SERICULTURE

Sericulture is the production of raw silk by raising silk worms. The productivity and profitability of sericulture depends on the yield of **mulberry** crop. It is a cottage industry combining agriculture and industry. The end product of this agro-industry is silk. The production process of silk involves a long chain of interdependent specialized operations such as mulburry cultivation, silkworm seed production, rearing of silk worm, reeling, twisting and weaving of silk, etc. which provide employment to about 60 lakhs people in the villages of India through family labour and is the second largest employer in the **country. Sericulture** is an export oriented agro - industry. Indian silks are exported to more than 50 countries and gains about 800 crores of rupees each year from it. We have a unique position among the silk producing countries, because India is the only country in the world producing all the four commercially important varieties of natural silk - Mulberry, Tasar, Eri, and Muga silk.

The silk industry originated in China and was kept in secret by them for about 3000 years. The sericulture industry is well established in India since the 4th century. Major silk producing states in India are Karnataka, Andhra Pradesh, Tamil Nadu and West Bengal. Only recently Kerala has got a place in the sericulture map of India.The scope and potentiality of sericulture industry is not limited in the production of silk as a textile fibre. The silk fibre produced by the mulberry silkworm and its byproducts can be utilized for many other purposes. The special properties of silk fibre makes it a raw material for making electric insulations, tyre linings, artificial blood vessels, surgical sutures, etc. Hydrolized proteins, aminoacids and vit B_7 (Riboflavin) are extracted from the silkworm pupa. The major by products in sericulture industry are rearing wastes, waste cocoons and silkworm faeces. Rearing wastes can be used for the production of biogas and vermicompost. Waste cocoons are the raw material of cocoon handicraft which involve the production of garlands; flowers, dolls, greeting cards etc. Chlorophyll and phytol can be extracted from the silkworm faeces. Phytol is a raw mater \\ for manufacturing vitamin E and K. The faeces is also used in plastic industry and as feed for fish, pig, cattle, etc. All these sideline developments of sericulture provide further employment opportunities and economic growth.

Fig. 2.8 Life cyle of Silk worm (Bombyx mori)

Egg. Each female lays about **400** eggs in clusters up on the mulberry leaves. The eggs are tiny smooth and ovoid. The colour of the eggs may vary from white, yellow or brown, depending on the races. Around 2000 eggs weighs to a gramme. The female dies within four to five days. Larva. After 9 to 12 days the silk worm hatches from the egg. The newly hatched larva is black or dark brown in colour. It has a large head and the body is covered with dense black bristles and looks like black ants. So they are generally refered to as "ants" or "ant worms". The body of the larva has 13 visible segments and is divisible into head, thorax and abdomen.

The head consists of six body segments, which are fused together. It is provided with a pair of five jointed antennae which are sensory in function. Six pairs of light sensitive ocelli are present at the base of the antenna. Mouth parts consist of mandibles, maxillae and labium. The mandibles are adapted for mastication. The maxillae are used to detect the taste of food. The labium has a chitinized prementum which carries a median process, a spinneret through which silk is secreted from the silk gland. The labial plaps are present on either sides of the spinneret.

The thorax consists of three segments. Each thoracic segment carries a pair of three jointed legs with distal sharp claws. All the larvae carry the charactristic larval markings called eye spots on the dorsal side of the mesothorax.

The abdomen consists of eleven segments, although only nine can be distinguished because the last three segments are fused together to form the nineth segment, anal piate and

a pair of caudal legs. In addition to the caudal legs, the abdomen is provided with four pairs of legs. All the five pairs of abdominal legs are fleshy unsegmented muscular protuberances called prolegs or pseudolegs. A short anal horn is present on the 8th segment.

The larval life lasts for 25 to 30 days. This is the most active period in the life cycle of *Bombyx mori.* The larva fees voraciously upon the mulberry leaves and grows very quickly about 10000 times its weight at the time of hatching. During the larval life the worms moult four times. The four larval moults divide the larval life into five instars which are commonly referred to as five different ages or stages. The first three instars constitute the "young age" and the last two instarthe "late age". Prior to each moylt, the larva stops its feeding and rest with its head held up. This resting for moulting is generally refered to as "going to sleep" and the emergence of the worm from the mouft as "waking up".

Pupa.

At the end of fifth instar the caterpillar stops feeding and begins to secrete a sticky fluid, from the silk gland through a narrow pore called spinneret. The sticky substance turns into a fine long ahd solid thread erf silk in the air. This thread is used for sp mning the pupal case or cocoon. A mature worm completes spinning of cocoon in 48 to 72 hrs. During the pupal period the larval body and its internal organs undergo changes and assumes the new form of adult moth. The pupal life may lasts 8 to 14 days. At the end of pupal period the adult moth pierces the fibrous cocoon with the aid of the alkaline salivary secretion.

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 are recognized in mulberry silkworm, Univoltines, bivoltines and multivoltines.

Mulberry silkworms can be categorized into 3 different, but connected groups or types. The major groups of silkworms fall under the univoltine ('uni-'=one, 'voltine'=brood frequency) and bivoltine categories.

- The Univoltine breed is generally linked with the geographical area within greater Europe. The eggs of this type hibernate during winter due to the cold

climate, and cross fertilise only by spring, generating silk only once annually.

- The second type of breed is called Bivoltine and is normally found in Asian regions such as China, Japan, and Korea and India. The breeding process of this type takes place twice annually, a feat made possible through the slightly warmer climates and the resulting two lifecycles.

- The Polyvoltine breed of mulberry silkworm can only be located in the tropics. The eggs are laid by female moths and hatch within nine to twelve days, so the resulting type can have up to 8 separate lifecycles throughout the year.

