PRACTICAL MANUAL

Management of Beneficial Insects

(APE 323) 2(1+1)

For B.Sc. (Hons.) Agriculture VI Semester

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Syllabus:

Honey bee species, castes of bees. Beekeeping appliances and seasonal management, bee enemies and disease. Bee pasturage, bee foraging and communication. Types of silkworm, voltinism and biology of silkworm. Mulberry cultivation, mulberry varieties and methods of harvesting and preservation of leaves. Species of lac insect, host plant identification. Identification of other important pollinators, weed killers and scavengers. Visit to research and training institutions devoted to beekeeping, sericulture, lac culture and natural enemies. Identification and techniques for mass multiplication of natural enemies.

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CONTENTS

EXPERIMENT NO. 1

Objective: Familiarization with different body regions of honeybee

Exercise: Observe the honeybee specimen in the laboratory using magnifying lens and note down the morphological characters of honey bee.

Observation to be Recorded:

Head: ……

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Thorax: ……

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Abdomen: ……

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Draw a well labeled diagram of the general morphology of the worker bee.

EXPERIMENT NO. 2

Objective: To study different species of honey bee

Exercise: Visit to the nearest field, note the different species of honeybees observed and record their character.

Materials Required:

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Observation to be Recorded:

Species	Characters
i. ……	……
ii. ……	……
iii. ……	……
iv. ……	……
v. ……	……

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EXPERIMENT NO. 3

Objective: To get familiarize with different castes of honey bee

Exercise: Depict different morphological character for the different castes of honeybee provided to you. Compare the developmental stages of different castes of *A. cerana and A. mellifera.*

Materials Required:

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Observation to be Recorded:

Characters	Diagram
Queen: ……... ……... ……... ……... ……... ……... ……... ……...	
Workers: ……... ……... ……... ……... ……... ……... ……... ……...	

Drones: ……... ……... ……... ……... ……... ……... ……... …….	

Precautions to be followed while handling bee colony:

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Caste	**Incubation period (days)**		**Larval period (days)**		**Pupal period (days)**		**Total developmental period (days)**	
	A.c	***A. m***	***A.c***	***A. m***	***A.c***	***A. m***	***A.c***	***A. m***
Queen								
Worker								
Drone								

EXPERIMENT NO. 4

Objective: Acquaintance with bee hive and various beekeeping appliances

Exercise: Draw the diagram of the bee hive and give the details of its different parts. Illustrate the beekeeping appliances that you observe in the Apiary.

Observation to be Recorded:

Hive stand: .....

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Bottom board: .....

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Brood chamber: .....

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Supers: ……

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Covers: ……

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Frames: ……

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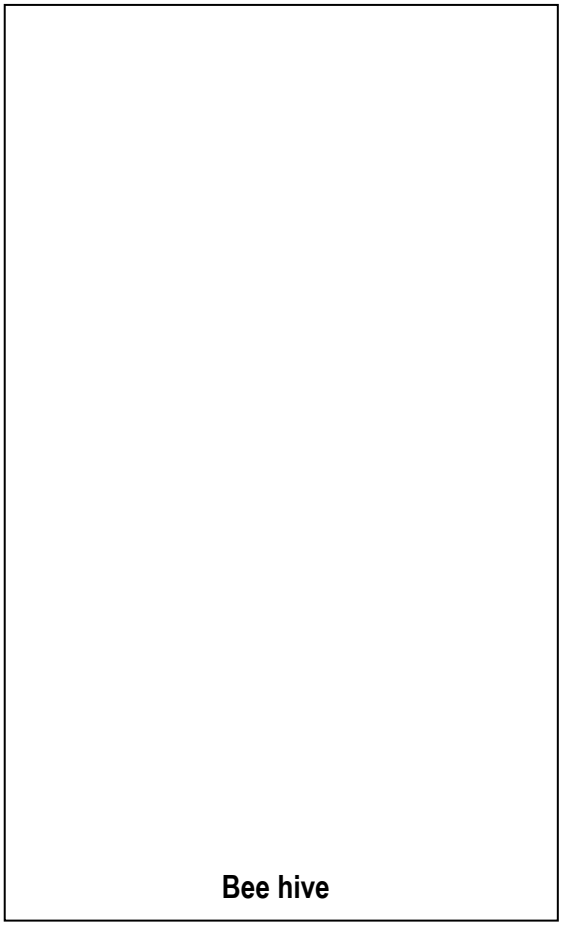

Bee hive

Other Bee-keeping Appliances

	Appliances	Uses	Diagram
1.	……	……	
2.	……	……	
3.	……	……	
4.	……	……	
5.	……	……	

6.	……	……	
7.	……	……	
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9.	……	……	
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11.	……	……	
12.	……	……	
13.	……	……	
14.	……	……	
15.	……	……	

EXPERIMENT NO. 5

Objective: Seasonal management of bee hive

Materials Required: ……..……..

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Exercise: Inspect the hive. Write the management scheduled at different season. Write the procedure for uniting the bee colony (Newspaper method).

Spring season management: ……

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Monsoon season management: ……

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Summer season management: ……

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Autumn/ fall season management: ……

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Winter season management: ……

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Procedure for uniting the bee colony (Newspaper method):

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Precautions and Safety Measures that you follow while handling the bee:

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EXPERIMENT NO. 6

Objective: Familiarization with enemies of honey bee and bee hives

Exercise: Inspect and identify the pest present in bee hive. Write their nature of damage (symptoms) and follow up the management for the observed pest.

Materials Required:

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Observation to be Recorded:

	Common name	Scientific name	Nature of damage	Management
1.	…… ……	…….... ……	……..….. …… …… ……	…….. …….. …….. …….. ……..
2.	…… ……	…….... ……	……..….. …… …… ……	…….. …….. …….. …….. ……..
3.	…… ……	…….... ……	……..….. …… …… ……	…….. …….. …….. …….. ……..
4.	…… ……	…….... ……	……..….. …… …… ……	…….. …….. …….. …….. ……..
5.	…… ……	…….... ……	……..….. …… …… ……	…….. …….. …….. ……..

