SEC: Unit 3: Rearing of Silkworms

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Zoology Sem-IV (UG)

Selection of mulberry variety and establishment of mulberry garden

Sericulture Proper

Sericulture : A process in which the mulberry silk worm *(B. mori)* is reared and unrefined silk threads are extracted from the cocoons and then the silk threads are refined, bleached and dyed for the commercial purposes, is known as sericulture. Sericulture is intimately connected with mulberry plants, so cultivation of mulberry plants is also included under sericulture.

Sericultural practices are done in Japan, China, Russia, Italy, France, Spain, and India. In West Bengal, sericulture is practised in the districts of Maldah, Murshidabad, Bankura, Birbhum, Midnapur and Darjeeling, Outside Bengal large scale sericulture is practised in Karnataka, Kashmir, Andhra, Uttarpradesh, Bihar and **Assam. Sericulture Practice in West Bengal :** Though the principles adopted by farmers of West Bengal have been described here still these principles are equally followed by the sericulturists of home and abroad. The process of sericulture is divided into two sections: *Section I* —**Cultivation of mulberry plants** and **Section *II* — Rearing of Bombyx mori.**

Mulberry propagation and cultivation (Selection of mulberry variety & establishment of mulberry garden):

As different larval stages of ***Bombyx mori*** eat only the soft green, young leaves of mulberry plants so propagation and cultivation of mulberry plants are prime important and

Table No. 1

	Larval Transformation	Moulting	Food	Feeding dyas	Tempera ture	Relative humidity
1.	Ist Instar larva Larvae hatching our from egg. 3 mm is lenght body with harry coverings.	Moults after 3 days (Ist moulting)	Finely chopped 4-5 mulberry leaves.	3 days.	26-27°C	80-90°%
2.	2nd Instar larva After first moult the larva is known as 2nd instar larva.	Moults after 2½ days (2nd moulting)	5-6 entire leaves.	2½ days.	25-26°C	75-85°%
3.	3rd Instar larva After 2nd moult the larva is known as 3rd instar larva.	Moults after 3 days (3rd moulting)	8-10 entire leaves.	3 days.	23-25°C	70-80°%
4.	4th Instar larva After 3rd moult the larva is known as 4th instar larva.	Moults after 4 days	4-5 entire leaves.	4 days.	24-24°C	65-70°%
5.	5th Instar larva The 4th instar larva moults into a golden brown 5th instar larva.	Does not moult but starts spinning.	8-10 entire leaves.	Eats for 8 days and ceases eating.	22-23°C	60-70°%

is the first step in setting up a mulberry silk industry. From time immemorial mulberry plants are cultivated in Europe and America for wood and fruits. They prepare various types of sweet–sour food from the ripe fruits of a mulberry plants. In our country mulberry plants are cultivated for their leaves to be used in silk industry which was a limited cottage industry and restricted in localised areas. With the development of silk industry at a large scale mulberry cultivation has got great attention and importance in our country. The systematic position of mulberry plants is -

Division	**Phenerogamia**
Sub division	**Angisopermae**
Class	**Dicotyledonae**
Sub class	**Apetalae**
Family	**Moraceae**
Genus	*Morus*
Species	*indica, lavigata, alba etc.*

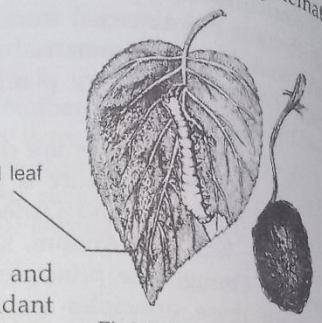


Fig1.9. Mulberry leaves attacked with Diacrisia

Mulberry plants are drought resistant, perennial plant and grow in most category of soils. It grows faster with an abundant foliage. They reproduce both by asexual and sexual means. In sexual reproduction seeds are produced which are sown to produce new plants : Fruits appear in mulberry plants in spring and seeds are collected from the ripe fruits and preserved for sowing. In asexual reproduction cuttings, grafting and layering processes are involved for the propagation. The tap root enters deep into the soil and except the sloping lands, of the hill mulberry grow in all types of soils. For bushy plants plain lands are preferable and for trees uneven land is the best. Mulberry cultivation is better practised in mineral riched soil; sandy and loamy soil are very good for mulberry cultivation. The soil which contains 40% minerals, 30% water, 20% air and 10% organic substance and having a pH is 6·5 is ideal for mulberry cultivation. For the production of quality leaves soil should be well manured. In West Bengal sericulturists apply compost, water hyacinth, decomposed bottom mud of the ponds, various oil cakes and decomposed woods as manures to the mulberry fields. Phosphates, nitrogen and potash as manures are applied to the field in the ratio of 75:160:50 kg per hectare area which give very good result.