Classification based on voltinism:

Voltinism refers to the number of breeds raised per year. Voltinism is a genetically determined heritable character under hormonal control.

- Univoltine races produce only one generation per year. The eggs laid remain in a diapausing (quiet) condition till the next spring. Larvae of univoltines are very sensitive to temperature and other environmental conditions. They are unsuitable for summer and autumn rearing by artificial breaking of egg diapause. The larval period is very long. All European races are Univoltines. The cocoons produced are commercially very superior.
- Bivoltine races have two generations per year, the first generation adults developing from eggs hatched in spring lay non dipausing eggs. The second generation adults developing from these eggs lay eggs which remain in the dormant state till next spring. The larval duration is as long as univoltines. Larvae are robust and tolerate environmental fluctuations. They can be used for 'Summer and autumn rearing and three crops can be raised per year. The

cocoons are commercially superior. Japanese and Chinese races have both uni and bivoltine varieties.

- Multi or polyvoltines have more than three generations per year. The larval duration is short, and larvae are resistant to high temperature and high humidity. Larvae and cocoons are small in size. Commercially cocoons are of poor quality. The adults lay non-diapausing eggs.

Different Types of Silkworm

1. **Mulberry silkworm (Bombiciidae: Order: Lepidoptera)**
2. **Tasar Silkworm (Saturniidae: Order: Lepidoptera)**
3. **Oak Tasar Silkworm (Saturniidae: Order: Lepidoptera)**
4. **Eri Silkworm (Saturniidae: Order: Lepidoptera)**
5. **Muga Silkworm (Saturniidae: Order: Lepidoptera)**

SILK WORM – TYPES

There are five major types of silk of commercial importance, obtained from different species of silkworms which in turn feed on a number of food plants: Except mulberry, other varieties of silks are generally termed as non-mulberry silks. India has the unique distinction of producing all these commercial varieties of silk.

Mulberry:

The bulk of the commercial silk produced in the world comes from this variety and often silk generally refers to mulberry silk. Mulberry silk comes from the silkworm, *Bombyx mori* L. which solely feeds on the leaves of mulberry plant. These silkworms are completely domesticated and reared indoors. In India, the major mulberry silk producing states are Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir which together accounts for 92 % of country's total mulberry raw silk production

Tasar:

Tasar (Tussah) is copperish colour, coarse silk mainly used for furnishings and interiors. It is less lustrous than mulberry silk, but has its own feel and appeal. Tasar silk is generated by the silkworm, *Antheraea mylitta* which mainly thrive on the food plants Asan and Arjun. The rearings are conducted in nature on the trees in the open. In India, tasar silk is mainly produced in the states of Jharkhand, Chattisgarh and Orissa, besides Maharashtra, West Bengal and Andhra Pradesh. Tasar culture is the main stay for many a tribal community in India.

Oak Tasar:

It is a finer variety of tasar generated by the silkworm, *Antheraea proyeli* J. in India which feed on natural food plants of oak, found in abundance in the sub-Himalayan belt of India covering the states of Manipur, Himachal Pradesh, Uttar Pradesh, Assam, Meghalaya and Jammu & Kashmir. China is the major producer of oak tasar in the world and this comes from another silkworm which is known as *Antheraea pernyi*.

Eri:

Also known as Endi or Errandi, Eri is a multivoltine silk spun from open-ended cocoons, unlike other varieties of silk. Eri silk is the product of the domesticated silkworm, *Philosamia ricini* that feeds mainly on castor leaves. Ericulture is a household activity practiced mainly for protein rich pupae, a delicacy for the tribal. Resultantly, the eri cocoons are open-mouthed and are spun. The silk is used indigenously for preparation of *chaddars* (wraps) for own use by these tribals. In India, this culture is practiced mainly in the north-eastern states and Assam. It is also found in Bihar, West Bengal and Orissa

Muga:

This golden yellow colour silk is prerogative of India and the pride of Assam state. It is obtained from semi-domesticated multivoltine silkworm, *Antheraea assamensis*. These silkworms feed on the aromatic leaves of Som and Soalu plants and are reared on trees similar to that of tasar. Muga culture is specific to the state of Assam and an integral part of the tradition and culture of that state. The muga silk, an high value product is used in products like sarees, mekhalas, chaddars, etc.

Mulberry cultivation

Mulberry (*Morus* spp., Moraceae)

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

Ecological requirements

Climate

Mulberry can be grown upto 800 m MSL. For the optimum growth of mulberry and good sprouting of the buds, the mean atmospheric temperature should be in the range of 13oC to 37.7oC. The ideal temperature should be between 24 and 28oC with relative humidity of 65 to 80 percent and sun shine duration of 5 to 12 hours per day.

Mulberry can be grown in a rainfall range of 600mm to 2500mm. Under low rainfall conditions, the growth is limited and requires supplemental irrigation. On an average, 50mm once in 10 days is considered ideal for mulberry.

Soil

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

Mulberry varieties

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

Propagation of mulberry

- Mulberry is mostly propagated through cuttings.
- Cuttings may be planted straight away in the main field itself or nursery may be raised and the sprouted and rooted saplings may be planted in the main field.
- The latter method is advisable because of its easy establishment in the main field.

Selection of planting material

- Generally, the mulberry plants are raised from semi-hardwood cuttings.
- Cuttings are selected from well established garden of 8-12 months old.
- Only full grown thick main stems, free from insect and disease damages having a diameter of 10-12mm are chosen for preparation of cuttings.
- The cuttings should be of 15-20 cm with 3-4 active buds and should have 45o slanting cut at the bottom end.
- Care should be taken to make a sharp clean cut at both the ends of cuttings without splitting the bark.
- Manually/power operated mulberry cutter (stem cutting machine) is available for quick cutting of propagation material.

