage, sparse eating stage, moderate eating stage, active eating stage, premoulting stage, last feeding stage, moulting stage. The larvae have good appetite at first feeding stage and comparatively little appetite at sparse and moderate eating stages. They eat voraciously during active stage to last feeding stage after which they stop feeding.

**Bed Cleaning :**Periodical removal of left over leaves and worms' excreta may be undertaken and is referred to as bed cleaning. It is necessary for proper growth and proper hygiene. Four methods are adopted: conventional method, husk method, net method, and combined husk and net method.

**Spacing :**Provision of adequate space is of great importance for vigorous growth of silkworms. As the worms grow in size, the density in the rearing bed increases and conditions of overcrowding are faced. Normally it is necessary to double or triple the space by the time of moult from one to other instar stage, with the result that from the first to third instar the rearing space increases eight fold. In $4^{th}$ instar, it is necessary to increase the space by two to three times and in $5^{th}$ instar again twice. Thus, the rearing space increases up to hundred folds from the time of brushing till the time of maturation of worms.

**Mounting** Transferring mature fifth instar larvae to mountages is called mounting. When larvae are fully mature, they become translucent, their body shrinks, and they stop feeding and start searching for suitable place to attach themselves for cocoon spinning and pupation. They are picked up and put on mountages. The worms attach themselves to the spirals of the mountages and start spinning the cocoon. By continuous movement of head, silk fluid is released in minute quantity which hardens to form a long continuous filament. The silkworm at first lays the foundation for the cocoon structure by weaving a preliminary web providing the necessary foot hold for the larva to spin the compact shell of cocoon. Owing to characteristic movements of the head, the silk filament is deposited in a series of short waves forming the figure of eight. This way layers are built and added to form the compact cocoon shell. After the compact shell of the cocoon is formed, the shrinking larva wraps itself and detaches from the shell and becomes pupa or chrysalis. The spinning completes within 2-3 days in multi-voltine varieties and 3-4 days in uni- and bi-voltine.

**Harvesting of Cocoon**s: The larva undergoes metamorphosis inside the cocoon and becomes pupa. In early days, pupal skin is tender and ruptures easily. Thus, early harvest may result in injury of pupa, and this may damage the silk thread. Late harvest has a risk of threads being broken by the emerging moth. It is, therefore, crucial to harvest cocoons at proper time. Cocoons are harvested by hand. After harvesting the cocoons are sorted out. The good cocoons are cleaned by removing silk wool and faecal matter and are then marketed.

The cocoons are sold by farmers to filature units through Cooperative or State Govt. Agencies. The cocoons are priced on the basis Rendita and reeling parameters. Rendita may be defined as number of kg of cocoon producing 1 kg of raw silk.

Post Cocoon Processing :It includes all processes to obtain silk thread from cocoon.

**Stifling :**The process of killing pupa inside cocoon is termed as stifling. Good-sized cocoon 8-10 days old are selected for further processing. Stifling is done by subjecting cocoon to hot water, steam, dry heat, sun exposure or fumigation.

**Reeling :**The process of removing the threads from killed cocoon is called reeling. The cocoons are cooked first in hot water at 95-97 $^{o}$C for 10-15 minutes to soften the adhesion of silk threads among themselves, loosening of the threads to separate freely, and to facilitate the unbinding of silk threads. This process is called cooking. Cooking enables the sericin protein to get softened and make unwinding easy without breaks. The cocoons are then reeled in hot water with the help of a suitable machine. Four or five free ends of the threads of cocoon are passed through eyelets and guides to twist into one thread and wound round a large wheel. The twisting is done with the help of **croissure**. The silk is transferred finally to spools, and silk obtained on the spool is called the **Raw Silk** or **Reeled Silk**. The Raw silk is further boiled, stretched and purified by acid or by fermentation and is carefully washed again and again to bring the luster. Raw Silk or Reeled Silk is finished in the form of skein and book for trading.

The waste outer layer or damaged cocoons and threads are separated, teased and then the filaments are spun. This is called **Spun Silk**.

**i) Feeding schedule:** After hatching the young tiny larvae should be fed 2 times a day with tender leaves, after first and second molt 3 times a day; after third molt 4 times a day. After forth moult 5 times a day (twice at night) Larvae of different instars be kept in different batches

**ii) Care at the moulting** - Moulting worms should not be disturbed. Full grown worms should be transferred to Bamboo flat baskets 'chandrika' covered with lids. It can be taken for granted that rearing is successful if the mortality does not exceed 15 %.

**d) Precautions:**

1. In summer, trays should be covered with moist cloth.
2. Fresh delicate leaves should only be fed at proper times.
3. Keep all equipments very clean and hygienic.
4. Rigid selection of disease free seeds (eggs) for rearing is the most important.