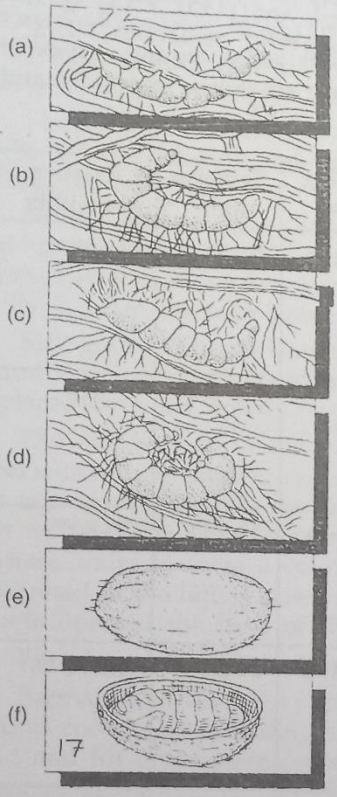


Fig.1.10. (a) to (d) different stages of cocoon formation and a pupa in a cocoon (e) Complete cocoon
(f) Pupa within a cocoon

Mulberry cultivation in West Bengal : In West Bengal bushy varieties are cultivated by sowing the cuttings. Cuttings are prepared from 4-5 year old plants whose branches are grey and average diameter is 1"; cuttings are 6" in length. In West Bengal in previously tilted and finely manured lands cutting are sown in three ways. They are (i) In a linear sequence, (ii) At one step distance and (iii) Two or three shelves process. In linear sequence three cuttings each 6"×1", are sown at a distance of 1·5" each. In step distance in 6 ft. sq. area five pieces are swon; one at each 4 corners and one at the centre. The next square lies at a distance of 3 feet. In Maldah district of West Bengal as there is higher rain fall so they prefer two or 3 shelves sowings but in Midnapur, Birbhum Murshidabad where rainfall is comapratively low distances 1·5" between two rows, are kept.

What ever may be the sowing practices the plants are not allowed to grow more than three feet in height. By repeated prunning the plants are allowed to be more bushy. The more bushy the plants the more soft, light green the foliage are. These soft, green leaves are the ideal food of the larvae of *B. mori*. If the land is properly cared, manured and watered in time, 10,000 kgs of leaves can be procured from 1 hectare of land. In W. B cuttings are swon in June and within Octobers the plants grow to a height of 3'-4'. Tender leaves can be procured from this stage onward. In W. B. mulberry cultivation covers an area of about 4000 areas of land.

By crossing and inter crossing among the species improved varieties can be produced which will be disease resistant, fast growing and more foliage bearing plants.

Fig.1.11. Tukra disease.

Rearing of *Bombyx mori* : Rearing of *B. mori* involves two rooms : (1) Breeding room and (2) Rearing room or insect room (Beng—Polu-ghar).

Fig.1.18. Mole Rat

Breeding room : Breeding rooms are situated near suitable places. These rooms are artificially equipped. Here scientists, technical persons and experts work. For breeding some good quality cocoons are selected and separated. The female larvae, the male larva and cocoons formed could be identified from the following table.

Identification of male and female larva and their cocoons:

Male Larva	Female larva
1. The male larva possesses one round spot on 11 and 12 abdominal segments. This spot is known as **Herolds bud**.	1. The female larva possesses two round spots on 11 and 12 abdominal segments. These spots are known as **Huswater point.**
2. The cocoons are light.	2. Cocoons are heavy.
3. Cocoon bears more thread.	3. Cocoon bears less thread.

Moths (male and female) emerging from the respective cocoons immediately engage in reproduction. Copulation takes place and after three hours the female begins to lay eggs. The female is allowed to lay eggs on blotting paper or card board covered by a funnel ended by a glass ring known as **cellule**. Within 24 hours the female lays about 400 -500 eggs. The eggs are adhered to the paper.