Nursery

Nursery bed preparation

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

Pre-treatment of cuttings

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

Nursery planting

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

Nursery management

- Irrigate the nursery once in three days.
- Dust one kg of any one of the following chemicals around the nursery bed to avoid termite attack.

1. malathion 5 D
2. quinalphos 1.5 D

To avoid root rot and collar rot, drench the soil with carbendazim 50 WP (2 g/l) or apply *Trichoderma viride* 0.5 g/m2 using rose can.

- After weeding, apply 100 g of urea/m2 between 55 and 60 days after planting at the time of weeding.

Age of sapling

- The saplings are ready for transplanting in the main field after 90-120 days of planting.

Planting methods

Paired row system : Plant the cuttings/saplings at a spacing of 75 / 105 cm x 90 cm. Raise intercrops in the wider inter row space (amenable for mechanization also).

Planting method	Spacing (cm)	
	Irrigated	Rainfed
Ridges and furrows	60 x 60 / 90x90	90 x 90
Pit system	90 x 90	90 x 90

No. of cuttings / ha. - 27,780 (60 x 60 cm) ; 12,345 (90 x 90 cm)

Time of planting

- Plant during rainy season
- Avoid planting during winter and summer months

Planting of saplings

Plant the well rooted and sprouted saplings at a depth of 15-20 cm

- Earth up and level the area around the saplings
- Gap fill during monsoon months.

Nutrient management

a) Irrigated / semi irrigated (kg/ha)

	Row system			Pit system		
	N	P	K	N	P	K
Recommendation	300	120	120	280	120	120
Split doses						
First crop	60	60	60	60	60	60
Second crop	60	-	-	40	-	-
Third crop	60	60	60	40	-	-
Fourth crop	60	-	-	60	60	60
Fifth crop	60	-	-	40	-	-
Sixth crop	-	-	-	40	-	-

- For V1, fertilizer schedule is 375 : 140 : 140 kg NPK/ha.
- Apply fertilizers as per soil recommendation wherever possible
- Apply the first dose of fertilizers three months after planting
- Follow subsequent fertilizer application after each leaf harvest and pruning
- Apply straight fertilizers to minimize the cost

b) Rainfed (Kg/ha)

	N	P	K
Recommendation	100	50	50
First dose	50	50	50
Second dose	50	-	-

- Apply the first and second doses coinciding with South West and North East monsoons respectively.

Bio-fertilizers

- Apply *Azospirillum* @ 20 kg/ha in five split doses. Apply phosphobacterium @ 10 kg/h in two equal splits.
- Mix the bio-fertilizers with 50 kg of FYM for uniform distribution
- Ensure irrigation after application
- Do not mix bio-fertilizers with inorganic fertilizers
- Growing and insitu incorporation of sunnhemp.

Micro nutrients

- Apply recommended major/secondary nutrients based on the deficiency symptoms.
- For micro nutrients according to the deficiency symptom expressed, apply micronutrients as foliar spary @ Zinc sulphate 5 g, Ferrous sulphate 10 g, Borax 2.5 g, Copper sulphate 2.5 g, Manganese 2.5 g or Sodium molybdate 100 mg/lit of water using high volume sprayer (spray fluid 500 lit/ha).
- Add wetting agent, Teepol @ 0.5 ml/lit. for better adherence on the foliage.

Methods of Irrigation
Ridges and furrows method

- Most efficient method of irrigation
- Comparatively requires less amount of water
- The furrows serve as drainage channels during heavy rainfall.

Flat bed method

- Rectangular beds and channels are formed
- Water run off is relatively low
- More land is wasted and requires more labour for field preparation.

Drip Irrigation

- Most efficient in water use
- Substantial saving in irrigation water
- Better crop growth
- Suitable for undulating terrains
- Fertilizers can also be applied along with irrigation water
- Clogging of emitters by physical, chemical and biological impurities
- Initial cost is very high

Weed Flora
The common weed flora in the mulberry garden is given below.

Botanical name	Tamil name	English name
1. MONOCOTYLEDONOUS WEEDS (Grassy weeds)		
Cyperus rotundus	Korai	Nut grass
Cynodon dactylon	Arugampull	Bermuda grass
2. DICOTYLEDONOUS WEEDS (Broad leaves)		
Abutilon indicum	Thuthi	Velvet leaf
Amaranthus viridis	Kuppaikeerai	Pig weed
Acalypha indica	Kuppaimeni	Copper leaf
Boerhaevia diffusa	Mookaratai	Hog weed
Croton sparsiflorus	Milakai poondu	Croton
Parthenium hysterophorus	Vizhachedi	Carrot grass
Trianthema portulacastrum	Saranai	Carpet grass
Tridax procumbens	Manjapoo	Tridax

Integrated Weed Management
Cultural method

- Remove the stubbles and roots of weeds while preparing the land
- Use well decomposed manure to avoid dissemination of weeds
- Clean the implements before use

Mechanical method

- Operate country plough after pruning in the interspace
- Remove the weeds by hand hoe

Chemical method

- As post-emergence application, use Paraquat (Grammoxone) @ 2-3 lit/ha.
- Spray Glycel 7.5 ml with 10 grams of ammonium sulphate per litre of water as post-emergence application. A total of 600 litres of spray fluid is required/ha.
- Use flooding / deflector / fan type nozzle for spraying weedicide. Apply the weedicide immediately after pruning or within 2-3 days after pruning.

