



ACHARYA N G RANGA AGRICULTURAL UNIVERSITY
Rajendranagar, Hyderabad – 500 030

PRACTICAL MANUAL FOR
SERICULTURE, APICULTURE AND LAC CULTURE
Course No: Ento 332(0+1)

(2012-13)

Editor

G. Raghavaiah

Professor & Head
Department of Entomology
Agricultural College, Bapatla

Co-editors

P.Rajendra Prasad
M.S.V.Chalam
P.Sitaramu

Acharya N.G. Ranga Agricultural University
Rajendranagar, Hyderabad 500030



Certificate

Cerified that this is bonafide record of practical work
done by Mr/Miss.....
I.D.No..... In course ENTO 332
(Sericulture, Apiculture and Lac culture) during
first/second semester of 201 - 201 .

Place:

Date:

Course in-charge
Dept.of entomology
Agricultural college

INDEX

EX. NO	DATE	TITLE	PAGE. NO	REMARKS	SIGNATURE
1		PLANTING MATERIAL, PLANTING of MULBERRY	4-8		
2		MAINTENANCE OF MULBERRY GARDEN	9-12		
3		INSECT PESTS, DISEASES AND NUTRIENT DEFICIENCIES OF MULERRY	13-18		
4		SILKWORM REARING HOUSE, REARING EQUIPMENT	19-20		
5		MULBERRY SILKWORM	21-23		
6		NON MULBERRY SILKWORMS	24-26		
7		mulberry silkworm races	27-29		
8		Silk Glands	30-31		
9		CHAWKI REARING	32-34		
10		LATE AGE LARVA REARING	35-37		
11		PESTS AND DISEASES OF SILKWORM	38-49		
12		MOUNTING, HARVESTING & STIFFLING	50-57		
13		HONEY BEE SPECIES AND BEE HIVES	58-65		
14		EQUIPMENT FOR HANDLING HONEYBEES	66-68		
15		INSECT PESTS AND DISEASES OF BEES	69-72		
16		LAC INSECT	73-79		

Mean temperature of 24-28⁰C, relative humidity of 65-80% are ideal for growth of mulberry. It can be grown with sunshine hours of 5.0-10.2 hrs/day in temperate conditions and 9.0-13.0 hrs/day under tropics.

Planting season :

Planting after the onset of monsoon is ideal under both rainfed and irrigated condition. Planting in winter and summer is to be avoided. Cuttings are to be planted either in north-south or east-west direction depending on sun shine hours and wind direction.

Land preparation :

The land should be tilled properly before planting to bring the soil to fine tilth. Land should be free from weeds and stubbles and leveled properly. FYM is to be incorporated @ 10 and 20 t/ ha for rainfed and irrigated crops, respectively as basal dose.

Preparation of planting material :

Mulberry can be propagated in two ways.

- a) Sexual propagation by means of seedlings.
- b) Asexual propagation by means of cuttings.

Propagation through cuttings is most common and widespread practice.

Shoots of proper maturity and thickness with active, well developed buds are chosen for cutting. The tips of tender branches and the bases of over matured branches are rejected. Branches with pencil thickness (10-12 mm dia) from 8-10 months old plants of desired variety are used for cuttings. The branches are cut into 18-20 cm (7-8") long cuttings with a minimum of 3 internodes with well developed buds. The ends are cut clearly with sharp knife with no splits or peelings in the bark. The cuttings are placed in the nursery bed with about 2.5 cm of cutting with one node projecting above the soil. The cuttings are watered regularly. In ten days, the roots develop from buds in the internodes below the soil and the leaves from bud in the internode above the soil. The cuttings may be planted directly in fields or may be grown in nursery for 2-3 months and then transplanted.

Planting systems :

a) Row system :

It is followed under irrigated conditions. Ridges and furrows are made at 60 cm distance. Two cuttings are planted at each spot along the edges of ridges. The crop is grown as bush type.

b) Pit system :

It is followed under rainfed condition with wider spacing. Pits of 40 x 40 x 40 cm are dug and filled with 1 kg each of FYM, red soil and sand. Three cuttings are planted in a triangle in each pit. Spacing is 90 x 90 cm for bush type of cultivation. Wider spacing of 180 x 90 cm and 270 x 270 cm is adopted for high bush and tree plantation, respectively.

c) Kolar system :

It is nothing but row system with slight modification in spacing, followed in Kolar district of Karnataka. A spacing of 30-45 cm between the rows and 10-15 cm within the row is adopted.

d) Strip System :

It is followed in West Bengal and similar to Kolar system. Mulberry is grown in strips of 2-3 rows. Each strip is separated by a wide distance so that harvesting, inter cultivation etc. is easy. Within the strip distance between rows and between plants within the row is 15 cm.

e) Angular System :

Mostly followed in hill regions of Nilgiris. Distance between plants is similar to pit system *i.e.*, 90 cm. Plants in adjacent rows are planted in such a way they form a triangular shape. It allows more plants per unit area.

Varieties :

	Situation	Varieties recommended
a.	Irrigated	Kanva-2 , S36, RFS135, RFS175, V1
b.	Rainfed	S13, S34, AR11, Anantha
c.	Alkaline with pH up to 9.5	AR12
d.	Intercrop in coconut	Sahana
e	.Moisture stress and low input	RC -1
f .	Fertile soils with low input	RC -2
g	Exclusively for chawki worms	G - 2
h	.Exclusively for late age worms	G - 4

a)Anantha :

- Light green leaves with big size, succulent and good in quality.
- Leaves can be fed to both chawki and late age worms.
- Yield : 65 – 70 t/ha/yr.

b). S-34. A selection from progeny of S30 x Ber 776.

- Suitable for black cotton soils for rainfed areas.
- Yield 15 t/ha/yr under rainfed condition
- Moisture content 70%, crude protein 23.7%, total sugar content 13.2%
- Resistant to mildew & rust.

c).S30 :

- Leaves boat shaped, succulent, shiny and green in colour.
- Branches grow straight.
- Leaves can be fed both to chawki and late age worms.
- Yield : 36 t/ha/yr under irrigation.

d).V-1 (Victory 1) :

- Released during 1987. Leaves dark green, oval, broad, thick, succulent.
- Suitable for feeding all stages
- Yield : 55 t/ha/yr..

e).S13 :

- Leaves dark green, succulent and good quality. Branches grow bushy and straight.
- Suitable for chawki and late age worms.
- Yield : 48 t/ha/yr.

f).S36 :

- Leaves heart shaped, thick, light green with glowing nature.
- Leaves have high moisture and more nutrients.
- Branches grow straight.
- Better for chawki rearing.
- Yield : 45 t/ha/yr.

g).S54 :

- Leaves dark green, succulent, big.
- Branches are bushy and will not grow tall.
- Wider spacing is required for plantation
- Suitable for all stages.
- Yield : 39 t/ha/yr

h). .RFS-135:

- An open pollinated hybrid selection from population of Kanva-2 with >80% rooting ability ,High nutritive value with high moisture content & retaining quality
- Yield 42 t/ha/yr under semi-irrigated condition

i).RFS-175:

- An open pollinated hybrid selection from population of Kanva-2 with >85% rooting ability ,
- Deep rooted , High nutritive value with high moisture content & retaining quality .
- Yield --30-35 t/ha/yr under protected irrigation conditions &

45-50 t/ha/yr under irrigated conditions

j).RC-1:

- Developed in 2002, by control hybridization of Punjab local x Kosen
- Rooting >90%, With high plasticity, Large, thick, succulent leaves
- Leaf yield potential of 25-28 t/ha/yr under 50% of recommended fertilizer inputs & suboptimal levels of irrigation.

k).RC-2:

- Developed in 2002, by control hybridization of Punjab local x Kosen
- Rooting >90%, With high plasticity,
- Leaf yield potential of 25-26 t/ha/yr
- Recommended for areas with poor groundwater source

l).Sahana:

- Developed in 2000, by control hybridization of K2 x Kosen .
- Rooting >80%,Large, thick, green and glossy leaves ,Tolerant coconut shade
- Yield 25-30 t/ha/yr in coconut plantation with a spacing of 30x30 feet.

m).AR-12:

- Developed in 2000, by control hybridization of S41(4x) x Ber.C-776(2x)
- Thick, large, dark green leaves,High survival under alkaline conditions i.e., more than 90% .
- Recommended for alkaline soils with $p^H < 8.5$.
- Yields up to 25 t/ha/yr

n). G2:

Developed by controlled hybridization of *M.multicaulis* x S34

- Quick sprouting after pruning or leaf harvest, Rooting 90%, High nutritive value and good keeping quality ,High molting ratio,Recommended exclusively for chalky rearing
- Leaf yield of 38 t/ha/yr

o). G4:

Developed by controlled hybridization of *M.multicaulis* x S13

- Rooting 90%, Short internodes and thick leaves ,Leaf yield 60-70MT/ha under irrigated condition ,Recommended for late age silk worm rearing .

p). .Kanva-2 x Kosen .

- Developed during 2001.
- Shade tolerant variety for growing as mixed crop with coconut .
- Yield - 44 T /ha/yr against Kanva-2 (28.5 T/ha/yr).

q).MYSORE 5 (M5)/Kanva-2 :

- Most popular variety in late 1960 & 1970's.
- Wide adaptability to various agroclimatic conditions.
- Leaves succulent with 70% moisture content,18% protein & 20% carbohydrate .
- High rooting ability, Hard branches with medium internodal distance Simple, cordate & smooth leaves
- Leaf yield 30-35MT/ha under irrigated conditions
-
-

Ex No. : 2

Date :

MAINTENANCE OF MULBERRY GARDEN – IRRIGATION, FERTILIZATION, LEAF HARVEST

Irrigation methods :

Judicious use of water for maximum production is important. During dry period, irrigation should be given at 7 to 15 days interval depending upon soil condition and water holding capacity.

Loamy soils – Once in 10 days

Clayey soils – Once in 15 days

a) Furrow method :

- Field is laid into ridges and furrows.
- Only one irrigation channel for every two rows of mulberry.
- Evaporation from soil surface is less.
- More efficient from the point of economy in water use.
- Furrow serves as drainage channel during heavy rains and avoids water stagnation.

b) Basin method :

- Suitable for tree plantation.

c) Flat bed method :

- Field is divided into rectangular bed with bunds all around and channels on sides.
- Bed size varies from 3.5 x 2.0 m to 4.0 x 6.0 m.
- Irrigation quicker but more labour required to make beds.

d) Overhead/Sprinkler method :

- Practiced in undulating lands where lower and high bushes are cultivated.
- Most efficient in economizing water use.

e) Micro irrigation by drip :

- More efficient in economizing water use.

Manure and fertilizers : under irrigation

Manure/fertilizer	Row system	Pit system
FYM (t/ha)	Irrigated	20
	Rainfed	10
NPK (kg/ha)	Irrigated	300:120:120
	Rainfed	100:50:50*
Fertilizer schedule	5 splits	6 splits

* In two equal splits, *i.e.* first dose in August at 6 to 8 weeks after application of FYM and second dose in late November during NE monsoon rains.

Fertilizer Schedule (NPK (kg/ha) :

Phase	Time	Row system	Pit system
I	1 st leaf harvest	60-60-60	60-60-60
II	2 nd leaf harvest	60-00-00	40-00-00
III	3 rd leaf harvest	60-60-60	40-00-00
IV	4 th leaf harvest	60-00-00	60-60-60
V	5 th leaf harvest	60-60-60	40-00-00
VI	6 th leaf harvest	60-00-00	40-00-00
Total		300:120:120	280-120-120

Pruning :

Certain branches of mulberry are periodically cut to give a proper shape and size to the plant, in order to increase the leaf yield and its feeding value. This is known as pruning.

Pruning objectives:

- To maintain a convenient height, shape and size of the plant.
- To induce more vegetative growth
- To synchronize leaf production with leaf requirement
- To extend leaf production period.
- To remove dead and defunct wood.
- To expose plant for better sunlight and aeration
- To make cultural operations easier.

Types of Pruning :

Based on the height of the plant from ground level where it is cut, there are 3 types of pruning.

- a. **Low cut pruning** : It is widely practiced in Japan. Plant is cut at a level less than 0.5 m above ground level.
- b. **Medium cut pruning** : Plant is cut at a height of 0.5 to 1.5 m above ground level. Large number of branches grows, but only 3-4 on the upper part are retained.

- c. High cut pruning :** Plant is cut at a height of more than 1.5 m above ground level. Leaf quality is poor with low moisture. Harvesting difficult due to more height. Less damage due to floods, but more susceptible to pests, diseases and winds.

Precautions to be taken while pruning :

- The cut should be clean without any cracks.
- The bark around the cut should be intact without any peels.
- Cut ends should be washed with lime to prevent entry of pathogens.
- Application of fungicides, wax coating to cut ends should be done.

During pruning, the injured region is susceptible to infection, leading to rotting and formation of dry and dead branches. Pruning also affects photosynthesis and hence the plant growth. When the shoots are cut off, sap oozes out of cut ends due to respiratory and root pressures.

To avoid excessive oozing of sap, the following pruning methods are useful.

a) Step up Pruning :

- Annual basal pruning is done to obtain first crop.
- For obtaining second crop, primary branches are cut 15 cm from the base.
- To obtain third, fourth and final crops the secondary, tertiary and tetra branches are cut 10 cm from the base.
- Finally the primary branches are cut to the base and the process is repeated next year.

b) Step down pruning :

- To obtain first crop, annual basal pruning is done.
- For obtaining second crop, primary branches are cut to about 60 cm after first harvest.
- To obtain third, fourth and fifth crop, the branch height is reduced to 45, 30 and 15 cm respectively at each pruning.
- Finally, the branches are cut to the base and the process is repeated.

1) Rejuvenation pruning :

Pruning over the years results in accumulation of cut portions in the crown that gets widened. Further, the new branches are intertwined with adjoining bushes. To overcome this, pruning is done at the utmost base. Rejuvenated branches give better quality leaf.

2) Alternate row harvest pruning :

If the plantation is closely spaced, branches of plants in alternate rows are cut. If the plantation is wide spaced, alternate pruning is done. This facilitates better exposure to sun light, better aeration, temporary increase in spacing and reduction in disease occurrence.

4) Multiple cropping patterns:

Among the total branches emerging after pruning, the leaves from weak and outer branches are harvested as first crop, allowing healthy, straight and centre branches to go as second crop. The outer branches are cut again as third crop and this is repeated.

Training :

Systematic pruning to give a specific shape to mulberry plant is called training.

1. Fist form of training :

Due to repeated pruning of branches at the same place every year, the top part of the trunk gradually increases in diameter without any increase in height. It resembles the shape of a closed fist when freshly pruned and is called the fist form of pruning. There can be simple, double or triple fist depending up on the number of fists allowed to develop.

2. Non fist form training :

The branching of point of shoot increases every year as branches are cut at a higher level above the branching point. For both fist and non fist form of training, low, medium and high end pruning is followed. These are known as Ono style, Yamagata style and Akita style respectively.

Leaf harvesting :

Leaf harvested during afternoon contain less water and more of carbohydrates due to active photosynthesis and transpiration taking place in day time and such leaves wither very quickly. Hence, leaf harvesting in early morning hours is recommended.

a) Leaf picking :

Leaves are picked individually from main stem with petioles. At the same time, terminal buds are nipped off so that lateral shoots develop rapidly. It requires more labour and leaves wither quickly.

b) Branch cutting (Batchi system in Kashmir) :

The entire branch is harvested and used to feed worms after third moult directly. It requires less labour and leaves retain succulence for longer period.

c) Whole shoot harvest :

The branches are cut to ground level by bottom pruning. The entire shoot is fed to leaves. Shoots are harvested at 10-12 weeks interval and 5-6 harvests are made per year.

Ex No. : 3

Date :

INSECT PESTS, DISEASES AND NUTRIENT DEFICIENCIES OF MULBERRY AND THEIR MANAGEMENT

Bihar hairy caterpillar : *Spilosoma (Diacrisia) obliqua*
Arctidae ; Lepidoptera

It is voracious feeder causing extensive damage to mulberry.

Life history :

Adults are light brown in colour with brick red abdomen, having dark rows of spots laterally and dorsally. Female lays about 1000-2000 eggs in batches on ventral surface of leaf. The eggs hatch in 5-7 days. The young larvae are gregarious in nature. The grown up larvae possess prominent setae (hairs) dorsally and laterally. The anterior and posterior regions are black in colour while rest of the body is reddish brown. The caterpillar moults 6 times and the larval duration lasts for 28-30 days. The pupation occurs in soil in a loose cocoon like structure. The pupa is brown in colour and its period lasts for 12-14 days. The life cycle is completed in about 48 days.