Procedures for checking the presence of Mite

For *Varroa* mite:

To examine from the pupa: ……..

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To examine mites on adult bees: ……..

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For tracheal (Endoparasitic) mites: ……..

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EXPERIMENT NO. 7

Objective: Familiarization with the diseases of honey bee

Exercise: Collect the infected honey bees in vials from the hives. Observe the symptoms cause by the pathogen and identify its causal organism.

Materials Required: ……

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Observation to be Recorded:

Disease Name	Causal Organism	Site of Infection	Stage Infected	Symptoms
Protozoan diseases:				
…… ……	…… ……	…… ……	…… ……	…… …… …… …… ……
…… ……	…… ……	…… ……	…… ……	…… …… …… …… ……
Fungal diseases:				
…… ……	…… ……	…… ……	…… ……	…… …… …… …… ……
…… ……	…… ……	…… ……	…… ……	…… …… …… ……

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Bacterial diseases:				
…… ……	…… ……	…… ……	…… ……	…… …… …… …… …… ……
…… ……	…… ……	…… ……	…… ……	…… …… …… …… …… ……
Viral disease:				
…… ……	…… ……	…… ……	…… ……	…… …… …… …… …… ……
…… ……	…… ……	…… ……	…… ……	…… …… …… …… …… ……

EXPERIMENT NO. 8

Objective: To study bee pasturage and bee foraging

Exercise: Visit the crop field and orchard. Note down the bee flora available in the campus and record the bee foraging behavior.

Observation to be Recorded:

Bee flora/ Pasturage	
Good nectar source	…… ……
Good pollen source	…… ……
Both source of pollen and nectar	…… ……

Procedures for Recording Bee Behaviour

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Results on Foraging Activity:

EXPERIMENT NO. 9

Objective: To understand the communication in honeybee

Exercise: Write in details and draw the dances perform by the bee in the hive as a means of communication.

Observation to be Recorded:

Round dance: ..……..…

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Wag-tail dance: ……..

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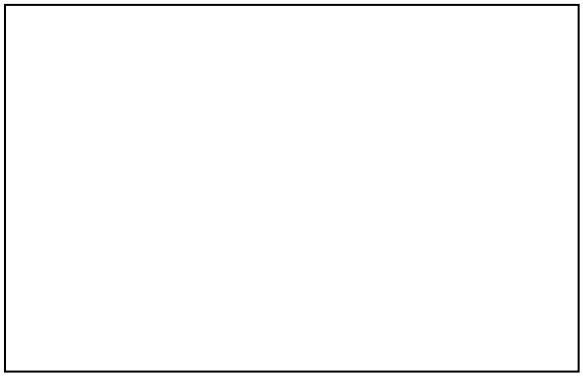
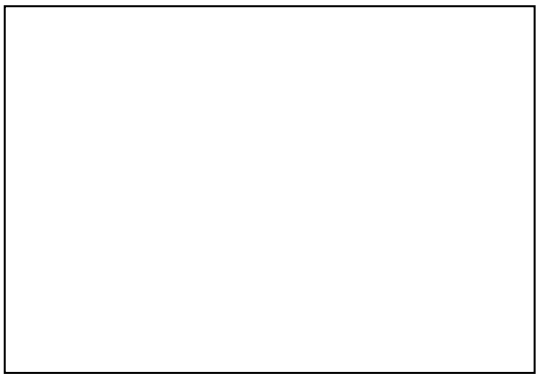
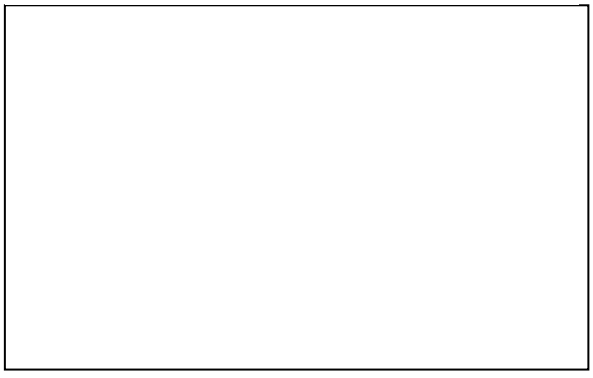


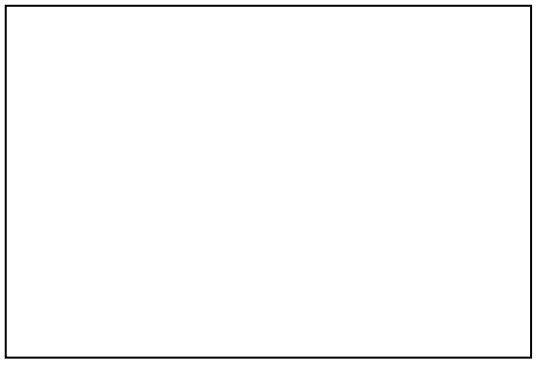
When food is in the direction of sun



When food is away from direction of



When food is to the left of the sun



When food is to the right of the sun

EXPERIMENT NO. 10

Objective: To get well acquainted with types of silkworm species

Exercise: Identify the specimen given to you. Draw the diagram and write its distinguishing feature.

Observation to be Recorded:

Mulberry silkworm: …… …… …… …… …… ……	
Tasar silkworms: …… …… …… …… …… ……	
Eri silkworm: …… …… …… …… …… ……	
Muga silkworm: …… …… …… …… …… ……	

EXPERIMENT NO. 11

Objective: Biology of mulberry silkworm, *Bombyx mori* on mulberry, *Morus alba*

Exercise: Evaluate the biology of mulberry silkworm.

