

PRACTICAL MANUAL

Management of Beneficial Insects

2(1+1)

For B.Sc. (Hons.) Horticulture

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Syllabus:

Honey bee species, casts of bees. Beekeeping appliances and seasonal management, bee enemies and disease. Bee pasturage, bee foraging and communication. Types 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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Batch

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Exercise No. 1

Objective: To study honey bee species, casts , different bee hives and beekeeping appliance.

Exercise: Observe the honeybee species and casts in given bee hive and note down the morphological characters. Write down about different type bee hives. Draw the diagrams of apiculture equipments.

Materials Required:

Observations: Honey bee species and their casts

Species-1..... **2**.....
3..... **4**..... **5**.....

Queen:.....

Worker:.....

Drone:.....

Draw a well labeled diagram of the general morphology of the honey bee cast.

Queen	Worker	Drown

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Observation to be recorded: different bee hives

1. Fixed comb hives:
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-
-
-
2. Movable comb hives:
-
-
-
-
3. Movable frame hives:
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-
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Draw a well labeled diagram of the apiculture equipment:

Observation:

Hive stand:

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Bottom board:

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Brood chamber:

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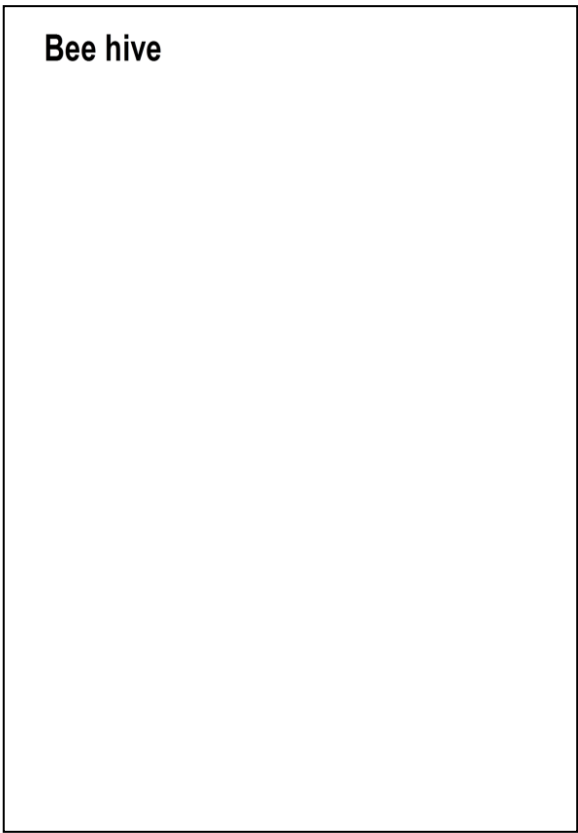
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Supers:

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Covers:

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Frames:

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Other Bee-keeping Appliances

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

		
6.	
7.	
8.	
9.	
10.	
11.	

		
12.	
13.	.....	..... ..... ..... ..... ..... ..... .....
14.	.....	..... ..... ..... ..... ..... ..... .....
15.	.....	..... ..... ..... ..... ..... ..... .....

Exercise No. 2

Objective: To study the honey bee colony establishment.

Exercise: Observe developmental site for apiary in campus and Observe that what are the difficulties faced in developing a Teri? Draw the diagrams of a well-developed apiary.

Materials Required:

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Observation:

Apiary site requirement:

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Ecological conditions:

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Topography of site:

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Fauna and Flora status of area:

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Major and minor food sources for apiary in site area:

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Recommended/suitable honey bee species for this site:

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Note down the difficulties:

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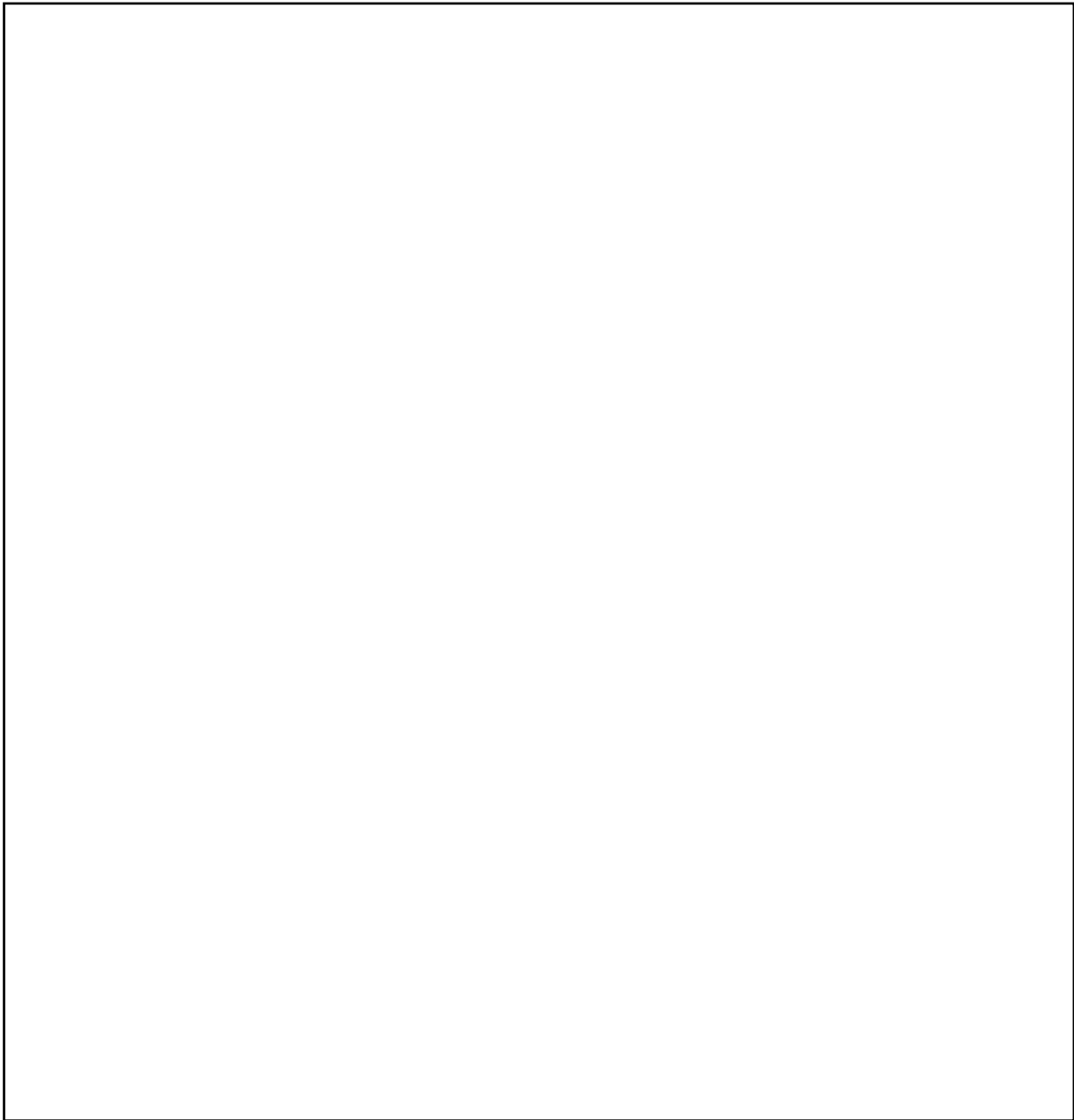
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Draw the diagrams of a well-developed apiary:



Exercise No.3

Objective: To study the seasonal management of colony.