Symptoms :

The young caterpillars feed on the chlorophyll layer of the leaf exposing the veins which impart dried/dead appearance to the leaves (Skeletonization). The grown up larva feed on the entire leaf rendering the branches without leaves.

Management :

- Monitor the garden regularly for collection and destruction of egg masses and gregarious young caterpillars.
- Ploughing the caterpillar infested garden to a depth of about 15cm to expose pupae to scorching sun on to the sight of its natural enemies like birds.
- Flood irrigation will help to kill the pupae.
- Digging trenches (30 cm width and 30 cm depth) around the garden and dusting with Methyl Parathion 1.5 % dust helps to check migration of caterpillars from other gardens.
- Mulberry leaves from one/two rows of plants around the garden along the trench should not be harvested for silk worm rearing.
- Spray DDVP @ 0.2% or dimethoate @ 0.2% prepared in 0.5% soap solution. Safe period is 12 and 13 days respectively.

Tukra disease:

It is caused both in irrigated and rainfed gardens by the pink mealybug, *Maconellicoccus hirsutus*.

Pseudococcidae : Hemiptera.

Mealy bugs are hard to kill pests. They live in protected areas such as cracks and crevices of barks at the base of leaf petioles, leaf whorls and on lower side of leaves which make them inaccessible for insecticide sprays. The later instar nymphs and adult females are protected by a water repellent, white filamentous waxy coating over their bodies. Even the ovisacs in which the eggs are laid are covered by waxy filamentous coating.

Seasonal incidence :

It occurs on mulberry throughout the year. Their population is negligible during rainy season, but gradually increases during winter and reaches maximum proportion during summer months.

Life cycle :

The female lays about 350-500 eggs in a loose cottony egg sac during a week time. Eggs hatch in 5-10 days. The emerging crawlers are orange in colour. The females have 3 nymphal instars, while males have 4. Males, when fully grown forms a white case, inside which they transform into tiny, active two winged fly like insects. The crawlers feed by sucking the sap from leaves or tender stem portions. Life cycle lasts for about a month. Females are bigger and wingless throughout their life.

Symptoms of damage :

- Damage leads to curling and crinkling of leaves of apical shoots.
- Swelling and twisting of apices of internodes.
- Flattening and thickening of the affected part of the shoot.
- Shoots become brittle.
- Leaves become dark green in colour and deformed.
- White cottony mealy bugs and crawlers seen at the base of leaves in the malformed regions of branches.

Management :

- Clipping of affected apical shoots and their destruction.
- Do not bury the infested plant parts in soil as nymphs/crawlers may crawl back on to the plant to infest it.
- Weeds viz., *Phyllanthus niruri*, *Clitoria ternatea* which harbour the mealy bugs may be destroyed.
- Mass release of *Cryptolaemus montrouzeri*, a predatory beetle @ 250 adults/acre.
- Spray Dichlorvos or Oxydemeton methyl or Monocrotophos @ 0.2% twice at an interval of 10-12 days, mixed with 0.5% soap solution (50 g of soap dissolved in 10 litres of water).
- Safe period for leaf harvesting is 3 days after second application of dichlorvos and 20 days after application of oxydemeton methyl or monocrotophos.

followed by silvery blotches.

Thrips :

Bathrips melenicornis

Frankliniella sp.

Megalurothrips distalis

Scirtothrips dorsalis

Thripidae: Thysanoptera

Seasonal incidence :

Incidence of thrips was high during dry weather with low rain fall and in rainfed mulberry. Thrips incidence is low with protected irrigation where whole short harvest is practiced.

Nature and extent of damage :

Both adults and nymphs lacerate the leaf tissue and suck the oozing cell sap from young buds and leaves. The infested parts get hardened; leaves become brittle, malformed with reduced leaf area. In addition, sap extraction by the thrips results in necrosis and drying up of leaves.

Due to thrips attack, the epidermal cells get punctured, leaves and buds become rudimentary resulting in premature fall. During laceration, the thrips secrete saliva which coagulate with sap resulting in the formation of white streaks in early stage

Biology :

The females are dark brown, measuring 0.9 mm in length. They reproduce both sexually and parthenogenitically. Female lays eggs on ventral side of tender leaves which hatch in 6-8 days. The nymphs are pale yellow and lasts about 15-18 days. The pest completes 7-8 generations a year.

Management :

I. Cultural methods :

a) Clean cultivation :

- Removal of alternate hosts/weeds helps in regulating thrips.
 - Periodical ploughing and digging helps in exposing the thrips pupae to hot sun and natural enemies.
1. **Pruning** : Thrips population is low in kolar/row planting where whole short harvest is practiced.
 2. **Physical methods** : Sprinkler irrigation reduces thrips population. Frequent irrigation helps in increasing the pupal mortality in soil.
 3. **Resistant/tolerant varieties** : Mysore local harbours low thrips population due to its higher leaf surface with, maximum trichomes/hairs on upper/lower surface of leaf with maximum leaf thickness.
 4. **Biological methods** : Predatory thrips, *Scolothrips indicus*, Parasites, *Tetrastichus* sp.

5. Chemical methods : Spraying with DDVP @ 0.2% / Dimethoate @ 0.1% with a safe period of 3 and 15 days, respectively.

Mites :

About 15 spp of mites belonging to Tetranychidae and Eriophyidae are known to infest mulberry. Of them, the important ones are

- a) Bud mites, *Aceria morikcifes* (Eriophyidae)
- b) *Tetranychus equitorius* (Tetranychidae)
- c) *T. ludani* (Tetranychidae)

Mite injury :

Mites are found on the leaves, bud scales, nodes and apical shoots. Both nymphs and adults insert their stylets in to leaf tissue and suck the sap. The affected portion of the plant turns grayish white and ultimately withers. The leaves infested by *T.ludani* show white speckles at the place of feeding. With increase in intensity of feeding, the speckles increase in number and gradually coalesce with one another, finally producing large patches. Infested plants remain stunted for a longer period without any sign of growth.

Seasonal incidence :

The population of *T.equitorius* is maximum during March-April and May-June. From June to August, the population declines and then remains at a lower level upto January-February. The low temperature (25.5 to 27⁰C) and high humidity (85-90%) coupled with heavy rainfall affects the population.

Management :

- Pruning of affected plant parts and then destruction.
- Dipping mulberry cuttings in 0.1% of monocrotophos / phosphomidon is effective in killing mites.
- Spraying of Phosalone / Endosulfan @ 0.5% against *T.ludani* /*T. equitorius* with a safe period of 9 days.

Root-knot disease :

It is caused by an endoparasitic nematode *i.e., Meloidogyne incognita*. It was first reported on mulberry in 1911 by Bessy. The males are small and worm like while the females are pear shaped. Each female lays 400-500 eggs in a mucilaginous egg sac attached to the root surface. The young ones hatch out as second stage larvae after undergoing first moult within the egg. They are highly infective and enter the roots to induce galls. Soil moisture is essential for the movement of larvae and hence the disease is prevalent under irrigated conditions.

d deNature of infection :

The roots damaged by the disease lose their efficiency to absorb the available moisture and nutrients from the soil resulting in reduced metabolic function leading to the deterioration in leaf quality and yield.

Symptoms :

a) On above the ground parts :

- Stunted growth
- Poor and delayed sprouting
- Reduced leaf size and yield
- Chlorosis and marginal necrosis of leaves
- Yellowing and wilting of leaves in spite of adequate soil moisture availability and
- Death of plants in severe cases.

These symptoms first appear as isolated patches, slowly spreading over the entire garden.

b) On the underground parts :

- Formation of galls/knots on roots.
- Reduced and stunted root system.
- Necrotic lesions on root surfaces and on roots.

Management :

Cultural methods.

- Saplings free of nematode infection should be used for planting.
- Minimise the damage by providing adequate nutrition, moisture etc.
- Heavily infected soils should be deep ploughed to expose nematodes and eggs to solar radiation.
- Inter cultivation with nematicidal plants like Marigold (*Tagetes erectus*), Sesame (*Sesamum orientale*) etc. is known to reduce the population of nematodes.
- Application of oil cakes @ 4 ton/ha, green manure etc.

Chemical methods :

- Application of carbofuran @ 40 kg/acre to the soil around plants or in burrows.
- Leaves from treated plants can be fed to worms after 45 days.

NUTRIENT DEFICIENCIES

NITROGEN:

- ✓ It is a constituent of protein. It is the basic nutrient in the synthesis of proteins, amino acids, chlorophyll & alkaloids. Nitrogen increases the vegetative growth, no, size & weight of leaves and ultimately yield. The leaves become succulent improving their feed value to the silkworms.

N deficiency:

- ✓ Slow & weak growth of plant with less branching & chlorosis of leaves.
- ✓ The young green leaves show mottling & chlorotic spots.
- ✓ The nitrogen deficient leaves do not support good growth of silk worms.

- ✓ The stem is slender & light yellowish green & the root system also becomes stunted.
- ✓ Urea is an excellent form of nitrogenous fertilizer for mulberry.
- ✓ N can also be applied in the form of Am. Sulphate (20%),

Phosphorus:

- It is a constituent of cell nucleus, essential for cell division & development of meristematic tissues in the growing regions.

Deficiency:

- Not readily recognized by visual observation and less characteristic than those of N deficiency.
- Stunted growth with small and very dark green leaves and the older leaves turn reddish purple.

Potassium:

It influences the development of woody parts of the stem. It is essential both for photosynthesis and translocation of starch. Essential for yield of quality leaves.

Deficiency:

- ✓ The older leaves become mottled & chlorotic with necrotic symptoms along with margin.
- ✓ Visual symptoms of K def.
- ✓ commenced from medium to mature leaf & progressed with increased leaf maturity along with shoot growth.
- ✓ At the full growth stage of the shoot, 5-10 leaves from the apex appear healthy while the lower leaves showed varied degrees of symptoms.

Micronutrients:

Mg: Yellowing or reddening of older leaves

Fe: Chlorosis of Younger leaves & greening of midribs of the leaves

Mn: Rugged outline chlorotic leaves and rotting in between the veins.

Boron: Breakdown of young growing tissues, plant to crack, blacken abnormal in shape.

Zn: Chlorotic leaves scorchy yellow & brown leaf colouration, sometimes with darkened veins.

Cu: Wilting of the upper tender leaves & dying of leaf tips often without pronounced bleaching or change of colour.

- Borax @3 kg & MgO @8 kg /acre are recommended annually.

Ex No. 4

Date:

SILKWORM REARING HOUSE, REARING EQUIPMENT

Rearing house and equipment

It is desirable to have a separate rearing house. Space requirement is minimum in shelf or stand rearing and maximum in floor rearing during old age rearing. Stand rearing is common in tropical countries. For a capacity of 200 to 250 dfls the features required can be provided in a 30' x 20' house with the following facilities.

1. Ante – room
2. Open Verandah
3. Leaf room
4. Rearing hall & working space
5. Leaf inlet
6. Litter outlet
7. Two-step roofing
8. Exhaust
9. Air inlet
10. Wire mesh protected windows
11. False roof

REARING SHED

Shed direction -- **East to West**

Windows direction -- **North to South**

Cross ventilation --

- Keep wire mesh to windows ,ventilators & doors to prevent entry of uzyflies.

Equipment for silkworm rearing

1. **Rearing stands:** These are made of wood or bamboo, portable and are 2.5 m high, 1.5 m long and 1 m wide with 10 shelves with a space of 20 cm between each shelf. The rearing trays are arranged in the shelves.

In whole shoot feeding method,Rearing stand width should be 5 -5.5 ft.With One ft above the ground level.and with –2 ft.Distance between rearing stand & wall

2. **Ant wells:** These are provided around the legs of stands to stop ants crawling on to the trays and attacking the worms. These are made of concrete stone base 20 cm² and 7.5 cm high with groove of 2.5 cm depth to hold water. The legs of the stands rest in the center of the block.

3. **Rearing trays:** These are used to rear silkworms and are made of bamboo. They are round (1.2 to 1.4 m dia) or rectangular (0.9 to 1.2 m x 0.7 to 0.9 m) with a depth of 7.5 cm.
4. **Rectangular wooden trays or boxes:** These are used for rearing early age larvae, made of light wood, size being 0.9 m x 0.7 m with a depth of 7.5 to 15 cm. About 8 boxes are required for 100 dfls.
5. **Paraffin paper:** It is a thick craft paper coated with paraffin. It is used for rearing early age worms, on the bottom and as a cover of the rearing bed to prevent withering of chopped leaves and to maintain humidity in the rearing bed.
6. **Foam rubber strips:** Long foam rubber strips of 2.5 cm wide and 2.5 cm thick dipped in water are used to keep all around silkworm rearing bed during first two instars to maintain humidity.
7. **Chop sticks:** These are made of bamboo, 17.5 - 20.0 cm long and thin and tapering to one end. A pair of chop sticks are used to pick early age larvae and also for preparing the bed.
8. **Feathers:** Bird feathers, preferably white ones are used for brushing the delicate newly hatched worms onto the rearing bed.
9. **Chopping board:** It is made of soft wood and used for cutting the mulberry leaf to suitable sizes and the size is 0.9 m x 0.9 m and 5 cm thick.
10. **Chopping knives:** These are used for cutting the mulberry leaves and are 0.3 to 0.5 m long with a broad knife blade and wooden handle.
11. **Mats:** Mats of 1.8 x 1.2 m are used for collecting the leaves when chopping is done on floor to prevent the dust and dirt on the floor getting mixed with the leaves.
12. **Leaf chambers:** These are maintained in rearing house for storing the harvested mulberry leaf ready for feeding the worms at set intervals.
13. **Cleaning nets:** These are made of cotton or nylon of different mesh sizes to suit the stage of the larvae. These are used for cleaning the rearing beds and at least two nets are required for each rearing tray.
14. **Mountages:** These are used as supports for the silkworms to spin cocoons and are made of bamboo, usually 1.8 x 1.2 m. Over a mat base tapes of 5-6 cm wide woven out of bamboo are fixed in the form of spirals with a gap of 5-6 cm in between (Chandrika).

Other equipment includes thermometers, hygrometers, feeding stands, feeding basins, sprayers, leaf baskets etc.

Disinfection and hygiene:

The rearing house as well as the appliances used in rearing should be disinfected with 2% formalin prior to commencement of every rearing.

For effective disinfection, the rearing house should be made air tight as far as possible and with the rearing appliances kept inside, the walls, windows, doors and the appliances should be sprayed with 2% formalin @ 7-8 lt for 100 sq mt and the doors closed immediately. After 24 hours of disinfection the doors and windows should be opened and the rearing house should be completely aerated at least 24 hours before the commencement of brushing.

Ex No.5

Date:

MULBERRY SILKWORM - SYSTEMATIC POSITION, DISTRIBUTION, DETAILED MORPHOLOGY AND BIOLOGY

Systematic position:

Kingdom: Animalia
Phylum: Arthropoda
Sub-phylum: Mandibulata
Class: Insecta
Order: Lepidoptera
Family: Bombycidae
Tribe: Bombyinae
Genus: *Bombyx*
Species: *mori*

Egg:

- Eggs of European races. Eggs laid early during oviposition are larger.
- Indian crossbreed- multivoltine , 400 eggs per laying - very small
- Av. egg wt. 0.55 - 0.6 mg (2,000 eggs/g)
- White cocoon races lay paler eggs compared to yellow cocoon races.
- The color of the eggs changes to deep brown when they enter into diapause.
- Non-diapausing races - color does not change till one day prior to hatching - Blue egg stage.
- Eggs are ovoid, spherical or ellipsoid in shape and are flat on one side i.e., - egg dimple.
- Protective covering of the egg is chorion and its opening is micropyle
- Chorion - exochorion - main component is chorion (more S & N than chitin) and endochorion - has a waxy layer below it
- The two membranes beneath the chorion are Serosa and Vitelline
- The eggs are centrolecithal: Yolk is concentrated in the middle of the egg and cytoplasm is pushed to the surface called - periplasm.
- At micropylar end the periplasm gets collected in a cup - like depression of the yolk called - 'Polarplasm'.

Larva:

- Eruciform - polypod
- Ant, newly hatched black larva with bristles 3 mm long
- The bristles or setae are situated on four pairs of tubercles in each segment.
- The tubercles are sub-dorsal, supra - spiracular, infrspiracular and basal in position.
- The larva 10 cm long
- The three body regions (Tagmata) of a larva are head, thorax and abdomen.

