PRACTICAL MANUAL

APICULTURE, SERICULTURE AND LAC CULTURE

PPH-321 2(1+1)

B.Sc. Horticulture
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.

Name of Student .....

Roll No. .....

Batch .....

Session .....

Semester .....

Course Name : .....

Course No. : .....

Credit .....

Price:-

CERTIFICATE

This is to certify that Mr./Miss. .....ID No..... has completed the practical of course.....course No. ..... as per the syllabus of B.Sc. (Hons.) Agriculture/ Horticulture/..... semester in the year.....in the respective lab/field of College.

Date: Course Teacher

CONTENTS

Practical No. 1

Objective: To study different body regions of honeybee

Activity: Observe the honeybee specimen in the laboratory using a magnifying lens and note down the morphological characteristics of the honey bee.

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

Practical No. 2

Objective: To study different species of honey bee

Activity: 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
1. ……	…… …… …… …… ……..……
2. …… …	…… …… …… …… ……
3. ……	…… …… …… …… ……
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5. ……	…… …… …… …… …… …… …… ……

Practical No. 3

Objective: To get familiarized with different castes of honey bee

Activity: Depict different morphological characters for the different castes of honeybees 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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Developmental stages of different castes of *A. cerana* (*A.c*) and *A. mellifera (A. m)*

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								

Practical No. 4

Objective: To acquainted with bee hive and various bee-keeping appliances

Activity: 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.

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.	……	…… …… …… …… …… …… ……	

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7.	……	……	
8.	……	……	
9.	……	……	
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11	……	……	
12	……	……	
13	……	……	
14	……	……	
15	……	……	

Practical No. 5

Objective: To study seasonal management of bee hive

Activity: Inspect the hive. Write the management schedule at different seasons. Write the procedure for uniting the bee colony (Newspaper method).

Materials required:……

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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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Practical No. 6

Objective: To study natural enemies of honey bees and bee hives

Activity: Inspect and identify the pest present in bee hive. Write the nature of the damage (symptoms) and follow up on the management of 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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Practical No. 7

Objective: To study diseases of bees and their symptoms

Activity: Collect the infected honey bees in vials from the hives. Observe the symptoms caused 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:				
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Fungal diseases:				
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Bacterial diseases:				
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Viral disease:				
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Practical No. 8

Objective: To study bee pasturage and bee foraging

Activity: 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 sources of pollen and nectar	…… …… …… ……

Procedures for Recording Bee Behavior

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Results of Foraging Activity:

Practical No. 9

Objective: To understand the communication in honeybee

Activity: Write in detail 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 sun

When food is to the left of the sun

When food is to the right of the sun

Practical No. 10

Objective: To get well acquainted with types of silkworm species

Activity: 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: …… …… …… …… …… …… …… ……	

Practical No. 11

Objective: To study biology of mulberry silkworm, *Bombyx mori* on mulberry, *Morus alba*

Activity: 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		…… …… …… ……

Practical No. 12

Objective: To cultivate mulberry and preservation of leaves

Activity: 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:……

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 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 %

Practical No. 13

Objective: To study Lac culture and its different species

Activity: Study the process of lac culture and identify different lac insect species, focusing on their characteristics and economic importance

Materials required:...

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Observation to be recorded:...

Practical No. 14

Objective: To study different host plants of lac insect

Activity: Identify and study the different host plant species of lac insects, focusing on their role in lac production and suitability for cultivation

Materials required:……………………………………………………………………………………………………

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Observation to be recorded:………………………………………………………………………………………

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Practical No. 15

Objective: To study about lac cultivation

Activity: Study the process of lac cultivation, including host plant selection, inoculation, and harvesting techniques for optimal production

Materials required:……

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Procedure**:**……

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Precaution……

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Host Plant of Lac Insect ……

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Practical No. 16

Objective: To study the composition of lac

Activity: Analyze the chemical composition of lac, focusing on its resin, dye, and wax components, and their industrial applications.