Intercropping

Intercropping with short duration pulse crop enriches the soil, gives additional revenue and also controls the weed growth. Grow any one of the following crops / varieties as intercrop

Black gram	-	Co 5, VBN 1, VBN 3, VBN 4
Green gram	-	Co 5, Paiyur 1, Pusa bold, VBN 2, VRM 1, Co 6
Cowpea	-	Co 4, Co 5, Pusa 152

- Seed rate : 10 kg/ha
- Sow the intercrop after pruning and earthing up

Mulching

Mulching with pruned mulberry twigs and other materials like straw and dried leaves will have the following advantages

- Controls weed growth
- Conserves soil moisture by reducing run-off
- Increases the infiltration of water
- Reduces the soil temperature

Pruning methods
i) Bottom pruning

The plants are cut at ground level leaving 10-15 cm stump above the ground. This type of pruning is done once in a year.

ii) Middle pruning

The branches are cut at 40-60 cm above the ground level. After bottom pruning, subsequent cuts are made at 45-50 cm height.

iii) Kolar or Strip system

In closely planted area, this type of pruning is done. The branches are cut at ground level every time. Thus, it receives five prunings every year. This type of severe pruning requires heavy fertilization and irrigation.

Harvesting

The method of leaf harvest depends on the type of rearing practiced. It is preferable to harvest the leaves during morning hours. There are three methods of harvesting of mulberry leaves

Leaf picking

Individual leaves are harvested with or without petiole. Leaf picking starts 10 weeks after bottom pruning and subsequent pickings are done at an interval of 7 - 8 weeks.

Branch cutting

The entire branches are cut and fed to the worms. Before that, topping is done to ensure uniform maturity of the lower leaves.

Whole shoot harvest

The branches are cut at ground level by bottom pruning. Shoots are harvested at an interval of 10-12 weeks and thus 5 to 6 harvests are made in a year.

Time of harvest

It is preferable to harvest the leaves during morning hours.

Preservation of leaves

Use leaf preservation chamber or wet gunny bags to store the leaves or cover the bamboo basket with wet gunny bags to keep it cool and fresh.

- Silkworm grows best when fed with succulent leaves which are rich in nutrients and moisture.
- The leaves, if not preserved properly, dry up and become unsuitable for feeding.
- The harvested leaves must be preserved in fresh condition in a wet gunny cloth.
- If the climate is too hot and dry, the leaves are preserved in a leaf chamber which is lined with gunny cloth.
- The cloth is kept wet by spraying water at frequent intervals.

Sericulture Technology :: Young Age Silkworm Rearing

YOUNG AGE SILKWORM (CHAWKI) REARING

- In a tray of 120 cm x 90 cm x 105 cm size, 20 dfls are brushed and reared upto second stage.

Selection of leaves

- From brushing to the end of second age, the larvae are fed with tender leaves.
- The leaves are selected from the largest glossy leaf, 3rd or 4th from the top.
- The next 6 to 8 leaves are used to rear the young age worms upto II moult.
- The size of the chopped leaf is around 0.5 to 1.0 sq.cm. during 2nd age.
- Illustrate with the help of a figure, the selection of leaves from a fully grown branch.

Leaf preservation

- Silkworm grows best when fed with succulent leaves which are rich in nutrients and moisture.
- The leaves, if not preserved properly, dry up and become unsuitable for feeding.
- The harvested leaves must be preserved in fresh condition in a wet gunny cloth.
- If the climate is too hot and dry, the leaves are preserved in a leaf chamber which is lined with gunny cloth.
- The cloth is kept wet by spraying water at frequent intervals.

Cleaning

- It is the process of removing the silkworm excreta and left over leaves in the rearing bed
- In the first age, one cleaning is given just a day before the worms settle for moulting.
- In the second age, two cleanings are given, one after resuming feeding and the other before second moult.
- A net with mesh size of 0.5 x 0.5 cm is spread over the rearing bed and feeding is given.
- The worms crawl through the net and come to fresh leaves.
- The net along with the worms and leaves are transferred to another tray.
- The left over leaves and litter are discarded.

Moulting

- At the time of moulting, care should be taken not to disturb the worms.
- Correct detection of moult and stopping or resuming feeds are very important for uniform growth of silkworms.
- During moult, the rearing bed should be kept thin and dry by applying lime @ 30 – 50 g/m2 and should have proper aeration.

LATE AGE SILKWORM REARING

- The third, fourth and fifth instar larvae are considered as late age worms. They are reared in bamboo trays. Newspapers are spread over the trays to absorb excess moisture in leaves and faecal pellets.
- The temperature and humidity requirement gradually comes down as the stage advances.
- Leaves of medium maturity (6th leaf onwards) are fed in the third and fourth age and coarse leaves are fed in the fifth age.
- Over matured and yellow leaves should be rejected, since they may induce disease outbreak.

Bed disinfectants

Apply bed disinfectants like TNAU Seridust, Resham Jyothi, Vijetha or Sajeevini @ 4 kgs/100 dfls.

Stage (before feeding)	Bed disinfectant (Qty/100 dfls) (g)
After 1st moult	50
After 2nd moult	150
After 3rd moult	800
After 4th moult	1000
On fourth day of final instar	2000
Total	**4000**

Moulting

- Remove the paraffin papers
- Evenly spread the larvae in the rearing bed 6-8 h before settling for moult.
- Provide air circulation to avoid excess humidity inside the room.
- Provide charcoal stove/heaters to raise the room temperature during winter.
- Apply lime powder at 60 minutes before resumption of feeding daily during rainy/winter seasons to reduce the dampness in bamboo trays.