Head:

- Hypognathous formed by the fusion of cranium
- Apical plate is Epicranium with epicranial suture.

- Clypeus has frontal - clypeus, post - clypeus and ante - clypeus.
- Labrum or upper lip hangs from ante - clypeus
- Prominent sense organs are three pairs of ocelli.
- Antennae, from 2nd head segment are short, 3 or 5 jointed each joint has 30-40 segments - they perceive odour.
- Head segments, 4th - mandible, 5thMaxillae and 6th- labium.

Mouth parts of larva:

1. Labrum: Unsegmented projection of the ante-clypeus i.e., upper lip.
2. Mandibles: Paired appendages of the fourth cephalic segment. The duct of salivary glands opens at their base.
3. Labium:
 - Lower lip, formed by fusion of the appendages of the last or sixth cephalic segment.
 - The cardo and stipes of two sides fused to form, lower, chitinized mentum and upper, heavily chitinized, black, prementum.
 - There is a median process in the distal end of the prementum called spinneret. Silk exudes through it during spinning.
 - Labial palps are short and separate and lie on either side of the spinneret - they are sensory in function.

Thorax:

Prothorax: Smaller with a pair of spiracles

Meso and meta thorax: Project slightly upwards and form dorsal hump.

A dorsal eye - spot on mesothorax.

Each thoracic segment has a pair of true legs.

Abdomen:

- Formed by 11 segments, but 9 only visible (9, 10, 7, 11th abdominal segments fuse to form apparent 9th segment, the caudal plate and paired caudal prolegs)
- Paired prolegs are also present in 3rd, 4th, 5th and 6th abdominal segments.
- Projection on the dorsum of the 8th segment is Caudal Horn.
 - First eight abdominal segments have a pair of spiracles laterally. Spiracles are atriate type - last spiracle is largest
- The number and distribution of nodules as well as markings are racial characters.

Sex differences in the larva:

- Female larvae has a pair of sex marks on ventral side of 8th and 9th abdominal segments, called Ishiwata's Fore glands and Ishiwata's Hind glands, respectively.
- Ishiwata's fore glands later modify into bursa copulatrix and receptaculum seminalis.
- Ishiwata's hind glands become posterior part of oviduct and the accessory glands.
- Male larva has a single median opening at the junction of 8th and 9th segments called opening of Herold's gland. It becomes seminal duct and ejaculatory duct of the adult.
- Then openings are seen only in freshly moulted larvae. Hence, marker genes in the sex-chromosomes are used in special races for easy separation. The sex marker genes are located on the w-chromosome of the female.

Pupa:

- Pupal moult occurs within the cocoon, non-motile and non-feeding.
- Head with a pair of compound eyes and antennae, and mouth parts vestigial.
- Thorax with two pairs of wing pads and three pairs of limb buds immovably pressed.
- Abdomen with nine visible segments and seven pairs of spiracles in the first seven segments. Last pair of spiracles non-functional.
- Female pupa is larger with broad abdomen, ventral line in the center of the 8th abdominal segment.
- Male pupa has small round spot on the ninth segment.

Adult:

- Moth is about 4 x 2 cm, no flight, does not feed and short life span of 3-6 days.
- Hypognathous head, bipectinate antennae and non-functional coiled proboscis.
- Thorax with a pair of wings and three pairs of legs.
- Abdomen with eight visible segments in male and only seven in female
- Six pairs of spiracles in the abdomen.

Sexual dimorphism in adults:

Character	Female	Male
1. Color	Paler	Darker
2. Activity	Less active	More active
3. Antennae	Small	Large
4. Body size	Large	Small
5. Abdomen	Large, Flat with 7 seg	Long, narrow with 8 seg.
6. External genitalia	The caudal end has a median knob - like projection with hairs. It can protrude to expel the pheromone	The caudal end has a pair of hooks, ' Harpens ' helping in copulation

Ex No. : 6

Date :

KINDS OF NON MULBERRY SILKWORMS

Many species of insects under the orders Lepidoptera, Trichoptera, Embioptera, Hymenoptera etc. produce silk. Among these, the silk producing insects of Lepidoptera have been commercially exploited. They belong to super family Bombycoidea and families Bombycidae or Saturnidae. Nearly 95% of world silk comes from mulberry silk worm, *Bombyx mori* and is known as mulberry silk. Three other commercially important silks under non mulberry silk are Eri silk, Tasar silk and Muga silk.

Eri Silkworm, *Samia cynthia ricini* Boisduval

Philosamia ricini – A wild species, Bivoltine (known as Alienthus silkworm)

Philosamia cynthia – A domesticated species, Multivoltine

Systematic position :

Order : Lepidoptera , Super family : Bombycoidea, Family : Saturnidae.

Genus : *Samia (Philosamia)* Species : *cynthia ricini*

Eri silk worm is found in Assam, Bihar, Meghalaya, West Bengal, Manipur, Nagaland, Arunachal Pradesh and Orissa.

Main hosts :

Castor, *Ricinus communis*

Kesseru, *Heteropanax fragrans*

Tapioca, *Manihot utilisima*

Papaya, *Carica papaya*

Eri cocoons are open ended cocoons utilized for spinning purpose. Cocoon is not compact, but loosely spun. Silk is white or brick red in color and not as glossy as mulberry silk. It is not in one single strand and therefore not reelable. Adult moth is stout and dark with darkish brown and white wings. Female lays 120-200 eggs in clusters. Eggs hatch in 7-10 days. The caterpillar has a green body with a brown head, and the body has small tubercles bearing short hairs. The full grown caterpillar is 8 cm long and the larval stage lasts for about 17-25 days and pupates anywhere. A complete life cycle lasts about 44 days in summer and 85 days in winter.

Muga silk worm :

Antheria assama

Synonyms : *A. assamensis*, *A. mejankari*

Saturnidae: Lepidoptera;

Muga (Assamese word) means the brown (amber) colour of cocoon.

Distribution :

Brahmaputra valley of Assam and foot hills of East goro hills of Meghalaya. Muga silkworm is polyphagous, semi domesticated and multivoltine in nature with 5-6 generations per year. The 6 generations in a year are mentioned here under :

Sl. No.	Generation	Season	Months	Remarks
1.	Jarua	Winter	Dec-Feb	Seed crop
2.	Chotua	Early spring	Mar-Apr	Seed crop
3.	Jethua	Spring	May-June	Second commercial crop
4.	Aherua	Early summer	June-July	Seed crop
5.	Bhodia	Late summer	Aug-Sept	Seed crop
6.	Kotia	Autumn	Oct-Nov	Main commercial crop

Host plants :

- 1) Som – *Machilus bombycina*, 2) Soalu – *Litsaea polyantha*

Secondary food plants :

- 1) Mezankari – *Litsaea citrate*, 2) Bajramani – *Zanthoxylum rhesta*
 2) Bagori – *Zizyphus jujuba*

Life cycle: Eggs are oval, dorso - ventrally flattened, bilaterally symmetrical. Newly laid eggs are brownish gray in colour, but after washing, they appear light green or creamy. Egg period is 7 days in summer, 16 days in winter. The larvae undergo 4 molts and pass through 5 instars. Larval period varies from 3 to 72 days. Pupal period varies from 14-40 days. On maturity, larva spins the cocoon with silk filaments around its body after selecting site for pupation.

Tasar silk worm, *Antharea mylitta* : It is known as Indian tropical tasar. It is multivoltine.

Indian temperate tassar (Indian oak tassar): *A. proylei*

Chinese tasar, *A. pernyi* , Japanese tasar, *A. yamamai*

Host plants :

- Asan, *Terminalia tomentosa* *Zizyphus* sps.
 Arjun, *Terminalia arjuna* *Quercus* sps.
Shorea robusta

Distribution:

Mainly in Bihar, Orissa, A.P, M.P, West Bengal,

On small scale in Maharastra, U.P, Manipur, Mizoram, Karnataka.

Biology:

These are semi-domesticated (larval stage open) and also thrive naturally. The moth varies in color but have a prominent eye spot on the wings. Each female lays about 150-200 eggs. Incubation period is 10 days. The larvae are brownish in I instar and are greenish with violet tubercles in final instar. Larvae pass through four moults and the larval period lasts for 30-35 days in summer but longer in winter. The cocoons of *A. mylitta* are compact. The pupal period lasts for 15-20 days in summer while the cocoons of bivoltine harvested in November / December undergo diapause. The cocoons are generally collected by tribal people from host trees in jungles.

Other silk producing insects

Fishline silkworm: *Eriogyna pyretorum* reared mainly on the Hainan Islands and the silk is used for gut in fishing. The host plant of the worms is *Liquidambar formosana*.

Anaphe Silkworm: *Anaphe rentia* Notodontidae: Lepidoptera

It is polyphagous, univoltine silkworm from Southern and Central Africa. They spin cocoons in communes or groups. It is used in velvet and plush. It is more elastic and stronger than mulberry silk.

Gonometa Silkworm (Egger moth): *Gonometa* sp

It is also a polyphagous silkworm from African savanna. Spins elongated un-releasable cocoons

Fagara Silkworm (Giant silk moth): *Attacus atlas*

It is from Indo-Australian biogeographical region. It spins pedunculate light brown cocoons.

Coan Silk : Pachypasa otus

Coan silk is used to make the crimson-dye and apparel worn by the dignitaries of Rome is produced by the larvae in the mediterranean region.

Mussel Silk : Pinna squamosa

The byssus threads (filamental structures) of the mussel are spun into a silk called fish wool in Italy.

**Spider silk : Nephila madagascarensis,
Miranda aurentia**

The silk secreted by some spiders and is used to produce spider silk. Though not exploited in textile industry, spider silk is used to produce the cross bars in optical instruments.

Ex. No.7**Study of mulberry silkworm races****Date :****Mulberry silkworm :** *Bombyx mori* Family : Bombycidae Order : Lepidoptera

The mulberry silkworm, *Bombyx mori* is a domesticated worm which has been exploited for over 4000 years.

Classification of silkworm races:

1. Classification based on voltinism : Voltinism refers to the number of broods raised per year. It is a genetically determined character which exerts its effect through hormones. Based on voltinism, three kinds of races viz , Univoltines, bivoltines and multivoltines are recognized in mulberry silkworm

2. Classification based on No. of larval moults : Number of molts during the life cycle is a hereditary character determined by Mendelian genes. On the basis of the number of moults which they undergo during larval life, *B. mori* is divided into three races – tri moulters, tetra moulters and penta moulters. Most of the commercially exploited races are tetra-moulters with five larval instars.

3. Classification based on geographical distribution : Based on their place of origin, *B.mori* is classified into Chinese, Japanese, European and Indian races. The races can be distinguished from one another on the basis of

1. Morphological characters of egg, larva, cocoon and adult.

2. Biological characters like duration of life cycle, diapause, number of larval moults and resistance to diseases as well as other environmental factors and commercial characters like length of filament, denier, defective cocoon percentage, reelability etc.

4. Classification based on genetic nature :Based on genetic nature, silkworm races are classified as pure races and hybrids.

Characters of races :**1. Multivoltine Races :**

Multivoltines or polyvoltines have more than three generations per year. The larval duration is short. Larvae are resistant to high temperature and high humidity. They are well adapted to tropical conditions where mulberry sprouts throughout the year. Larvae and cocoon are small in size. Commercially these cocoons are poor quality. The adults lay non-diapausing eggs. Multivoltine races of tropical region generally produce coloured cocoons i.e greenish/ golden-yellow.

i. C. Nichi : This was originally a Japanese bivoltine race which was imported and introduced in the state of Mysore. Due to continuous rearing by seed producers, this race has now degenerated to a multivoltine race.

ii. Nistari : This is one of the indigenous multivoltine race which is continuously being reared not only for producing cross breed hybrids, but also as a commercial indigenous race. It was introduced in 1881 from China and continues to dominate commercial rearing in the entire North India, especially in West Bengal.

iii. Pure Mysore : It was imported from China in 1895. The main demerit of this race is its long larval period (about 27-28 days).

iv. Sarupat : This race belongs to the North – Eastern part of India.

v. Tamil Nadu white : Some multivoltine races of India are able to produce white cocoons. Tamil Nadu Sericulture Department isolated the race called TNW in 1975.

Other races are Kolar Gold, Kollegal Jawan, Mysore princess, Hosa Mysore, MY 1, MY 2, BL 23, BL 24 and BL 67.

2. Bivoltine Races :

Bivoltine races have two generations per year, the first generation adults developing from eggs hatched in spring lay non- diapausing eggs. The second generation adults developing from these eggs lay eggs which remain dormant till next spring. The larval duration is longer as that of univoltines. Larvae are robust and tolerate environmental fluctuations they are used for summer and autumn rearing in temperate regions. By careful manipulation of artificial breaking and incubation, a third crop can be raised using late summer and early autumn leaves. The bivoltine cocoons are commercially superior. Japanese and Chinese races have both uni and bivoltine varieties.

Races: Races developed by CSR & TI, Mysore : NB 7, NB 18, NB 4 D2, CSR 2, CSR 3, CSR 4, CSR 5, CSR 6, CSR 12, CSR 16, CSR 17, CSR 18 , CSR 19.

Races developed by RSRS, Kalimpong : KA (Kalimpong).

Races developed by KSSRDI, Bangalore : KSO 1 and SP 2

Comparison of uni / Bivoltine and Multivoltines

Characteristic feature	Uni / Bivoltine	Multivoltine
Egg	Diapausing / Non-diapausing	Non - diapausing
Length of silk filament in cocoon (m)	1000 – 1600	300 -400
Shell ratio (%)	15 -25	10 -12

3. Multivoltine X Bivoltine (cross breeds)

In India, over 95% of the commercial silk being produced is from multivoltine female x bivoltine male parent (cross breed). i. PM x NB4 D2 ii. PM x NB 18

These races have limitations, especially lower shell weight, high renditta, low cocoon shell ratio and poor fiber quality.

iii. BL 23 x NB4 D2 : This hybrid is meant for rainfed areas like Chamrajanagar and Kollegal of Karnataka.

iv. BL 24 x NB 4 D2: This hybrid is meant for irrigated areas in all the seasons and is superior over the existing hybrids.

v. PM X CSR 2 (Kolar Gold) : The most popular cross breed

vi. Swarnaandhra (APM 1 x APS 8)

vii. Kapila (BL 43 x NB 4 D2)

viii. Cauvery (BL 67 x CSR)

ix. MH 1 x CSR 2

x. GEN 2

xi. GEN 3

Multivoltine x Multivoltine hybrid : PM x C. Nichi Varuna (BL 24 x C. Nichi).

4. Bivoltine hybrids : Keeping in view production of quality silk, the breeding work initiated at CSR &TI, Mysore under Bivoltine Sericulture Technology Development (JICA) Project utilizing two Japanese commercial hybrids has resulted in the evolution of highly productive CSR breeds. During the course of breeding, high raw silk recovery, robustness and production of cocoons with high quality silk were mainly considered. The full potentially of these hybrids can be realized only when optimum inputs to mulberry and good rearing management are assured. Therefore they are recommend for rearing during

favourable months (August to February) in southern India and during spring in temperate and sub-tropical zones. The new hybrids are better over the check hybrid KA x NB4D2 in terms of cocoon weight, SR%, raw silk%, filament length and neatness. The yarn of new hybrids is comparable to international standards (2A to 3A Grade).

Races

- i. CSR 2 x CSR 4
- ii. CSR 2 x CSR 5
- iii. CSR 3 x CSR 6
- iv. CSR 12 x CSR 6
- v. CSR 16 x CSR 17

These races are suitable for rearing from August to February.

- vi. CSR 18 x CSR 19 (sex – limited , All seasons)
- vii. CSR 48 x CSR 4 (Thin denier hybrid)
- viii. KSO 1 x SP 2
- ix. Kalpatharu
- x. Hemavathy (AP 55 x AP 54)

Comparison of pure race, cross breed and bivoltine hybrid

Sl.No.	Parameter	Native pure lines	Cross breed PMxNB4D2	Bivoltine hybrid CSR2xCSR4
1	Cocoon weight (g)	1	1.7	1.9
2	Shell weight (g)	10	17	24
3	Filament length (m)	300-400	730	1150
4	Neatness (points)	Less	82	94
5	Renditta	10-15	9	5

Ex.No.8 Study of Silk glands of Mulberry silk worm

Date :

Description of Salivary glands : These are the transformed labial glands, cylindrical and tubular in structure. They are situated on the ventro- lateral sides of the mid intestine. The slender duct passes through chitinous state of mandibular flexor muscles and open below the mandible into mouth cavity.