Materials required:………

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Procedure:………

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Practical No. 17

Objective: To study the extraction of lac and types of lac

Activity: Explore the methods of lac extraction and classify the different types of lac based on their processing and quality

Materials required:………………………………………………………………………………………………

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Procedure:……………………………………………………………………………………………………

Practical No. 18

Objective: To study lac production and their uses

Activity: Investigate the process of lac production and identify its various uses in industries like cosmetics, food, and varnish manufacturing

Materials required:……

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Procedure:……

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Practical No. 19

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

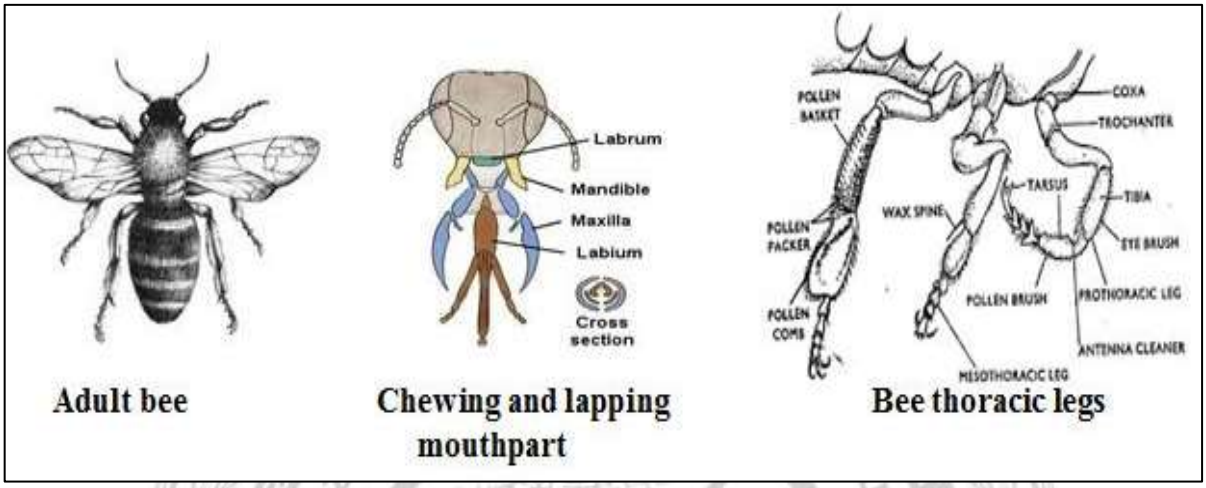
Activity: Make a report of the visit

Report:.....

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 mouth part

Thorax: Two pair of membranous wings and hamulate wing coupling mechanism. Three pairs of legs densely covered with hairs. Foreleg- eye brush and an antenna 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. Hind leg-pollen basket or corbicular. (concave outer surface of hind tibia is fringed with long curved hairs) basket.



Abdomen: First abdominal segment fused with meta thorax 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.

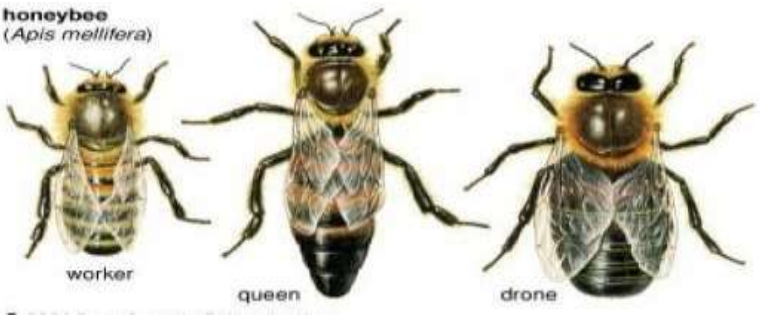
European bee / Italian bee (*Apis mellifera*)

- 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.

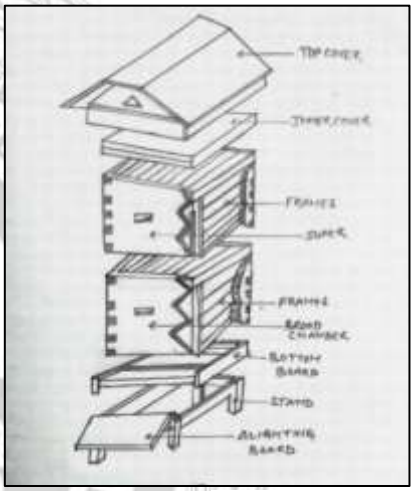
CASTES OF HONEY BEE

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 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.