REARING on ARTIFICIAL DIET:

## Ex.no.11. STUDIES ON STRAINS/SPECIES OF LAC INSECT, HOST PLANS AND THEIR IDENTIFICATION

**STRAINS OF LAC INSECT**: In India, Lac insect is known to have two distinct strains: kusumi and rangeeni. The kusumi strain is grown on kusum or on other host plants using kusumi brood. The rageeni 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, tow crops are: i). Karrtiki (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 corps contributing about 90% of lac production, remaining 10% is contributed by kusumi crops. However, the kusumi crop lac is considered superior resin, because of the lighter colour of resin,

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. Although lac insect is natural pest on host plant, these insects enjoy the privileged position not being treated as pest. This is because: i) they yield a useful product, ii) the host plants are economically not so important, and iii) the insects cause only temporary and recoverable damage to the host plants. 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- M.P. & U.P.) 8. *Shorea talura* ( grown in mysore)

9. *Cajanus cajan* (Vern. Pigeon-pea or Arhar) 10. *Grewia teliaefolia* ( preferred in Assam)

11. *Albizzia lebbek* (Vern. Siris/Gulwang) 12. *Flemingia macrophylla* (Vern. Bholia)

13. *Ficus benghalensis* (Vern. Bargad) 14. *Ficus religiosa* (Vern. Peepal) Of these host plants, palas, kusum, ber and khair are of major importance, while others are of regional and minor importance. It is also important to mention that the quality

## EX.no.12 IDENTIFICATION OF OTHER IMPORTANT POLLINATORS, AND SCAVENGERS

Pollination is transfer of pollen grain from anthers to the stigma of either same flower or of different flowers on same plant or different plants.

Self-pollinated plants -Need no agent for transfer of pollen.

Cross pollinated plants -Need wind, water, insects or other agents for transfer of pollen.

**Insect Pollination:**

Result in uniform crop and in some cases in improvement of quality of fruit.

Horticultural, crops, vegetables and fields crop like cotton and tobacco are pollinated by various insects.

Flowers of insect pollinated crops show adaptations like:-

1) Bright attractive colours 2) Scented flowers 3) Showy large petals

4) Nectaries 5) Sticky stigma and sticky pollen.

Insect visit the flower for nectar, the pollens get dusted all over the body and is transferred to stigma of flower next visited. Thus cross pollination is brought about.

* Insect pollinators: Examples:-

| | | | |
|---|---|---|---|
| Honeybees, | Bumble bees, | *Sarcophaga,* | Butterflies |
| *Xylocopa* , | *Bombus* spp, | Beetles, | *Acherontia* |
| *Andrena* , | *Syrphus*, | Black ants, | *Deilephila,* |
| *Halictus,* | *Bombylius,* | Thrips. | |

- Wide use of broad spectrum .insecticide has caused decrease in wild pollinators hence practice of employing honeybees artificially for, pollination in fields is increasing.
- Carrots, Umbelliferous plants depend on wasps and flies.
  Tobacco: honeybees and Bumble bees.
- Fruit crops like apple, plum, blackberry, raspberry, strawberry, citrus, grapes, papaya, cherry, vegetables, like lady's finger, brinjal, tomato, cucurbits and field crops like cotton: alfalfa. clover depend on honeybees for pollination.
- In western countries honeybees are hired out in flowering seasons, such forced bee populations increase apple yield by 3 folds and alfalfa yield by 4 times. Cotton yields increased 23 to 53 % due to honey bee pollination reported in Coimbatore district of Tamilnadu State.
- Bumble bees are generally fewer but useful to pollinate large flowers with long corollas and deep seated nectaries like cotton and lady's finger.

Dependence of plant on insect for pollination Ex. fig tree

Smyrna fig - produce only female flowers but fruit is fleshy, edible and sweet

Capri fig - produce plenty of pollen but non-edible fruits.

Capri fig is normal host for Aganotid wasp i.e.*Blastophaga psenes.* This wasp lays eggs in ovary of Capri fig flower. The eggs hatch and larvae grown in the ovaries. The males are wingless while female adults are winged. They copulate inside the flower and female flies away for oviposition. While it files, it carries pollen from Capri fig for oviposition it may visit a Smyrna fig flower but is unable to deposits eggs as a ovary is deep seated but it deposits pollen grain on Smyrna flower thus affecting fruit formation.

Hence, in fig plantations Capri and Smyrna figs are planted side by side and pollination done by wasps.

**Pollination service:**Practice of renting bee colonies for pollination service started in U.S.A. in to 1910. Every year about a million of hives are hired for pollination in U.S.A.