Silk glands : The silk thread of the cocoon is secreted by a pair of glands which are actually modified labial glands. These glands are well differentiated in the 4th and 5th instar. They lie below the alimentary canal. They are large and they are fully grown. In the final instar it occupies most of the body cavity ventral to the alimentary canal and accounts for 50 per cent of the body weight. The silk glands are tubular in nature and the width of the tube varies in different regions of the glands. The entire gland is formed by 3-layers

- 1) The outer tunica propria of uniform thickness
- 2) Middle glandular layer
- 3) Inner tunica intima

The inner tunica intima is very thick in the anterior region and it is shed at each moult. There are 3 distinct regions in the silk gland differing in the structure and function. They are posterior region, middle region and anterior region. The posterior most region is highly folded and the folds lie in the midst of the dermo visceral muscle. They secrete a major protein of the silk viz., fibroin. The middle region is the most prominent region and is also widest it is folded into 'W' shape structure and the middle region acts as a reservoir of the fibroin secreted by the posterior region. The fibroin matures in this region during the storage period. The layer of the sericin secreted by posterior limbs of the middle region is called Sericin-1 that added around the sericin-1 by the middle limb with the sericin-2 and that added around the sericin-2 by the anterior is the sericin-3. The anterior region is of uniform thickness and is very thin and does not secrete any material and it serves only to conduct the silk fibre assembles in the middle region of the two sides open at the base of the median projection in the labium called **Spinneret** which draws out silk in the form of fine filament. The silk is moulded to a thread as it passes through silk press which resembles a typical salivary pump. The threads of the two sides are called brims and the sericin layer binds them together into a single filament or bave.

Ex No.: 8

Date:

Study of Silk Glands

Silk glands:

- A pair of modified **labial glands** well differentiated in the **4th and 5th instar larvae**.
- Lie below alimentary canal; occupy most of the body cavity and accounts for **50%** of the weight and **4 times** the length of larva.
- Formed of 3 layers, outer **tunica propria** of uniform thickness, middle **glandular** layer and inner **tunica intima** which is very thick in the anterior region and is shed at each moult and in the other regions it is thin and is not shed at each moult.
- The number of cells in the glandular layer is fixed and they grow only in size. European races have more number of cells.
- The decreasing order of number of cells in the races are European, Japanese univoltine, bivoltine and Chinese bivoltine, multivoltine and oriental race.
- The nuclei of glandular cells are round in young worms and are branched in mature worms.

- The three distinct regions of silk glands are **posterior, middle and anterior regions**.
- The silk filament is made up of inner **fibroin (75%)**, a tough elastic protein and outer **sericin (25%)**, a gelatinous protein
- The posterior most regions highly folded and secrete major protein precursor of the silk, fibrinogen, which gets denatured to fibroin.
- The widest middle region is folded into w-shape with three limbs, the posterior, the middle and the anterior limbs. It acts as reservoir for fibroin and it gets matured here.
- The posterior limb of the middle region secretes **sericin I**.
- Middle limb secretes **sericin II** around **sericin I**.
- Anterior limb secretes **sericin III** around **sericin II**.
- The anterior region is uniform, thin, no secretions but conducts the silk fiber assembled in the middle region to the spinneret.
- The anterior region of the two sides open at the base of the median projection in the labium called spinneret, which draws out silk in the form of a fine filament.
- A pair of glands known as **Filippis's or Lyonnet's glands** is situated at the junction of the two anterior regions. A viscous waxy fluid is secreted by these glands serves as lubricant at the time of silk thread ejection
- The silk is molded to a thread as it passes through the silk press, which resembles typical salivary pump.
- The threads of the two sides are called the **Brins**, and the sericin layer of the two bind them together into a **single filament or Bave**

Dissection of silk glands:

- ❖ Kill healthy fifth instar silkworm larva by exposing it to hot water or formaldehyde fumes.
- ❖ Pin the larva in a dissection tray exposing its dorsal side.
- ❖ Give a longitudinal cut on the mid dorsal line from the tip of the abdomen to head.
- ❖ Spread opens the viscera by pinning the cut edges to the sides.
- ❖ Locate the silk glands and clean them from fat bodies, trachea, visceral muscles etc.
- ❖ Remove the alimentary canal carefully by cutting its anterior and posterior ends.
- ❖ Locate stout, W-shaped middle region and identify its three limbs i.e. Posterior, Middle and Anterior limbs
- ❖ Trace highly folded posterior region after the posterior limb.
- ❖ Locate very thin anterior region by closely following the anterior limb.
- ❖ Locate the spinneret and Filippis's / Lyonnet's glands at the junction of the anterior regions.
- ❖ Keep black paper underneath different regions and label them with paper pointers

Ex No.: 9

Date:

CHAWKI REARING

Incubation

To ensure uniform hatching of the eggs, they are incubated at optimum temperature of 24-26°C and Relative humidity of 70-80%

Black Boxing

Eggs incubated under optimum conditions reach pin head or head pigmentation stage by 7/8th day i.e. 48 hrs before hatching. A day later i.e. 24 hr before hatching eggs turn bluish / brownish called as blue egg or body pigmentation stage. All eggs are kept in darkness at pin head stage which is called black boxing of eggs. Darkness arrests the hatching of the fully developed eggs but facilitates the lagging embryos to develop faster. Eggs after black boxing can be stimulated to hatch by exposing them to sunlight stimulus.

Brushing

Brushing is the process of separating newly hatched larvae gently and carefully from empty egg shells or egg sheets and transferring them to the rearing sheets. After black boxing and exposure to light, good hatching is obtained by 9 A.M. to 10 A.M which is ideal time for brushing also.

Bird feather or fine camel hair brush are used for brushing

Chawki Rearing

Rearing of I, II & III instars is called chawki rearing or young age rearing. Young age worms are more resistant to high temperature and humidity and grow healthier in such conditions. Young age worms require tender and succulent mulberry leaves. Of the total leaf requirement, only 6.33% is utilized during chawki, but 400 times increase in body weights, 300 times in body size and 500 times in silk gland weight are achieved.

Environmental conditions

The ecological factors, chiefly temperature, humidity, light and air have significant influence on growth larvae and cocoon quality. The standard temperature and humidity recommended are as follows.

<u>Instar</u>	<u>Temperature (°c)</u>	<u>%Relative Humidity</u>
I	26 – 28	85
II	26 – 28	85
III	24 – 26	80

During moulting low humidity of 70% RH is preferable. Humidity is maintained by using paraffin papers as cover for the rearing bed and wet foam pads. Silkworms are fond of dim light of 15 to 30 lux. It influences distribution of larvae in rearing bed. The worms are more crowded in dark and distributed in several layers. Photoperiod during early instars influences the type of eggs produced (hibernating / non-hibernating). A photoperiod of 16 hours light and 8 hours dark is ideal for young age rearing. The composition of air and its circulation in rearing room are important for silkworm rearing. In rearing room, the air is polluted by CO₂, formaldehyde gas, ammonia (from silkworm excreta) and sulphur dioxide. The safe limit for silkworm rearing is 1 to 2% CO₂, 1% formaldehyde, 0.1% ammonia and 0.02% sulphur dioxide. The accumulation of

the gases during chawki rearing is much less because of less production, hence aeration is less important.

Mulberry leaf

Mulberry leaves for chawki rearing must be soft and rich in water content, protein, carbohydrates etc. For chawki rearing, the largest glossy leaf method is adopted to pluck the correct leaves. The largest glossy leaf is the one, light green and glossy, being the largest among the first few leaves. From glossy leaf to 5 or 6 leaves below for I instar, another 4 or 5 leaves for II instar and further down upto all tender leaves for III instar are used in young age rearing.

Feeding

About 600, 800 and 1000 kgs of leaf are required to rear 100 dfls (40,000 larvae) of old cross, improved cross and bivoltine hybrid from brushing to spinning, respectively. Out of this 0.33%, 1% and 5% are utilized in I, II & III instars, respectively. Cut leaf method is found good during young age. The standard method is to give 4 feeds (6.00 AM, 11.00 AM, 4.00 PM and 10 PM) per day at equal intervals as far as possible. Amount and size of leaf required in chawki rearing are,

Instars	Leaf quantity (kg/100dfls)		Leaf size in cm ²		
	Uni/Bivoltine	Multivoltine	To start	Peak eating	Preparation for with age moult
I	1 - 2	1 - 2	0.5	2.0	1.0
II	5 - 6	2 - 3	2.0	4.0	1.5
III	20 - 55	15 - 20	4.0	Full leaf cut into 4 pieces	2.0
Total	26 - 63	18 - 25			

Bed area

To attain full larval growth, good survival and successful cocoon crop, maintenance of optimum bed area is important. For multivoltine x bivoltine hybrid 360 ft² and for bivoltine x bivoltine 480 ft² / 100 dfls are found optimum by the end of V instar. Rearing bed area has to be increased daily to match the growth of silkworms.

The space requirement for larvae during chawki rearing is given below.

Instar	Uni/Bivoltine		Multivoltine	
	Beginning	End	Beginning	End
I	0.2	0.8	0.2	0.5
II	1.0	2.0	0.5	1.5
III	2.0	4.5	1.5	3.0

Bed cleaning

Leftover leaf and litter accumulate in rearing bed leads to increase in humidity and temperature and multiplication of various pathogens. Hence, regular cleaning of bed is necessary. Since the young age worms are delicate, cotton / nylon nets are used for bed cleaning. The cleaning net is applied on the bed, one feed before cleaning, and the feed is given above the net. The worms crawl through the meshes and come up to feed on the leaves on the net. At the next feed the net along with the worms above is transferred to another tray and fresh feed given. The feces and left over feed are collected and put in manure pit. Cleaning is done once in I instar prior to I moult (on 3rd day), twice during II instar, first on resumption of fresh feed and the second prior to II moult, and thrice during III instar, first on resumption of fresh feed, second during the middle and the third prior to III moult. The mesh size of nets used for I & II instars is 2 mm² and for III instar 10 mm².

Handling of silk worm during moult

During moulting the rearing bed should be thin and dry. Silkworms stop eating just prior to moult. The rearing bed is then thinned out for drying and a layer of lime powder is sprinkled. Comparatively low humidity (70% RH) is desirable during moulting. Worms in moult should not be disturbed and there should be good ventilation. During III instar paraffin paper cover is provided only on the top but not at the base and use of foam pads is also dispensed. If any irregularity in settling for moult is observed, the late larvae may be segregated and reared as a second batch.

Different methods of rearing early age silkworms

The two methods used at present for chawki rearing are **Paraffin paper rearing and Box rearing**. The most popular method is Box rearing. In the first method paraffin paper is used as a bottom layer and as a cover for rearing beds to maintain optimum humidity. Feeding is restricted to 2 or 3 times a day in this method. The top paraffin paper must be removed at least 30 minutes prior to feeding for adequate aeration of the bed. In box rearing boxes with lids or without lids of 10-15 cm deep are used. Paraffin paper, wet foam rubber pad, etc. are used as usual. Boxes with lids are placed in shelves while boxes without lids are piled one over the other, but in II instar a space of 2-3 cm between boxes is provided for ventilation. The boxes with lids are not covered during III instar. However, prior to moult the paraffin paper, wet foam pad and the lids are removed to keep the bed dry.

Cooperative rearing of young silkworms

Young age silkworm rearing requires technical skill and hence cooperative rearing centers have been organized which are provided with ideal rearing houses, with necessary equipment and the rearing conducted by technical experts. Because of scientific rearing in cooperative rearing centers (collective chawki centers) the worms are vigorous and healthy and ensure successful crop with rearers during late age. In Japan 90% of young age rearing is done in cooperative rearing centers. Young age worms raised in collective chawki centers are distributed in III instar in trays as such or rearing beds can be rolled and 5 to 6 such rolls can be arranged in wooden trays for transportation or collected in nets and 8 to 10 such bundles are arranged in trays. It is better to transport the worms during cooler hours of the day either in morning or late in the evening.

Ex No.: 10

Date:

Late age / old age larval rearing

The IV and V instar silkworms are late age worms. Late age worms require slightly lower temperature and humidity. During this period the silkworm body increases in size by 29 times, in weight by 25 times, and silk gland weight by 200 times. The different aspects of old age rearing are as follows:

Environmental conditions

The ideal standard rearing temperature and humidity during late age rearing are as follows:

<u>Instar</u>	<u>Temperature (°C)</u>	<u>Relative humidity (%)</u>
IV	24-25	75
V	23-24	70

Above 36°C, the temperature affects survival and pupation rate. Comparatively low humidity is preferable during moulting. During late age rearing air get polluted with CO₂, CO, ammonia, sulphur dioxide etc. produced by working men, silkworms, mulberry leaves, burning of charcoal for warming and fermentation of litter. Hence, rearing rooms should have good ventilation. It is essential to ventilate the rearing rooms from III instar by removing paraffin paper cover at least for one hour before each fresh feed. CO₂ exceeding 1% in a rearing room is bad for silkworms. Air current of 1.0 m/s during V instar considerably reduces larval mortality. Silkworms are fond of dim light of 15 to 20 lux and avoid strong light or darkness. A photoperiod of 16 hours light and 8 hours dark are desirable during late age rearing also.

Feeding:

Too tender and too mature leaves are not fit for feeding in late age. Morning time is good to pick mulberry leaves. Care must be taken during leaf harvest to avoid over mature and yellowing leaves. Clipping off the terminal buds in row system, a week prior to the shoot harvest is desirable for IV and V instars. Quantitative requirement in late age forms the bulk (93.67%) of the total larval feed.

The feed requirement for 100 dfls is as follows.

<u>Instar</u>	<u>Leaf quantity in kg</u>	
	<u>Uni/Bivoltine</u>	<u>Multivoltine</u>
IV	80 - 90	35 - 50
V	450 - 475	335 - 325
Total	530 - 565	335 - 375
Grand total from I to V instars	550 - 600	350 - 400

Leaf harvest is done by individual leaf plucking or shoots harvest. In leaf plucking, whole leaf is fed without cutting. In case of shoot harvest it is cut into convenient length to accommodate in rearing trays. Four feeds/days is the practice in late age rearing which can be

reduced in rainy season or increased in summer, without changing the total quantum of feed. The feeding time usually is around 5.00 AM, 11.00 AM and 10.00 PM.

Bed spacing

The successes of silkworm crop and cocoon quality also depend on spacing. Over crowded rearing leads to insufficient consumption of feed, poor growth, susceptibility to diseases and low cocoon yield of inferior quality. The spacing should be increased daily in proportion to the growth of silkworms. The rearing bed spacing recommended for IV and V instars is as follows.

Instar	Space in mm ² /larva			
	Uni/Bivoltine		Multivoltine	
	Beginning	End	Beginning	End
IV	5.0	10.0	3.0	9.0
V	10.0	20.0	9.0	18.0

Bed cleaning

During IV and V instars bed cleaning is done every day with nylon or cotton nets of appropriate mesh size (20 mm or 2 cm X 2 cm). As in chawki rearing the net is fixed over the rearing tray one feed prior to cleaning and feed is given above the net. Before next feed the net along with worms and leaves is transferred to another tray. The faeces and left over leaf are collected and put into manure pit. Paddy husk or charred husk is also used for bed cleaning in late age rearing. They are spread in a thin layer over the bed prior to feeding. The worms crawl through this layer and start feeding on fresh leaves. The worms and the leaves are removed to a fresh tray and the litter and old leaves are put in a manure pit.

Methods of rearing late age worms

There are three methods commonly known for late age rearing.

1. **Shelf rearing:** Rearing of silkworms in rearing trays arranged one over the other in tiers on rearing stands is called shelf rearing. Each rearing stand can accommodate upto 10 trays. Cleaning is more frequent in this method and the amount of labour required is greater. But it accommodates more silkworms in a limited area.
2. **Floor rearing:** Rearing silkworms on fixed rearing seats arranged in two or three tiers is called floor rearing. The rearing seats measure 5-7 m X 1-1.5 m. The space between tiers is 0.6 to 0.8m. Bed cleaning is followed as for shelf rearing, but less frequently, twice during IV instars and thrice during V instar. The floor rearing requires less labour but maximum space.
3. **Shoot rearing:** It is similar to floor rearing. Silkworms are reared on big branches in one or two tiers. The big shoots harvested from field, are fed straight to the worms. The rearing seats are 1m wide and as long as the rearing house and usually on a single tier, 20 cm above ground. In two tiers the gap between tiers is 1 m. It can be carried outdoors or indoors. In this method as shoots are supplied for every feed, the larvae keep moving upward and get distributed in three dimensions. There is better aeration of rearing beds. Hence it is possible to have 50% more worms/unit area of rearing seat compared to shelf or floor rearing. Cleaning is also

reduced to minimum i.e. once in IV instar and once in V instar. To clean the bed, ropes of convenient length are spread parallel to each other lengthwise on the bed under the branches and after two or three feeds, when all the worms have crawled onto new branches; the bed held by ropes is rolled into loose bundles by cutting the ropes every 2 m. After clearing the beds, the rolled up branches and the worms are transferred back on the rearing beds and spread out again. This method requires far less labour.