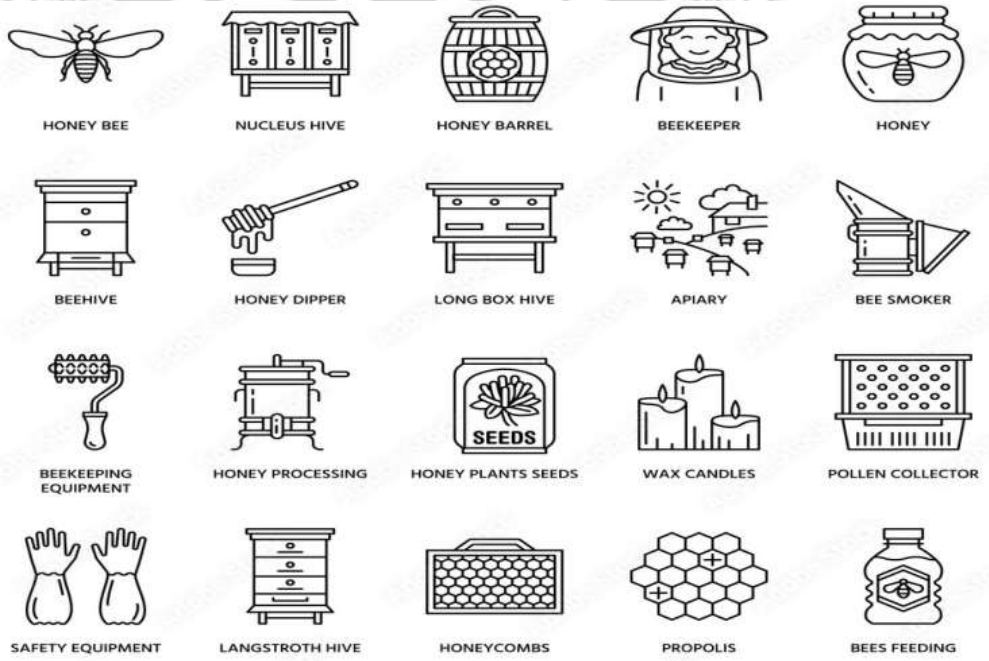
Covers: It insulates the inner portion of the hive. There are two covers:

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: Bee veil, Overall, Bee gloves, Bee brush, Hive tool, uncapping knife, Feeder, Dummy division board, Comb foundation sheet, Honey extractor, Smoker, Queen excluder, Queen cage, Pollen trap, 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.

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 (*Braula 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 disease	*Ascosphaera apis*	Gut; Larvae	• The pathogen mainly infects drone brood and less often to worker brood of the honey bee • 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, Soap nut 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.
- **Pollen and nectar source:** 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.

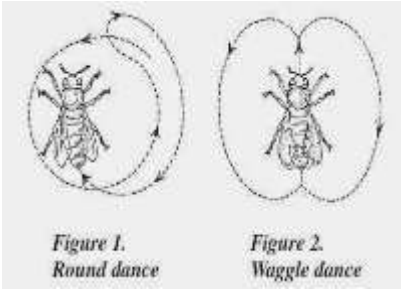


Figure 1. Round dance *Figure 2. Waggle dance*

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 3-4active 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	:	Kanva2, MR 2, S 30, S 36, S 54, DD (Viswa) V1
Semi-irrigated	:	Kanva2, MR2
Rainfed	:	S 13, S 34, RFS 135, RFS 175, S1635

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.

LAC CULTURE

Lac culture is the scientific management of lac insects to obtain a high amount of quality lac. This involves selection and maintenance of host plants, inoculation of host plants with healthy lac insects, collection and processing of lac and protection against enemies.

Lac: Lac is the resinous secretion of lac insects. Two species of lac insects *Tachardia lacca* and *T. chinensis* are common, of which theformer one is predominant in India. India is the highest lac-producing country.

Lac Insects species: *Kerria lacca, Tachardia signoret, Tachardiella cockerell, Tachardina cockrell. Kerria lacca* is available in Bangladesh. The first scientific account of the lac insect was given by J. Kerr in 1782 which was published in Philosophical Transaction of Royal Society of London. The first scientific name given to it was *Tachardia lacca* following the name of French Missionary Father "Tachardia". It was later changed to *Laccifer lacca* Kerr. The other name given to it has been *Kerria Lac* Kerr. **Phylum** – Arthropoda; **Class –** Insecta; Order – Hemiptera; **Suborder** – Homoptera; **Super family** – Coccoidea; **Family** – Lacciferidae; **Genus** – Laccifer

Morphology:

- Lac insect is a minute crawling scale insect which inserts its suctorial proboscis into plant tissue, sucks juices, grows and secretes resinous lac from the body.
- Its own body ultimately gets covered with lac in the so called„ CELL.
- Lac is secreted by insects for protection from predators.
- The head, thorax and abdomen are not clearly distinct.
- Eggs hatch within a few hours of laying, and a crimson-red first instar nymph called crawlers come out.
- The crawler measures 0.6 x .25 mm in size.
- At this stage, both male and female nymphs live on the sap of the trees.
- They insert their suctorial proboscis into plant tissue and suck the sap.
- The resin secreted is semi-solid which hardens on exposure to air into a protective covering.
- The nymphs molt thrice inside the cells before reaching maturity.
- The duration of each instar is dependent on several factors, viz. temperature, humidity and host plant.
- Biology and behavior

Eggs: The female lays eggs inside the encrustation 200-500 eggs are laid which may be either fertilized or unfertilized. Female lays 3 types of eggs. Equal no. of male and female; more males and less females and more females and less males. Female lays eggs which will hatch within few hours- Ovoviviparous type

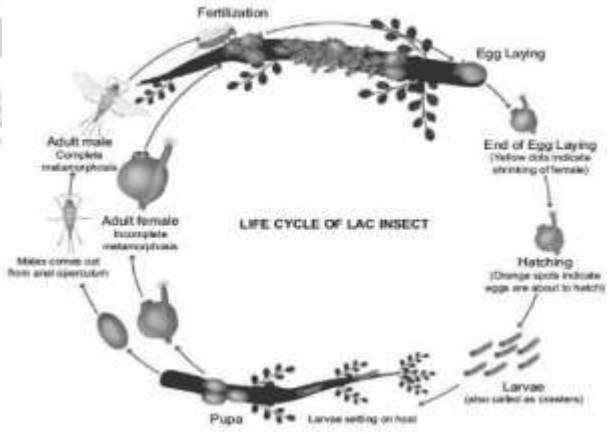
Nymphs:

- Nymphs are minute, about 0.6 mm long, soft bodied, pointed posteriorly, deep red in colour with black eyes
- Wander on the shoots (swarming), move mostly upward towards tender branches and settle on them
- They start feeding by piercing the shoot and settle on the shoot and do not move about They secrete resin over their body after one/two days of settling
- The resin glands are situated all over the cuticle except near mouth parts, anus and breathing pores
- The resinous covering increases with the growth of insect The nymphs moult thrice and become the adults
- After first moult, both male and female nymphs lose their eyes, antennae and legs Sex dimorphism is more pronounced after 1stmoult
- Male cell is elongate with a pair of holes at the anterior end from which white hairs comes out
- Female cell is globular with an irregular margin with 6 holes, 3 at top, 1 at hind and 2 at anterior end
- Male nymphs start developing the organs after 2ndmoult

Adult: Male and female are different from each other i.e., female is 3 times larger than male

Male: Two types, winged or wingless. Only 1 pair of wings and winged males appear during dry season (Baisakhi and Jetwi) Survives for 3-4 days and die after copulation. Elongate and slipper shaped. The males regain their lost appendages at the last moult.

Female: Short and spherical. After second moult, the female nymphs become swollen with no trace of segmentation. The posterior end of abdomen is bent upward and insect becomes roundish. Females never regain lost appendages. Mesothoraxis provided with appendage through which spiracles are open. The male copulates with the female even while the later remains inside the cell.



- A copulated female grows up very fast and secretes lac abundantly and the size of the insect The female cell size reach several times that of male cells
- Thus, the female insects are the chief producers of the lac Before egg laying, female develop 2 yellow spots posteriorly

- Spots enlarge and turns orange by the time the female oviposit the eggs into ovisac. At this stage, the twigs are cut and removed for inoculation (Brood lac) to new trees
- Egg laying ceases when the temperature inside the cell falls below 17^0C and the nymph becomes inactive below 20^0C

HOST PLANTS

- Lac insects thrive on twigs of certain plant species, suck the plant sap, and grow all the while secreting lac resin from their bodies. These plants are called host plants.
- Although lac insect is natural pest on host plant, these insects enjoy the privileged position not being treated as pest.
- This is because: i) they yield a useful product, ii) the host plants are economically not so important, and iii) the insects cause only temporary and recoverable damage to the host plants.
- About 113 varieties of host plants are mentioned as lac host plant.