Usually five colonies are maintained for two hectares. Number of colonies per unit area depend upon concentration of flowers, attractiveness, the presence and number of other pollinating insects and presence of competing crops in the vicinity. The colonies should be moved well before flowers have not lost their receptivity to fertilization. The interval between two colonies should about 90 m. as bee activity is concentrated within this radius.

**SCAVENGERS**

These are insects that feed upon dead and decaying plant and animal matter.

Advantages:i) Remove dead and decaying bodies from earth surface. ii) Decrease the health hazard due to this decomposing matters iii) Clean filth form human habitations. iv) Convert the complex body materials to simpler ones making available for growing plants then easily

Important scavengers:1) Coleopterans: Rove beetles, Darkling beetles. Skin beetles, Chafer beetles, Ptinidbeetles, Jewel beetles, Carrion beetles, Water scavengers beetles

2) Dipterans: (Larvae serve as scavengers)Dady-long-legs, Sand flies, Moth flies, Midges or gnats, fungus gnats, hover flies, Muscids.3) Isopterans: Termites.

## Ex.NO.13. MASS REARING OF FACTITIOUS HOST INSECT, *Corcyra cephalonica* STATION IN THE LABORATORY

In India most of the trichogrammatids are mass reared on rice moth, *Corcyra cephalonica* Stain. Enough care is taken to avoid excess of direct sunlight to rearing room. A temperature of 27 ± $1^0$C with R.H. of 80% ± $5^0$C and moderate light are to be maintained for good production of rice grain moth, Corcyra.

**MATERIALS :**

i. One rearing room of 15' x 12' x 8' size with A.C. installation.
ii. Wooden trays of 45 x 30 x 15 cm size
iii. Coursely ground grains of sorghum / Bajara
iv. Yeast
v. Oviposition cage / drum
vi. Slotted angle iron racks, working tables
vii. Refrigerator
viii. Glass vials, brush, measuring cylinder, cotton, honey, formalin
ix. Hot air oven
x. Vacuum pump with moth suction device
xi. Exhaust fan.
xii. UV chamber / laminar flow
xiii. Eggs of *Corcyra*

**PROCEDURE :**

1. Procure sorghum pearl millet grains suitable for human consumption. i.e. The grains should not be treated with insecticides. (To test this, a sample of 100 g from each bag is crushed and 1st or 2nd instar *Corcyra* larvae are allowed to feed for 2-3 days to find out whether the sorghum has previously been treated with any of the insecticides. (The conclusion could be drawn on the basis of mortality of the larvae).
2. The required quantity of sorghum grains should be milled coursely to make 3-4 pieces of each grain.
3. The coarsely ground grain should be heated / sterilized in an oven at $100^0$C for 30 minutes.
4. These grains should be then 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. Dry the grain with fan air.

**5.** Pour 5 kg coarsely ground grains of sorghum or bajra in each wooden box and add 10 gm yeast powder in it to enhance the growth of the insect. Fill required number of boxes considering the yield of 7 to 10 g eggs box.

**6.** Obtain pure culture of eggs of *Corcyra* from research laboratories engaged in this type of work or collect the rice grain moths from the godowns and cage them in oviposition jar to obtain the eggs.

**7.** Then mix 1 cc (18 to 20 thousand) egg of *Corcyra* in the box filled with the grains secure the lid of box for about 30 days. Keep the boxes on the racks. Maintain the temperature of the rearing room at $30^0$C. Allow the insect larvae to grow in the boxes. Observe the boxes critically after about 4 weeks period for the emergence of moths, as this insect takes about 30 to 40 days to complete its life cycle.

**8.** The moth emergence continues for two months. On alternate day collect the adults emerged in morning. Put about 1000 adults / oviposition drum cage having 40 mesh wire sieve at bottom. The female moths start laying eggs on the mesh wire bottom and the eggs get sieved down on the lower container / paper. The moths can be used for oviposition upto 3 days period economically. Remove dead moths from drum and release in freshly emerged.

**9.** Collect the deposited eggs, clean them from scales, legs an other debris etc. of the insects. The collected eggs again passed through 40 mesh sieve and then run over a slope of blotting paper to eliminate dust particles. Keep these eggs in small glass vials and plut it with cotton. Store for 3 to 4 days in refrigerator at $10^0$C, if not used immediately.

10. If required, these eggs may be treated with UV rays (30 W UV tube for 45 minutes at a distance of 2 feet) to prevent hatching.

**YIELD :**

About 4-5 thousand per box could be obtained and as such from 1 ml of *Corcyra eggs* reared in each wooden box give about 10 ml eggs. About 100 months of *Carcyra* could lay 1.5 cc eggs during 4 days period. These eggs can be used for rearing of *Trichogramma.* Such eggs are glued @ 18,000 to 20,000 (1 C.C.) eggs/card of 17 x 14 cm size leaving 1 cm uncovered space along length at both the sides for facilitating stapling. 'Phule Trichocard' is designed to give 20 segments each containing 900 to 1000 parasitized eggs.