Mounting

- Apply Sampoorna @ 20 ml (dissolved in 4 l of water) per 100 dfls over the leaves for early and uniform spinning of cocoons.
- After attaining full growth in the final instar, the worms cease to feed and are ready to spin.
- Such worms are slightly translucent and raise their heads to find a place for spinning.
- These worms have to be picked up and transferred to a mountage for spinning cocoons.
- Mounting of worms should not be delayed as the ripened worms will waste silk.
- About 800-900 worms per m2 are to be kept on a mountage. For 100 dfls, about 30 to 40 chandrakis are required.
- Mountages should be kept under shade in well ventilated place.

Care during spinning

- Quality of silk depends on the care taken at the time of spinning.
- Mature worms are sensitive to temperature, humidity, light, etc., at the time of spinning.
- The ripe worm requires space equal in area to square of the length of its body for spinning.
- Proper spacing avoids wastage of silk for forming preliminary web and avoids double cocoons.
- To prevent staining of cocoons, keep mountage in an inclined position so that the urine may drop to the ground.

Maintenance of humidity

- Fluctuation of humidity causes abrupt thinning and thickening of silk filament.
- A relative humidity of 60-70% is ideal for spinning.
- Provide proper ventilation and straw mats below the mountage to quid excreta.
- Provide even and moderate lighting. Improper lighting (bright light or dark shadow) causes crowding of larvae to shaded area leading to double cocoons.
- Remove dead worms and non-spinners on the 2nd day of spinning.
- To protect the silkworm from predatory ants, apply malathion 5% dust/lakshman rekha at the base of mountage stand.

Harvesting

- The silk worms complete spinning in 2 to 3 days but the cocoons should not be harvested at this time as the worms inside are still in the prepupal stage.
- Harvesting should be done on the fifth day (7th day for bivoltine hybrids) when pupae are fully formed and hard.
- Do not harvest when the pupa is in amber colour.
- Dead and diseased worms on the mountages should be removed before harvest.
- Marketing of cocoons should be done on the sixth day (8th day for bivoltine hybrids).

Shoot rearing for late age worms

Silkworm larvae consume 85% of their food requirement during fifth instar. Fifty per cent of the labour input is utilized during the last seven days of rearing.

Rearing house

- Provide separate rearing house for shoot rearing in shady areas. Separate room should be provided for young age worm rearing, leaf storing and hall for late age worm rearing.

Shoot rearing rack

- A rearing rack of 1.2m x 11m size is sufficient to rear 50 dfls.
- Provide 15 cm border on all sides of the shelf to prevent the migration of the larvae.
- Arrange the shelves in three tier system with 50 cm space between the tiers.
- Fabricate the rack stand with wood, or steel and the rearing seat with wire mesh/bamboo mat.

Shoot harvesting

- Harvest the shoots at 1 m height from ground level at 60 to 70 days after pruning.
- Store the shoots vertically upwards in dark cooler room.
- Provide thin layer of water (3 cm) in one corner of storage room and place the cut of shoots in the water for moisture retention.

Feeding

- Provide a layer of newspaper in rearing shelf.
- Disinfect the bed, spread the shoot in perpendicular to width of the bed.
- Place top and bottom ends of the shoots alternatively to ensure equal mixing of different qualities of leaves.
- Transfer the third instar larvae to shoots immediately after moulting.
- Watch for feeding rate from 4th day of fourth instar. If 90% of larvae have not settled for moulting, provide one or two extra feedings.
- Provide 3 feedings during rainy/winter months and 4 feedings during summer rearing.

Spacing

- 18-36 m2/100 dfls.

Bed cleaning

- Bed cleaning is done once during second day of fifth instar following rope (or) net method.
- In rope method, spread 2 m length of rope (two numbers) at parallel row leaving 0.5m on other side.
- After 2 to 3 feedings, ends of the ropes are pulled to the centre to make it into a bundle.
- In net cleaning method, spread 1.5 cm2 size net across the bed.
- After 2 or 3 feedings, the nets are lifted and the old bed is cleaned and disinfected.
- Transfer the net to newer shelf, spread the net over the shoots; larvae will migrate to lower layer.

Advantages

1. Labour saving upto 70% when compared on hour to hour basis with leaf feeding method.
2. Leaf saving upto 15-20%. Hence, leaf cocoon ratio is less by 2-3 kg and extra cocoon production.
3. Better cocoon characters and effective rate of rearing (ERR).
4. Better preservation of leaf quality both during storing and on the bed.
5. More organic matter production (upto 18 tonnes per ha per year).
6. Better hygienic conditions can be maintained.
7. Handling of silkworms minimised. Hence, contamination and spreading of disease reduced.
8. Bed cleaning only once after IV moult.
9. Worms and leaves are kept away from the litter. Hence, chances of secondary contamination are minimised.
10. Labour dependent risk is reduced.

Disadvantages

1. Required rearing room floor area is more (by 30%)
2. Bed refusals will not be available as a cattle feed.
3. Planting materials (cuttings) will not be available.

Mounting

Mounting is transferring mature **silkworms** from rearing beds to montages to start spinning. Spinning starts 8 days after worms get into fifth (5^{th}) stage. Larvae cease to feed and crawl restlessly in search of a corner to attach themselves for spinning.

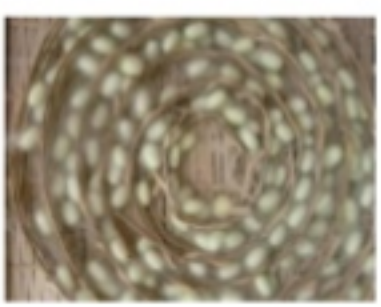
MOUNTING OF WORMS

The process of transfer of fully mature or ripe worms to the suitable mountages from the rearing bed is called mounting. Mountages or cocooning frames are certain devises or contrivences which give support to the worms for the spinning of cocoons. At the end of larval life the following sigins of maturity are shown by the larvae. They stop feeding, their stomachs appear as empty. Larvae become translucent and yellow. Active raising of head is another feature. Worms move towards the periphery of rearing tray. At the end of fifth instar the silk worms stop feeding and show signs of maturity and get ready for pupation. After the fourth moult the worms take six or seven days to reach maturity. The worms which show signs of maturity should be picked up in time and mounted. A skilled rearer can identify the suitable time for mounting.