Very common in India: *Butea monosperma* (Vern. Palas); *Zizyphus* spp (vern. Ber); *Schleichera oleosa* (Vern. Kusum); *Acacia catechu* (Vern. Khair); *Acacia Auxilia* (Vern. Babul); *Acacia auriculiformis* (Vern. Akashmani); *Zizyphus xylopyrus* (Vern. Khatber- grown in part of M.P. & U.P.); *Shorea talura* (Vern. Sal grown in mysore); *Cajanus cajan* (Vern. Pigeon-pea or Arhar); *Grewia tiliaefolia* (Vern. Dhaman preferred in Assam); *Albizzia lebbek* (Vern. Siris/Gulwang); *Flemingia macrophylla* (Vern. Bholia); *Ficus benghalensis* (Vern. Bargad); *Ficus religiosa* (Vern. Peepal). of these host plants, palas, kusum, ber and khair are of major importance, while others are of regional and minor importance. It is also important to mention that the quality of Lac Culture lac is directly related to the host plant and to the strain of lac insects. Based on industrial parameters, kusumi lac is better and fetches higher price in market. In this respect, ber tree as a potential kusumi lac host is already getting momentum. This host species is available in plenty and can supplement and fulfill the kusmi brood lac requirement in many areas. Similarly, siris (*Albizzia* sp.) has also been identified as good host for kusumi brood lac. The trees can be raised and utilized within a period of 5-6 years of plantation in comparison to around 15 years for kusum. *Flemingia semialata* is a bushy host plant and has also been identified as well as established as a good kusumi lac host on plantation basis. Thus, these three hosts viz., ber, siris, semialata and lately *Prosopis juliflora* (in Gujarat areas) are expected to enhance kusumi lac cultivation. Adoption of this activity may enhance lac production to the tune of 3-4%.

LAC PRODUCTION/ CULTIVATION

Done by inoculating brood lac on suitably prepared specific host plants. The brood lac contains gravid females which are to lay eggs to give birth to young larvae. After emergence, the young larvae settle on fresh twigs of host plants, suck the plant sap and grow to form encrustation

Local practice:

- The host plants are continuously exploited without giving rest for recoupment
- Only natural inoculation occurs and partial harvesting is done.
- Few branches are left untouched for auto inoculation.
- The host trees lose the vigour and become weak and die.

Improved practice:

- To provide much needed rest to host plants after harvest.
- Trees are divided into coupes i.e., groups that consist certain number of trees.
- Only few numbers of trees in a coupe are inoculated.
- After harvest, these trees are made to rest and recoup the last vigor.
- Other trees are ready with succulent twigs for inoculation.
- Alternate groups of trees are put to lac cultivation.
- Kusum is slowly growing, hence 18 months rest is given
- The trees are divided into 4 coupes and inoculating each coupe once in two years
- Plants of resting coupes are pruned
- In Rangeeni hosts like Palas and ber, trees are divided into 3 coupes i.e., two large and one small in ratio of 3:1:3
- The baisakhi crop is raised in 2large coupes in alternate years
- So that each coupe has a rest of 16 months in between and the katki crop is raised in small coupe every year allowing a rest period of 8 months between two successive crops.
- Selection of Site Pruning

Inoculation:

- Propagation of lac insects is done by inoculation of newly hatched (brood lac) nymphs on host plants
- Lac sticks bearing alive mother cells which are about to oviposit are called as Brood Lac
- One to 20 kg of brood stick is needed for inoculating a tree based on size of kusumi strain, 0.4 to 5 kg in case of Rangeeni natural/self/auto inoculation: swarmed nymphs infest the same plant again
- Natural inoculation, repeated on the same host, makes the host plant weak nymphs do not get proper nutrition
- Uniform sequence of inoculation does not take place

Artificial inoculation:

- The old weak and diseased twigs of host plants are pruned in January or June.
- Induces host plants to throw out new succulent twigs.
- The cut pieces of brood twig (i.e., 20 x 30 cm in length) are tied to fresh twigs.
- Each stick touches the tender branches at several places.
- The nymphs swarm from brood and migrate to tender and succulent twigs and infest them.
- Following swarming, brood twigs should be removed from the host plant to prevent pest infestation.