**PRECAUTIONS :**

i. Use low heightened room or cloth cabin for rearing of *Corcyra,* as the escaped moths resting on the walls and roof ceiling can be collected easily.

ii. Use separate room for mass rearing of *Corcyra* to avoid the adultration of the culture. Blotting paper should be used to collect the eggs to facilitate cleaning.

iii. Each box should be kept for 3 months and then clean with 2% formalin.

iv. Conceal only 1000 adults/drum to avoid over crowding in oviposition drum.

v. Moths should be fed with Vit. E capsules to enhance fecundity.

vi. Treat the *Corcyra* eggs with UV rays to prevent hatching during parasitization by the *trichogramma* or to store for some period.

**UTILITY :**

The *Corcyra* eggs are used in biological control laboratory as unnatural / factitious host for mass multiplication of certain parasitoids like *trichogramma, Chelomus, Copidosoma,* and predators like *Crysoperla* etc. the *Corcyra* larvae are also used to multiply larval or larval-pupal parasitoids.

## Ex.NO.14.MASS PRODUCTION TECHNIQUE OF EGG PARASITOID, *Trichogramma chilonis* ISHI (F : Trichogrammatidae O : hymenoptera)

*Trichogramma* spp. are widely distributed species of egg parasitoid in India and abroad. Over 200 insect species belonging to 70 families and 8 order in diverse habitats are parasitized by species, subspecies and various strains of Trichogrammatids. Out of 26 *Trichogramma* species recorded in India *T. chilonit, T. japonicum* and *T. achaea* are widely distributed and are key mortality factors for many crop pests. In India, this parasitoid is mostly used against pests like, sugarcane borer, *Chilo* spp and *Scirpophaga excerptalis,* paddy stem borer, *Scirpophaga incertulas,* tomato fruit borer, *Helicoverpa armigera*, cutoworms, *Agrotis* spp cotton bolloworms, *Pectinophra gossypiella* and *Earias* spp maize stem borer, *Chilo partellus* etc.

**BIOLOGY :**

A female lays 1-20 eggs in one host depending on size of eggs but in the eggs of sugarcane borers, only 1-2 eggs are deposited / egg. Its fecundity varies from 20-200 eggs according to species and longivity of adult parasitoid.

Duration of different stages at 28 ± $2^0$C

Incubation period:1 day (16-24 hrs. Larval period : 2-3 days

Prepupal period: 2 days Pupal period: 2-3 days

Total life cycle completed in 8-10 days during summer and 9-12 days during Winter months. Genus *Trichogrammatoidea* takes 1-2 days more than *Trichogramma* to complete development. Longivity of adult :6-8 days Release period : 24 hrs.

Host eggs become dark in 3-4 days after the parasitization due to accumilation of urate granules. Unparasitized eggs remain light in colour until black head stage is formed.

Sex ratio of male to female is normally 1 : 1

Host searching capacity is very poor (upto 3-5 meters)

**MASS REARING OR *TRICHOGRAMMA CHILONIS* ISHII**

*Trichogramma chilonis* (*F : trichogramatidae, Hymenoptera*), being indigenous parasite, is proved to be one of the most potent egg parasitoid for various lepidopteran tissue borers. Rice moth, *Corcyra cephalonica* (Galleridae), angumoise grain moth, *Sitotruga cerealella* 9gelechidae) and oak silk moth, *antharaea perniyi* (Saturnidae) are used as factitious host for multiplication of *Trichogramma.*

**MATERIALS :**

i. Egg cards : Phule 'Trichocards', 17.5 cm x 14 cm sized with 17 cm x 10 cm space for gluding host eggs and 5 cm x 1.75 cm sized 20 prepunched segments, *Corcyra* eggs, Gum Arabic, Camel hair brush / cotton swab, cotton wool, Test tubes, Refrigerator, Glass / plastic jars, polyethene bags, muslin cloth, rubber bands, scissors, clips, UV chamber, fluorescent tube light (15 W) / Laminar flow, Honey solution 20%, Working tables

**METHOD :**

Steps involved in production (preparation of Trichocards)