Exercise: Visit to the nearest apiary site and record seasonal problems in bee-keeping and writ your suggestions in defense of them.

Materials Required:

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Observation:

Honey flow season management:

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Summer season management:

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Winter season management:

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Rainy season and monsoon 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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Exercise No. 4

Objective: To study the honey extraction and bottling techniques.

Exercise: Write down the processor of honey extraction and packing of honey.

Materials Required:
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Observation:

Honey Harvest:
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Honey Extraction:
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Packing of honey:
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Exercise No. 5

Objective: To study insect pests and diseases of honeybees and their managements.

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:
.....
.....

Observation:

	Common name	Scientific name	Nature of damage	Management
A.			Predatory wasps	
1.
2.
3.
4.
B.				
1.

2

3

4

5

Exercise No. 6

Objective: To study the establishment of mulberry garden.

Exercise: Develop mulberry garden on given area in Campos.

Materials Required:
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Observation:

Selection of site:
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Selection of planting material:
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Nursery bed preparation:
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Recommended **verities:**
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Nursery management:
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Exercise No. 7

Objective: To study preparation of mulberry cuttings, planting methods under irrigated and rainfed conditions.

Exercise: Write the processor of mulberry cutting, planting processor for irrigated and rainfed conditions.

Materials **Required:**

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Observation:

Mulberry cuttings:
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Planting for irrigated condition:
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Planting for rain fed conditions:
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Exercise No. 8

Objective: To study the maintenance of mulberry garden-pruning, fertilization, irrigation and leaf harvest.

Exercise: Write the pruning processor of mulberry, fertilization processor, irrigation methods and leaf harvesting.

Materials **Required:**

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Observation:

Pruning methods:

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Fertilization:

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Irrigation:

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Harvesting:

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Exercise No. 9

Objective: To study mulberry pests and diseases and their management and nutritional disorders.

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

Materials **Required:**

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Observation:

S. No.	Common name	Scientific name	Damaging symptoms	Management
A	Insect pests			
1
2
3
4
5
6
7

		
8	..........	..........	...............	...............
B	Diseases			
1	..........	..........	...............	...............
2	..........	..........	...............	...............
3	..........	..........	...............	...............
4	..........	..........	...............	...............
5	..........	..........	...............	...............

Nutritional disorders:

S. No.	Nutrient	Deficiency symptoms and diagnosis
1.	Nitrogen	..........
2.	Potassium	..........
3.	Phosphorus	..........
4.	Magnesium	..........
5.	Calcium	..........

6.	Sulphur	..........
7.	Zinc	..........

Exercise No. 10

Objective: To study mulberry silkworm morphology, different kinds of silkworms and silk glands.

Exercise: Observe the silkworm in the laboratory using magnifying lens and note down the morphological characters. Observe different kind of silkworm. Observe silk gland in silkworm caterpillar.

Materials

Required:

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Observation:

Head:

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Thorax:

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Abdomen:

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Different kinds of silk:

S. No.	Type of silk	Scientific name and family	Characters	Host plant's and Producing states
1.
2.
3.
4.
5.

Silk gland:

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Exercise No. 11

Objective: To study about sericulture equipment for silkworm rearing.

Exercise: Draw the diagram of the sericulture equipment and give the details of its different parts.
Illustrate the sericulture appliances that you observe in the sericulture.

Materials Required:

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Observation:

S. No.	Equipment	Uses	Diagram
1	Rearing stands	
2	Ant wells	
3	Rearing trays	
4	Paraffin paper	..... ..... .....
5	Foam rubber strips	..... ..... ..... .....
6	Chopsticks	..... ..... ..... .....
7	Feathers	.....

		
8	Leaf chamber	..... ..... ..... .....
9	Chopping boards, knives and mats	..... ..... ..... .....
10	Clearing nets	..... ..... ..... .....
11	Mountages	..... ..... ..... .....
12	Miscellaneous appliances	..... ..... ..... .....

Exercise No. 12

Objective: To study mulberry silkworm rearing room requirements.

Exercise: Visit silkworm rearing center and observe and note down requires condition for silkworm rearing room. Draw the diagram of the silkworm rearing room.

Materials Required:
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Observation:

Silkworm rearing house:
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Requires temperature and Relative Humidity:
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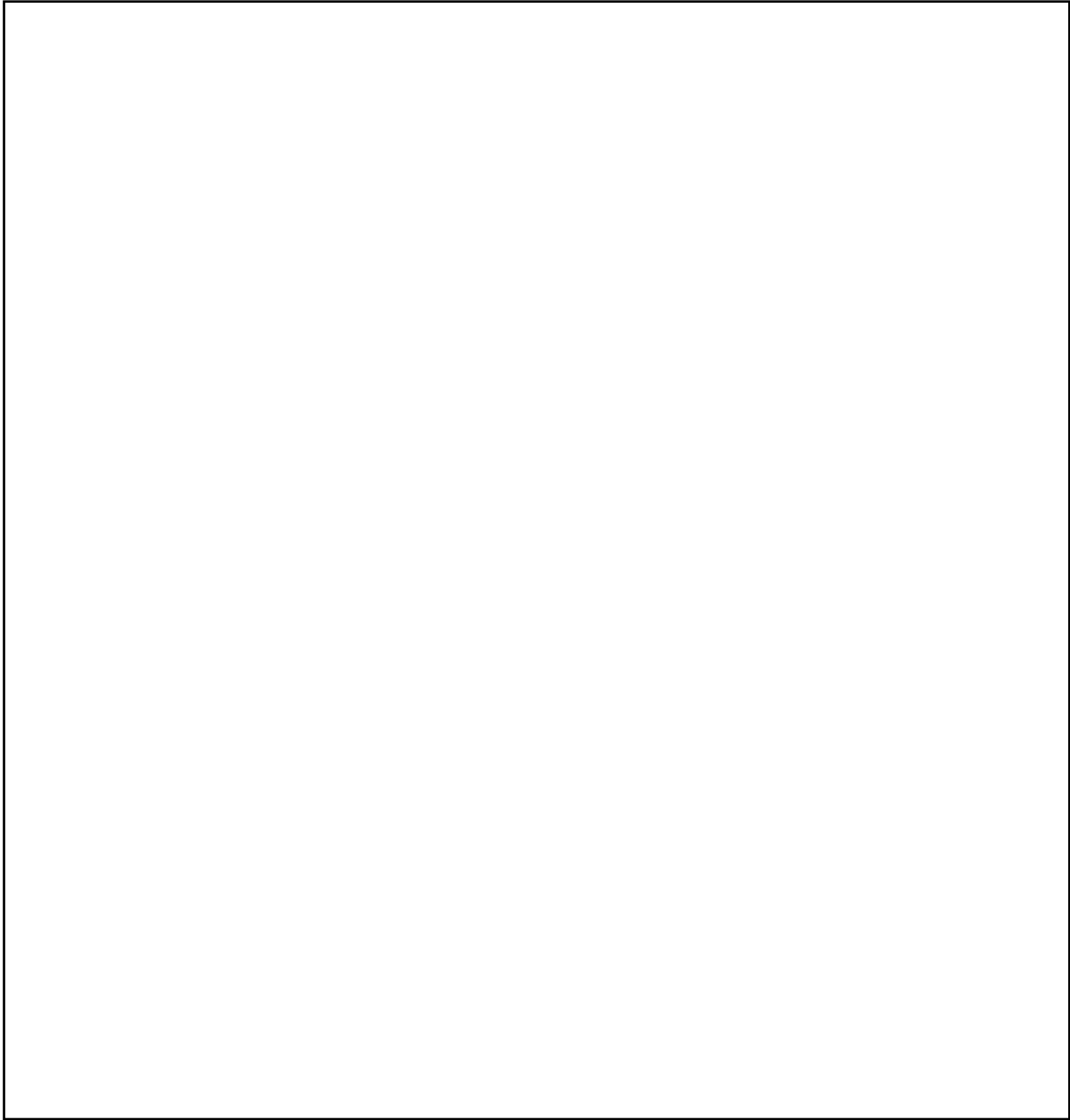
Light or illumination:
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Ventilation:
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Rearing Bed Area Requirement for Silkworms:
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Diagram of the silkworm rearing room:



Exercise No. 13

Objective: To study the rearing of silkworms-chalky rearing.

Exercise: Visit silkworm rearing center and observe and note down silkworms-chalky rearing.

Materials Required:
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Observation:

Silkworms-chalky rearing/ Young age silkworm rearing house:
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Important instructions for silkworm house:
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Exercise No. 14

Objective: To study the rearing of silkworms, late age silkworm rearing and montages.

Exercise: Visit silkworm rearing center and observe and note down late age silkworm rearing.

Materials Required:
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Observation:

Silkworms late age silkworm rearing:
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Important instructions for silkworm house:
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Exercise No. 15

Objective: To study insect pests of silkworm and their management.

Exercise: Inspect and identify the insect pest present in silkworm rearing house. Write their nature of damage (symptoms) and follow up the management for the observed insect pests.

Materials Required:

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.....

Observations:

Insect pests of silkworm:

S. No.	Common name	Scientific name	Damaging symptoms	Prevention
1
2
3
4

Exercise No. 16

Objective: To study diseases of silkworm and their management.

Exercise: Inspect and identify the disease present in silkworm rearing house. Write their nature of damage (symptoms) and follow up the management for the observed insect pests.

Materials Required:

.....

.....

Observation:

Insect pests of silkworm:

S. No.	Common name	Scientific name	Damaging symptoms	Prevention
1
2
3
4

Exercise No. 17

Objective: To study Lac insects-biology.

Exercise: Observe life cycle of lac insect rearing under nearest area and note down the morphological characters.

Materials

Required:

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Observation:

Nymph:
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Male adult:
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Female adult:
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Exercise No. 18

Objective: To study on natural enemies of lac insects.

Exercise: Inspect and identify the natural enemies of lac insect. Write their nature of damage (symptoms) and follow up the management for the observed insect pests and disease.

Materials Required:

Observation:

Predators and parasites of lac insect:

S. No.	Common name	Scientific name	Nature of damage	Management
A	Predators			
1
2
3
4
5
B	Parasites			
1
2
3
4
5

Exercise 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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Exercise No. 20

Objective: To identify pollinators, scavengers, weed killers, natural enemies and study techniques of mass multiplication of natural enemies.

Exercise: Inspect and identify pollinators, weed killers, scavengers and natural enemies of insect pests. Write their mass multiplication techniques.

Materials Required:

.....

Observation:

Pollinators, weed killers, scavengers, Predators and parasitoids:

S. No.	Common name	Scientific name	Host	Multiplication technique/ Identification
A	Predators			
1	.....	.....	.....	.....
2	.....	.....	.....	.....
3	.....	.....	.....	.....
4	.....	.....	.....	.....
5	.....	.....	.....	.....
B	Parasitoids			
1	.....	.....	.....	.....
2	.....	.....	.....	.....
3	.....	.....	.....	.....
4	.....	.....	.....	.....
5	.....	.....	.....	.....
C	Pollinators			

1	.....	.....	.....	.....
2	.....	.....	.....	.....
3	.....	.....	.....	.....
4	.....	.....	.....	.....
D	Scavengers			
1	.....	.....	.....	.....
2	.....	.....	.....	.....
3	.....	.....	.....	.....
E	Weed killers			
1	.....	.....	.....	.....
2	.....	.....	.....	.....
3	.....	.....	.....	.....

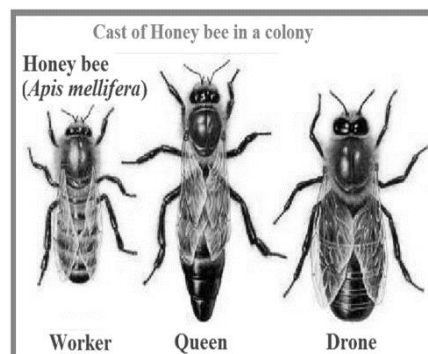
Honey bee cast in a colony, different bee hives and apiculture equipment

Honey bee cast in a colony: Queen and her functions: A mother queen is found in a colony except under supersedure or swarming instinct. Major function is to lay eggs around 1500-2000 (both fertilized and unfertilized) eggs per day. She is fed lavishly by a large number of nurse bees with highly nutritious food known as royal jelly. It has larger thorax than worker and her abdomen gets greatly distended during egg laying. Fertilized eggs produce workers (also queens) and unfertilized eggs produce drones. A good mated queen may work satisfactorily for 2 or more years, although queens can live eight years or longer. Queen releases queen substance (pheromone) stimulate brood rearing, comb building, hoarding and foraging in a colony and thus play important role in normal working of a colony. She is 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.

Workers and her function: Workers are imperfect females and 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. 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 queen less conditions for a long duration.

Drone and his functions: 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.