Precautions for artificial inoculation:

- Use fully matured and healthy brood
- Inoculation should be done immediately after cutting the brood lac
- Tie the brood stick on upper surface of branches securely
- Raise brood sticks at room temperature to 200C to induce swarming
- Avoid cultivation of rangeeni in kusumi area and vice versa
- Inoculate only on non-rainy day

Harvesting of lac (Cropping): Cutting the lac encrusted twigs when the crop is mature. It is of 2 types.

Immature harvesting:

- In this method, lac is collected before swarming and lac obtained is known as "ARI LAC"
- In this method, lac insect may be damaged during harvest
- Ari lac harvesting is recommended on Palas only

Mature harvesting: In this method, lac is collected after swarming and lac obtained is mature lac. Symptoms of swarming of nymph include the following-

- A yellow spot develops on the posterior side of lac cell towards crop maturity
- Dried out appearance of encrustation two weeks before swarming
- Appearance of cracks on the encrustation at a later date
- Harvest can be done at any time between stages while yellow spot occupies one third to one half of the cell area
- It is sometimes desirable to wait till the emergence of first few nymphs.
- The brood lac left after emergence of nymphs is known as stick lac or phunki lac

COMPOSITION OF LAC

Lac resin –68%, Lac wax –6%, Lac dye-1-2%, Others-25%

TYPES OF LAC

Stick lac: After harvest, lac encrustations are removed from the twigs of host plant by scraping. The raw lac thus obtained is known as crude/scraped/stick lac. The optimum moisture content is 4% for storage of stick lac to avoid lump formation

Button lac: Lac formed into cakes shaped like buttons by melting and solidifying. Button Lac is the preferred choice for French Polishing, Floor Finishing, tough & moisture resistant finishes. Button Lac contains wax and may not be as compatible as dew axed shellac when being used in combination with other finishing products like Polyurethane, Water lox etc.

Seed lac/grain lac: The stick lac is crushed and sieved to remove sand and dust, washed in large vats. Decaying bug bodies turn the water a deep red that is processed further to get the by-product, lac dye. The remaining resin is dried, winnowed and sieved to get the semi refined commercial variety product called seed lac. The seed lac is in the form of grain of 10 mesh or smaller and yellow/reddish brown in colour.

Shellac: The seed lac is processed into shellac by any of the 3 methods i.e., handmade country process/heat process/ solvent process/ Solvent process

LAC PRODUCTS

Lac dye:

- Lac dye is a mixture of anthroquinoid derivatives.It is traditionally used to color wool and silk.
- Its colour varies between purple red, brown and orange often depending upon themordant used.
- It is used in food and beverages industry for coloring.
- In recent past, lac dye has been replaced by synthetic dye.
- But, now-a-days with increasing stress and awareness on use of eco-friendly and safe material particularly associated with human contact and consumption has made revivalof great demand of lac dye as a coloring material.

Lac wax: Lac wax is a mixture of higher alcohols, acids and their esters. It is used in Polishes applied on shoes, floor, automobiles etc., Food and confectionary, and drug tablet finishing, lipsticks and Crayons

Shellac:

- Shellac is a natural gum resin, a nature's gift to the mankind and is used in over 100 industries.
- It is natural, nontoxic, physiologically harmless and edible resin.
- Shellac is a hard, tough, amorphous, and brittle resin containing small amount of wax and a substance responsible for its

characteristic pleasant odour.

- The lac resin is not a single chemical compound, but an intimate mixture of several components.
- Shellac is slightly heavier than water. Its natural colour varies from dark red to light yellow.
- When slowly heated, it softens at 65-70^{0}C and melts at 84-90^{0}C.
- Shellac is insoluble in water, glycerol, hydrocarbon solvents and esters, but dissolves readily in alcohols and organic acids.
- The solvent most commonly employed to dissolve shellac is methylated spirit.
- Usually the milder alkalis, ammonia, borax and sodium carbonate can also be employed to prepare aqueous solutions.
- Shellac is acidic in character. Acid value is 70. It is an ester.
- Saponification value 230. It has free five hydroxyl groups and has hydroxyl number 260. It has unsaturation indicated by iodine value of 18.
- Free aldehydic group also has been indicated by carboxyl value of 18. Its average molecular weight is 1000.
- Normal wax content of shellac is 5% which is insoluble in alcohol.
- It is soluble in n-hexane, pure Auxiliary, and other hydrocarbon oils. It is hard and having melting point 84^{0}C.