1. Paste 1 c.c. (18,000 to 20,000) eggs of *Corcyra* on thinly smeared gum arabic on segment marks side of egg card with the help of suitable strain. Remove the excess eggs with soft hair brush gently.
2. Expose the eggs to UV rays (15 watt UV tubes for 45 minutes at a distance of 2 ft to prevent hatching during and / or after parasitization of the eggs.
3. On backside of the 'Trichocards' write name of the parasite species, date of release of parasitoid for parasitization, expected date of emergence, name of the manufacturing institute, initials of technical person, etc.
4. The processed egg card is then placed conveniently in the plastic jar. Introduce the 6 day old duly parasitized egg card in such container or expose these unparasitized egg cards to adult females of *Trichogramma* for 24 hrs. The parasitized and unparasitized eggs in each of the containers should be in the ratio of 1: 6 (parasite : host) to have optimum parasitization. Close the containers conveniently. The adult female parasitoids emerge from the parasitized blackened egg cards and parasitize the unparasitized eggs of *Corcyra* after mating.
5. After 4 days of parasitization, brush out all the host larvae if any hatched from unparasitized eggs, as these larvae may destroy parasitized eggs. The parasitoid complete its life cycle mostly within 7-8 days.
6. The parasitized eggs of *Corcyra* start changing their colour from creamy white to blackish due to accumulation of urate granules after 4 days of parasiization. Such parasitized egg cards could be stored for about 20 to 30 days at $10^0$C temperature in refrigerator.

**PRECAUTIONS :**

i. To avoid contamination of culture and host larvae feeding on parasitized eggs, the eggs of the host should be frozen at 0-5$^0$C for 2 hrs in refrigerator or exposed to UV light (15 w) irradiation for 30 minutes to kill the host embryo as well as contaminating species.

ii. Runts (underdeveloped individuals) can be avoided by keeping the host : parasite ratio of 6 : 1.

iii. Use only 0-24 hrs old eggs of host. *Corcyra* for assured breeding the parasites.

iv. Transfer the parasitized egg cards on 3$^{rd}$ day of parasitization, which indicate blackenings of the host eggs.

v. During shipment, Trichocards should be packed keeping the parasitized surface on innerside.

vi. Emergence date should be specified on the cards for the guidance of the user.

vii. Cut pieces of Trichocards should be stappled on the lower side of the leaf to provide shade and to avoid direct sunlight.

viii. Card pieces should be stappled in morning hours and just before emergence to avoid predation.

ix. In the case of release of emerged adult *Trichogramma,* open the bag / container move it along the rows and go on tapping the bag till all the adult parasitoids fly out.

x. Refrain from using the pesticides in the field where *Trichogramma* are released. If need arises, use selective / safer pesticides following strip or staggered spray method ensuring that pesticides are used 15 days before or after the *Trichogramma* release.

**USE OF TRICHOCARDS :**

1. Read instruction on the card and use before date.
2. First cut the card breathwise along middle cross line into equal big strips. Then make small segments along marking as per requirement. One card gives 20 segments.
3. Stapple two segments / plant in cotton and one segment / plan in other crops under middle leaf of plant at 10 m x 10 m distance

| Sr. No. | Crop & Pest | Cards / ha/ release | Crop Age at 1$^{st}$ release days | No. of releases | Release interval (days) | Most effective spp. |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Sugarcane borers | 3 to 4 | 21 | 4 to 6 | 10 | *T. chilonis* |
| 2. | Cotton bollworms | 10 | 45 | 10 | 7 | *T. japonicum & T. chilonis* |
| 3. | Tomato / okra / brinjal fruit borer and cabbage DBM | 3 to 4 | 45 | 4 to 5 | 7 | *T. achae, T. pretresums & T. chilonis* |
| 4. | Maize stem/cob borer | 3 to 4 | 45 | 3 to 4 | 10 | *T. chilonis* |
| 5. | Paddy | 3 to 4 | 30 | 3 to 4 | 10 | *T. japonicum* |

A private firm, Pest Control India Ltd., BCRL P.O. Box 3228, 479, 5th cross, HMT layout, R.T. Nagar, Bangalore 560032 and such other several private personnels have started the mass production of *Trichogramma,* at present in India. Such egg cards are available for sale @ Rs. 16 to 40 per card, containing 16,000 to 20,000 parasitized eggs.

**Method of mass rearing of *Chilonis blackburni***

*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 complete in 26 days. Following steps are involved in mass rearing of *C. blackburni* on *C.cephalonica* culture.

1. obtain Corcyra eggs from the rearing units as described earlier and glue oone cc eggs cards sparsely. For this purpose, use only freshly laid or 0-24 hrs old eggs of the host.

2.put this egg card in breeding glass jar and released the freshly emerged adult parasitoids *C.blackburni* on Corcyra egg card with the help of aspirator. During parasitization, adult parasitoids may be provided with 50% honey solution on wax paper or in cotton wicks. About 100 adult parasitoids can be used to parasitize 0.25 cc of *C.cephalonica* eggs with the embryo in the host eggs.

3. after exposure of 24 hrs, the eggs card which is kept for parasitization is removed and another egg card can be placed for parasitization.