Materials Required: ……

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Procedure: ……

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Observation to be Recorded:

Observation	Duration	Description
Incubation period		…… …… ……
Larval period		…… …… ……
Pupal period		…… …… ……
Adult longevity		…… …… ……
Fecundity		…… ……

EXPERIMENT NO. 12

Objective: Cultivation of mulberry, selection of mulberry varieties and method of harvesting and preservation of leaves

Exercise: Compare the survivability of mulberry plants by different propagation method. Mention the name of mulberry varieties grown in your orchard. Write about methods of harvesting and preservation of mulberry leaves.

Materials required: ……

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PROCEDURE:

Cuttings: ……

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Grafts: ……

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Mulberry Varieties: ……

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Methods of Harvesting:

Leaf picking:

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Branch cutting: ……

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Whole shoot harvest: ……

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Preservation of Leaves: ……

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Plant ten cuttings each from upper, middle and lower portions of shoot. Find out the difference in their survivability

Cuttings	No. of cutting planted	Survival %
Upper		
Lower		
Middle		

Prepare a graft leaving more space and less space between stock and scion at the place of union

Method of Preparation of Grafts	No. of Grafts Planted	Survival %

EXPERIMENT NO. 13

Objective: To study the cultivation of lac insect and host plant identification

Exercise: Inoculate the brood lac on specific host plants. Enlist the host plant of lac insect grown in your university campus.

Materials Required: ……..

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Procedure: ……

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Precautions: ……..……..

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Host Plant of Lac Insect: ……

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EXPERIMENT NO. 14

Objective: Identification of important insect pollinators

Exercise: Identify the observed pollinators. Draw and write their characteristic features

Observation to be Recorded:

Pollinators observed:

…… ……	

EXPERIMENT NO. 15

Objective: Identification of important weed killers and scavengers

Exercise: Collect the specimen from the field and identify the weed killer/ Scavenger using magnifying lens/microscope.

Materials Required: ……..……..

Observation to be Recorded:

Specimen Name	Role
……..	…… ……
……..	…… ……
……..	…… ……
……..	…… ……
……..	…… ……
……..	…… ……
……..	…… ……
……..	…… ……
……..	…… ……
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……..	…… ……
……..	…… ……
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EXPERIMENT NO. 16

Objective: Identification of important parasitoids and predators

Exercise: Identify the parasitoid as seen under microscope and write their distinguishing characters. Collect and identify the predators from the field

Materials Required: ……..

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Observation to be Recorded:

PARASITOIDS	FAMILY	IDENTIFYING CHARACTER
……	……..	…… ……
……	……..	…… ……
……	……..	…… ……
……	……..	…… ……
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……	……..	…… ……
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……	……..	…… ……
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PREDATORS	FAMILY	IDENTIFYING CHARACTER
……	……	…… ……
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……	……	…… ……
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EXPERIMENT NO. 17

Objective: Mass multiplication of an important parasitoid -*Trichogramma* sp

Exercise: Follow the mass rearing technique of *Cocyra* and *Trichogramma*

Materials Required: ……

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Flow Chart (Elaborate steps involved in mass multiplication):
Mass culture of the laboratory hosts (*Corcyra cephalonica*) of the *Trichogramma:*

Mass multiplication of *Trichogramma* (egg parasitoid)*:*

EXPERIMENT NO. 18

Objective: Mass multiplication of an important predator-*Chrysoperla carnea*

Exercise: Draw Flow Chart for the mass multiplication of *Chrysoperla carnea*

Materials Required: ……..……

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Procedure:

PRECAUTIONS: ……..……

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EXPERIMENT NO. 19

Objective: To visit research and training institutions devoted to beekeeping, sericulture, lac culture and natural enemies

Exercise: Make a report of the visit.

Report: .....

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APPENDICES

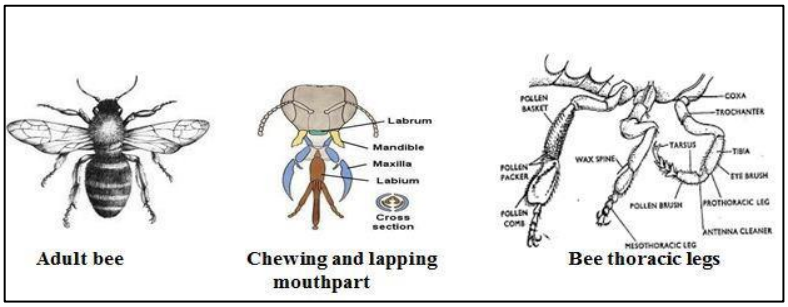
HONEYBEE: GENERAL MORPHOLOGICAL CHARACTERS

Head:

- 3 ocelli and a pair of compound eye which can distinguish different colour but blind to red
- A pair of geniculate antennae
- Chewing and lapping mouthpart

Thorax

- Two pair of membranous wings and hamulate wing coupling mechanism
- Three pairs of legs densely covered with hairs.
- Foreleg - eye brush and an antennal cleaner.
- Middle leg - bushy tarsi for cleaning of thorax. Spur like spine at end of tibia for loosening pellets of pollen from pollen basket and wax from the abdomen.
- Hindleg - pollen basket or corbicula. (concave outer surface of hind tibia is fringed with long curved hairs) basket



Abdomen

- First abdominal segment fused with metathorax forming propodeum
- wax secreted from 4 to 7 abdominal sternite (wax gland) and scent glands (on last two terga)
- ovipositor is modified into stinging organ in case of worker but queen uses ovipositor for egg laying and for stinging rival queen.

SPECIES OF HONEY BEE

Rock-bee (*Apis dorsata)*

- Largest honeybee; builds single open comb on high branches of trees and rocks.
- Produces large quantity of honey, but difficult to domesticate. They produce about 36 Kg honey per comb per year.
- This bee is ferocious, stings severely causing fever and sometimes even death.

Little bee (*Apis florea)*

- Small sized; builds single small combs in bushes, hedges, etc.
- Honey yield is poor approx. half a kilo of honey per year per hive.
- They can't be domesticated as they frequently change their place.