Care during moulting

The fourth moult takes nearly 30 hours under optimum conditions of temperature (24⁰C) and humidity (60-70%). As usual prior to stopping the feed for moulting, the rearing bed is spread to a thin layer and a thin layer of lime powder is applied after the last feed when the worms settle for moult. Feed should not be given and the worms should not be disturbed during moulting. **CSRZTI, Mysore has developed a dust formulation called, Resham Keeta Oushad' (RKO) to dust on moulting worms. The liquid formulation developed by CRSZTI, Berhampore is 'Labex'.**

Other chemicals used during rearing:-

A) Rearing bed disinfectant-

1. **VIJETA**-for all diseases
2. **ASTRA**-Multipurpose broad disinfectant effective against all diseases
3. **ANKUSH**—ECO & user friendly powerful nonhazardous bed disinfectant
4. **SERICHLOR-20**- power disinfectant for rearing house and appliances.

B) Silk worm growth promoters-

- 1.**SAMRUDHI**-silk enhancing juvenile hormone , which increases cocoon size and weight
- 2.**SERINUTRID**-semisynthetic diet for chawki rearing
- 3**SAMPOORNA**-A plant based steroids isolated for hastening the maturation and synchronized spinning.

Ex No. : 11.

Date :

PESTS AND DISEASES OF SILKWORM

The pests of mulberry silkworm are a) insects, b) mites and c) vertebrates.

Insect pests of mulberry silk worm are parasitoids and predators. Of the insect parasitoids, seven species belonging to Tachnidae : Diptera are important.

1. *Compsilura concinnata* 2. *Exorista larvarum* 3. *Gaedia ignavus*

4. *Gaedia puella* 5. *Neopalas pavidus* 6. *Thrycholyga sorbillans*

7. *Crossocosinia (ugimyia) sericariae*

Of the predators, ants, beetles (Dermestids), bugs, cockroaches, earwigs, wasps, the mites (*Pyemotids*) and the vertebrates viz., lizards, rodents, birds, cats and dogs are common.

Based on geographic distribution and hosts, four kinds of Uzi flies are known to infest and kill silkworms.

- a) Japanese uzi fly, *Crossocoamia sericariae*
- b) Hime uzi fly, *Ctenophorocera pavidus*
- c) India uzi fly, *Exorista bombycis*
- d) Tasar uzi fly, *Blepharipa zobina*

Indian uzi fly was found parasitizing mulberry silk worm in Karnataka during May, 1980. It has been causing 40-75% loss of cocoon crop.

The Indian uzi fly is known to infest 44 species of Lepidopteran caterpillars belonging to 36 genera including silk worms.

Biology :

The uzi fly complete 2 generations within the host larval period. It prefers III, IV and early V instar larvae for oviposition. It does not lay eggs on silk worms settled for moult and spinning worms (ripened) on mountages.

The fly lays 300-1000 creamy white eggs **singly** mostly on ventral surface of inter segmental regions. The eggs hatch in **2-3 days** and the maggots bore into the body of the silkworm. The maggots have **3 instars** and the maggot period is **5-8** days and the mature maggot pierces the integument and pupates outside on the floor in **10-20** days. The pupal period lasts **10-12** days.

Symptoms :

Black spots can be observed on the **inter segmental** surface of larvae from where the maggots enter into the body of the silk worm. **White creamy oval** shaped eggs can also be observed on the skin of infested larva.

Control measures :

- a) Use of nylon net (40-70 mesh) to prevent entry of uzi fly into rearing house.
- b) Application of uzicide as mentioned below

Age of silkworm	Bed area (sq.ft.)	No. of trays (3.5' dia)	Quantity of uzicide (lit/100 DFL'S)
III instar 2 nd day	90	10	0.7
IV instar 2 nd day	100	20	1.4
V instar 2 nd day	270	30	2.1
4 th day	360	40	2.8

- c) Dusting with levigated china clay with a muslin cloth @ 3g/100 larvae before mounting and 4 grams /sq. ft on bamboo mountages to prevent uzi fly attack during spinning.
- d) Collection and destruction of uzi fly affected silkworm larvae and cocoons.
- e) Destruction of uzi fly maggots and pupae collected from rearing trays, mountages, cracks and crevices in the floor of rearing house.
- f) Application of diflubenzuron (Dimilin 25 WP) with levigated China clay as diluent (1:9) on third instar maggots.

PREADATORS

1.Dermestid beetles : <i>Dermestes cadverinus</i>	<i>Trogoderma versicolor</i>
<i>D.valpinus</i>	<i>Anhrenus sp</i>
<i>Attagenus sp.</i>	Dermestidae: Coleoptera

The stored cocoons after stiffling are mostly infested by the grubs of dermestid beetles. They make hole and feed on the pupae inside.

Control :

- Cleaning of rearing house and cocoon store room.
- Do not store rejected cocoons and perished eggs for long time.

- Fumigate the dried cocoon storage rooms with Methyl bromide @ 0.5 kg/283 m² for a day or with chloropicrin @ 0.5 kg/283m² for 3 days.

2. Mites, *Pediculoides ventricosus* :

The female mites attack silkworm larvae, pupae and adults causing death. The body surface of silkworms struck with mites develops **black specks**. The infested ones **lose appetite**, become inactive and have difficulty in excreting and the excreta is **attached bead like to the anus**. If severely infested, the worms vomit yellowish green fluid. The mite takes nutrition from silk worm and gives out a toxic substance which kills the silkworm.

Control :

- Avoid the storage of wheat/rice straw near rearing house,
- Treat the building and thatched materials with acaricide or fumigant before use.

3.) Ants :

They attack silkworms in rearing trays. They can be prevented by placing ant wells with water below the rearing shelves.

4.) Nematode, *Hexameris microamphidis* :

It is mostly found in silkworms of late autumn rearing. The nematode attacks the young stage larvae and penetrates into their bodies. The head of affected silkworm becomes transparent and the body milky white.

Diseases of mulberry silkworm :

The silkworm *Bombyx mori* is prone to the attack of a number of diseases. Among the diseases, pebrine, grasserie, flacherie and muscardine are important.

1. Pebrine :

It is caused by a protozoan parasite, *Nosema bombycis*.. It belongs to

Phylum	: Protozoa	Class	: Sporozoa
Sub class	: Coidosporidia	Order	: Microsporidia
Family	: Nosamatidae		

Pebrine disease is also known as Pepper disease or corpuscle disease.

De Quatrefuges (1860) gave the popular name pebrine to this disease because of the characteristic infection and appearance of dark pepper like spots on the body of the infected silkworm larvae. **Pasteur** (1885) observed that the disease is transmitted through the egg in three ways *i.e.*,

- a) By contact with the diseased silkworms.
- b) By ingestion of contaminated food.
- c) By transovarial transmission

The life cycle of *N. bombycis* is completed in 7 days after infection in a cold climate and in about 4 days in hot weather.

Symptoms of infection :

Egg stage :

- a) Few number of eggs on egg cards
- b) Overlapping of eggs one over the other, instead of closely side by side
- c) Easy to detach eggs from egg card due to lack of adhesiveness. Eggs to egg card.
- d) Poor/less egg hatching.

Larval Stage :

- a) No external symptoms in early stages of disease
- b) With advance in disease, larvae become sluggish and dull.
- c) Poor appetite, retarded growth resulting in irregular moulting.
- d) Presence of larvae in unequal size in the rearing bed.
- e) Appearance of irregular dark brown spots or black spots on the body of larvae.
- f) Hanging down of the head, instead of holding up.
- g) Infected larvae may die before spinning or it may spin only a poor and flimsy cocoon.
- h) Affected larvae lack luster and in later instars turn rusty brown.

Pupal stage :

- a) The abdominal area is soft, swollen and dark in colour.
- b) Black spots present on sides of the abdomen.
- c) Pupa loses its luster and become dull in its movements.

Adult Stage :

- a) Discolouration of scales on abdominal area
- b) Black spots may be seen on abdomen
- c) Deformed wings
- d) Distorted antennae
- e) Low fecundity

Prevention and control :

- a) Production and supply of disease free layings through mother moth examination.
- b) Surface sterilization of disease free layings by dipping the egg cards in 2% formalin for few minutes and then washing in running water.
- c) Maintenance of strict sanitation, hygienic rearing.
- d) Destruction of diseased material.
- e) Disinfection of rearing rooms and appliances.

Mother moth examination for identifying and destroying the pathogen is an essential programme in a grainage.

There are 3 methods of moth examination

- a) Individual moth examination
- b) Sample testing
- c) Mass examination of moths

Individual moth examination :

It is ideal to check disease, but laborious. In this case, the individual moth is crushed in a moth crushing set. It consists of 10-20 cavities (mortar) and pestle. A drop of KOH solution is added to the crushed fluid. A drop of crushed fluid is taken on a glass slide and cover slip is placed over the drop of the fluid and a smear is prepared. This is observed under a microscope with 600 magnification (*i.e.*, eye piece 15 x objective 40). The pebrine spores are visible as shining oval bodies.

Even if one moth out of 10-15 thousand moths of a batch of cocoons show pebrine the entire lot is rejected.

A moth examiner can examine about 200 smears in a day of 8 hours. This method cannot be practiced in commercial grainages due to shortage of time between egg laying and

disposal. This can be followed in Jammu and Kashmir etc where bivoltine hibernated eggs are produced.

Sample testing :

In this method, about 20% of emerged moths picked at random are examined. Four moths picked at random from an egg sheet of 20, which forms 20% are examined for pebrine. This is generally followed in India.

Mass examination of moths :

This is a quick and dependable method of moth examination for pebrine disease and can be practiced in commercial grainages.

In this case, the samples of moths are drawn considering the number of moths to be examined after 24 hours of egg laying / oviposition.

Each sample consisting of 30 moths are kept in perforated paper covers after marking the date, lot number, sample number etc.

They are stored in hot air oven and dried at $70^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 6 hrs. After 6 hrs of drying, the temperature in the oven is maintained at 30°C to avoid accumulation of humidity and putrefaction. These batches are examined next day.

Thirty dried moths are kept into each mixer cup and 90 cc of 0.5% potassium carbonate solution is added. The material is ground for 2 min at 10,000 rpm. This helps in macerating moth tissues. The fluid is allowed to settle for 2 minutes and filtered by using an absorbent cotton filter. This helps in removing scales and other materials. This fluid is taken into a centrifuge tube and centrifuged at 3,000 rpm for 3 min. Then the supernatant is rejected. A few drops of 2% KOH is added to the sediment which is a thick paste. It is properly mixed by keeping the tube over a cyclomixer for about a minute. A drop of solution is taken on a micro slide and smear is prepared by putting a micro cover slip and examined under microscope. At least 2 smears are examined from each cup and each smear is examined at least in 5 fields.

This method of examination can be practiced for both live and dry moth examination.

Dry moth examination is more effective in pebrine detection than live moth examination.

Viral diseases :

Silkworm viruses are two types

a) Occluded (Inclusion type) :

Ex : Nuclear polyhedrosis virus (NPV) – Baculoviridae

Cytoplasmic polyhedrosis virus (CPV) - Reoviridae

b) Non occluded (Non inclusion type) :

Ex : Inflections flacherie (IFV) – Unclassified small RNA viruses

Densonucleosis (DNV) – Parvoviridae

Kenchu virus

Occluded/Inclusion body viruses :

The virions/viral particles are embedded by a thick protein coat, thereby they have more viability.

Nuclear polyhedrosis virus :

(Grasserie, Jaundice, Hanging disease)

- Caused by borrelina virus
- Polyhedrons are hexagonal or octagonal
- Measure 0.5 to 8.0 μ in size.
- Virion measures 400 x 80 nm
- The polyhedra engulfed along with food will get dissolved in midgut and virions infect the midgut cells. Later, they enter haemocoel and invade fat bodies, silk glands, trachea, haemocytes and the polyhedral formation occurs inside the nucleus of the target cells.
- Fourth and fifth instar larvae are more susceptible.

Symptoms :

- No external symptoms in early stage of disease
- Larvae become sluggish and lose appetite
- Swelling of inter segmental region
- Shining yellowish, fragile skin without elasticity
- Larvae become restless
- Crawling out of larvae from rearing tray and falling down, thus resulting in rupturing of fragile skin, there by releasing turbid dirty whitish haemolymph containing numerous polyhedra
- The diseased larvae lose the holding power of legs except the last pair with which they hang head downwards.

Predisposing factors :

- a) High temperature, high humidity and their fluctuation in rearing room.
- b) Excess moisture in leaf and rearing bed
- c) Insufficient ventilation
- d) Overcrowding during rearing
- e) Inferior quality mulberry leaves
- f) Feeding mature leaf followed by tender leaf
- g) Feeding leaf with accumulated dew drops and rain drops.

Prevention and control :

1. Strictly avoiding the predisposing factors
2. Surface sterilization of eggs with 2% formalin
3. Use of bed disinfectants like dusting reshamkeetoushad @ 2-2.5 g/sq. ft during chawki rearing and @ 3.5-4.5 g/sq. ft during late age rearing once after each moult.

Cytoplasmic polyhedrosis virus (CPV) : (Bilisappe, Sappe) :

- Caused by smithia virus
- Polyhedra of this virus are tetragonal or hexagonal and measure 3-10 μ in size.
- Virions are spherical and measure 60 nm in diameter
- Virus invades the posterior part of midgut epithelium.
- The cylindrical/columnar cells are infected.
- Polyhedra are formed in the cytoplasm showing characteristic chalky white appearance of the whole midgut.
- Due to increased pressure, the cell walls break and numerous polyhedra are released in to the lumen of midgut which pass through excreta and further contaminate the mulberry leaves in bed.

Symptoms :

- Early instar larvae more susceptible.
- Loss of appetite
- Retarded growth and development followed by vomiting gastric juice and diarrhea.

Prevention and control :

1. Thorough disinfection of rearing room and equipment
2. Rearing under hygienic conditions and feeding good quality mulberry leaves

Densonucleosis virus (DV) :

- Caused by a parvo virus measuring 20 nm in diameter.
- It invades the nucleus of the cylindrical cells of midgut epithelium.
- Late age worms more susceptible.

Symptoms :

- Infected nucleus gets swollen considerably.

Gattine :

- Caused by a non inclusion type virus (Sub microscopic and a bacterium, *Streptococcus bombycis*).
- Also called as Luzette or Clarette.
- Popular names are Salpa (W.Bengal) and Hasirumoto (Karnataka).
- Virus affects the epithelial cells of midgut followed by bacterial infection.

Predisposing factors :

Fecal matter containing virus excreted by infected larvae cause contamination.

Symptoms :

1. Infected larvae show translucent cephalothorax. (Since the gut is devoid of mulberry leaf)
2. Diarrhoea
3. Vomit alkaline liquid

Prevention and control :

- 1) Rearing under hygienic conditions
- 2) Proper disinfection

Infectious Flacherie :

- Caused by mortar virus
- It is spherical and measures 27 ± 2 nm in diameter.

- It invades the goblet cells of anterior midgut epithelium and multiplies in cytoplasm

Symptoms :

- Stunted larval growth
- Translucent cephalothorax and shrinkage of body
- Flaccidity of the body
- Frequent evacuation of semisolid and whitish fecal matter
- Soiling of anal region
- Excreta in the form of chain with beads
- Rectal protrusion
- Whitish midgut

Predisposing factors :

- Mulberry leaves with poor nutrition
- Feeding with yellowish/soiled leaves or leaves grown in shade/contaminated with pesticides
- High temperature and humidity of rearing room
- Improper ventilation and accumulation of poisonous gases

Prevention and control :

- Avoid predisposing factors
- Disinfection of beds with RKO
- Disinfection of rearing room and appliances with 2-4 per cent formalin
- Destruction of infected larvae, fecal matter and bed refuse by burning

Bacterial diseases :

These are referred to as Flacherie

It is of three types

a) Bacterial diseases of digestive organs – Caused by

Streptococci

Coli aerogenous bacilli

Proteus group bacilli

b) Bacterial toxicosis :

- Also called as sotto disease

- Caused by *Bacillus thuringiensis* whose spores produce toxic substances and affect nervous system leading to spasm and paralysis.