Collecting and mounting worms require a lot of work. Generally the mature worms are collected in hand trays and later mounted on suitable mountages by skilled labourers. The most popular form of mouniage in India is Chandrika. Mounting of worms should be done in v itilated room, at a rate of forty to fifty worms per sq. feet. This helps to obtain superior quality cocoons.

Chandrika

Chandrika is made of bamboo. It consists of a rectangular mat having the size 1.8 x 1.2 m. A spiral of bamboo tape about 5 cm broad fixed on the mat leaving a space about 5 cm between the spirals. Chandrika provides all the advantages of a good mountage. There is sufficient space for spinning cocoons so prevents the formation of double cocoons to a minimum. It allows free circulation of air. So the excreta of the worms dry up quickly and do not remain to stain the cocoons. It is easily available from the villages where bamboo weaving industry is common. It can be easily transported and stored. The mountages can be used again and again.



Method of mounting

Hand picking.

The mature worms are separated from the rearing bed by hand picking and collected in a small tray. These worms are immediately transferred on to suitable mountages. It is labour consuming process and expensive.

Mounting by shaking.

To collect worms from the rearing bed, place branches of green leaves or spread a net over it. Since the silk worms have a natural tendency of moving upwards, they crawl on to the leaves or the nets. Then branches or nets are taken out and shaken over a mat to detach the worms from it. These worms are collected and mounted on suitable mountages.

Self mounting. Bottle brush type of mountages are used for this method. The mountages are placed directly on the rearing bed and the worms naturaly crowl up to the mountages and pupate. Straw mountages are also used for self mounting. When sufficient number of larvae reach the mountage it should be replaced by a new one. This method save much labour and expenses for mounting. It is applicable, only if the larvae are uniformly mufured and also difficult to get the appropriate density of the larvae on mountages.

- **REARING APPLIANCES**

- **APPLIANCES USED FOR KEEPING THE WORM**

- **Rearing stand:** used for supporting the rearing trays which are placed in vertical rows.
- **Rearing trays:** Silkworm are accommodated and fed in the rearing trays and these are placed one above the other. Circular bamboo trays are the most commonly used in India.
- **Ant well:** placed below the legs of the rearing stand, filled with water to prevent ants.
- **Paraffin paper:** thick craft paper coated with paraffin wax is used to prevent evaporation of moisture and to maintain high humidity in the rearing bed. polythene sheets, dried banana leaves and dried banana barks.

- **Foam rubber strips:** used to maintain high humidity in the bed of young worm.
- **Chop stick:** Used for picking the diseased worm away from the bed.
- **Feather:** bird feather used for brushing newly-hatched larvae from the egg card to the rearing trays and to spread the young worms during the spacing operations.

- **APPLIANCES USED FOR FEEDING**

- Leaf basket: bamboo baskets of convenient size used for collecting and transporting the mulberry leaves from the filed to the rearing house.
- Leaf chamber: to stored harvested mulberry leaf
- Chopping board: rectangular board made of soft wood used for cutting mulberry leaf
- Chopping knife: for chopping mulberry leaves prior to feeding larvae.
- Mats: placed below the chopping board prior to chopping and used to collect cut leaves. Clean newspaper can be used.
- Feeding stand: folding stand on which the trays removed from the stand are placed, one at a time for feeding and bed cleaning.
- **APPLIANCES USED FOR BED CLEANING**

- Nets for different mesh size made of cotton or nylon thread are placed above the trays
- On which fresh mulberry leaves are sprinkled to enable the silkworms crawls from the old bed which can be cleaned.
- Cloth/paper can be used and made holes to crawls from the old bed.

APPLIANCES USED TO SUPPORT THE SPINNING LARVAE

- Cocoonage or mountage

- Determines both quality and the quantity of good cocoons harvested and their performance.
- Made of wood, bamboo, card-board, plastic, grass, dry leaves and twigs.
- Optimum space: 0.9 to 1.0”
- Optimum height: 4 and 6”

DISINFECTION: It is the most important operation that to be carried out prior to the commencement of rearing. Disinfection of everything including rearing places is carried out by physical, chemical or radiation methods.

(i) Physical methods:

These are cheap, convenient and easy to operate, e.g.

(a) Sunlight:

Drying of rearing appliances in sunlight can cause disinfection. However, sun drying cannot be carried out during winter and rainy seasons, and some appliances are likely to be damaged by exposure to sunlight,

(b) Steam:

Disinfection by steaming may be used for rearing room and some appliances (not made of bamboo or wood).

However, initial cost for installing the steaming apparatus like boiler and pipeline is high.

(c) Hot air:

It is also a good sterilising method but cannot be used in routine sericulture because of its production cost.

(ii) Chemical method:

- The most commonly used disinfection method in sericulture is chemical method.
- Chemicals generally used are non-toxic to man and animals, have broad spectrum activity, stable and readily mixable with water and fair in cost.
- Chlorine as chloramine, iodine as iodophores, phenol as cresol and hexachlorophene, formaldehyde as formalin (2%), bleaching powder, etc.
- These are used as spray or fumigant.
- Spray 2 % formalin with 0.3% slaked lime or
- 2.5 % chlorine dioxide with 0.5 % slaked lime @ 2 l/m2 area for disinfecting the rearing house immediately after completion of rearing and three days before brushing.
- Dip the rearing equipments in 2 % bleaching powder solution and sun dry before use.
- Dust 5% bleaching powder with slaked lime powder @ 200 g/m2 around the rearing house and passages and sprinkle water @ 1 lit / m2 floor area.