4.put 2.5 kg crushed grains of sorghum already treated with 0.1% formalin solution in each Corcyra rearing wooden boxes, or sufficient quantity of crushed grains in glass jar, where in the grain layer should be 2.5 cm thickness.

4. place the convenient sized pieces of parasitized egg cards on the layer of the crushed grain with the proportion of 0.5 cc eggs per 2.5 kg grains. Cover the top o0f wooden box with it lid or

jar with muslin cloth and rubber band. the parasitized larva hatched out and the larvae already parasitized in its egg stage start feeding on broken grains and remain developed in it.

5. After a period of 1 month, the parasitoid complete its life cycle and adult emergence start , 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 $10^0$ c temperature.

In case of mass culturing of *C. blackburni* on PTM, follow same procedure as given for *C. koehleri* parasitoid. Here egg sheets of PTM may be exposed to adults of *C. blackburni* and the parasitized egg sheet after 24hrs. of exposure, may be established In to plastic basket with the punctured potato tubers already placed on a soil layer. The silvery white earten pupae of the parasitoid could be collected by sieving the soil or collect emerging adults with aspirator.

FIELD UTILIZATION OF C. BLACKBURNI

Potato:The adult parasitoid could directly be released in the field crops or even in stored potatoes(Arni) as descriebed for earlier parasitoid. Release of 60,000 adults/ha (i.e 15,000 adults/week/release and such 4 releases in the ffield crop). In case of stored potatoes, release 2 adults/kg tubers.
Cotton: release 2 lakh adults/ha with total 6 releases starting after 60 days of planting.
Precautions:-1.Do not keep the height of broken grains more than 2.5 cm in the rearing jar/box, otherwise parasitoid emergence may be affected.
2. plan 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 or follow staggered spray technique and release the parasitoid on alternate untreated strips.

**Mass production of *Goniozus nephantidis***

**Introduction:** *Goniozus nephantidis* is the most widely used parasitoid of *Opisina arenosella*. It is a sturdy gregarious larval or prepupal ectoparasitoid. The female practices maternal care of eggs and larvae. The host larvae are parasitized and the parasitoid even feeds on host body fluid. The parasitoid is also capable of suppressing the population by merely stinging and aralyzing 1st – 2nd instar larvae. *G. nephantidis* is the most common and effective parasitoid of late instars caterpillars of *O. arenosella* in several parts of the country. The parasitoid is being mass multiplied and released in Karnataka, Kerala and several other states.

**Procedure:**

- The parasitoid is multiplied on *Corcyra cephalonica* larvae in diffused light. A pair of parasitoid is introduced in tube (7.5 x 2.5 cm).
- The adults are provided honey in the form of small droplets on wax coated paper. After a pre-oviposition period of six days one healthy last instar larva is provided in a vial.
- The larvae parasitized and containing eggs of *G. nephantidis* are removed regularly from the vials till the death of the female. Such larvae are kept in accordion type strips of paper in plastic boxes which are covered by muslin cloth.

- Considering the fecundity as 20-50, the female is capable of parasitizing 6-7 larvae in three oviposition spells each separated by 4-5 days.

The life cycle of the parasitoid is completed in 10-14 days (incubation 24-36 hrs, larval feeding 36-48 hrs, prepupal stage 48-60 hrs and cocoon period 48 to 56 hrs + resting adult inside the cocoon 108-128 hrs).

**Ex.no.15. MASS REARING OF A PREDATOR, GREEN LACE WING,**

## *Chrysoperla carnae* (CHRYSOPIDAE : NEUROPTERA)

Sucking pests cause serious losses to many field, plantation and horticultural crops. Green lace wing (Aphid lion). *Chrysoperla* spp. a potent predator of many sucking pests. The mass production technique of a predator is given below :

**MATERIALS :**

1.
2. *Corcyra cephalonica* rearing unit as given in exercise No. 2 for the egg production.
3. Nucleus culture of *Chrysoperla spp.*
4. Rearing trays, plastic jars.
5. Slotted angle iron racks, working tables.
6. Weighing balance
7. Scisors, brushes, cotton wool, forceps, tissue paper, brown paper separators.
8. Foam sheet, sponge, acrylic sheet.
9. Fructose, protinex, honey, yeast, castor, pollen etc.

**LABORATORY HOST :**

Eggs of *Corcyra cephalonica* St.

**TARGET HOST :** Aphids, white flies, jassids, eggs and early stages of lepidopterous caterpillars.

**METHOD :** *Chrysoptds* have a great potential for use as biocontrol agents against aphids, jassids, thrips, white flies and early stages of lepidopterous pests. This predator is used for the suppression of pests of cotton. Sunflower, groundnut and some fruit crops in many parts of the country. In India, 67 species belonging to 21 genera have been recorded from various crop ecosystems. Amongst them, *Chrysoperla carnea, C. scelestes, Mallada boninensis, M. astur* and *Aptertochrysa crassinervis* are the most common. The green lace wing is being mass produced primarily on the eggs of rice moth, *C. cephalonica* in India.