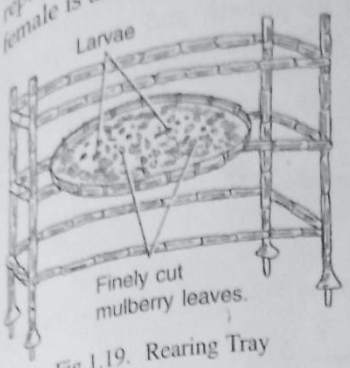


Fig.1.19. Rearing Tray

Blotting paper or card-board containing eggs are transferred to rearing trays. Bombyx species may be univoltine i.e. lays eggs once in a year or bilvoltine twice in a year or multivoltine many times in a year. Univoltine culture is practised at Kalimpong and Darjeeling in West Bengal. The silk produced from univoltine moth is superior to any other silk. Multivoltine culture is practised in the districts of Murshidabad, Biribhum and Bankura but culture of bivoltine moth is more profitable. One year time is taken to hatch the eggs of univoltine races but in multivoltine the eggs hatch within 10-12 days time. The larva or polu as it is called is about 2mm long. Larvae immediately start eating mulberry leaves. Larvae are reared in the trays made of bamboo splits or straws. The first one is known as ***chandraki*** and the last one is known as ***mabhushi***. Very finely cut mulberry leaves are given as food to larvae. Rearing trays cleaned several times a day. The rearing trays are transferred to rearing rooms.

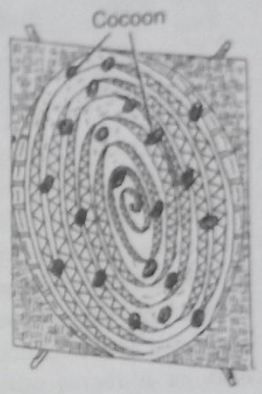


Fig.1.20. Coccon formation in Chandraki

Rearing room : This room is also known as *insect room* (B-kit-ghar or Polughar). The room is cooler as it is formed of mud wall and thatched roof. The room has large windows for proper aeration. Windows are covered with finely meshed wire nets to prevent the entry of insectivorous birds and other insects. The floor is washed twice with dilute formalin to kill the germs. The temperature is maintained between 22^0C-25^0C. Larvae (B-Polu) are reared in round and shouldered rearing trays made of bamboosplit. Rearing trays are kept in a slanting position on the shelves in the rearing room and mulberry leaves are given as food. (See table 1 for details)

After 30-40 days cocoons become elliptical in shape and yellowish in colour and formed of a 500 metre single thread. Larva is transformed into pupa within the cocoon.

In India different types of rearing are practiced in different state. They are (i) **Cellular rearing,** (ii) **Box rearing,** (iii) **Shelfrearing** (iv) **Mud floor rearing** (v) **Commercial rearing.** In West Bengal shelf rearing and mud floor rearing is generally practiced.

Larvae form cocoons in the **chandraki.** Larvae after reaching the 5th stage become matured and cease feeding. At this stage they are transferred to chandraki one by one at a suitable place for cocoon formation.

Bed cleaning and spacing : Two condition must be followed an silkworm rearing. (i) To maintain the good health of the larvae the litter containing uneaten leaves faecal matter of the larvae and dead larvaes, to be cleared regularly (ii) With the growth of larvae spaces should be provided accordingly. In West Bengal for 100 larvae of nistari variety the following spaces are taken to be ideal.

Ist stage.	After hatching.	2¼ sq. ft.
After Ist stage	Before moulting	12½ sq. ft.
After 2nd stage		25 sq. ft.
After 3rd stage		50 sq. ft.
After 4th stage		125 sq. ft.
After 5th stage		250 sq. ft.

Production of disease free seeds :

Production of disease free seeds depend on certain factors. As follows :

(a) **Temperature :** Temparature influences the rearing of silk moths directly. As silk worm is a poikilothermic animal 0^0 temparature changes influence its growth and development and the ideal temparature of larval development is 20^0 to 28^0C. The ideal temparature ranges for multivoltine species are -

Ist stage larva	28^0–29^0C
2nd stage larva	27^0–28^0C
3rd stage larva	26^0–27^0C
4th stage larva	25^0–26^0C
5th Stage larva	24^0–25^0C

(b) **Humidity :** For the production of quality cocoons follwoings are the ideal ranges of humidity.

Ist Larval stage	80% – 90%
2nd larval stage	75% – 85%
3rd larval stage	70% – 80%
4th larval stage	65% – 75%
5th larval stage	60% – 70%

Besides these light, air, food etc also influence the life cycle of ***Bombyx mori*** directly.

The colour of the cocoon depends on flavone and carotinoid. Depending on the mixture of these two colours the colour of the cocoon becomes white, rosy, golden yellow etc. The cocoon produced by male larva is light coloured and contain more silk thread.