PESTS OF MULBERRY SILKWORM

1. UZIFLY: *Exorista bombycis (Diptera : Tachinidae)*

- Period of occurrence : Throughout the year, severity is more in winter months
- Maximum infestation is recorded during rainy season followed by winter.
- The infestation is least during summer months.

Factors responsible for outbreak of Uzifly

- Large scale and overlapping rearing of host (silkworm).
- Favourable climatic conditions (temperature range of 20 – 30°C and
- relative humidity of 60 – 90%) facilitates continuous host / silkworm rearing which in turn helps the host availability.
- Increased adult (uzi fly) longevity.
- Higher egg production and egg hatchability.
- Reduced activity of the natural enemies like parasitoids, predators and pathogens in nature.

SYMPTOMS

- Presence of creamy white oval eggs on the skin of larvae in the initial stage.
- Presence of black scar on the larval skin
- Silkworm larvae die before they reach the spinning stage (if they are attacked in the early stage).
- In later stage, pierced cocoon is noticed.
- Mature maggot causes reduction in yield of cocoons and cocoon quality.
- Causes death of silkworm larva.
- **MANAGEMENT**
- Maintain sanitary and hygienic conditions in the rearing room.
- Provide physical barriers like wire mesh in the doors and windows of the rearing rooms.

- Spray 1 per cent benzoic acid over the larvae to kill the eggs of uzi fly.
- **a) Cultural / Mechanical**
- □ Silkworm rearing in a village should be conducted at a time by all farmers.
- □ A minimum gap of 20 days should be maintained between the two silkworm
- rearings.
- □ The cracks and crevices on the rearing house floor must be kept closed.
- □ Collection and destruction of uzi infested silkworm larvae.
- □ Collection and destruction of uzi maggots and pupae from rearing house,
- grainage, cocoon market and reeling establishment.
- □ Collection and destruction of adult uzi fly.

b) Exclusion is by avoiding the contact of uzi fly with the silkworm.

- □ Use nylon net enclosure to the rearing stand (Fig).
- □ Fix wire mesh to windows and doors (Fig.2.11).
- Provide a small ante-room at the entrance of rearing house. Cover the
- individual rearing tray with nylon net.

c) Physical

- □ Keep uzitrap solution in white trays near doors and windows
- (3 ft above ground level) both inside and outside the rearing house to trap adult uzi fly (Fig.).
- Dissolve the uzi trap tablets (uzicide) in the water (2 tablets/l) to attract the adults.

d) Biological: Release the gregarious, ectopupal hyperparasitoid, *Nesolynx thymus* (Eulophidae: Hymenoptera) @ 1 lakh adults/100 dfls during night hours.

- Release the hyperparasitoid in three split doses @ 8000, 16,000 and 76,000/100 DFLs during fourth and fifth instars and after cocoon harvest.

e) Chemical

- □ Spray / dust the ovicides like uzicide / uzipowder to kill the uzi eggs laid on silkworm body .
- □ Spray 2% bleaching powder solution on the body of silkworm larvae to detach / kill the uzi egg.

f) Legislative / Quarantine

- □ Avoid transportation of uzi infested cocoons from infested area to new area.
- The above management methods when applied individually do not keep the pest incidence below the economic injury level (5%).
- Hence, an Integrated Pest Management (IPM) package is developed for the suppression of the pest by selecting a few effective management strategies listed above.

2. Dermestes Beetle: ***Dermestes spp. (Coleoptera: Dermestidae)***

- Occurrence & Symptom:
- Adults and grubs are attracted to smell of cocoons in storage
- They eat the cocoons, enclosed pupae and often the eggs of silkworm
- They lay their eggs in crevices, organic matter and wooden boards
- Generally they attack the abdominal region of the moth.
- The damage is estimated to be 16.62% on cocoons and 3.57% on moths.
- **Factors responsible for pest outbreak**
- □ Storage of large quantities of moth pierced as well as stifled cocoons over a long period of time (more than 6 months).
- **Preventive measures**
- Storage of rejected cocoons and perished eggs for long period should be avoided.

- Provide wire mesh to door & windows in pierced cocoon (PC) storage rooms.
- Wooden articles of storage room & grainage should be dipped in 0.2% malathion solution for 2-3 minutes.
- Trays etc., should be thoroughly washed & sun dried for 2-3 days before reusing.
- **Mechanical control:**
- Collect the grubs and adults by sweeping or by using a vacuum cleaner, destroy by burning or dipping in soap water.
- **Physical**
- □ Exposure of beetle infested (grubs and adults) pierced / stifled cocoons packed in HDPE (black) bags to sunlight for a period of 6 hours.
- **Chemical control:**
- Store pierced cocoons in Deltamethrin treated bags ie., soak the bags in 0.028% Deltamethrin solution (1 ltr :100 ltr water) and dry in shade.
- Spray 0.028% Deltamethrin solution on walls and floor of PC room once in 3 months.
- **3. Ants (Monomorium spp., Formicidae: Hymenoptera)**
- They attack silkworm in rearing tray
- **MANAGEMENT**
- Legs of rearing stands should be dipped in antwells (filled with water+ insecticide)
- At the time of spinning, ash or kerosene is put at the handles of the mountage to keep the ants off
- **4. Lizards, bird, rats and squirrels**
- They feed on silkworms.
- Predate on the pupae by biting the cocoons
- **MANAGEMENT**

Rearing room should be kept free from lizard

Birds should be scared away from the viscinity

Trapping can be carried our for rats and squirrels

I. DISEASES

1. GRASSERIE:

Causative agent: Bombyx mori Nuclear Polyhedrosis Virus

Occurrence: The disease prevails all through the year but its severity is more during Summer and Rainy seasons.