**BIOLOGY :** The eggs of *Chrysoperla* are stalked and green in colour. They are laid singly or in clusters. The eggs turn pale whitish and then black before hatching. Egg period is 3-4 days. The newly hatched larva is white in colour. On hatching it undergoes 3 instars within 8-10 days. These larvae spin whitish round cocoons (pupal period : 7 days) from which the adults emerge in 5-7 days. The adults mate repeatedly. Pre-oviposition period lasts for 3-7 days. Adults start

laying eggs from 5th day onwards and peak egg laying period is between 9 and 23 days after emergence. Longivity of male is 30-35 days and for female, it significantly 35-55 days. Fecundity is 600-800 eggs / female on an average in *C. carnea*. Rearing of *Chrysoperla sp.* require one room of 6 m x 6 m maintained at 27 ± $1^0$C, 70% R.H. and constant light of normal illumination levels emitted by fluorescent tube.

**STEPS INVOLVED IN MASS REARING OF *CHRYSOPERLA***

**1.** Conceal 200 pairs of adults in oviposition case, measuring 75 x 30 x 30 cm. The sides of the cage are lined with smooth nylon wiremesh (not preferred for egg laying) and the sliding top cover is fitted with black cloth for obtaining eggs. To prevent damage to the eggs, the top is slided over a comb fitted on both the sides of the cage. The sliding top cover is replaced on alternate days starting from 4th day onwards. The oviposition cage is kept for 30 days and the dead adults are removed every alternate day.

**FEEDING ADULTS :**

The adults in oviposition cage are fed on alternate days on cotton wool swabs soaked with I) Drinking water, ii) Honey 50% solution, iii) Protinex mixture (equal quantity of protinex + fructose + powdered yeast dissolved in small quantity of water). Two swab of each of the three liquid should be hanged in case with the help of thread and thin iron wire.

If sometime such case is not available, the emerged adults may be kept in dessicators or plastic jar containing honey solution soaked cotton wicks and closed with black cloth. Keep in side cotton leaves or tissue paper or brown paper or black paper for oviposition.

2. One day old eggs (Egg chorion gets hardened) are dislodged from the black cloth top cover of oviposition cage by gently moving a piece of sponge. Thus, eggs collected can be used for further multiplication.

3. Since the larvae of chrysopids are cannibalistic, rear them individually in plastic louvers or in hexagonal cells. Place a foam sheet of the convenient size in the plastic rearing tray. Then, put the paper separators having hexagonal cells on the foam. Sprinkle about 300 to 400 *Corcyra* eggs (already inactivated by exposure to 15 W UV light for an hour) in each hexagonal cell. Introduce 3 day old 1-2 Chrysopid eggs / hexagonal cell. The covered may be secured with the help of lid of the tray. Small opening at the centre of the lid should be provided with wire mesh for aeration.

For rapid method mix 3 day old 120 eggs of Chrysopid with 0.75 ml UV radiated *Corcyra* eggs in a plastic container. After hatching of larvae on 3rd day transfer these larvae into individual cubical cells of plastic louvers. Such each louver can hold 192 larvae. The Corcyra eggs, are sprinkled in all the louvers through modified salt sprinkler in 2 doses. Give first feeding of 1.5 ml eggs and second feeding of 2 ml eggs/100 larvae with 1 3-4 days gap. Total 4.25 ml *Cocyra* eggs are required for rearing of 100 chrysopid larvae. The louver is secured on one side by brown paper sheet and after transfer of larvae, it is covered with acrylic sheet and clamped. Brown paper is used for clear visibility of *Corcyra* eggs and for pupal formation.

4. The matured larvae pupate in round white cocoons which may be collected after 24 hours of formation by removing paper top. These cocoons are kept in oviposition eage/jar for adult emergence.

**UTILIZATION FOR FIELD RELEASE AND DOSE :**

Normally Chrysopids are released in the fields in its 1st instar larval stage against different field crops at the rate of 50,000 to 1,00,000 larvae/ha. or 10-20 larvae/fruit plants. Depending upon pest saturations, 2 releases at fortnightly interval are recommended for control of following sucking pests and early instar larvae of Lepidopteran pests.

| Pest | | Dose/release |
|---|---|---|
| a. American bollworm | *H. armigra* | Spotted/Spiny |
| Spotted/Spinry bollworm | *Earias sp.* | *Chrysoperla* @ |
| Pink bollworm | *P. gossypiella* | 50,000 larvae/ha |
| White fly | *B. tabaci* | or 1 to 2 |
| Aphids | *A. gosspii* | larvae / plant or 10 – |
| Tobacco aphids | *M. persicae* | 20 larvae / tree. |
| Tobacco caterpillar | *S. litura* | twice during the |
| Groundnut aphids | *A. crassivora* | Season with a |
| | | gap of 15 days. |

**METHODS OF RELEASE :**

The *Chrysopid* larvae can be released in the field by

1. Broadcasting larvae with saw dust on thick crop canopy.

**2.** Dropping 1 or 2 larvae / plant on leaves or 10-20 larvae / tree placing corrugated paper strip on the plants / trees or the eggs mixed in saw dust are dropped on crop canopy.