Three main types of bee hive:

- 1. Fixed comb hives:** These are containers made from whatever materials are locally available: typically, hollowed-out logs, bark formed into a cylinder, clay pots, woven grass or cane. This keeps bees safe from predators and protected from extremes of heat or cold. In a fixed comb hive, the bees build their nest inside the container, just as they would build it in a naturally occurring cavity. The bees attach their combs to the inside upper surface of the hive. This means that combs cannot be removed without being broken when the small-scale farmer harvests the nest to obtain crops of honey and beeswax.
- 2. Movable comb hives:** Low-technology hives have been developed as a way of obtaining the advantages of movable frame hives (no need to break combs, standardisation, manageability, efficient honey harvest) without the disadvantage of high cost manufacture. Bees are encouraged to construct their combs from the undersides of a series of top-bars – instead of attaching comb to the ceiling of the hive (as in a fixed comb hive) or building comb inside a rectangular, wooden frame (as in a frame hive). The combs can then be replaced back in the hive, removed Beekeeping and sustainable livelihoods for harvest, or maybe moved to another hive or colony. Advantage of this type of equipment is that it opens up beekeeping to new sectors of society. The volume of the brood box should equate roughly with the volume of the cavity occupied by wild-nesting honeybees. Other necessary materials are hive tools, smokers, protective clothing and containers for harvesting, storing, processing and marketing honey.
- 3. Movable-frame hives:** These are using in industrialized and developing countries. The objective of movable-frame hive beekeeping is to obtain a maximum honey crop. The possibility of recycling beeswax combs means that the colony can quickly build up honey stores during the flowering season, and may also be managed specifically for the pollination of particular crops. Frame hives must be constructed with precision. The spacing between frames must achieve the same spacing as in a natural nest. Frames are contained within boxes and each hive consists of a number of boxes placed on top of one another. Usually the bottom-most box is used as the brood chamber. This means that brood is present only in this box: this is achieved by placing a queen excluder between this box and one above it. The queen excluder is a metal grid with holes of a particular size such that worker bees can pass through but the queen is unable to do so because of her larger size. In addition to the boxes and frames, a floor and roof are required, along with various other specialized items of equipment.

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.

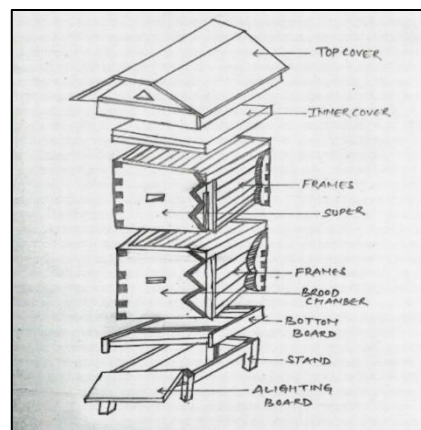
Covers: It insulates the inner portion of the hive. There are two covers:



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	6.	Comb foundation sheet	11.	Uncapping knife
2.	Overall	7.	Honey extractor	12.	Feeder
3.	Bee gloves	8.	Smoker	13.	Dummy division board
4.	Bee brush	9.	Queen excluder	14.	Pollen trap
5.	Hive tool	10.	Queen cage	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 queen less colony.
- Winter packing is followed in cooler areas.

Procedure of honey extraction:

- To remove sealed honey combs, give few puffs of smoke to the colony and brush off bees from the honey combs using soft bee brush or bunch of soft green grass.
- Place the honey combs in bee tight hive bodies and shift to honey extraction room.
- Never rob the colonies of their entire honey stores.
- Depending on strength, keep with each colony at least 5-10 kg of honey in case of *Apis mellifera* and 2-3 kg with *A. cerana* for summer and monsoon dearth periods.
- Honey extraction room should be bee tight. After bringing the honey frames for extraction, these can be uncapped either with a steam heated double walled uncapping knife or with ordinary uncapping knife by heating in boiling water.
- Keep these uncapped frames in hive bodies with drip trays below, till extraction.
- Put the uncapped frames in honey extractor and work at about 150 revolutions per minute for 1 to 2 minutes. Then reverse the sides of the frames and repeat the extraction process.
- Stock the emptied frames in hive bodies and return these to the colonies for cleaning. Shorten the hive entrance to avoid robbing.
- Since freshly extracted honey is warm and easy to strain, arrangements for straining using muslin cloth and packing should be promptly made so as to prevent subsequent heating.
- Clean the appliances and the place where honey is extracted.
- Beeswax collected during uncapping of honey frames should be allowed to drain off its honey. Then purify this beeswax by putting in a muslin bag and boiling in a water bath. On, cooling pure beeswax will float over the surface of water and all impurities will remain in the muslin bag.

COMMON ENEMIES OF HONEY BEE AND BEE HIVES

Common name	Scientific name	Nature of damage
A. Wax moths Greater wax moth Lesser wax moth	<i>Galleria mellonella</i> <i>Achroia grisella</i>	<ul style="list-style-type: none"> 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	<i>Vespa orientalis</i> , <i>Vespa magnifera</i> , <i>Palarus orientalis</i>	<ul style="list-style-type: none"> 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	<i>Aethina tumida</i>	<ul style="list-style-type: none"> 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	<i>Dorylus labiatus</i> , <i>Componotus compressus</i>	<ul style="list-style-type: none"> Take away honey and brood Weaken and destroy the colony
E. Mites	<i>Varroa destructor</i> <i>Tropilaelaps clareae</i> (Ectoparasitic mites) <i>Acarapis woodi</i> (Tracheal)– (Endoparasitic mites)	Disfigured or stunted bees or pale and dark reddish-brown spots. Lives inside the breathing organs of bees. Deformed winged/ K winged condition.

DISEASES OF HONEY BEE

DISEASE NAME	CAUSAL ORGANISM	PLACE & STAGE INFECTED	SYMPTOMS
Protozoan diseases: a. Nosemosis	<i>Nosema apis</i> <i>Nosema ceranae</i>	intestinal tract of adult bees; Adult	<ul style="list-style-type: none"> Dysenteric with distended 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	<i>Malpighamoeba mellifica</i>	Malpighian tubules; Adult	<ul style="list-style-type: none"> 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 disease	<i>Ascospaera apis</i>	Gut; Larvae	<ul style="list-style-type: none"> The pathogen mainly infects drone brood and less often to worker brood of the honey bee White and chalky appearance
b. Stone brood disease	<i>Aspergillus flavus</i> <i>A. fumigates</i>	Alimentary canal; Larvae and adults	<ul style="list-style-type: none"> Dead larvae turn black and become difficult to crush, hard like mummies

	<i>A. niger</i>		<ul style="list-style-type: none"> Fungus erupts from the integument of the larva and forms a false skin and larvae are covered with powdery fungal spores.
Bacterial diseases:	<i>Paenibacillus larvae</i>	Late larval or early pupal stage	<ul style="list-style-type: none"> 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).
a. American foul brood (AFB)			
b. European foul brood disease	<i>Melissococcus plutonius</i> , <i>Streptococcus pluton</i>	Gut; Mid-gut; usually young larvae uncapped stage	<ul style="list-style-type: none"> Larvae turns yellow and then brown and the tracheal system becomes visible. Larvae die in a coiled stage causing foul smell.
Viral disease:	<i>Morator aetatulus</i> (Thai strain)	Skin; Larvae	<ul style="list-style-type: none"> Capping darker, concave & punctured frequently Dead larvae dry up in brood cell forming loose scale or sac like
a. Thai sac brood disease			
Colony collapse disorder (CCD)	stresses, malnutrition, pathogens and GM crops	colony; worker bees	Worker bees from a beehive colony abruptly disappear

NATURAL ENEMIES OF LAC INSECT:

Predators: Three most important insect predator are damages lac population viz. *Eublemma amabilis* Moori, *Pseudohypatropa pulvrea* Meyr and *Chrysoperla spp.* Commonly known as lace wing bug, order Neuroptera.