Extra ordinary properties: It is thermoplastic. It is approved for various applications in the food industry. It is uv-resistant. It has excellent dielectric properties, dielectric strength, a low dielectric consent, good tracking resistance etc. It has excellent film forming properties. Its film shows excellent adhesion to wide variety of surfaces and possess high gloss, hardness and strength. Shellac is a powerful bonding material with low thermal conductivity and a small coefficient of expansion. Its thermal plasticity and capacity of absorbing large amounts of fillers is noteworthy. Shellac under tropical conditions of storage, may soften and form a solid block, without adverse effects on its properties. Long storage under adverse conditions, however, may lead to deterioration in properties.

Uses:

- Fruit coatings, e.g. for citrus fruits and apples, parting and glazing agents for sweets, marzipan, chocolate etc. Also used as binder for foodstuff stamp inks e.g. for cheese and eggs.
- Binder for mascara, nail varnish additive conditioning shampoo, film forming agent for hair spray, micro-encapsulation for perfumes.
- Enteric (i.e. digestive juice-resistant) coatings for tablets and as odour barrier for dragées.
- Manufacturing of photographic material, lithographic ink and for stiffening felt and hat material.
- Preparation of gramophone records.
- Jewelers and goldsmiths use lac as a filling material in the hollows in ornaments.
- Preparation of toys, buttons, pottery and artificial leather.
- Sealing wax.

With increasing environmental awareness of consumers, this natural and renewable raw material is being used increasingly in the development of new products apart fromthe conventional user industries. Few to name:

- **Leather:** Seasoning, Leather care products
- **Printing inks:** As binder for flexographic printing inks for non-toxic printing of food packaging
- **Wood treatment:** Primers, polishes, matt finishes
- **Textiles:** As stiffeners
- **Electrical:** Insulation, capping, lamination
- **Abrasives:** Binder for grinding wheels
- **Others:** Binder for inks and water colours, Micro-encapsulation for dyes

Bleached shellac

- Bleached shellac is non-toxic, physiologically harmless (edible), and is widely used in the food industries, food packaging and allied industries.
- Apart from the above, bleached shellac is also used for its qualities i.e. binding, adhesive, hardening, gloss, odourless, fast drying, and extending shelf life (in absence of refrigeration) etc.
- Clear and transparent or very light coloured alcoholic or water – alkali solutions can be obtained from bleached shellac.

Use of Bleached shellac:

- Paints (primer for plastic parts and plastic film), Aluminum industry (primer for Aluminum and Aluminum foils), Flexographic printing inks, Pharmaceuticals (for coating of pills, tables and gel caps and coating for controlled release preparation), Confectionery (in coating of confections, chewing gums, marzipan chocolates, nutties, jelly- and coffee-beans etc.), Binder for food marking and stamping inks and Binder for egg coating, Barrier coating for processed food, vegetables, fruits and dry flowers, Textiles (used as textile auxiliaries and felt hat stiffening agents), Cosmetics (used in hair spray, hair and lacquers, hair shampoos, and binder for mascara), Wood finishing (as binder for wood coatings and wood stains and as filler/sealer for porous surfaces and cracks), Antique frames for paintings and Wood polish (French polish), Fireworks and pyrotechnics (as binder for fireworks, matches etc. and used in coating of magnesia, Electric (as binder for lamp cements).
- **Electronics** (it is binder for insulation materials, serves as additive to moulding compounds. Mass coating for print-plates and is adhesive for si-cells.)
- **Grinding wheels** (it is binder for additive of grinding wheels)
- **Plastic** (it is primer for plastic parts and films)
- **Rubber** (it is additive to natural rubber)
- **Leather** (in leather auxiliaries)
- **Dewaxed bleached shellac:** Dewaxed white shellac is used in the same way as any other grade of shellac. The major difference between this shellac and the others is that it is a bit harder, shines a bit brighter, is completely free from wax.
- Use: Coating of fruits and vegetables. Coating in tablets & capsules. Coating in confectionary. Coating in aluminum foil, paper. Coating in cosmetic industry. In cosmetics, it is used in hair sprays (pump sprays or aerosol sprays, hair setting lotions, hair shampoos, mascara, eyeliners, nail polishes, lipsticks, micro-encapsulation by coacervation of fragrances and perfume oils. In food, it is used for coating of confections, chewing gum, candles, cakes, eggs, citrus fruits and apples, and printing inks for eggs and cheese.