**PRECAUTIONS :**

1. Rear the grub stage individually to avoid cannibalism.
2. Release should be made in early morning hrs. to settle larvae on crop canopy.
3. Avoid to release freshly laid eggs as they may be parasitized predated in more no. in the field.
4. Do not use pesticides in the field where the predators are released : otherwise use selective / safer pesticides after or before 10-15 days of release following strip or staggered spray method.

## MASS REARING OF COCCINELLID, AN AUSTRALIAN LADY BIRD BEETLE, *Cryptolaemus monotrouziery* MULSANT, (COCCINELLIDAE : COLOPTERA), A PREDATOR ON MEALY BUG.

Mealy bygs, *Planococcus citri* and *Maconellicocus hirsutus* are potential pests of guava, Citrus, Custard apple, pomegranate, 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 montrouziery* 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. The mass production technique of the lady bird beetle is given below :

**MATERIALS :**

1. Nucleus culture of *C. montrouzeri* predatory beetle and Mealy bug, *Maconellicoccus hirsutus* G. or *Planococcus citri* Risso.
2. Red pumpkins, sprounted potatoes.
3. Rearing cages, plastic trays, plastic jars and slotted angle iron racks.
4. Burlaps strips / paper strips, scissors, muslin cloth, rubber bands, paraffin wax, Bavistin 0.1% solution, brush, etc.
5. Honey-agar diet prepared with 10 ml honey, sugar 5 g, agar-agar 250 mg and water 25 ml mixture.

**LABORATORY HOST :** Mealy bugs, *M. hirsutus* and *Planococcus citri* : Eggs, Nymphs and adults. **TARGET HOST :** Mealy bugs on grape vine and other fruit crops.

**METHOD :** The predatory beetle, *C. montronziern* 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 also. But its rearing on red pumpkins is more practicable and economical.

**REARING OF MEALY BUGS ON POTATO :**

The technique of using potato sprouts as an insectory host for mealy bug culture was 1st reported by Branigan (1916) and further modified by Smith and Armitage (1920) and later elaborated by Fisher (1963).

Fill wooden trays of 45 x 45 x 10 cm sized with sandy silt soil upto 2 to 3 cm depth for 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 $30^0$C. Put ovisacks 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 groves with small stalk and of medium sized may be selected for 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 ovisacs 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 then 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 350—500 eggs in its ovisac : 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 is completed in 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. mountrouzieri* could be placed in the rearing cages containing infested red pumpkins or potato sprout at the temperature of 20-$30^0$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 and wooden

tray. Remove the ovipositing adults from the trays after 12 days. On hatching, larvae feed on stages of mealy bugs. Attach Burlaps strips to the front of the trays to accommodate pupating larvae of the predator. During this period keep darkness in the room. If Burlaps strips not available, 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 petric plate or plastic jar with lid and use for further mass production.

**BIOLOGY OF *C. montrouzieri***

| | | |
|---|---|---|
| Preoviposition period : | 7-12 days | |
| Oviposition period | : | 39-63 days |
| Incubation period | : | 4-8 days |
| Grub period | : | 1 days $1^{st}$ instar : 2-4 days |
| | | with 4 $2^{nd}$ instar : 3-5 days |
| Prepupal period | : | 1-2 days |
| Pupal peirod | : | 7-11 days |
| Sex ratio | : | 1.07 : 1 (M to F) |

**UTILIZATION OF *C. montrouzieri* FOR FIELD RELEASE :**

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

**DOSE :** i. Release 2-3 larvae / mealy bug colony

ii. Release 1500 adults/ha

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

**PRECAUTIONS :**Do not feed adult predatory beetles only on honey-agar diet, but supplement it with mealy bugs eggs as it affects fecundity of the predator. 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 $1^{st}$ spray alternate tree and release predator on remaining untreated (alternate) trees after 4 to 5 days. Next time after 15 days spray predator released trees .

**Ex.no.16,17 and 18. VISIT TO RESEARCH AND TRAINING INSTITUTE/UNITOF BEE KEEPING,SERRIULTURE,LAC CULTURE AND BOADGENT PRODUCTION UNITS.**