Indian bee: *Apis cerana indica*

- Medium sized, larger than *Apis florae* but smaller than *Apis mellifera*; several parallel combs in dark places.
- Not so ferocious and can be domesticated.
- The average honey yield of 6-8 kg per colony per year.
- More prone to swarming and absconding.

European bee / Italian bee (*Apis mellifera*)

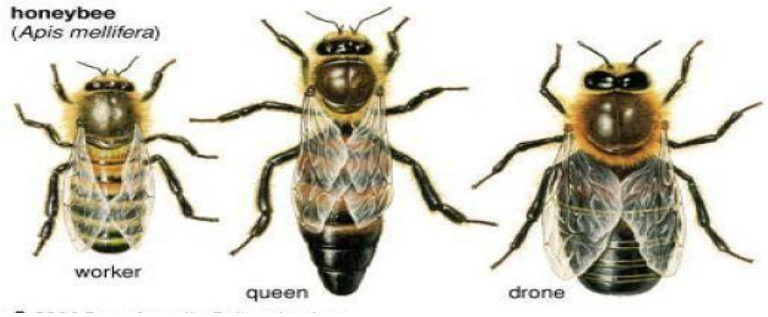
- Similar in habits to Indian bees which build parallel combs but bigger
- The average production per colony is 25-40 kg.
- Less prone to swarming and absconding.

CASTES OF HONEY BEE

Queen	Workers	Drones
• A fertile female with elongated abdomen, short wings and strong legs. • Fed with royal jelly throughout their larval period. • Their main role is reproduction. • Lays about 1000 to 1500 eggs per day and lives for 2-3 years.	• Smallest member of the colony; ovipositor modified into stinging organ • They are the sterile female produced from the fertilized eggs • Their function is to collect honey, looking after their young ones, cleaning the comb, to defend the hive and to maintain the temperature of the hive.	• Larger than worker with blunt abdomen • These are fertile male bee develops parthenogenetically from unfertilized eggs. • They are stingless and their sole function is to fertilize the female.

Precautions:

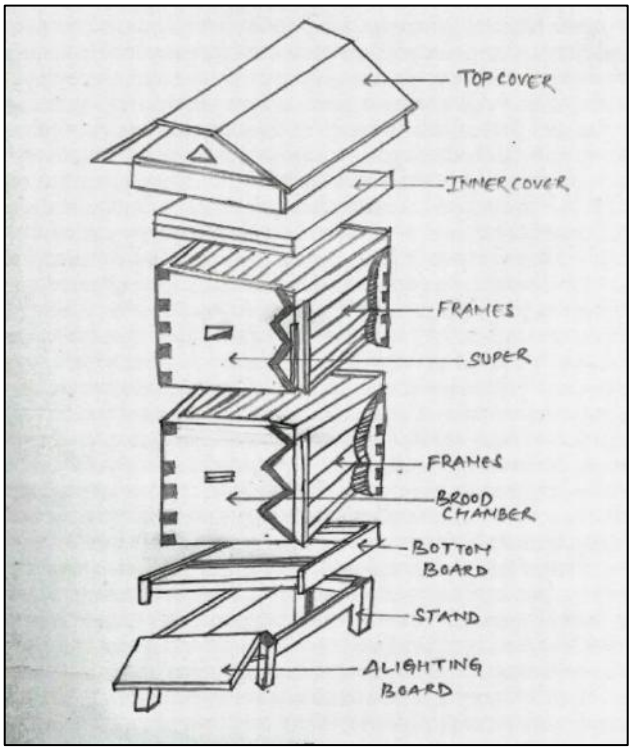
- Before handling bee colonies, it is better to wear a bee veil.
- Do not wear black or dark clothing as bees are furious to black colour.
- Any kind of perfume or strong-smelling hair oils or metals like ring, watch etc which would induce bees to sting, should be removed before handling the bees.



- Do not be shaky while handling bees. Take care and avoid quick and jerking movements.
- If a bee stings, do not get nervous. Gently pull out the sting with the sharp edge of hive tool or finger nail from the base and not from the top without squeezing the venom out of it. Rub some grass on the stung area to mask the smell of alarm pheromone which otherwise induces other workers to sting in that area.
- Hive should not be opened on a windy, chilly day or the period when bees are not working outside the hive.

BEEKEEPING APPLIANCES

Hive stand: It can be a few bricks/ concrete blocks stacked under each hive corner, or it might be a wood frame with an alighting board. Keeps the hive off the ground reducing dampness in the hive, prolong the life of the bottom board and helps the hive entrance free from weeds.



Bottom board: Serves as the floor of the hive which act as takeoff and landing platform for foraging bee. It has an open space at the middle as the hive entrance gate for bees.

Brood chamber: It is a rectangular wooden box without a top and bottom which rest on the floorboard. Notches are made on the outer surface of the side wall for lifting. Rearing of the brood takes place.

Supers: Chambers above the brood chamber and below the covers are called supers. Used for storage of surplus honey.

Covers: It insulates the inner portion of the hive. There are two covers:

Inner cover - flat cover with an oblong hole in the center for the exit of the bee.

Outer cover - waterproof lid made of metallic sheet that rests on the edges of the top super. It protects the hive against rain and sun.

Frames: These are the wooden structure consist of a top bar, two side bar and a bottom bar, inside parts that hold the comb. The underside of the top bar is grooved to hold the comb foundation. The side bar had four holes for wiring the frame. Frames keep

comb-building regular and allow easy inspection and honey removal.

Other beekeeping appliances

1.	Bee veil
2.	Overall
3.	Bee gloves
4.	Bee brush
5.	Hive tool
6.	Uncapping knife
7.	Feeder
8.	Dummy division board
9.	Comb foundation sheet
10.	Honey extractor
11.	Smoker
12.	Queen excluder
13.	Queen cage
14.	Pollen trap
15.	Queen cell protector

SEASONAL MANAGEMENT OF BEE HIVE

Spring management:

- On the onset of spring, provide dilute sugar syrup solution (30%)
- Provide raised comb or frames with comb foundation sheet
- Prevent swarming
- Divide the colony if colony multiplication is needed
- Follow queen rearing technique to produce new queens for new colonies (if required)

Monsoon management:

- Inspect the bees and make sure that the queen is present.
- Destroy the diseased comb.
- Introduce queen to queenless colony/ unite the weak queenless colony to the right colony.
- Provide dummy division to the weak colony.
- Supplement with artificial feeding (sugar candy/dry sugar more prefer)
- Keep the hives in tilted position so as to drain out the accumulated water inside the hive.