C) Septicemia – Caused by Sreptococci and Staphylococi

Predisposing factors :

- a) Diseased silkworms
- b) Fecal matter
- c) Contaminated mulberry leaves
- d) Rearing appliances
- e) Wide fluctuation in temperature and humidity

Symptoms :

- a) Larvae become sluggish
- b) Poor appetite
- c) Retarded growth
- d) Body shrinkage
- e) Vomiting of gut juices
- f) Excretion in the form of beads/chains
- g) Body of dead larva turns black and emit a foul smell

Prevention and control :

- a) Maintenance of hygienic condition in rearing room
- b) Avoid the predisposing factors
- c) Avoid fluctuation of temperature and humidity

Fungal diseases :

White muscardine – *Beauveria bassiana*

Also known as Calcino. Infection occurs through skin

Life cycle : 4-10 days.

Symptoms :

- a) Presence of oily specks on body
- b) Infected larvae lose appetite and become sluggish
- c) After death, larvae become mummified and gets hardened
- d) Body covered with white powdery conidia

Predisposing factors :

Diseased worms, fecal matter.

Prevention and control :

- 1) Disinfection of room/equipment with 2% formalin / 5% bleaching powder
- 2) Reduce humidity in bed with lime powder
- 3) Application of formalin chaff @ 0.4, against I and II instars and 0.5, 0.6 and 0.8%, against III, IV and V instars, respectively.

Other muscardine diseases :

- a) Green muscardine : *Metarrhizium anisopliae*
 - b) Yellow muscardine : *Paecilomyces farinosus*
 - c) Brown muscardine : *Aspergillus falvus..*
-

Ex No.:12

Date:

MOUNTING AND HARVESTING OF SILKWORM COCOONS AND STIFFLING.

Mounting:

- The process of transferring the ripe worms (full grown final instar larvae ready to spin the cocoon, where as immature worms are called green larvae) to the appliances used to support the spinning larvae i.e., mountages is called mounting
- Type of mountage and environmental conditions are important
- Semi-solid reddish excreta by ripe worms soon after mounting are called as Red feces. They contain large amount of uric acid and the colour is due to tryptophan metabolites
- The first spun loose layer or hammock is called Blaze or floss. It is un-reelable and, 2% and 10% in cocoon weight in bivoltine and multivoltine races, respectively
- The filament is spun in the shape of \sim in outer layers and α in the middle and inner layers
- After the compact shell is formed the larva shrinks and covers itself with Gossamer or thin layer of silk called Pelade layer
- The physical process of coagulation of two liquid silk Brins into one Bave is called Dragging. It is done with a load of 0.01g/denier with a spinning rate of 0.4 to 1.5 cm/second

Methods of mounting:

1. Hand picking of ripe worms
2. Simultaneous mounting of mixture of immature and mature and over-ripe worms
3. Net method
4. Small branch spreading method
5. Free mounting by larvae themselves

Population density in mounting:

- For Chandrika 50 worms/0.1 m²

Precautions:

- Only ripe worms should be mounted but not either the green or over-ripe worms
- Temperature around 24°C and humidity 60-70%
- Worms must not be disturbed
- Clean mountages

Cocoonages or mountages:

- Weeds, straw and dry twigs in Russia
- Made of wood, bamboo, card-board, plastic, glass, dry leaves and twigs.
- Proper attention must be given to the manner in which the worms spin their cocoons and to their requirements for space, air ventilation, temperature and humidity.
- The optimum space to be provided between two adjacent folds of a cocoonage is 0.9 to 1.0 inch at a height in between 4 to 6 inches in the folds.

An ideal mountage should

- Provide convenient space of suitable dimension.
- Should not promote formation of double cocoons, malformed cocoons and flimsy cocoons.
- Have provision for drying of liquid excreta passed by the worms.
- Be suitable for easy mounting and harvesting.

- Be cheap, durable, easy to handle, easily available and occupy less space.

Mountages used in India:

1. Traditional mountages

- Coconut fronds, mango leaves, paddy straw and dried weeds.

2. Chandrika

- Bamboo spiral mountage popular in South India and West Bengal
- Bamboo mat size 1.8 m X 1.2 m supported by bamboo reapers on all sides.
- Bamboo tape of 4 to 5 cm width is wound in a spiral supported by V-shaped struts.
- About 1,000 worms can be mounted on this mountage.

3. Screen type mountage

- Evolved by CS & TI, Mysore.
- Made of bamboo or wooden or plastic reapers on which longitudinal strips with triangular peaks are present.
- The screen can be folded and stored.
- More durable than chandrika.
- Demerits: loses shape due to elasticity there by double, un-uniform, unripened cocoons.

4. Plastic Mountages

- Based on model of chandrika but made of plastic.
- Various models like screen type are also available.
- Maintenance cost is less but initial cost is more
- Recommended to be placed on wooden trays, which are available with chawki rearing farmers.
- Holes in them are big-hence some trays are required to collect the worms fallen through the holes.
- Expensive, problem of disease spread, double and un-uniform cocoons.

5. Polymer mountage

- Netlon extruded polymer mesh by name netrika from Ms. Netlon India Ltd.
- Easy for cleaning and staking
- Uniform good quality cocoons

6. Japanese low cost mountage

- Modification of a Japanese model.
- A wooden frame made of four longitudinal wooden rods, attached by cross spokes at the ends of a central axis.
- Each rod of the frame has a number of pegs at equal distances, which are connected by long threads of twisted rice straw.
- It is cheap, each farmer can fabricate his own mountage
- Frame and straw can be disinfected separately.
- Quality of the cocoons is good.

7. Bamboo strip mountage

- Bamboo strips (3ft long) measuring 3 cm width and 0.5 cm thickness placed 3 cm apart from each other and nailed to wooden reapers.
- 10 such strips on a reaper of 3 ft length with a gap of 3 cm between for spinning cocoons.
- Can be stacked one over the other, the bottom one on wooden blocks 1ft above the ground.

- 2000 bivoltine larvae require 11 such frames costing Rs. 200/-
- Cocoons are made horizontally with minimum damage to pupa.

8. Bottle brush moutage

- Consists of a thick coconut or jute fiber rope into which 6 to 9 inch sticks (mid rib of coconut leaf) are inserted very closely.
- Silk worms spin their cocoons in between the sticks.
- Very cheap.

9. Plastic bottle brush

- Developed by the Rearing Technology and Innovation Laboratory of the Central Sericulture Research and Training Institute, Mysore.
- Each piece is having 8 branches of 1.5 cm length with 2 sub-branches of 9 cm length.
- The branches are equally distributed at a distance of 1 cm at base and 4 cm at the ends in a circular fashion
- Distance between two sub-branches is 3 cm.
- The circle formed by branches and sub branches is 24 cm in diameter.
- 50 such individual pieces can be joined with 2 cm gap by an iron rod with a steel stopper at the end.
- The surface of the branches and sub-branches is granulated.

10. Rotary moutage

- Not in much use in India.
- Consists of frame with 10-12 boards, each with 12 sections.
- Each section has 13 rows making a total of 156 chambers open at both the ends.
- Ten such frames are assembled on a turning wooden frame.
- They are kept above the rearing beds and rotated at a low speed.

Harvesting of cocoons:

- After hardening of the pupal cuticle i.e., 5th day after spinning for tropical and 7th day for temperate races
- Delay results pierced cocoons due to moth emergence
- Early harvest results in spoiled cocoons due to injury
- Harvesting is done normally by hand

HARVESTING OF COCOONS, COCOON CHARACTERS AND DEFECTIVE COCCONS

- Harvesting of cocoon is done on the 5th day of spinning.
- In winter, it may be done on 6th day in case of multivoltines for commercial use.
- Seed cocoons may be harvested on 8th/9th day of spinning depending on temperature.
- Harvesting should not be done immediately after pupation, since the soft cuticle of the pupae may rupture due to bad handling.

Physical and commercial characteristics of cocoons :

In depth study of the physical characters of cocoons will enable a reeler to

(A) Determine the size and quality of raw silk so that he can produce the yarn at an economic cost.

(B) To choose the right type of reeling machine, proper method of cocoon boiling and proper size of raw silk thread to be produced at an economic cost, the number of ends manageable for maximum output per reeler and highest recovery of good silk from the lot.

The cocoon characters may be heritable and are not influenced by rearing or feeding.

a) Colour :

- It is essentially a racial character.
- Indigenous multivoltine in South India is pale yellow to greenish yellow.
- In West Bengal, they are deep yellow to golden yellow.
- The uni and bi voltine exotic races of China, Japan and Europe are generally greyish white to bright white.
- The colour is only superficial and due to the presence of colouring pigments in the sericin layer of the bave.
- The colour may show a declining tendency from the outer layer to the inner layer.

b) Shape :

- It is essentially a racial characteristic and partly due to the type of moutage used.
- Each race has its own characteristic shape.

Japanese races	-	Peanut or bag shape
Chinese races	-	Elliptical
Indigenous races	-	Spindle like with pointed ends

c) Size : (cocoon volume) :

- It is influenced by race, rearing and feeding conditions.
- It is determined by the number of cocoons per liter and varies among the races.

Bivoltine-70-100/lit

- In 500 g of raw cocoons the number will be in the range of 230 and 350.

Multi voltine-120-200/lit

- The number of cocoons per 500 g may range between 350 and 500.

d) Granules or wrinkles :

- Granular formation can be clearly seen on the surface of cocoons in uni and bivoltine cocoons.
- The size and formation of grains are dependent on the races.
- The degree of fineness and hardness of the granular formulation varies with the type of race viz., Japanese, Chinese or European.
- The grains progressively show a decrease in size and intensity from outer layer to the middle and inner layer.

i) Length of silk bave :It indicates the quantity of silk to be unwound in reeling, the rate at which it can be unwound and the manner of boiling to be done to ensure maximum recovery of the filament.

- The mono cocoon reeling machine with an adjustable speed mechanism enables the reeler to determine the length of filament available in a cocoon.

Average total length of filament in a single cocoon in

Indian multivoltine pure race	300-400m
Indian multivoltine hybrids	400-650 m
Indian multivoltine cross breeds	800-1200 m
Indian bivoltine cocoons	1000-1600 m

j) Non breakable filament length (NBFL) :

- The longer the non breakable filament length, the better is the quality.
- It is dependent on the races used. The uni and bivoltine races with higher silk content register a higher length contributing to the less number of casts/replacements in the course of reeling a specified size of raw silk.

NBFL = Average filament in the lot under test x Reelability ratio

For eg :

Average Filament length assessed = 1344 m

The Reelability % number of cocoons used = 273

Number of casts made = 320 i.e., 83.2%

NBFL = 1344 x 83.2

k) Reelability :

- It is the index of the quality of cocoons used in reeling.
- The unwinding of the filaments from the cocoons should be smooth without frequent stoppages of the reel or breakages of the unwind filaments in the course of reeling.
- If frequent casts/additions of filaments arise, the output of raw silk and the rate of production is affected, rendering the cost of production high.

The reelability is expressed as percentage on the basis of number of cocoons used for reeling divided by the number of casts made while reeling

$$\text{Reelability \%} = \frac{\text{Number of cocoons used for reeling}}{\text{Number of casts made}}$$

I. Size of

- This is expressed in terms of denier. Denier (derived from the smaller French coin) represents the weight of 9000 meters of silk thread in gram.
- Filament denier decreases from outside of the cocoon to the inside.
- Value of denier varies from 1.7 to 2.8 g

$$\text{Denier} = \frac{\text{Wt of filament (g)}}{\text{Length of filament (m)}} \times 9000$$

m) Floss

- It is the entangled loose filament around cocoon shell and is un-reelable.

Multivoltine – 8 - 12%

Bivoltine – 2 - 5%

n) Renditta :

- The number of kilograms of cocoons required to obtain one kg of reeled silk is called Renditta.

Multivoltine – 8 - 14%

Bivoltine – 6 - 8%

o) Raw silk percentage :

- It is the percentage of raw silk that can be obtained per unit of cocoons

Bivoltine – 80 - 85%

Newly evolved multivoltine – 55 - 60%

Multivoltine pure races – 40 - 45%

Defective cocoons

I. Defects due to heritable racial characters :

a) Thin middle cocoons :

- The entire shell is thin and constricted in the middle.
- The cocoons have poor silk content and hence have poor reelability.

b) Thin ends of weak points :

- The cocoons are loosely spun at one end or at both the ends.
- It is most common in females than in males and in cocoons spun vertically in the mountages.
- Due to thin ends, cocoons become water logged and are un-reelable.

II. Defects due to mistakes in rearing and mounting :

- a) **Double cocoons** : When too many worms are mounted on the same mountage, due to lack of space, two worms lying nearly, while spinning their silk become entangled and they spin a single cocoon. They are un-reelable. Hence, used for spinning.
- b) **Immature cocoons** : When an unripe worm is mounted, it wanders about for sometime in search of food and settles to spin when food is not available. It spins small sized cocoons with lesser silk.
- c) **Unsize cocoons** : When worms are not fed with adequate quantity of leaves, the growth of worms become nonuniform. They reach spinning stage at different times and spin cocoons of different sizes.
- d) **Malformed cocoons** : These include cocoons of abnormal shape with impressions of mountage *etc.* These are formed either due to defects in the mountage or violent fluctuations in environment during spinning.
- e) **Black stained/inside spoiled/mute cocoons** : These are cocoons which contain a dead pupa, putrefying fluid of which oozes out and spoils the cocoons. This may be due to disease, early harvesting or crude handling of cocoons.
- f) **Rust or outside soiled cocoons** : These cocoons have black patches on the outer shell formed due to the excreta of other worms falling on them.
- g) **Spotted cocoons** : These are normally healthy cocoons which are stained due to various reasons.
- h) **Loose knot/Fragile/Thin shaped cocoons (Straw bags)** : These are loosely woven with spaces between the layers of cocoon shell.
- i) **Double layered cocoons** : When spinning worms are subjected to sudden changes in environment, they spin cocoons with 2 or 3 layers of shell. This defect can be seen only during reeling.

III. Defects due to parasite infestation :

Perforated cocoons : When spinning larvae are infested with maggots of Uzi fly, maggots pierce the through body of the host and cocoons and pupate in crevices of the room or in the soil. They have broken threads and are un-reelable.

STIFFLING : It is the process of killing the pupae inside the cocoon by reducing the high moisture level of cocoon shell and body of pupa to a safe moisture level to prevent the emergence of moth .The safe level of moisture should be low enough to reduce fungi and microbial growth which cause decomposition and effect the quality and appearance of silk fiber.

-

Ex No. : 13

Date :

STUDY OF DIFFERENT SPECIES OF HONEY BEES AND DIFFERENT BEE HIVES

Apiculture : The science and art of rearing honey bees.

Apiary : A bee yard where colonies, hives and other equipment are assembled in one location for bee keeping.

Importance of bee keeping/apiculture :

1. Bee keeping does not require a) Own land, b) labour, c) full time attention, d) Heavy continuous investment, except initial establishment cost.
2. Does not compete with other agricultural operations/activities.
3. Provides additional income through a) Honey-a hygienic food, tonic and medicine, b) Bee products – wax, propolis, royal jelly, pollen and bee venom, c) Sale of colonies.
4. Provides employment to village artisans for fabricating equipment.
5. Provides wealth and valuable food from material (*i.e.*, pollen and nectar) at present going waste.
6. Improves crop yields and
7. Helps to maintain natural plant diversity through cross pollination.

Limitations :

Lack of

- a) Awareness about importance of bee keeping
- b) Knowledge about bee management
- c) Skill in bee management
- d) Patience to gain experience in bee keeping
- e) Man power to popularize bee keeping
- f) Expectation of immediate returns
- g) Fear of bee stings
- h) Non availability of equipment and bees at door steps
- i) Increased cost of timber
- j) Psychology of bee keepers to discourage the others to enter the profession.