Source of infection: Silkworm gets infected when it feed on contaminated mulberry leaves. The milky white fluid released by the grasserie larvae, contaminated silkworm rearing house and appliances are the sources of infection.

Predisposing factors: High temperature, low humidity and poor quality mulberry leaves.

Symptoms:

- The skin of infected larvae becomes shining before moult and fails to moult.
- Inter segmental swelling appears and the colour of the body becomes yellowish.
- The infected larvae move restlessly in the rearing bed/ along the rim of the trays.
- Infected larval body ruptures easily and turbid white haemolymph oozes out.

Management:

- Practice thorough disinfection of rearing house, its surroundings and appliances with any recommended disinfectant.
- Conduct an optional disinfection with 0.3% slaked lime solution when high incidence of disease noticed in the previous crop.
- Practice personal and rearing hygiene.
- Collect the diseased larvae and ensure its proper disposal.
- Maintain optimum temperature and humidity in the rearing house.
- Feed quality mulberry leaf and avoid overcrowding.
- Apply recommended bed disinfectant as per schedule and quantity.
- Feed Amruth as per schedule to control grasserie disease.

2. FLACHERIE:

Causative agent: Bombyx mori Infectious flacherie virus/Bombyx mori Densonucleosis virus or different pathogenic bacteria viz., Streptococcus sp./Staphylococcus sp./Bacillus thuringiensis/Serratia marscesence individually or in combination of bacteria and viruses.

Occurrence: The disease is common during Summer and Rainy seasons.

Source Infection: Silkworm gets infected by eating contaminated mulberry leaf. Dead diseased silkworm, its faecal matter, gut juice, body fluid are the sources of pathogen contamination. The infection can also takes place through injuries/cuts/wounds.

Predisposing factors: Fluctuation in temperature, high humidity and poor quality of leaves.

Symptoms:

- The larvae become soft and flaccid.
- The growth of infected larvae retarded, becomes inactive and vomit gut juice. The faeces become soft with high moisture content. Sometimes chain type excreta and rectal protrusion also observed.
- Larval head and thorax become translucent.
- When infected with Bacillus thuringiensis symptoms of toxicity such as paralysis and sudden death are observed. After death, larvae turn black in color and gives foul smell.
- Some times, the dead larvae turn red when infected with Serratia sp.

Management:

- Disinfect the rearing house, its surroundings and equipments with recommended disinfectant mentioned above.
- Pick up diseased larvae and dispose them by burning.
- Provide good quality leaf grown under good Sunlight and recommended inputs. Do not provide over matured/over stored /dirty leaf to the silkworms
- Avoid starvation, overcrowding and accumulation of faeces in the rearing bed.
- Rear silkworms under optimum temperature and humidity.
- Avoid injury to the larvae.
- Apply recommended bed disinfectant as per schedule and quantity.
- Feed Amruth as per schedule to control flacherie disease.

3. MUSCARDINE:

Causative agent : Among fungal diseases, White Muscardine is common. The disease is caused by Beauveria bassiana.

Occurrence: The disease is common during Rainy and winter seasons.

Source of Infection: The infection starts when conidia come in contact with silkworm body. Mummified silkworms / alternate hosts (most are lepidopteron pests), contaminated rearing house and appliances are sources of infection.

Predisposing factors : Low temperature with high humidity.

Symptoms:

- The larvae loose appetite and become inactive.
- Presence of moist specks on the skin.
- The larva vomits and turns flaccid.
- After death, larva gradually becomes hard followed by mummification due to growth of aerial mycelia and conidia over the body and body turns chalky white.

Management:

- Disinfect the rearing house, its surroundings and equipments with recommended disinfectant as mentioned above.
- Control mulberry pests in the mulberry garden.
- Pick up diseased larvae before mummification and dispose them by burning
- Avoid Low temperature and high humidity in the rearing house. If required use heater/stove to raise the temperature.
- Regulate bed humidity during rainy season by dusting slaked lime powder during moult.
- Apply bed disinfectant, Vijetha and Vijetha supplement/Ankush/any recommended bed disinfectant as per schedule and quantity.

4. PEBRINE:

Causative agent: Nosema bombycis / different strains of microsporidia.

Occurrence: Non-seasonal

Sources of Infection: Silkworm gets infected through eggs (Transovarian/Transovum transmission) or by eating contaminated mulberry leaf. Infected silkworms, faecal matter, contaminated rearing house and appliances and alternate hosts (mulberry pest) are the sources of infection.

Symptoms:

- Irregular hatching of silkworm eggs.
- Irregular size of the larval body and moulting.
- The infected larva looses its appetite and becomes inactive with wrinkled skin.
- Black pepper-like spots appear on the body of the infected worms.
- White postules appear on the silkgland when examined under microscope with presence of shining oval spores.

Management:

- Disinfect the rearing house, surroundings and with recommended disinfectant as mentioned above.
- Conduct strict mother moth examination and surface disinfection of silkworm eggs to produce and rear disease free layings.
- Follow strict hygiene maintenance during rearing.
- Control mulberry pests in and around the mulberry garden.
- Apply recommended bed disinfectant, Vijetha/Ankush as per schedule and quantity.
- Monitor seed crops constantly to eliminate the microspodian infection.