Reeling and Extraction of Silk fibre : Cocoon of 9 - 10 days old are immersed in hot water and the pupae die immediately. Now - a days pupa are killed by fumigation. Cocoons are then assorted according to quality. Hot water removes the glued substance of the cocoons and as a result silk threads (b-khai) easily open out. With great skill fibres from 5 to 14 cocoons together are reeled at a time by a specialised wheel. The fibre thus obtained is known as ***reeled silk***. If the number of cocoons taken together at a time is more, then the fibre becomes thick and is known as **danier**. Fibres rejected during reeling are knows as **chasam**. Cocoons through which the imago emerges are known as **latkoa**. Fibres obtained from latkoa are known as **matka**. Nearly 25,000 cocoons are required for the production of one pound of reeled silk. One ounce of eggs of multivoltine race produces 45-52 thousands of larvae which give rise to nearly 40 kg. of cocoons from which 2kg. of reeled silk are obtained. **Spun silk** is obtained from **chasam**.

Rearing House and Rearing Appliances

Rearing house

Mulberry silkworm rearing, being completely domesticated, demands specified environmental conditions like temperature (24-28 C) and relative humidity (70-85%). It is therefore necessary to evolve measures for economic cooling through selection of proper material for wall and roof fabrication, orientation of building, construction method, design, etc. Further, enough space must be available to carry out leaf preservation, chawki rearing, late age rearing and moulting. It should also be convenient enough to conduct effective cleaning and disinfection.

The size of the rearing house depends upon the quantum and type of rearing. A floor area of 400 sq ft. can provide rearing space for 100 dfls (dfl: Disease Free Layings; 1 dfl = 500 larvae)

Rearing appliances

The late age silkworms do not tolerate high temperature, high humidity and poor ventilation. Hence, the rearing house should have cross ventilation facilities to bring down the room temperature and for removal of vapour and harmful gases generated from large quantities of excreta produced by silkworms. The minimum requirement of equipments for 100 dfls (50,000 larvae) is given in Table .

Table : Rearing appliances required for rearing 100 dfls (50, 000 larvae)

Sl. No.	Item	Quantity
1	Shoot rearing rack (40' x 5) 5 tiers	1
2	Rotary mountages or chandrike	35
3	Power sprayer	1
4	Hygrometer	1

Disinfectants: Formalin, Bleaching Powder, RKO

Disinfectants and Disinfection Methods

Disinfection is an integral part of healthy and successful silkworm rearing. It aims at the total destruction of disease causing pathogens. Several diseases caused by bacteria, viruses, fungi and protozoa affect the silkworms. These pathogens released by diseased silkworms easily accumulate and spread in the rearing environment through different routes. They are not easily destroyed and can persist / survive for long periods under congenial conditions. The spores of the pathogens, especially those of fungi are light and can easily be drifted by air current resulting in easy spread of diseases. There are no curative methods for any of the silkworm diseases and they are best prevented than cured. This is achieved by adoption of proper and effective methods of disinfection and stepwise maintenance of hygiene during rearing. To realize the benefit of disinfection (mass) and rearing at village or block level considering them as one unit.

Chemical Disinfectants available for use in Sericulture

Formalin

It is commercially available as 36% formaldehyde in solution form. A mixture of 2 % formalin + 0.05 % detergent is an effective solution that can be used for disinfection purpose as spray. Formalin is effective only in rearing houses, which can be made airtight and it is faster and more pronounced at temperature above 25 ^{0} C and humidity more than 70 %.

Bleaching powder

It is white amorphous powder, with a pungent smell of chlorine. For effective disinfection, a high-grade bleaching powder with an active chlorine content of 30 % must be used. It should be stored in sealed bags, away from moisture, failing which it will be rendered ineffective. The action of bleaching powder is optimal under wet and contact conditions and therefore the surfaces of equipment and walls should be drenched with this solution. A 2% bleaching powder in 0.3 % slaked lime solution is used for disinfection as spray.

Slaked lime

A very useful bed disinfectant in sericulture. especially against viruses. It absorbs moisture and can be used to regulate bed humidity and maintain hygiene. Application of lime dust in combination with bleaching powder in and around rearing houses and premises improves hygiene in the environment.

Chlorine dioxide

Chlorine dioxide marketed as sanitech is an ideal disinfectant available at 20,000 ppm concentration is a strong oxidizing agent, effective at broader pH range and at 2.5 % concentration in combination with 0.5 % slaked lime is effective against all silkworm pathogens. It is stable and may be activated at the time of its use. it possesses tolerable odour and is least corrosive at the suggested concentration.

Material required for disinfection

Disinfectants, detergent, sprayer – Rocking or Power sprayer, buckets, measuring jar, weighing scales, gas masks, metal pans, room heaters, slaked lime powder, hand gloves and muslin cloth.