Parasites: Lac insects are parasitized by small so many parasitic species of insect belonging to super family *Chalcidoidea*, order Hymenoptera.

Damage: These insect pests lay their eggs in lac cells and their grubs feed internally on lac insects within the cells.

Precautionary measures: Only healthy pest-free brood lac should be used for inoculation. The twigs for inoculation should be cut just before swarming to get healthy brood. Entire crop should be harvested at the maturity, partial harvesting should be avoided. The inoculation stick or phunki lac should be removed timely and fumigated or immersed in water to kill the pest. Stick lac should be scrapping as soon as possible and should be processed immediately to convert into seed lac. Infected stick lac should be treated with fumigant insecticide along with predators and pests. Remove eggs of *Chrysoperla* from the plant or lac cells time to time. Regular monitoring is nessori for observation of any deformity or attack of insect pest.

Control measures: For *Chrysoperla* spry Dichlorovos (Nuvan) @0.03% (14.5ml/10 lit water). First insecticide after one month of lac inoculation cartap hydrochloride 50 SP @ 0.05 % (10g/10 lit water) solution or ethofenprox 10 EC (Nukil) @ 0.02 % (2 ml/ lit). In rangeeni crop endoxacarb 14.8EC @ 0.007% (5 ml/10 lit) water solution should be spry on the crop. Second spry of the insecticide should be done at two month (60 days) of lac inoculation or one month after first spray application. In jethwi crop of kusmi strain application of Bavistin 50 WP should be spry @ 3gm/14 lit water after 45-60 days or as per need time to time. Similarly in both the crop of rangeeni strain. Avoid pesticide spry at male emergence.

Mulberry (*Morus spp.*, Moraceae): The important character of the members of the family Moraceae especially *Morus spp.* is the presence of idioblastan enlarged epidermal cell in the leaf.

Ecological requirements: Climate: Mulberry can be grown upto 800 m MSL. The temperature range is required for the optimum growth is 13°C to 37.7°C with relative humidity of 65-85% and sunshine duration of 5-12 hours per day where rain fall range of 600-2500mm.

Soil: Slightly acidic soils (6.2 to 6.8 pH) free from injurious salts are ideal for good growth of mulberry plant. Saline and alkaline soils are not preferred

Mulberry varieties:

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

Propagation of mulberry: Mulberry is mostly propagated through cuttings. Cuttings may be planted straight way in the main field itself or nursery may be raised and the sprouted and rooted samplings may be planted in main field.

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

Selection of planting material: Generally, the mulberry plants are raised from semihardwood cuttings. Cutting are selected from well established garden of 8-12 months old. Only full grown thick main stems, free from insect and disease damages having a diameter of 10-12 mm are chosen for preparation of cuttings. The cutting should be of 15-20 cm with 3-4 active buds and should have 45° slantingcut at the bottomend. Care should be taken to make a

sharp clean cut at both the ends of cuttings without splitting the bark. Manually/power operated mulberry cutter (stem cutting machine) is available for quick cutting of propagation material.

Nursery bed preparation: Select 800m² area of red loamy soil near water source for raising saplings for planting one hectare of main field. Apply 1600 kg of Farm Yard Manure (FYM) @ 20 t/ha and mix well with the soil. Raise nursery beds of 4m x 1.5m size. The length may be of convenient size depending upon the slope, irrigation source etc. Provide a drainage channel and avoid shady area.

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

Nursery planting: Apply VAM @ 100 g/m² of nursery area. Irrigate the nursery bed. Plant the cuttings in the nursery at 15 cm x 7 cm spacing at an angle of 45°. Ensure exposure of one active bud in each cutting.

Nursery management: Irrigate the nursery once in three days. Dust 1 kg of any one of the Malathion 5% DP or Chlorpyrifos 1.5% DP around the nursery bed to avoid termite attack. To avoid root rot and collar rot, drench the soil with carbendazim 50 WP (2 g/l) or apply *Trichoderma viride* 0.5 g/m² using rose can. After weeding, apply 100g of urea/m² between 55 and 60 days after planting at the time of weeding.

Planting methods: Paired row system:

Plant the cuttings/saplings at a spacing of 75 / 105 cm x 90 cm. Raise intercrops in the wider inter row space (amenable for mechanization also). No. of cuttings / ha. 27,780 (60 x 60 cm) ; 12,345 (90 x 90 cm).

Time of planting: Plant during rainy season. Avoid planting during winter and summer months.

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

Integrated Weed Management: Remove the stubbles and roots of weeds while preparing the land.

Use well decomposed manure to avoid dissemination of weeds. Clean the implements before use.

Operate country plough after pruning in the interspace. Remove the weeds by hand hoe. As post-emergence application, use Paraquat (Grammoxone) @ 2-3 lit/ha.

Spray Glycel 7.5 ml with 10 grams of ammonium sulphate per litre of water as postemergence application. A total of 600 litres of spray fluid is required/ha.

Use flooding / deflector / fan type nozzle for spraying weedicide. Apply the weedicide immediately after pruning or within 2-3 days after pruning.

Seed rate: 10 kg/ha.

Disease of mulberry plant:

Fungal diseases: We can observe 11 fungal disease in mulberry tree Major disease and its pathogen are given in brief viz., Leaf spot (*Cercospora naicola*), Powdery mildew (*Phyllactinia corylea*), Leaf rust (*Cerotelium fic*), Red rust (*Aecidium mori*), Twig blight (*Fusarium pallidoroseum*), White root-rot (*Resellinia necatrix*), Violet root-rot, (*Helicobasidium mompa*), Stem canker (*Botryodiplodia theobromae*), Stem rot (*Polyporus hispidus*), Collar rot (*Phoma mororutn*), Stem blight (*Phanw eigua*) and Bud blight (*Fusarium lateritium*).

Bacterial Diseases: We observe four major bacterial diseases notice in mulberry tree viz., Bacterial blight (*Pseudomonas nnni*), Bacterial rot (*Bacterium maricowln*), Bacterial wilt (*Pseudomonas solanacearum*) and Shoot soft rot (*Erwinia carotovora*).