Summer management:

- Keep the hive under trees or artificial structure.
- Sprinkle water on gunny bag or rice straw provided in the hive to minimize the intense heat.
- Provide proper ventilation, sugar syrup and pollen substitutes well in time.
- Provision of freshwater, liquid fluid, shade and windbreak becomes necessities of the colony

Autumn/ fall management:

- Management practices during this period depend on the climatic and floral conditions where bees are kept. Fall management prepares the hive for winter.
- Inspect the hives for the presence of queen, diseases and pests.
- Provide sugar syrup solution, if there is scarcity of bee flora in nearby area.
- Reduce the comb space by removing extra frames and by providing dummy division board.

Winter management:

- Reduce the size of hive entrance to protect from cool weather.
- Plugging all cracks and crevices in the hive
- Protecting the colonies from direct chilly winds.
- Give artificial feeding
- Provide queen to the queenless colony.
- Winter packing is followed in cooler areas.

COMMON ENEMIES OF HONEY BEE AND BEE HIVES

Common name	Scientific name	Nature of damage
A. Wax moths Greater wax moth Lesser wax moth	*Galleria mellonella* *Achroia grisella*	• Eggs laid in cracks between hive parts. • Larva tunnel into wax combs and feeds on wax, honey and pollen in comb. • Cocoons attached to the wooden parts of equipment, their silk trails, and damaged combs all throughout the hive.
B. Predatory wasp	*Vespa orientalis,* *Vespa magnifera,* *Palarus orientalis*	• Wasps prefer the thorax portion of adult bees and discard the head and abdomen of the bees. • Some species wait on the back of the hive and capture bees coming out of crevices. • Sometimes kill the guard bee and feed on the brood and young bees.
C. Small hive beetle	*Aethina tumida*	• Small reddish brown or black beetle covered in fine hair. • Feed pollen, wax, honey, bee eggs and larvae. • Excrete in the honey, causing it to ferment.
D. Ants	*Dorylus labiatus,* *Componotus compressus*	• Take away honey and brood • Weaken and destroy the colony
E. Mites	*Varroa destructor* *Tropilaelaps clareae* (Ectoparasitic mites)	Disfigured or stunted bees or pale and dark reddish-brown spots.
	Acarapis woodi (Tracheal)– (Endoparasitic mites)	Lives inside the breathing organs of bees. Deformed winged/ K winged condition.

CHECKING THE PRESENCE OF *VARROA*

To examine from the pupa: Pick up a frame of brood. 50 sealed brood cells to be open for removal of pupae using forceps. Count number of mites in each cell and pupa

To examine mites on adult bees: Shake adult bees off of an open brood frame into a collection receptacle. Collect half cup of adult worker bees (approx. 300) from the chamber into the jar. Spray the ether starter fluid into the container. Shake and roll the jar. Roll the jar along the side several times. Count the varroa mites that that stick to the side of the jar and under the lid. **OR**

Take 100 adult bees from a colony in a wide mouthed bottle. Sprinkle about 15 gram of finely powdered sugar and shake the container after closing its mouth. Fine sugar particles will dislodge the mites as these stick to mite foot pads and disable them to grip the bee body surface. Take a white paper sheet and release the contents over it. The adult bees will fly away whereas mites can be seen in the collected sugar powder. Count the number of mites

For tracheal (Endoparasitic) mites: Collect older bees. Place them in a 70% ethyl alcohol or rubbing alcohol solution or freeze them in a glass jar. The bees can then be examined and dissected to see if they contain tracheal mites.

F. Bears: They destroy the bee hive and stole the honey. Besides the above-mentioned enemies, there are other organisms which attack on the bee colony/ bee hive: the bee louse (*Brauia coeca*); European bee-eater (*Merops apiaster*), Small green bee- eater (*M. orientalis*); Drongos/king crows; Tyrants: *Tyrannus tyrannus* (the eastern king bird or bee marten).

DISEASES OF HONEY BEE

DISEASE NAME	CAUSAL ORGANISM	PLACE & STAGE INFECTED	SYMPTOMS
Protozoan diseases: **a.** Nosemosis	*Nosema apis* *Nosema ceranae*	intestinal tract of adult bees; Adult	• Dysenteric with distened abdomen with faeces, shining and swollen abdomen. • On dissection of the infested bees, the mid intestine is seen swollen & dull greyish-white in colour as it is full of spores.
b. Amoebic disease	*Malpighamoeba mellificae*	Malpighian tubules; Adult	• The bees get infected by ingesting the cysts which accumulate in the posterior end of the midgut or in the rectum. • The cysts get loose, swollen and enter the glassy malpighian tubules entering intestine and show faecal matter at that place.
Fungal diseases: **a.** Chalk brood	*Ascosphaera apis*	Gut; Larvae	• The pathogen mainly infects drone brood and less often to worker brood of the honey bee

disease			• White and chalky appearance
b. Stone brood disease	*Aspergillus flavus* *A. fumigates* *A. niger*	Alimentary canal; Larvae and adults	Dead larvae turn black and become difficult to crush, hard like mummies Fungus erupts from the integument of the larva and forms a false skin and larvae are covered with powdery fungal spores.
Bacterial diseases: **a.** American foul brood (AFB)	*Paenibacillus larvae*	Late larval or early pupal stage	• Sunken and punctured capping • Infected larvae normally die after their cell is sealed, turn dark brown and later changes into sticky mass-producing foul smell (Infected larvae darken and die).
b. European foul brood disease	*Melissococcus plutonius, Streptococcus pluton*	Gut; Mid-gut; usually young larvae uncapped stage	• Larvae turns yellow and then brown and the tracheal system becomes visible. • Larvae die in a coiled stage causing foul smell.
Viral disease: **a.** Thai sac brood disease	*Morator aetatulus* (Thai strain)	Skin; Larvae	• Capping darker, concave & punctured frequently • Dead larvae dry up in brood cell forming loose scale or sac like
Colony collapse disorder (CCD)	stresses, malnutrition, pathogens and GM crops	colony; worker bees	Worker bees from a beehive colony abruptly disappear