RKO:

Resham Keet Oushadh (RKO is a bed disinfectant which can be applied on the silkworm rearing bed to inactivate pathogenic microbes responsible for muscardine, Grasserie and nuclear polyhedrosis diseases in silkworm. RKO is economical and its usage increases the cocoon yield on an average of 7.00 kg per 100 diseases free layings (dfls). It is easy to use and has no adverse effect on silkworm health, human beings and domestic animals. The quantity of RKO required for treating 100 dfl's is 3.25 kg. RKO is produced from locally available chemicals and the shelf life of RKO is six months from the date of manufacture.

Silkworm rearing technology: Early age and Late age rearing

Rearing of Young Age Silkworms:

The success of silkworm rearing depends to a large extent on the successful rearing of young worms. The young larva of the silkworms shows vigorous growth at a temperature around 27°C and a relative humidity of 80 to 90%. Under these ecological conditions, they complete their growth in the minimum period. Such vigorously growing worms are healthier and more resistant to adverse climatic factors and disease in the late ages, thereby ensuring success of the cocoon crop.

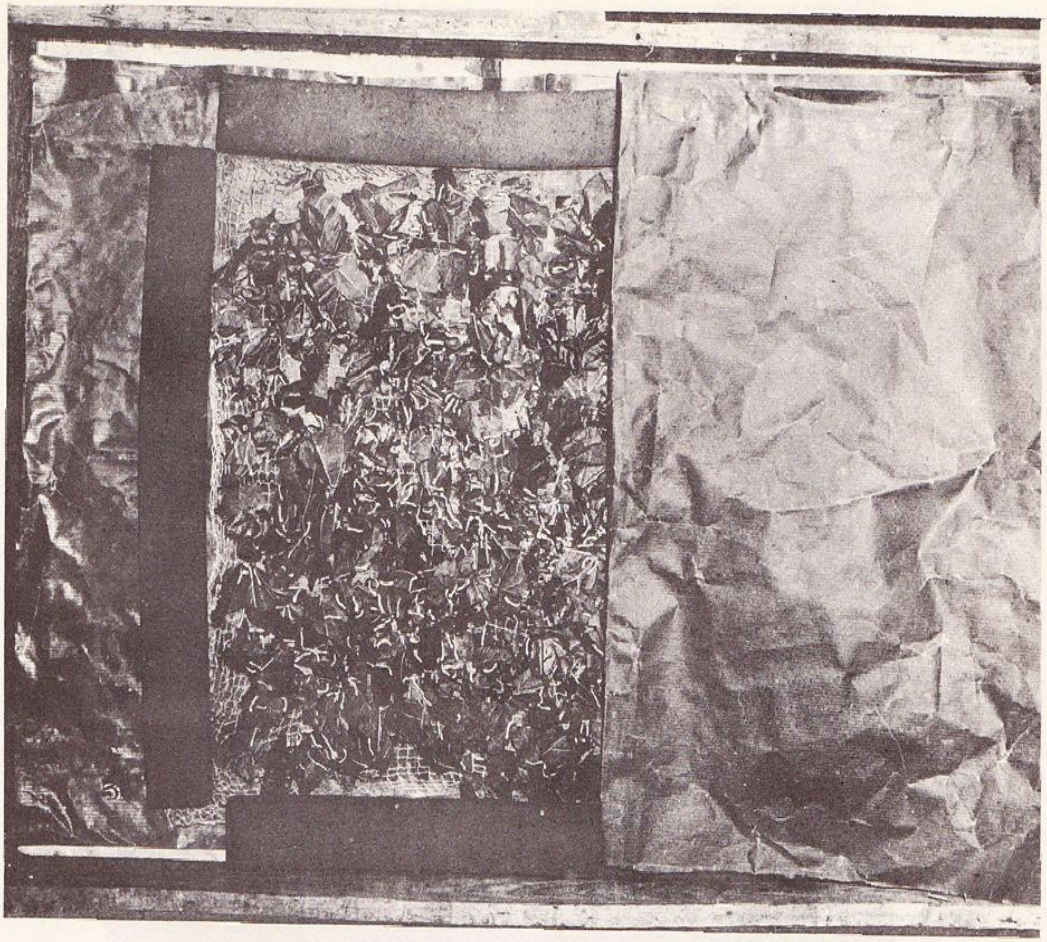
Therefore, the rearing of the young silkworms must be carried out diligently. At the time of brushing, suitable tender leaves should be chopped into 0·5 to 1 cm. squares and sprinkled over the egg sheet of the hatching worms. After the worms have crawled on to the leaves they should be gently brushed on to the tray prepared for rearing the young age worms. In order to prevent drying of the chopped leaves, the rearing of the first two instars should be conducted in between paraffin paper sheets. If the atmospheric temperature is high and the humidity is low, it may be necessary to even provide wet paper or foam rubber bands allround the rearing bed in between the paraffin sheets as shown in Figure-4.