Viral Diseases: Two major viral diseases are 9 to 10 Mosaic disease Yellow net vein.

S. No.	Common name	Scientific name	Family	Order	Damaging stage
Sucking insect pests					
1.	Black scale insect	<i>Saissetia nigra</i>	Coccidae	Hemiptera	Nymph & adult
2.	Jassid	<i>Empoasca flavescens</i>	Cicadellidae	Hemiptera	Nymph & adult
3.	Long-tailed mealybug	<i>Pseudococcus longispinus</i>	Pseudococcidae	Hemiptera	Nymph & adult
4.	Mulberry thrips	<i>Pseudodendrothrips mori</i>	Thripidae	Hemiptera	Nymph & adult
5.	Mulberry whitefly	<i>Dialeuropora decempuncta</i>	Aleyrodidae	Hemiptera	Nymph & adult
6.	Papaya mealybug	<i>Paracoccus marginatus</i>	Pseudococcidae	Hemiptera	Nymph & adult
7.	Pink mealybug	<i>Maconellicoccus hirsutus</i>	Pseudococcidae	Hemiptera	Nymph & adult
8.	Soft scale insect	<i>Megapulvinaria maxima</i>	Coccidae	Hemiptera	Nymph & adult
9.	Spiralling whitefly	<i>Aleurodicus disperses</i>	Aleyrodidae	Hemiptera	Nymph & adult
10.	Thrips	<i>Pseudodendrothrips bhattii</i>	Thripidae	Hemiptera	Nymph & adult
Defoliators					
1.	Bihar hairy caterpillar	<i>Spilosoma obliqua</i>	Arctiidae	Lepidoptera	Caterpillar

2.	Cutworm	<i>Spodoptera litura</i>	Noctuidae	Lepidoptera	Caterpillar
3.	Green weevils	<i>Myloccerus viridanus</i>	Curculionidae	Coleoptera	Grub & adult
4.	Leaf webber	<i>Diaphania pulverulentalis</i>	Pyralidae	Lepidoptera	Caterpillar
5.	May-June beetle	<i>Holotrichia serrata</i>	Scarabaeidae	Coleoptera	Grub & adult
6.	Moringa hairy caterpillar	<i>Eupterote mollifera</i>	Eupterotidae	Lepidoptera	Caterpillar
7.	Noctuid Moth	<i>Tiracola sp.</i>	Noctuidae	Lepidoptera	Caterpillar
8.	Tussock caterpillar	<i>Euproctis fraternal</i>	Lymantriidae	Lepidoptera	Caterpillar
9.	Wasp moth	<i>Amata passalis</i>	Arctiidae	Lepidoptera	Caterpillar
10.	Wingless grasshopper	<i>Neorthacris acuticeps nilgriensis</i>	Acrididae	Orthoptera	Nymph & adult
Internal feeder or borers					
1.	Long horn beetle	<i>Apriona germari</i>	Cerambycidae	Coleoptera	Grub
2.	Mango stem borer	<i>Batocera rufomaculata</i>	Cerambycidae	Coleoptera	Grub
3.	Shoot borer	<i>Oberea artocarp</i>	Cerambycidae	Coleoptera	Grub
4.	Stem girdler beetle	<i>Sthenias grisator</i>	Cerambycidae	Coleoptera	Grub
Soil inhabiting insects					
1.	Termites	<i>Odontotermes sp.</i>	Termitidae	Isoptera	Worker
Nematodes pest					
1.	Root knot nematode	<i>Meloidogyne incognita</i>	Meloidogynidae	Tylenchida	Juvenile & adult

Nutritional disorders

S. No.	Nutrient	Deficiency symptoms and diagnosis
1.	Nitrogen	Slow and weak growth of plant with less branching/vigour. Young green leaves show chlorosis, stem is slender and yellowish green and stunted root growth. Apply nitrogenous fertilizers like urea, ammonium nitrate and calcium nitrate for correction.
2.	Potassium	Marginal scorching of leaves in younger stage and later become coarse, non-juicy and necrotic. Stem and root systems become weaker. Apply potassium fertilizers for correction.
3.	Phosphorus	Intra-veinal chlorosis of older leaves. The chlorosis spreads throughout the leaf followed by marginal necrosis and defoliation. Stem is slender, without fresh growth and stunted growth of roots. By adding of phosphorus and NPK fertilizer, the deficiency can be controlled.
4.	Magnesium	Chlorosis and necrotic spots on leaves. The leaf tip and margin become dry and scorched. Apply magnesium sulphate or magnesium oxide for correction.
5.	Calcium	Defoliation of young leaves with necrosis along the veins. The stems become woody and short with yellowish tips. Roots are stubby and dry. Apply calcium ammonium nitrate or single super phosphate for correction.
6.	Sulphur	Slight chlorosis of leaves, lack of plant growth with slender stem. Apply gypsum or ammonium sulphate for correction.
7.	Zinc	Young leaves show interveinal chlorosis and yellowish white spots on leaves. Apply zinc sulphate for correction.

Life cycle of silkworm:

S. No.	Different stages of silk worms	Muga		Eri		Mulberry	
		Summer (Max. days)	Winter (Max. days)	Summer (Max. days)	Winter (Max. days)	Summer (Max. days)	Winter (Max. days)
1.	Egg stage Diapuse eggs	7	14	9	18	10 (4-10) months	15 Bivoltine-Univoltine
2.	Larval stage	22	45	17	45	25	31
3.	Spinning stage	3	7	3	6	4	6
4.	Pupal stage	14	35	13	22	13	15
5.	Moth stage	4	6	4	6	2	3
Total Days		50	107	46	97	54	70

Commercialize silkworm in India:

S. No.	Type of silk	Scientific name and family	Host	Producing states
1.	Mulberry silk (White or creamy colour)	<i>Bombyx mori</i> (Bombycidae)	Mulberry plant (<i>Morus alba</i> , <i>M. indica</i> , <i>M. serrata</i> & <i>M. latifolia</i>)	Karnataka, Andhra Pradesh
2.	Tropical tasar silk (Copperish in colour)	<i>Antheraea mylitta</i> (Saturniidae)	Asan, (<i>Terminalia tomentosa</i>); Arjun, (<i>Terminalia arjuna</i>) Saal (<i>Shorea robusta</i>); Ber (<i>Zizyphus jujuba</i>)	Jharkhand, Orissa, Chattisgarh, Maharashtra, West Bengal, Andhra Pradesh
3.	Oak tasar (Temperate)	<i>Antheraea proylei</i> , <i>A. roylei</i> , <i>A. pernei</i> (Saturniidae)	<i>Quercus</i> sps.	Sub Himalayan belt
4.	Eri silk (Endi or Errandi) (White colour)	<i>Samia cynthia</i> , <i>S. einthia</i> (Saturniidae)	Castor, (<i>Ricinus communis</i>)	North eastern states, Bihar, West Bengal, Orissa

5.	Muga silk (Golden yellow colour)	<i>Antheraea assama</i> (Saturniidae)	Som (<i>Persia bombycina</i>), Sualu (<i>Litsea polyantha</i>)	Assam
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SILKWORM REARING HOUSE

First we need a house for rearing of silkworm because as you known silkworms is fully domesticated. A silkworm-rearing house is the place where the silkworms are reared to produce cocoons. The cocoon quality and yield are adversely affected if the optimal environmental conditions i.e. temperature, relative humidity, ventilation, illumination; hygiene, etc. are not provided to the silkworms. The rearing house should be rationally designed in order to keep the micro-climatic and environmental conditions for rapid and healthy growth of the silkworms. It should, therefore, have facilities for creation and maintenance of the optimal environmental conditions inside the silkworm-rearing house. The rearing house should also provide sufficient space and healthy environment for the workers attending the silkworm rearing.