BEE PASTURAGE AND FORAGING

Important bee pasturage

- Good nectar source: tamarind, moringa, neem, *Prosopis juliflora, Soapnut tree, Glyricidia maculata, eucalyptus, Tribulus terrestris* and pungam.
- Good pollen source: sorghum, sweet potato, maize, and tobacco, millets like cumbu, tenai, varagu, ragi, coconut, roses, castor, pomegranate and date palm.
- Both source of pollen and nectar: banana, peach, citrus, guava, apple, Sunflower, berries, safflower, pear, mango and plum.

Recording bee behavior

- Select a particular crop and 2 m^2 are (preferably rapeseed mustard)
- Count the no. of bee visiting in that particular area per 5 min
- Number of bee visiting in the same flower per 2 min
- Time duration of the bee landing on the flower
- Take the observation in morning, afternoon and evening

COMMUNICATION IN HONEYBEE

Types of dances: The scout bees perform two types of dances

Round dance	Wag-tail dance (Waggle dance)
Communicates the direction of the supply, not the distance. The performing bee takes quick short steps and runs around in narrow circles on the comb; once to right and then left and then repeating for several seconds.	Bee starts dancing on the comb making a half circle to one side and then takes a sharp turn and runs in a straight line to starting point. Thereafter takes another half circle on the opposite direction to complete one full circle. Again the bee runs in a straight line to the starting point. In the straight run the dancing bee makes wiggling motion with her body that is why this dance is known as wag-tail dance.

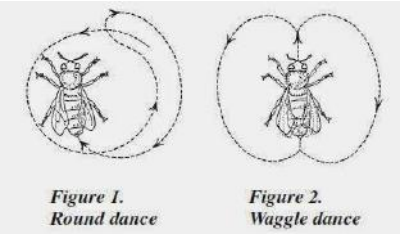


Figure 1. Round dance *Figure 2. Waggle dance*

SPECIES OF SILKWORM

Silkworm species	Colour of cocoon	
1. Mulberry silkworm (*Bombyx mori)*	Creamy white	
2. Tasar silkworms- Tropical tasar (*Antheraea mylitta)* Temperate tasar (*Antheraea proylei)* Chinese tasar (*Antheraea pernyi)* Japanese tasar (*Antheraea yamamai)*	Coppery	
3. Eri silkworm - *Samia ricini*	White	
4.Muga silkworm (*Antheraea assamensis)*	Golden yellow	

BIOLOGY OF MULBERRY SILKWORM

Procedure: Collect eggs after mating pairs of silk moth. When the incubation period completed, transfer the hatched egg to rearing tray with the help of feather. Sprinkle the chopped pieces of mulberry leaves over the newly hatched young larva. Spread the larva on the bed with the help of chopstick. The food, spacing and cleaning to be carried out as per the stages of the larvae and requirements. Four feedings of chopped mulberry leaves to be given in a day. The size of the chopped leaves is to regulate according to conditions and size of the larvae. During moulting don't provide any food to the larva and not disturbed. The quantity of food should increase as per the growth of the silkworm. When the larva ceases to eat and become translucent with creamy colour, transfer them to the mountage for spinning the cocoon. Allow the larva to spin the cocoon and note for the emergence of adults.

CULTIVATION OF MULBERRY

Cuttings: Harvest the shoots (well grown for 6-8 months) from a mulberry garden (seed garden) with a secateurs / pruning saw. Cover the shoots with wet gunny cloth. Avoid thin upper portion and thick lower portion of the shoots. After selecting the shoots, prepare the cuttings by a secateur without damaging the bark. Cuttings can also be prepared with the help of cutting machine. Prepare cuttings of 12-15 cm length and 10-15 mm diameter with 3-4 active buds.

Grafts: Make a slanting cut to the stem which is to be used as scion. Take a seedling and prepare the stock out of it. Scion should be of lesser diameter than the stock to facilitate union of the two. The stock can be prepared by giving a slanting cut out of the roots of the seedling. The stock is mostly prepared from a well-adapted variety to the local conditions. Insert the scion into stock carefully in between the bark and woody portion of the stem. Ensure that a minimum gap is left while inserting a scion into a stock. Bandage the portion of the newly prepared graft at the place of union of stock and scion. Plant

the graft in the well-prepared nursery bed. Irrigate the nursery immediately and as and when required. Uproot the grafts same as of saplings raised through stem cuttings.

Mulberry varieties

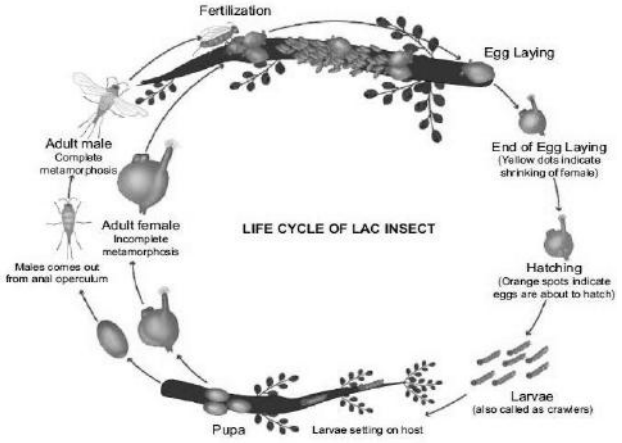
Irrigated	:	Kanva 2, MR 2, S 30, S 36, S 54, DD (Viswa), V1
Semi irrigated	:	Kanva 2, MR 2
Rainfed	:	S 13, S 34, RFS 135, RFS 175, S 1635

Method of Harvesting:

Leaf picking: Harvest individual leaves with or without petiole. Starts leaf picking 10 weeks after bottom pruning and follow subsequent pickings at an interval of 7 - 8 weeks.
Branch cutting: Cut the entire branches for feeding the worms. Ensure topping before that for uniform maturity of the lower leaves.
Whole shoot harvest: Cut the branches at ground level by bottom pruning. Harvest shoots at an interval of 10-12 weeks and thus 5 to 6 harvests are made in a year.
Preservation of leaves: Use leaf preservation chamber or wet gunny bags to store the leaves or cover the bamboo basket with wet gunny bags to keep it cool and fresh.