As an additional precaution to prevent drying of cut leaves, the trays could be piled up one over the other to a convenient height (upto 10–15 trays) as shown in Figure–5.

If, however, the relative humidity is over 90–95%, as it would be during heavy rains, and if the leaves happen to have excess moisture, it may be necessary to do away with the wet paper or foam rubber bands and even resort to the removal of the paraffin paper at the bottom of the rearing bed.

The intention in all these manipulations is to ensure that the rearing beds are not allowed to dry more than the optimum required or to remain too moist as to hamper the health of the young age worms. Experience has shown that it is in this important technical task that proper attention is not being given. This mainly leads to problems of disease at later stages.

During the first three instars, care should be taken to start with **tender** leaves that have reached normal size (*i.e.* top-most full blown leaf) and somewhat dark green in colour, for feeding the newly hatched worms. As the young age worms continue to grow, more mature leaves should be fed to them. The size of the chopped leaves



Rearing of young age worms between paraffin papers—provided with foam rubber bands allround the rearing bed.

should also gradually increase from 0·5–1 cm. to 6 cm. squares by the time they reach the end of the third age. When a feed is due, the paraffin paper covering the rearing bed should be removed atleast half an hour before the actual feeding so that uneaten leaves, alongwith the rearing bed itself, may completely dry before the fresh feed is given. Immediately after giving the chopped leaf, the rearing bed should be covered with the paraffin paper. Under our climatic conditions it is found that during wet weather the wilting of the leaves takes a longer time due to the high humidity. According to the climatic changes, we need to manipulate the rearing operations to ensure that the leaves do not dry quickly in dry periods and do not remain over-moist for unduly long periods during rainy seasons.

Piling up of the chawki rearing trays—an additional precaution to prevent drying of cut leaves.

The early age larvae can be best reared in trays measuring 2′ × 3′ and $2^1/_2$″ - 3″ in height. Upto 10–15 disease free layings can be brushed in a tray of this measurement from hatching till the second moult.

The first age worms settle for moult within 3 - $3^1/_2$ days and in another 20 hours they will enter the second age. The second age is passed within $2^1/_2$ - 3 days and after 20–24 hours of moulting, they will enter the third age.

The third age worms coming out of the second moult are removed to round bamboo trays. During the third age, the humidity in the bed should be slightly lower and for this, the silkworms need to be reared only under the paraffin paper cover, but without any paraffin paper at the base. It is also no longer necessary to have any wet paper pads. The third age will take 3 to $3^1/_2$ days to settle for the third moult and in one day come out of the moult to enter the fourth age. Thus, the total period taken for the young age rearing lasts from 11 to 12 days.

The number of feeds to be given during the young age is three to four between 6 a.m. and 9 p.m. which may be at 6 a.m., 1 p.m., and 8 p.m. or at 6 a.m., 11 a.m., 3 p.m:, and 8 p.m. during the summer months. Bed cleaning will have to be done once in the first age prior to settling for moulting, twice during the second stage, *i.e.* first after first two feeds, and again prior to settling for second moult, and three times in case of third age worms, *i.e.* once after two feedings after moulting, second after two days and third just prior to settling for third moult. These operations can be summarised as shown in the table below:

Rearing Schedule of Young Age Silkworms
(For 100 Disease free layings)

Age of Silkworm	Temperature °C	Humidity %	Size of Leaves (cms.)	Total quantity of leaf (kgs.)	No. of feeds/day	No. of cleaning/ instar	Spacing (Reaing seat for 100 dfls) (sq. ft.)
Improved Multivoltine Hybrids							
I	27	80–90	0·5 to 2·0	2 to 2·5	3 to 4	1	4 to 14
II	27	80–90	2·0 to 4·0	6 to 7·0	3 to 4	2	15 to 45
III	26	80	4·0 to 6·0	25 to 30	4 to 5	3	45 to 90
Bivoltine Hybrids							
I	27	80–90	0·5 to 2·0	2·5 to 3	3 to 4	1	4 to 14
II	27	80–90	2·0 to 4·0	8 to 9	3 to 4	2	15 to 45
III	26	80	4·0 to 6·0	35 to 45	4 to 5	3	45 to 90