Optional environmental conditions for silkworm under rearing house:

Temperature and RH: The optimum rearing temperature and relative humidity for different stages of the silkworms are as I, II, III, IV and VI instar are 27-28°C & 85-90%, 27-28°C & 85-90%, 26-27°C & 75-80%, 25-26°C & 70-75% and 25-26°C & 70-75%, respectively. So we should continue to watch the internal environment of rearing house. When the temperature and relative humidity inside the rearing house are below optimum conditions, they are artificially raised through charcoal or electric heaters and running humidifiers. When the rearing room temperature and relative humidity are above the optimum conditions, arrangements for natural cooling through good ventilation or forced cooling through wet curtains on windows, air coolers or air-conditioners should be made besides covering the roof with mats made up of coconut fronds, grass etc.

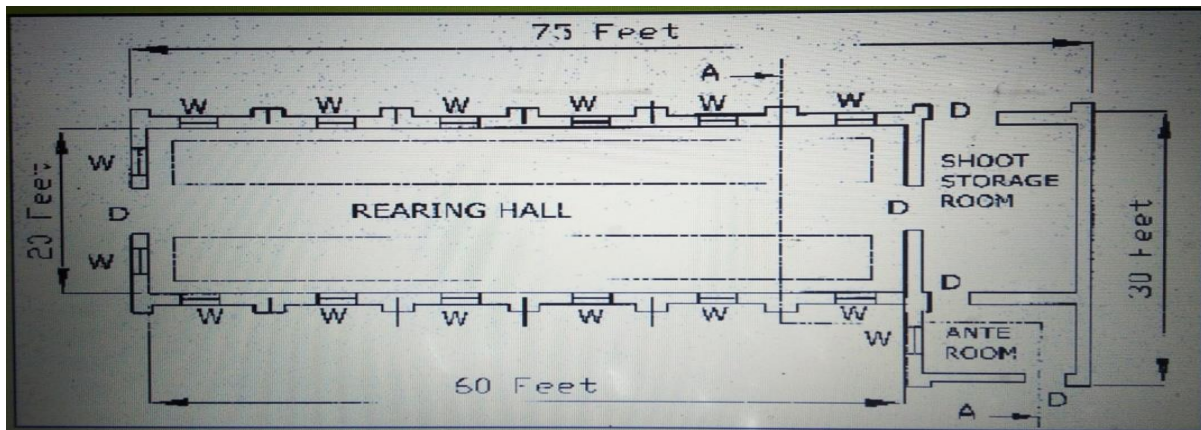
Light or illumination: Young Silkworms prefer dark or dim light [15-30 lux]. Light intensity influences the even distribution of the larvae in the rearing bed. Silkworms are crowded in dark place in the rearing bed.

Ventilation: A silkworm rearing house should be well ventilated. Poor ventilation leads to humidity built up and accumulation of gases like carbon monoxide, carbon dioxide, ammonia, etc., which adversely affect the growth of silkworms and make them susceptible to diseases.

Rearing Bed Area Requirement for Silkworms: The rearing bed area required for different races of the silkworms during different stages of growth is given below for 100 Dfs (2 Boxes) resulting in approximately 40,000 larvae. Rearing bed area required for silkworms during different stages for 40000 larvae:

Instar→	I	II	III	IV	V
Bed area for Multivoltine (sqm/sqft.)	1.5/15	4.50/45	9.00/90	24.00/240	50.00/500
Bed area for Bivoltine (sqm/sqft.)	1.75/17.5	5.25/52.5	12.0/120	133.0/330	77.0/700

*(1 sqm=10 sq.ft.).



Type of rearing house for silkworm:

1. **Young age silkworm rearing house:** The Young age silkworm rearing houses are often called as Chawki Rearing Centre (CRC). Adequate care in terms of temperature, relative humidity and hygienic conditions should be provided to young silkworms for their good and healthy growth. A CRC for brushing 5000-6000 dfs per batch consists of a rearing hall of 30' x 30', leaf storage room of 10' x 20' and ante-room of 10' x 10' size. Adequate ventilation in the rearing hall is recommended. A continuous water channel inside the rearing hall along the walls helps in keeping the ants away from silkworms and also maintaining the humidity. The windows should be fitted with wire mesh to avoid entry of uzi fly. The ceiling should be kept at 9'-10' from floor. In case of more roof height a false ceiling at 8' to 9' from floor helps in reducing the volume of air in the rearing hall so that required temperature and humidity can be maintained conveniently.

2. **Late age silkworm rearing house:** The silkworm rearing house should be located on an elevated place to avoid moisture migration from floor to rearing house, provide good cross ventilation, facilitate drainage of the water at the time of cleaning and disinfection. The rearing house should be north facing i.e., the windows face north and south. This will avoid direct entry of the sunlight into the rearing house. Ventilators should be provided above and below the windows for air circulation inside the rearing house. The rearing house should have cement flooring for maintaining hygiene. A 10-15 cm deep channel inside all around the rearing hall should be provided to prevent entry of ants in the rearing area and also to drain out water at the time of cleaning and disinfection. During summer, the water in channel helps in increasing the humidity and cooling the air entering in through the lower ventilators. The roof of the house should be of either Asbestos sheets or RCC to avoid entry of the Uzi-fly. In hot regions, coconut fronds or straw should be placed over the roof to avoid heat radiations during day time. A false ceiling of plywood or thermocol sheet is also effective in reducing the solar radiation from roof. The minimum width of a rearing house for late age rearing should be 5.5 m (18'). **The length of the rearing house can be calculated as follows:**

1. For 4 tier shoot rearing stand there is length of rearing house is $0.20 \times \text{no. of dfls} + 10$ feet and for 5 tier shoot rearing stand there is length of rearing house is $0.16 \times \text{no. of dfls} + 10$ feet.