CULTIVATION OF LAC INSECT

Inoculation: Prune the host plants in Jan or June. Only light pruning should be carried out. Cut the brood twigs in of size 20 - 30 cm in length. Tie the cut pieces of brood twig to fresh tree twigs in such a way that each stick touches the tender branches of trees at several places. After swarming, remove the brood twigs from the host plant



Precautions

- Fully mature and healthy brood free from pest infestations should be taken.
- Brood meant for inoculation should not be kept for long and used immediately after crop cutting.
- Tying of the brood lac stick should be done securely on the upper surface of branches. This will prevent falling of twigs and provide full contact for quick and easy crawling of the nymphs. One should keep a watch on the brood lac dropping down.
- Sometime due to bad weather, swarming of nymphs from brood is prevented. Hence, the room storing brood lac sticks is moderately heated to 200°C to induce swarming, and then sticks are tied.
- Generally, cultivation of kusumi in rangeeni area and vice versa should be avoided. Brood lac from a particular host used year after year is likely to deteriorate in quality. Therefore, alternation of brood and host give production of a better quality of brood lac.

Host plant of Lac insect includes:

Butea monosperma (Palas)	*Zizyphus* spp (Ber)	*Cajanus cajan* (Pigeon-pea)
Schleichera oleosa (Kusum)	*Acacia catechu* (Khair),	*Grewia teliaefolia* (Dhaman)
Acacia arabica (Babul)	*Acacia auriculiformis* (Akashmani)	*Albizzia lebbek* (Siris)
Flemingia macrophylla (Bholia)	*Shorea talura* (Sal)	*Ficus religiosa* (Peepal)

INSECT POLLINATORS

Important insect pollinators includes Honey bees, Carpenter bee, Digger bees wasp, Hoverflies, Butterflies, Moths, Ants, flies, stingless bees, beetles etc.

i. Bees (honey bees, solitary species, bumblebees):

Body covered with hairs and have structural adaptation for carrying nectar and pollen.

ii. Hoverflies *Syrphus* sp.

Brightly coloured flies

Body is striped or banded with yellow or blue

Resemble bees and wasps

Larval stage predatory, adults are pollinators

iii. Carpenter bee, *Xylocopa* sp.

Robust dark bluish bees with hairy body

Dorsum of abdomen bare, pollen basket absent

Adults are good pollinators

Construct galleries in wood and store honey and pollen

iv. Digger bees, *Anthophora* sp.