Rearing of Late Age Silkworms:

The fourth and fifth instars of the silkworms are somewhat more delicate and therefore, need more rigid conditions of temperature and humidity. They normally thrive well under comparatively lower temperature and are sensitive to high temperature and humidity conditions. Under high humidity conditions as in rainy days, more ventilation and greater spacing should be resorted to, and all care should be taken not to over feed the worms, as it would lead to bed thickening resulting in wet beds. It may also be found advisable to chop the leaves during the rainy days, although under normal conditions, the entire leaf could be fed to the fourth and fifth age worms. For these late age worms, more mature leaves which contain less of moisture in them should be given. As already mentioned earlier, during dry days all attention must be focussed on the proper preservation of leaves, as the health of the worms depends very much on the quality and quantity of leaves consumed. If the leaf is not sufficiently fresh, its edible quality is reduced and the worms tend to go under starvation inspite of the presence of leaves in the trays.

The late age worms of fourth and fifth instars are real feeding stages consuming about 90 to 95 per cent of the total feed and therefore, adequate spacing and adequate amount of feed should be given at these two ages. The worms in the fourth and fifth ages need be given only four feedings at 6 a.m., 11 a.m., 3 p.m. and 9 p.m. and during hot months five feedings at 6 a.m., 10 a.m., 2 p.m., 6 p.m. and 10 p.m. It would be advisable to give a fairly large feed at night.

When the worms are reared on trays, it would be necessary to give bed cleaning once in the morning every day. The operation connected with the rearing of the late age worms can be summarised as shown in the table below.

Rearing Schedule of Late Age Silkworms
(For 100 Disease free layings)

Age of Silkworm	Temperature °	Humidity %	Size of Leaves (cms.)	Total quantity of leaf (kgs.)	No. of feeds/day	No. of cleaning/ instar	Spacing (Rearing seat for 100 dfls) (sq. ft.)
Improved Multivoltine Hybrids							
IV	Atmospheric Temperature	70–75	Entire Leaf	75–85	4–5	Once in the morning daily	90–180
V	"	70	Entire leaf or branches	600–625	4–5	Daily	180–360
Bivoltine Hybrids							
IV	"	70–75	Entire leaf	105–125	4–5	Once in the morning daily.	90–180
V	"	70	Entire leaf or branches	700–725	4–5	Daily	180–360

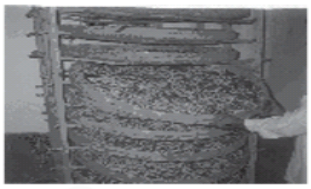
Note: Ensure circulation of air if too warm and humid

REARING METHODS

Let us understand the different methods of late age silkworm rearing. It is a process of feeding the right quantity of mulberry leaves to silkworms. The second stage silkworms after moult are transferred to late age rearing house. Rearing of late age silkworms is conducted by different methods depending on the space availability, economic condition of the farmer and the availability of labour. Accordingly, three methods of rearing are popular, the tray rearing method, the shelf (rack) rearing method and the floor rearing method.

Tray Rearing

Traditionally, in India, rearing is conducted in wooden/ bamboo trays of convenient size (3-4'diameter) and fed individual mulberry leaves plucked from the mulberry tree/bushes. The bamboo trays are arranged in stands made of wood/ Bamboo/ Iron with 10-12 tiers (Fig. 3.1) Though, leaf rearing is more labour intensive for various activities like plucking, feeding, bed cleaning, the tray rearing is very popular with small scale and marginal farmers, as it needs less space for conducting rearing. This type of rearing is common in rearing-cum-dwelling houses. Feeding is done 3-4 times every day and cleaning of the rearing bed, removing old leaves and litter is done every day. Cleaning of bed is done using nylon nets of mesh size 2"× 2". Larval bed space is maintained at each instar depending on the silkworm breed.



: Tray Rearing

Shelf (Rack) Rearing

In this type of rearing, whole shoot or branch with mulberry leaves are used for feeding the silkworms. A shoot rack of 5 ft width and as long as rearing house with 3-5 tiers are used for rearing silkworms. The gap between the tiers is kept at 2 feet to facilitate easy feeding of larvae. The height of the rearing rack will be 6-7 ft. and the bottom tier will be one ft above ground level (Fig. 3.2). Shoot rearing racks are made of wood, iron or bamboo and can be easily assembled by the farmer. If more than 3 tier system is followed, it is difficult to monitor the growth of silkworms, but, more larvae can be accommodated in the rearing house. While assembling the rack, a distance of 2 ft is made between the wall and the rack and 4ft between the racks so that sufficient work space is available to work in the rearing house.