Species of honey bee :

Honey bees :

- Well known, popular and economically beneficial insects
- Social insects like ants, termites and some wasps
- Vegetarians unlike ants and wasps
- Derive protein from pollen, carbohydrate from honey which they make from nectar
- Live together in colonies, cooperate in foraging tasks and take care of young ones

The position of honey bees in the animal kingdom is mentioned below :

Phylum : Arthropoda

Class : Hexapoda/Insecta

Order : Hymenoptera

Family : Apidae

Genus : Apis

Species :

a) *dorsata*

b) *florea*

c) *indica*

d) *mellifera*

Honey bee species

	Character	Rock bee/giant bee <i>A.dorsalis</i>	Little bee/dwarf bee <i>A.florea</i>	Indian bee <i>A.cernana indica</i>	European/Italian bee <i>A.mellifera</i>
1.	Wild/domesticated	Wild in nature	Wild in nature	Domesticated species	Domesticated species
2.	Size	Largest of all species	Smallest of all the species	Intermediate	Bigger than <i>A.cerana</i> but smaller than <i>A.dorsata</i>
3.	Distribution	Present all over India in plains and in hilly areas upto 1600 m above sea level	Found in plains of India upto 300 m above sea level	Present all over India in plains and hilly areas upto 2500 m above sea level	Imported species. Got acclimatized to different climatic conditions all over India
4.	Worker	Light brown 16-	Deep black	Thorax dark	Black with

		18 mm in size	with white strips on the posterior part of the bright orange abdomen	coloured with brown hairs. Abdomen brown with dark bands	yellowish hairs
5.	Queen	Darker and much larger than workers and drones	Bigger and abdomen is golden brown	Thorax dark and sparsely hairy. Abdomen and legs coppery brown. Abdomen is big, distended and without black bands	Brownish body longer than worker and drone
6.	Drones	Black and as big as workers	Black with smoky brown hairs on the abdomen	Stout and slightly bigger than workers	Amber/ yellow body with yellowish hairs
7.	Nesting/comb construction	Constructs single, big comb in open where they get some diffused light (1-2 m from side to side and 0.5 to 1.25 m from top to bottom)	Constructs single, small comb (15 cm long and 30 cm height) in open where they get some diffused light	Constructs several parallel combs (13-18) <i>i.e.</i> , parallel to the direction of the entrance in plains and at right angles to the entrance at high altitude	Constructs a series of parallel combs inside some enclosures.
8.	Place of nesting	Suspends its comb to large tree branches/building projections/water reservoirs/ceilings etc protecting it from direct sun rays and rain	Constructs the comb in the files of cotton sticks/bushes/house chimneys/house arches and other such places	In nature, constructs combs inside some enclosures such as hollows in the walls/rocks/tree trunks/ inverted baskets etc.	In nature, construct comb in the hollows of walls/rocks/tree trunks/inverted baskets etc.
9.	Temperament	Ferocious	Very mild, but they do sting when irritated	Gentle temperament	Moderately mild

10.	Habit	Migratory. Hence, cannot be domesticated	Migratory. Hence cannot be domesticated	Has strong tendency for swarming. domesticated	Domesticated
11.	Sting	Present	Absent	Present	Absent
12.	Honey gathering per year/colony	Heavy gathers 37 kg	Poor gathers 0.5 to 1.0 kg	Fair gather 3-5 kg in plains, but yields are as high as 20-25 kg in Kashmir	15-20 kg. A strong colony can gather upto 50 kg if abundant bee flora is available

Morphology of honey bee :

Honey bees share the general characters of class insecta. But the organ systems are variously modified to lead a specific life *i.e.*, food habits, social life etc.

Body :

- Covered with a hard external skeleton to protect the internal organs.
- Divided into three regions *i.e.*, head, thorax and abdomen.

Head : Bears

- a) A pair of geniculate antennae. Flagellum (third segment) having chemo and mechano-receptors.
- b) A pair of large compound eyes on lateral sides and three simple eyes (Ocelli). Bee can distinguish colour, but are red blind.

Ocelli : Perceive only the degree of light and do not form an image on the retina.

- c) A pair of mandibles : Mandibles differ in the three castes.

Mandibles in		
Workers	Queen	Drone
Narrow in the middle, broad at the base and distal end	Have bilobed distal end	Smaller in size
Has a channel with fringed hairs on both sides. The channel leads to a groove which ends at the opening of mandibular glands.	There is no groove from mandibular gland opening	Have a fair groove, covered with long hairs, with an apical projection
Used for grasping, scraping pollen from anthers, feeding pollen and manipulating wax		

during comb building

d) Mouth parts : These are modified for sucking and lapping in worker.

The proboscis (tongue) is formed by median labium and two lateral maxillae and is used for ingesting liquids.

e) Thorax : Consists of three segments and joined to the abdomen by a narrow propodeum. Besides locomotion, legs modified to perform other function *i.e.*, prothoracic legs for antenna cleaning, meta thoracic legs for pollen and propolis collection, meso-thoracic legs for wax picking.

f) Abdomen : bears a sting, wax and scent glands and genital organs and viscera internally.

g) Sting : In worker, the ovipositor (egg laying apparatus) is modified into a sting

Wax glands : Situated in the sternites of 4th to 7th abdominal segments. Become active in worker bees at the age of 14-18 days. Wax is secreted in liquid form which solidified into thin flakes

h) Scent glands : Present in the thin membrane connecting the last two abdominal terga. Bee bends her abdomen and exposes the membrane to produce the scent. The odour produced from the cells is derived from scented waste products of metabolism.

Biology :

Honey bees undergo metamorphosis. Through four developmental stages *i.e.*, egg, larva, pupa and adult.

Eggs :

Queen lays both fertilized and unfertilized eggs which are similar in size and shape. Fertilized eggs develop into females (worker and queen) and unfertilized eggs develop into drone bees. Eggs are laid singly and attached vertically to the bottom of cell wall. Eggs hatch on 3rd day.

Larva :

After hatching, all the larvae fed with royal jelly (bee milk produced by worker bees) for 3 days. Thereafter, the worker and drone larvae are fed with nectar and pollen. A queen larva is fed continuously with royal jelly up to 8th day, when the queen cells are further packed with royal jelly and are sealed. The capped royal larva (queen) continues to feed until it pupates. Initially, the larvae are loop shaped, but towards cell capping, they get stretched in the cell with head facing upwards. After passing through four moults, larvae enter into the prepupal and final pupal stage.

Pupa :

Before entering into pupal stage, the larva spins a thin silken cocoon around itself and undergoes gradual, but drastic changes. At this stage, head, thorax and abdomen are clearly distinguishable. The compound eyes and various appendages are also clearly visible.

Adult :

When pupal development is completed, the insect metamorphoses into adult and finally adult bee emerges by gnawing its way out of the sealed cell.

The development stages of all the three castes of honey bees are similar, but the time taken for development, sexual maturity and also longevity of different castes are variable as shown in table.

Duration (days) of developmental stages of different castes :

Stage/species	Queen	Worker	Drone
EGG			
<i>A.c</i>	3	3	3
<i>A.m</i>	3	3	3
Larva			
<i>A.c</i>	5	4-5	7
<i>A.m</i>	5	5	7
Pupa			
<i>A.c</i>	7-8	11-12	14
<i>A.m</i>	8	12-13	14
Adult			
<i>A.c</i>	15-16	18-20	24
<i>A.m</i>	16	21	24

Ac. : *Apis cerana*

Am: *Apis mellifera*

• **BEE HIVES**

- Primitive Beekeeping was revolutionized through discovery of Bee space by Rev. L.L. Langstroth and successful use of movable frames which in turn led to designing of modern beehive.
- **The “Modern” bee hive is based on understanding of “Bee Space” 1/4”- 3/8” .**
- Bee space (passage way) is the space required between any two frames for bees to move about between the combs & too small to build combs & too large to deposit propolis.
- Bee space for *Apis mellifera* is 5/16 “ & for *Apis cerana* is 1/ 4”

Different types of bee hives :

1. Pot hive
2. Hook hive
3. Madusagar hive
4. House hive
5. Nucleus hive Jeolikote's hive
6. Dadant's hive (Single walled & Double walled)
7. British standard hive
8. Langstroth's hive (*A. mellifera*)
9. Newton's hive (*A. cerana*) .

A **beehive** is an enclosed structure in which some honey bee sps live & raise their young.

- Natural beehives (referred to as "nests") are naturally occurring structures occupied by honey bee colonies,
- The beehive's internal structure is a densely packed matrix of [hexagonal](#) cell made of [beeswax](#), called a [honeycomb](#). Bees use cells to store food (honey and pollen), & to house "brood" (eggs, larvae, & pupae).
- **Natural bees' nests:**
Honey bees in subgenus *Apis* use caves, rock cavities & hollow trees as natural nesting sites. Members of other subgenera have exposed aerial combs.
Nests - composed of multiple honeycombs, parallel to each other, with a relatively uniform [bee space](#), usually with a single entrance.

Artificial bee hives:

- **Traditional beehives**
- **Modern beehives**
- **Skeps** are made of baskets with single entry points at the bottom for the bees & no structure inside. It is not feasible to inspect bees inside, & harvesting means destroying entire hive by killing / driving away bees.

Bee Gums – Hives of this type are located exactly on hollowed body part of gum trees. **Sticks** are attached to honeycombs for easier pulling out by the time of harvesting.

Langstroth Hive:

- Frames - thin rectangular structures (wood / plastic) & with a wax / plastic foundation to draw out the comb - hold [beeswax honeycomb](#) formed by bees.
- Ten frames side-to-side / hive & leave right amount of bee space between each frame & between end frames & hive .
- Frames - reinforced with wire, making it possible to extract honey in centrifuges to spin honey out of comb.
- Empty frames & comb - returned to hive for use in next season.
- Bees require - require one kg of beeswax to make eight kg of honey
Comb reuse - significantly increase honey production.

Hive Type	Hive Dimensions (Inches)	Brood Chamber Cells	Bee Space	Full Super Weight (Approx.)	Frame Lug Length	No of Frames In Brood Box
National	$18 \frac{1}{8} \times 18 \frac{1}{8}$	50,000	Bottom	25 lbs.	Long	11
W.B.C.	$19 \frac{7}{8} \times 19 \frac{7}{8}$	45,000	Bottom	25 lbs.	Long	10
Commercial	$18 \frac{5}{16} \times 18 \frac{5}{16}$	70,500	Bottom	25 lbs.	Short	11
Langstroth	$20 \times 16 \frac{1}{4}$	61,400	Top	30 lbs.	Short	10
Modified Dadant	$20 \times 18 \frac{1}{2}$	85,000	Top	35 lbs.	Short	11
Smith	$16 \frac{3}{8} \times 18 \frac{1}{4}$	50,000	Top	25 lbs.	Short	11

National hive:

- widely used hive in [U. K.](#) A square hive, with grooves to serve as hand grips.
- Frames - smaller than standard Langstroth hive & have longer hand grips (or "lugs").

WBC hive

- Invented by & named after [William Broughton Carr](#),
- A double-walled hive with an external housing that splays out towards the bottom of each frame covering a standard box shape hive inside.
- Offers extra level of insulation for bees by its double-walled design.
- Inconvenient to remove external layer before hive can be examined.

Ex No. : 14

Date :

STUDY OF EQUIPMENT FOR HANDLING HONEYBEES

The successful use of movable frames and the discovery of bee space revolutionized the primitive way of keeping bees and paved the way for designing of modern bee hive. In 1851, Rev. L. L. Langstroth improved the earlier type of hive based on his discovery of "Bee Space". Bee space (Passage way) is the space required between any two frames for the bees to move about between the combs and is too small to build combs and too large to deposit propolis. Bee space for *Apis mellifera* is 5/16 inches and *Apis cerana indica* is ¼ inches. Langstroth hive and Newton's hive are generally used for beekeeping with *A. mellifera* and *A. cerana indica* respectively.

Beehive :

- It is a tool/equipment used in a scientific method of bee keeping.
- It consists of a bottom board, brood chamber, brood frame, super chamber, super frame, inner cover and top cover.

Bee Keeping Equipment

Beehive stand	This is made of RCC or wood or iron with provision for water cups to prevent ants from entering beehive. Bee hive is kept on the beehive stand.
Smoker	This is made of a tin or copper container attached with a leather bellow. This is used to smoke bees to subdue them while handling.
Hive tool	It is made of a thick iron plate to clean the hive, to handle the frames and to remove propolis etc.
Bee veil	This is made of mosquito net type material for being worn to protect the face from being stung by bees while handling.
Gloves	These are used to protect hands from bee sting while handling.
Honey extractor	This is made out of tinned copper, brass or zinc drum with basket cages to hold frames and wheel to rotate them in order to extract honey by centrifugal force generated in it.
Queen gate	This is made out of zinc sheet with perforations to prevent queen from going out or from deserting hive
Queen excluder	This is made out of zinc sheet with perforations and is placed between brood chamber and super chamber to prevent the movement of queen bee from brood chamber to super chamber.
Drone excluder	This is used to prevent the reentry of drones into the hive after the bees have come out of the hive in evening.
Drone trap	It is useful for fixing in front of the hive entrance when workers and drones come out for play flight. Workers can easily go out through the groove at the bottom, but drones are trapped. Drones, thus trapped can be removed and killed, when they are no longer required in the hive.

Comb foundation sheet	This is made of pure wax. It is used to aid the bees to construct straight parallel combs.
Dummy division board	This is useful to reduce the inner area of the broad chamber so that the bees can be confined to a limited space when bee population in the hive is low.
Swarm trap	It is a rectangular box open at one of the broader sides and wire gauge fixed to about 2/3 of its height on the other side and the remaining 1/3 portion with a queen excluder sheet made of zinc in a slanting position. During swarming season, when bees construct queen cells, the box is kept on the alighting board with open side close to the hive and tightly secured. One or two frames with comb foundation sheets are kept inside the box. When the swarm is issued in a few days, the queen is trapped in the box and settles in the comb foundation sheet with a few workers. Thus the swarm is induced to settle in the frame and it can then be transferred to any hive at a desired place
Bee brush	It is used to brush off bees from honey comb before it is taken away for extraction.
Feeders	These are used to feed sugar syrup to bees. The division board feeder is commonly used. It is a wooden trough of regular frame dimensions of the hive to hang in the hive just like any other frame with a wooden strip to serve as a float
Queen cages	Several types of queen cages are available for caging the queens
Queen cell protector	A queen cell which may have to be introduced from a queen-right to a queen less colony is protected with a queen cell protector until its acceptance by the bees

Bee pasturage:

Honey bees have close link with flora because they live solely on nectar and pollen. To maximize the honey production, bee keeper should have a thorough knowledge of floral cycle, on set of major honey flow and dearth periods.

1. The plants which are visited by bees only for nectar are:

Tamarind (*Tamarindus indicus*) (rich source), Neem (*Azadirachta indica*), Soap nut (*Sapindum* spp.), *Eucalyptus* spp., Pungam (*Pongamia glabra*), *Morinda tinctoria*, *Prosopis spicigera*, *Quisqualis indica*, *Legasca mollis*, *Tribulus terrestris*, *Glyricidia maculata*.

2. Plants which supply pollen to the bees are:

Sorghum (rich source), maize, roses, bajra, finger millet, pomegranate, sweet potato, tobacco, castor, tea etc.

3. Plants which supply both nectar and pollen are:

Banana, citrus, apple, pear, plum, peach, guava, mango, coconut, sesamum, safflower, mustard, cruciferous and cucurbitaceous vegetables, bhendi, onion, Lucern, clover, hollyhock, aster, *Cassia fistula*, cotton (very rich source).

Honey extraction and processing:

When the honey flow begins to slow down, the frames with honey should be removed for extraction. To remove honey comb, the colony is smoked, the desired combs taken out and bees brushed off with a soft brush or leaves. These combs are placed in tight hive bodies, carried to the extraction room. A room with wire gauged bee tight doors is necessary for honey extraction. Frames should be uncapped with a hot knife. The uncapped frames should be placed in extractor and rotated slowly and then at a faster speed. Then the frames are reversed and extraction is again worked. Finally, honey collected in the container is strained and packed in tins or bottles. After the extraction, the place should be swabbed with water and the appliances cleaned. The empty wet combs should be returned to the hives for bees for cleaning and reuse.

Ex. No. : 15

Date :

STUDY OF INSECT PESTS AND DISEASES OF BEES

A) Greater wax moth, *Galleria melonella*:

Adult is brownish grey, 10-18 mm length. The colour and size of adults vary according to food eaten during larval period. Dark brown combs containing pollen give rise to darker and bigger adults. The fore wing of male has a semi lunar notch, while that of females are smooth. Female lays 300-400 eggs in clusters in 4-10 days. Eggs hatch in 3-5 days. Caterpillars are highly active and consume gnawed pieces of comb. They soon spin silken tunnels in the comb or tubular galleries on bottom board to protect themselves. Life cycle is completed in 6 weeks to 6 months. Caterpillars eat away the combs by making tunnels in midrib of combs. The presence of small pieces of minute particles of wax outside the holes is the first indication of entry of larva into comb. Later, faint webbings are perceptible over some cells of comb. In case of severe infestation, brood rearing is stopped and the bees desert their nest.