Instructions for silkworm house: The wall height in a rearing house should be minimum 10' on the sides and 14' at the center. An ante-room should be provided for washing hands and disinfecting legs before entering into the rearing area. Doors and windows should be fitted with wire mesh to avoid entry of uzi-fly into the rearing house. Water facility should be provided in a rearing house for cleaning/washing and disinfection and also for humidification purpose. The rearing house should have adequate lighting arrangements for working during night. Electrical points in the rearing house should be provided for using heaters, humidifiers, coolers and lighting the building for workers during night hours. Provisions must be made for exhaust fans for evacuating humidity from rearing house during rainy days. Arrangements should be made to ward off rats, lizards, etc. and avoid entry into the rearing house. Shade trees around the rearing house should be planted to protect the walls and the roof from afternoon sun.

Major equipments for silkworm rearing:

1. **Rearing stands:** These are stands of frames on which are placed rearing trays containing silkworms. They could be made of wood or bamboo.
2. **Ant wells:** Ants are a serious menace to silkworms. To protect them, the legs of the rearing stand are kept in rectangular/circular enamel or concrete bowls containing water mixed with some insecticide.
3. **Rearing trays:** These are trays, generally circular, made up of locally available cheap material like bamboo. Sometimes, box type wooden trays are employed to rear early (I and II) instars.
4. **Paraffin paper:** Thick craft paper sheets coated with paraffin wax is required to cover the rearing trays to maintain humidity and prevent withering of leaves.
5. **Foam rubber strips:** Pieces (2.5 x 2.5 cm) of foam rubber soaked in water are kept all around silkworm rearing beds to maintain humidity. Newspaper folded strips moistened with water could be convenient substitute.
6. **Chopsticks:** Chopsticks are tapering bamboo rods meant to pick up younger stages of larvae to ensure their hygienic handling and preventing from injuries.
7. **Feathers:** Feathers, preferably white, are important items of silkworm rearing room. They are used for brushing together newly hatched worms to prevent injuries.
8. **Leaf chamber:** Mulberry leaves meant for feed are stored in chambers made up of 7.5 cm wide wooden strips fixed some distance apart or of some porous board. The chamber with leaves is covered all over with gunny bag cloth kept moist during the summer months and dry days.
9. **Chopping boards, knives and mats:** As mulberry leaves are offered to the worms in a chopped condition, chopping board, knives and mats are required. Soft-wood-chopping-board is placed on mat. Two sized knives, small and large for chopping small pieces for younger instars and large pieces for older instars are needed. Chopped leaves falling on the mat are better collected in an enameled receptacle.
10. **Clearing nets:** Nets made up of cotton or nylon of the mesh size suitable for different instars are used for changing the rearing beds so that the leftover leaf-pieces and either are filtered out without the larvae being touched by hand. Manual separation of larvae from the litter has the risk of injuring and killing many of them. Mesh sizes suitable for I, II and IV and V instars are 2 mm, 10 mm and 20 mm respectively.
11. **Mountages:** Mountages (cocoonages, Hindi-chandrikes) are contrivances made up of rectangular bamboo mat tied on 4 bamboo sticks and bearing on its surface spirals of bamboo tapes. Ripe worms about to spin cocoons are transferred on to them. The larvae suspend themselves to the spirals and spin cocoons. The advantages of chandrikes are that they are cheap and easily made, you can be easily stored/stacked, excreta of spinning worms dry up soon due to free passages and thus prevent cocoons from getting stained, you can be easily shifted from place to place, and you can be easily disinfected.
12. **Miscellaneous appliances:** These include a hygrometer to measure humidity, a thermometer to record temperature of the rearing room, a charcoal stove to heat the rooms in winter, disinfection pads of gunny soaked in 2% formaline to disinfect the feet of the workers entering the rearing room, a sprayer to disinfect the rooms themselves, wooden stands of crossed legs to place trays during feeding and bed cleaning, a stand for wash-basin containing 29% formaline to disinfect the hands of the worked handling the worms and leaf-baskets to transport mulberry leaves from the gardens to the rearing house.

INSECT PEST OF SILKWORM:

Taxonomy of pest	How to harmful to silkworm	Prevention
Common name: Uzi fly Scientific name: <i>Tricholyga bombycis</i> , Family: Tachinidae, Order: Diptera.	These flies are parasites on silkworms. They lay their eggs on them and the maggots on hatching eat away the body of the caterpillars.	Fly-proof doors, windows and ventilators should be used in the silkworms rearing house. All crevices of the rooms should be closed to prevent maggots pupating in the soil.
Common name: Beetles, Scientific name: <i>Dermestes cedevevinus</i> , Family: Dermestidae Order: Coleoptera	Adults and grubs (larvae) of this and other dermestid beetles are attracted to the smell of cocoons in storage. They eat the cocoons, enclosed pupae and often the eggs (seeds) of the silkworms.	The females of these beetles lay their eggs in crevices, organic matter and wooden boards. Therefore, closure of the crevices, and cleaning of the rearing room is the first requirement of prevention. Occasionally, the rooms could be fumigated with CH ₃ Br (methyl bromide) and stifled cocoons should not be stored for long.
Ants species, Order: Hymenoptera	Ants act as a predator on silkworm caterpillars and also attack silkworms in rearing trays	Legs of rearing stands should be dipped in antwells (filled with water + insecticide). At the time of spinning, ash or kerosene is put at the handles of the chandrikes to keep the ants off.
Lizards, birds, rats and squirrels:	All these animals feed on silk-worms. Mammals predate also on the pupae by biting open the cocoons.	Rearing rooms should be kept free of lizards with the help of insecticides. Birds could be scared away from the vicinity and for rat and squirrel trapping could be carried out in rearing houses.

Disease of silkworm:

Disease →	Pebrine	Flacherie	Grasserie	Muscardine
Causal organism	Sporozoa (<i>Nosema bombycis</i>)	Bacteria (Bacillus bombysepticus)	Nuclear Polyhedrosis virus	Fungus White muscardine (<i>Beauveria bassiana</i>), Green Muscardine, (<i>Spicaria prasina</i>), and Yellow muscardine (<i>Iscaria farinosei</i>)
Susceptible stage	All stages of life	Larvae	Larvae	Larvae, pupa and adult
Symptoms	Peeper like black spots, Laying of unfertilized & dead eggs, Spotted and wrinkled skin, sluggish swollen abdomen, The infection spread to successive generation through eggs of diseased moth (transovarial transmission)	Loss of appetite, semisolid excreta, becomes lethargic, skin becomes flaccid body purification and emission of foul smell	Swelling of segments & easy avoidance of injury rupture of skin, body fluid becomes thick and cloudy and they die	Hyphae come out from intersegmental membranes, Body becomes too hard, mummified larvae vomit, diarrhea
Management:	Mother moth examination, Use of disease-free females, sterilization of eggs with 2% formalin, Destruction of infected eggs and females	Proper incubation of eggs and proper rearing conditions	Avoidance of injury	Proper rearing conditions and sterilization