pollen collecting bees

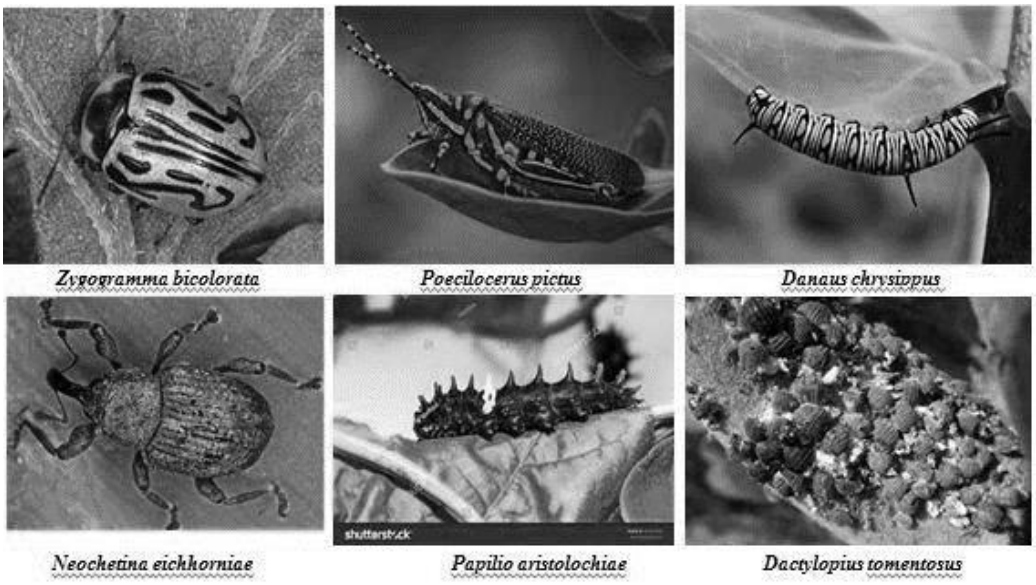
ith black and blue bands

v. Fig wasp *Blastophaga psenes*

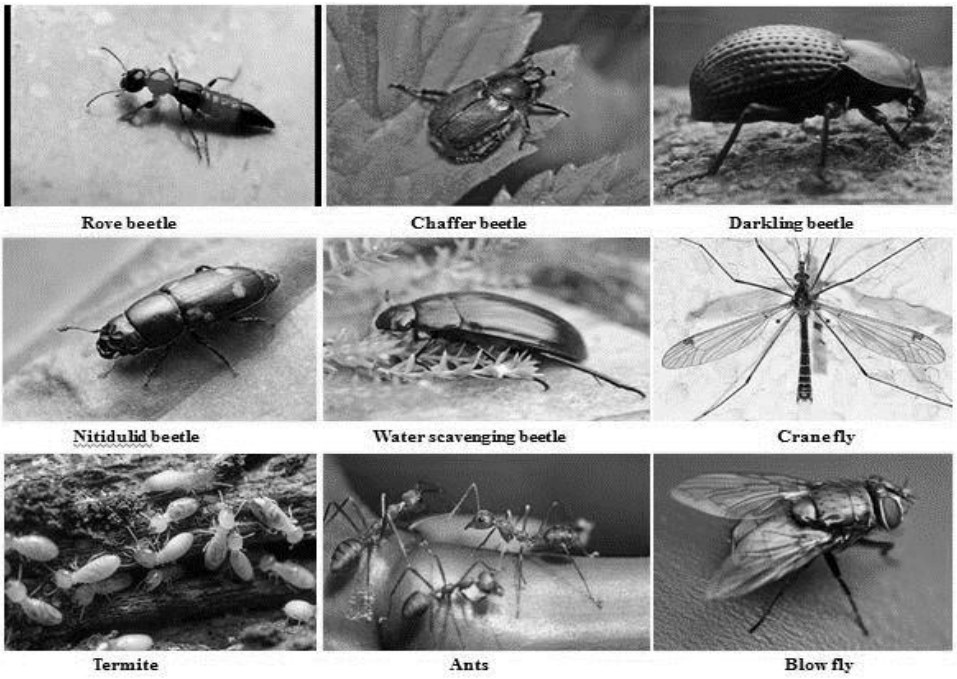
Fig is pollinated by fig wasp only. There is no other mode of pollination.

WEED KILLERS AND SCAVENGERS

Some important weed killers:



Some important scavengers:



PARASITOIDS AND PREDATORS

Parasitoids:

Trichogrammatidae: Very minute insect with three segmented tarsi. Forewings-broad, stubby and paddle shaped with a long fringe of seta around the outer margin.

Ichneumonidae: Size 5-10mm; long antennae, long ovipositor and extruded permanently. Distinct pterostigma and narrow costal cell on forewing; two distinct recurrent cross veins.

Braconidae: Tiny wasp upto 5mm, only one recurrent vein, cross vein m-Cu is absent in forewing

Chalcididae: Among the smallest metallic coloured insects (<3 mm). Hind femur stout with rows of short teeth; Ovipositor short and straight.

Other parasitoid families: Evaniidae, Scelionidae, Platydasteridae, Bethylidae, Encyrtidae, Tachinidae, etc

Predators:

Coccinellidae: Adult-small, oval or spherical, convex, brightly covered with coloured spots. Larvae campadeiform usually covered with minute tubercles or spines

Chrysopidae: Bright green body with wing veins and iridescent eyes. Eggs with long pedicel

Syrphidae: Wasp or bees like, brightly coloured with yellow stripes or bands. These are distinguished from other flies by a spurious vein, located parallel to the fourth longitudinal wing vein.

Mantispidae: Pronotum elongated and doesn't cover the head. Forelegs are raptorial

Other Predatory families: Reduviidae, Gerridae, Anthocoridae, Carabidae, Meloidae, Staphylinidae, Asilidae etc

MASS MULTIPLICATION PARASITOID -*Trichogramma* sp

Mass culture of the laboratory hosts (*Corcyra cephalonica*) of the *Trichogramma:*
Sterilized 500g of maize grind in oven at 100 °C for 30 minutes. Spray the cool sterilized grains with 0.2% formalin and air dry the grains. Pour the grains into rearing boxes @ 2.5 kg / box. Inoculated each box with 0.5cc *Corcyra* eggs and close by placing the lid. Collect the emerged moths daily starting from 40 days after inoculation and transfer to oviposition cages. Place the oviposition cage over a plate for egg laying. Cover the upper and lower side of the cage with fine GI wire net with a circular window hole on its upper side. The eggs were collected every day, cleaned and the scales were removed by

blowing by a fan.

Mass multiplication of *Trichogramma* (egg parasitoid)*:*

Sterilize fresh eggs of *Corcyra* by exposing to UV light to kill embryo. Glue the sterilized eggs to Trichocard in a uniformly thin layer (1 cc to each Trichocard). Divide the card into six strips and insert into another glass tube having newly emerged adults of the *Trichogramma* sp. Apply honey on the inner sides of the tube bands to feed the adult parasitoid and cover with muslin cloth and rubber. Change the card after 24 hours (for 3-4 days or till the female remains productive) and replace with fresh card. After 3 days of parasitization on the host egg, the parasitized eggs can be used for field release or stored at 10°C for fortnight.

MASS MULTIPLICATION OF PREDATOR-*Chrysoperla carnea*

Mass production of *Chrysoperla carnea* (green lace wing)

Release adult *Chrysoperla* (approximately 200 in numbers) into an oviposition cage with sliding top cover fitted with black cloth for depositing the eggs. Provide protein diet (water + honey + protinex mixture + castor pollen) for the adults. Replace the eggs on the black cloth of sliding top cover on alternate days starting from 5th day onwards. Keep the eggs on the black cloth for 24 h to facilitate hardening of the chorion and later dislodge by gently rubbing with piece of sponge. Collect the eggs for larval rearing. Mix 3 days old chrysopid eggs (approx. 120 in no.) with 1.0 cc of inactivated *Corcyra* eggs in plastic containers. On 3rd day, transfer the *Chrysoperla* larva to 2.5 cm cubic cells of plastic louvers for individual rearing (to prevent cannibalism). The total amount of *Corcyra* eggs required for 100 *Chrysopid* larvae is 5.0 cc. Collect cocoons after 24 hrs of formation and place in the oviposition cages for adult emergence and egg laying. The eggs that are laid can be used for field release or used for further culturing.

Precautions: *Chrysopid* eggs should always packed in container with saw dust and paper strips in order to reduce the contact and cannibalism. Releases should be made early in the morning. Don't release them as eggs as they can be eaten by other predators. Do not use pesticides in the field where the predators are released.