Management :

- a) Maintain the colonies strong to resist wax moth.
- b) Keep the hives without cracks and crevices.
- c) Reduce hive entrance size for effective guarding by bees.
- d) Keep the bottom board neat and clean without debris.
- e) Hold the comb against sun rays to observe the larvae.
- f) Extra combs stored should be fumigated with sulphur.

B) Black ant, *Componotus compressus* Fab.

They carry adult bees as well as brood.

C) Bee hunter wasps, *Palaras orientalis* Kohl

Philanthus ramakrishnae T.

They wait near hive entrance and collect 20 bees in a day. Apart from loss of workers, the whole colony is frightened and disturbed.

Diseases :

1. Broad diseases :

Honey bee brood suffers from a variety of diseases. Adult bees are not affected by brood diseases, but they can spread the causal organism. Brood diseases are more serious than adult diseases.

Bacterial diseases :

- a) American foul brood (*Bacillus larvae*)
- b) European foul broad (*Mellissococcus pluton*)

Viral diseases :

- a) Thaic sac brood
- b) Sac brood

Fungal diseases :

- a) Chalk brood (*Ascophera apis*)
- b) Stone brood (*Asperigillus flavous*)

Symptoms of brood diseases :

	American foul brood	European foul brood
General appearance of brood comb	Brood irregular, intermingling of capped, open and punctured cells. Much dead brood in capped cells, cells with punctured cappings and cells uncapped by bees.	Brood irregular Dead brood mostly in open cells
Time of death	Late larval/early pupal stage	Coiled larvae in unsealed cell and rarely late larval
Cell capping	Cappings sunken and usually have holes	Some cappings perforated
Consistency of dead brood	At first watery/Slightly viscid becoming ropy, finally brittle	At first soft and watery, afterwards pasty, rarely visual and ropy
Position of dead brood	Extended on the cell base	Coiled, twisted or collapsed
Colour of dead brood	Dull white to dark brown or almost black	Dull white to yellowish white, often dark brown
Odour of dead brood	Putrid faint	Strong and sour
Appearance of scale of dead larva	Dark, thin, brittle, adheres to cell walls	Irregular in colour, thick, easily removed from cell

Brood affected	Worker, rarely drone or queen	Worker, drone and queen
Control	Tetramycin 0.25-0.40 g in 5 lit sugar syrup fed to infection colonies. Repeat after 7-10 days	Tetramycin 0.25-0.40 g in 5 lit sugar syrup fed to infection colonies. Repeat after 7-10 days

Thai sac brood disease :

The virus multiples in adults which transmits to larvae. Infected brood die in prepupal, but in unsealed stage. Dead larvae straighten out and lie on their backs, with tip of head capsule turned upwards. Dead larvae or Prepupae dry up in brood cells forming loose scales. Affected larvae are yellow/greyish, later darkening to blackish, the change in colour first starts from mouth parts and head. No definite preventive/curative measures available.

- Keep the colonies strong
- Avoid exchange of hive parts and
- Restrict the bee movement

Sac brood virus :

Infected larvae fail to pupate and lie stretched on their back with head turned upwards. Larvae become sac like due to filling of fluid between new integument and unshed skin. Colour of larvae turns pale yellow and finally become dark brown, the darkening starts from head.

2. Adult bee diseases

a. Protozoan diseases – *Nosema apis*

Infected bees become dysenteric with distended and swollen abdomens. They have disjointed wings and found crawling in front of the hive. Disease is severe during spring and wintering with more colony strength with sufficient brood food stores and open sunny sites helps in overcoming the disease incidence.

b. Acarine disease-

- i. ***Acarapsis woodi***: Endoparasitic mite of adult bees. It infests the trachea of first thoracic spiracle where they suck haemolymph.

Symptoms:

- I. Presence of bee crawlers at hive entrance
- II. Bees are unable to fly and wings are disjointed in K winged condition

III. Infested bees are short lived

ii. *Varroa jacobsi*:

Female mite enters the cell of 5 – 5.5 day old larvae before sealing and lays 2-5 eggs on walls of the cell. Feeds on haemolymph of the larva or pupa. Adult female mite lives on adult workers and drones under abdominal sclerites. They feed by making holes in the intersegmental membrane. Dead mites can be seen on bottom board in the debris. In queen rearing and mating yards, *Varroa* infestation causes shortage of drones for mating.

iii. *Tropilaelaps clareae*

It is an ectoparasitic mite. Infested colonies have irregular brood pattern, dead and malformed larvae and pupae in brood combs. Malformed adults with missing or poorly formed wings and shrunken abdomen can be observed crawling around the hive.

It can be controlled by dusting with sulphur @ 1 gr/ comb.

Ex No. : 16

Date :

LAC INSECT-BIOLOGY, BEHAVIOUR, FOOD PLANTS AND PRUNING

Lac insects are exploited for their products of commerce *i.e.*,

- a) Resin
- b) Dye and
- c) Wax.

Lac cultivation provides

- a) Livelihood to millions of lac growers
- b) Conserves vast stretches of forests and biodiversity associated with lac insect complex

Lac Complex comprises of 87 species under 9 genera. In India, 19 species belonging to two genera *i.e.*, *Kerria* and *Paratachardina* are found. Lac insects thrive on 400 plant species. 22 species of lac predators, 30 species of primary parasites, 45 species of secondary parasites, several fungal pathogens represent the rich biodiversity of this system.

India is the largest producer of lac (*i.e.*, a resinous compound secreted by lac insect while feeding on phloem sap of certain plants called Lac hosts) in the world, accounting for about 50-60% of total world lac production. Production of raw lac in India is 20,000 mt / year. Major lac producing states are Jharkhand (57%), Chattisgarh (23%) and West Bengal (12%) while minor producers are Orissa, Gujarat, Maharashtra, U.P. and A.P.

Over 3 million tribals are dependent on lac. About 20-38% of agricultural income of Jharkhand tribal's is from lac. Nearly one million man days /annum are generated by industries engaged in post harvest processing of lac. Lac fetches Rs.120-130 crores of foreign exchange.

Lac resin – Natural, biodegradable, non toxic, Used in food, textile, pharmaceutical industries, in addition to surface coating, electrical and other fields.

Species belonging to *Paratachardina* produce a hard, horny substance which is insoluble in alcohol. These are univoltine and are generally treated as parasites of economically important plants like tea and sandal and are biocontrol agents on weeds.

Species belonging to *Kerria* are bivoltine except

K. lacca mysorensis on Jalari (*Shorea talura*),

K. sharada on Kusum (*Schleichera oleosa*) and Rain tree (*Albizia saman*) are trivoltine.

Indian lac insect *i.e.*, *Kerria lacca* (*Laccifer lacca*) Kerr is the most important and widely exploited insect. It belongs to

Order: Hemiptera,

Super family: Coccoidea,

Family: Tachardiidae (Lacciferidae).

It is distinguished into two strains or sub species forms *i.e.*, Rangeeni and Kusumi on the basis of differences in life cycle, host preference and quality of lac produced.

Rangeeni strain is characterized by unequal duration of bivoltine life cycle and non preference of kusum as a host. Kusumi strain is characterized by more or less equidurational life cycle and preferring kusum as a host. Quality of resin produced by kusumi is superior to the resin produced by rangeeni.

Biology and behaviour :

The female lays eggs inside the encrustation. They hatch almost immediately and the nymphs crawl out of the cell. A single female may produce 300-1000 nymphs, of which a third would be males. Nymphs are minute, about 0.6 mm long, soft bodied, pointed posteriorly, deep red in colour with black eyes. They wander on the shoots, move mostly upward towards tender branches and settle on them. They start feeding by piercing the shoot. The nymphs 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. The males regain their lost appendages at the last moult and females never regain them. 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 occupying the entire space in the cell. The males may be winged or apterous and they live for 3 or 4 days after emergence. The male and female cells can be distinguished even during early stages. The male has grown up in its longitudinal axis and is slipper shaped. The female has grown up in its vertical axis and is spherical shaped. 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 and the cell reach several times that of male cells. Thus, the female insects are the chief producers of the lac. Egg laying ceases when the temperature inside the cell falls below 17°C and the nymph becomes inactive below 20°C.

Host plants :

- 1) Palas – *Butea monosperma* – Jharkhand, Chattisgarh, West Bengal
- 2) Kusum – *Schleichera oleosa* – Jharkhand, Chattisgarh
- 3) Ber – *Zizyphus mauritiana* – Jharkhand, Chattisgarh, W.Bengal
- 4) Ghont – *Zizyphus xylopyra* – Chattisgarh

- 5) Arhar – *Cajanus cajan* – Assam
- 6) Jalari – *Shorea talura* – Tamil Nadu
- 7) Raintree – *Samanea saman* – W. Bengal
- 8) Fig – *Ficus* species- Jharkhand, Punjab, Karnataka

The time of inoculation and harvesting of different lac crops are

Strain	Crop	Time of inoculation	With brood lac from	Time of harvesting
Rangeeni	Baisakhi	Oct – Nov	Katki	June - July
	Katki	June - July	Baisakhi	Oct – Nov
Kusumi	Jethwi	Jan – Feb	Aghani	June - July
	Aghani	June – July	Jethwi	Jan – Feb

Lac cultivation :

It is done by putting 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 from mother cells, the young larvae settle on fresh twigs of host plants, suck the plant sap and grow to form encrustations.

a) Local practice :

In this method, the host plants are continuously exploited without giving rest for recoument. Only natural inoculation occurs. Partial harvesting is done leaving few branches untouched for auto inoculation of next crop and no pruning is done. The host trees lose the vigour and cannot throw out new succulent shoots. In course of time, the trees become weak and die.

b) Improved practice :

The principle in improved practice is to provide much needed rest to host plants after harvest. For this, coupe system of lac cultivation is adopted. In this, the trees are divided into coupes *i.e.*, groups that consist certain number of trees. In practice, only few numbers of trees in a coupe are inoculated. After harvest, these trees are made to rest and recoup the last vigor while other trees are ready with succulent twigs for inoculation. Thus, in a coupe system, alternate groups of trees are put to lac cultivation. In case of slowly growing kusum, 18 months rest is given by dividing trees into 4 coupes and inoculating each coupe once in two years. In

case of rangeeni hosts, 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 2 large coupes in alternate years. So that each coupe has a rest of 15 months in between and the katki crop is raised in small coupe every year allowing a rest period of 7 months between two successive crops.

INCOULATION METHODS, CROPPING AND ENEMIES OF LAC INSECT

Inoculation methods :

Propagation of lac insects is done by inoculation of newly hatched (brood) nymphs on the same or different host plants.

- a) **Natural/self/auto inoculation:** This is a simple and common process, when the swarmed nymphs infest the same plant again. Natural inoculation, repeated on the same host, makes the host plant weak and thereby nymphs do not get proper nutrition. Uniform sequence of inoculation does not take place.
- b) **Artificial inoculation:** The old weak and diseased twigs of host plants are pruned in January or June. It 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 in such a way that 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:

- a) Use fully matured and healthy brood
- b) Don't keep the brood meant for inoculation for long and use immediately after cutting.
- c) Tie the brood stick on upper surface of branches securely.
- d) Raise brood sticks at room temperature to 20°C to induce swarming.
- e) Avoid cultivation of rangeeni in kusumi area and vice versa.
- f) Inoculate only on non rainy day.

Harvesting of lac (Cropping):

It is done by cutting the lac encrusted twigs when the crop is mature. It is of 2 types.

- a) **Immature harvesting:** In this method, lac is collected before swarming. The lac, thus, obtained is known as "ARI LAC". In this method, lac insect may be damaged during harvest. Ari lac harvesting is recommended on Palas only.

b) Mature harvesting: In this method, lac is collected after swarming. The lac obtained is known as mature lac. Symptoms of swarming of nymph include the following.

- a) A yellow spot develops on the posterior side of lac cell towards crop maturity.
- b) Dried out appearance of encrustation two weeks before swarming and appearance of cracks on the encrustation at a later date.

Cutting of twigs for 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 kartiki crop is harvested in Oct/Nov, baisaki in May/June; aghani in Jan/Feb and Jethwi in June/July. 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%

Lac processing:

1. 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 crude lac consists of resin, encrusted insect body, lac dye, sand and twig debris. The stick cannot be stored for long duration, as the lac has a tendency to form lump and there is a loss in quality of lac. High moisture content is responsible for lump formation. The optimum moisture content is 4% for storage of stick lac to avoid lump formation.

2. Seed lac/grain lac:

The stick lac is crushed and sieved to remove sand and dust. It is then washed in large vats repeatedly to break open the encrusted insect bodies, to wash out the lac dye and twig debris. Decaying bug bodies turn the water a deep red that is processed further to get the byproduct, 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

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

Handmade process:

The seed lac is filled into long sausage shaped cloth of 2" diameter and 30 ft long. The long bag is passed gradually in front of a charcoal fired heat hot enough to melt the lac. By twisting the bag, molten lac is squeezed through cloth. The residue left inside cloth bag is another variety of refuse lac known as Kirilac. The molten filtered mass is stretched into sheets approximately 0.5 cm thick. Alternatively the molten mass is allowed to solidify in the form of discs and then it is called button lac.

Heat Process:

To the granular seed lac 4 -5 % resin and 2 -3% yellow pigment are added and the mixture is filled in cloth bags of about 3"long × 2" in diameter. The mixture is melted before the furnace in which charcoal is kept burning. The material is cooled inside and oozes out through the cloth and drops on the stone slab in front of the furnace. When sufficient amount has been collected on the stone slab, the molten mass is rapidly transferred to a porcelain cylinder containing hot water and spread flat with palmyrah leaves. This is again warmed before the furnace and stretched by men into a thin sheet with the help of his hands and feet. Defects like knots, air bubbles, etc are punched and removed out. This is broken into pieces and is known as shellac.

Solvent process:

The seed lac is dissolved in refrigerate alcohol and filtered through filter press to remove wax and impurities. The colour may be removed by any required standard by charging with activated carbon and then alcohol is recovered. The molten shellac is stretched with a roller.

4. Button lac:

It is manufactured by pouring the molten lac into dies in a zinc sheet instead of stretching for shellac preparation. (This results in buttons of lac 7cm diameter and 0.6 cm thick.)

Enemies of lac insect:

Include both predators and parasites and non insect pests like monkeys, squirrels, rats, birds and lizards.

Predators:

Larvae of *Eublemma amabilis* (Noctuidae) and *Holcocera pulviria* (Gelichidae) are predators on lac both in field and store. Adult moths lay eggs on or near lac encrustation. The caterpillars bites its way into the encrustation and makes the tunnel lined with silk, excrete or pieces of lac in which it spends whole of its larval and pupal life. A single caterpillar *E. amabilis* can devour 40-45 lac cells.

H. pulviria is more severe in stores than in fields. Katki and Aghani crops are greatly affected than Baisaki and Jethwi crops.

Minor predators:

Ephestia sps (Phytitidae)

Chrysopa sps (Chrysopidae)

Larvae of *Chrysopa* suck the body fluid of the lac insect and do not feed on the lac. The predators affect not only the quantity of lac produced, but also the quality by the presence of their larvae, pupae and their frass.

Parasites:

Parecthodryinus clavicornis

Erencyrtus dewitzi

Euplenus tachardiae etc.

Methods of control:

- a) Select brood lac from healthy trees.
- b) Cut the brood lac from the trees as near the time of swarming, never more than a week before.
- c) Remove the brood lac sticks immediately after two weeks of inoculation
- d) Remove the lac sticks from field after harvest
- e) Do not leave the crop in field for natural inoculation
- f) Pack the brood lac in 30-60 mesh wire net before inoculation.

One to 20 kg of brood stick is necessary for inoculating a tree depending up on its size in case of kusumi strain, 0.4 to 5 kg in case of Rangeeni strain.

g) Heavier inoculation is not desirable as it may result in death of host tree.

h) The crawlers start moving out in one/two days after inoculation. The brood lac sticks are to be removed within three weeks of inoculation. Otherwise, the enemies of lac insect may be spread from broad lac to fresh crop.

Yield: About 2.5 to 3 times the weight of brood lac can be expected as yield.

REFERENCES :

1. An introduction to Sericulture – Ganga, G; Sulochana Chetty J 1997 (2nd edt).
2. Sericulture manual – Silkworm – Krishnaswamy, S 1990, FAO
3. Bee keeping in India – Singh S, 1975.
4. Lac cultivation in India – Glover P M 1937.
5. Honey bees and their management in India – Mishra R C 1995
6. Principles of Sericulture – Hisao Aragu 1994.