Shelf Rearing

Floor Rearing

This method is followed traditionally in Kashmir and some parts of China. Here, the difference is that, rearing is conducted on the floor using mulberry shoots/ branches. Rearing bed of 5 ft width and as long as rearing room is made on either side of the floor on old newspaper (Fig. 3.3). Before spreading the newspaper, a thin layer of lime is dusted on the floor to prevent the attack from ants. Feeding is done as in shoot feeding method and no cleaning of bed is practiced. Since no rearing racks are used for rearing, it is highly economical and hygienic.

Floor Rearing

Mountages

Meaning of Mountage:

The most important device that helps or supports the silkworms (larvae) for comfortable spinning their cocoon is called cocoonage or mountage. It determines both the quality and quantity of the cocoons. Different types of cocoonages are used in different parts of India. In general, these are made of wood, bamboo, cardbaord, plastic, grass, dry leaves, twigs, etc.

However, ideal mountage should fulfill the following requirements:

(i) Convenient space with suitable dimension for spinning proper-sized cocoon.

(ii) Should not allow formation of double or malformed or flimsy cocoons.

(iii) Should have provisions for cleaning the excreta of spinning larvae.

(iv) Should be suitable for easy harvesting of cocoons.

(v) Should be cheap, durable and easy to handle.

Types of Mountage:

In India following types of mountages are used:

(1) Chandrika:

This round- or rectangular- shaped mountage is made of bamboo mat supported by split bamboo reapers on all sides (Fig. 3.7). On the mat, a bamboo tape of 4-5 cm width is wound in a spiral manner. About 1000 worms can be mounted on this mountage. These are easy to handle, repairable and cocoons spinned on Chandrika are of good quality.

However, bamboo being a protected plant, nowadays Chandrika is rare and costly. It is prone to damage by rodents and requires a lot of area when not in use. Besides, occurrence of stained cocoons is more in chandrika. Chandrika is popular in South India and West Bengal.

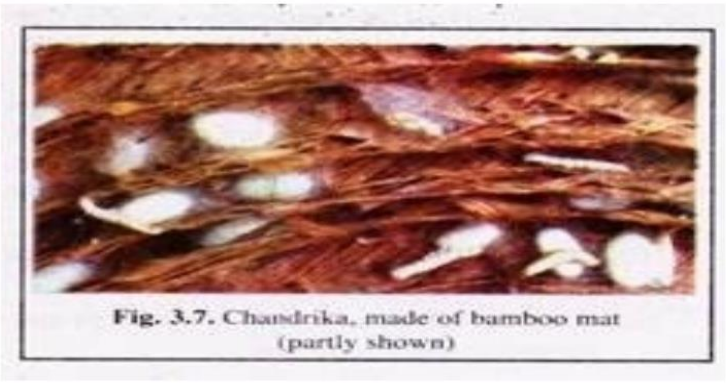


Fig. 3.7. Chandrika, made of bamboo mat (partly shown)

(2) Screen-type Mountage:

It is made of bamboo or wooden or plastic reapers on which, instead of spiral bamboo tape, longitudinal strips with triangular peaks are placed. The screen can be folded and stored.

This mountage can be kept clean and well- ventilated and hence, cocoons spun on this mountage are of good quality. It is more durable than chandrika. But occurrences of double cocoons are frequent in it.

(3) Plastic Mountage:

Like Chandrika, but is made from plastic instead of bamboo and hence, more durable, easy to clean, not prone to rodent attack, and produce lesser number of double cocoons. Once invested, further maintenance, care or expenditure are not incurred.

But these mountages are costly than Chandrika. The cocoons produced on these mountages are more flimsy and not of uniform size and hence not frequently used by farmers.

(4) Japanese low Cost Mountage:

In this modified Japanese mountage, a wooden frame of 4 longitudinal rods is attached by means of cross-spokes at two ends to a central axis. Each rod has a number of pegs placed at equal distances. These pegs are connected by long threads of twisted rice straw in a regular pattern like that of charpoy.

The size of frame and the number of pegs can be modified according to the requirement of the rearer. This mountage is cheap, more durable and make less chances of disease spread.

(5) Bamboo Strip Mountage:

Made of bamboo stirps that are either nailed on wooden reaper or placed in grooves of wooden reapers. Several such frames are placed one above the other with the lower one keeping on four uniform bricks or wooden blocks. This mountages are cheap, durable, easy to handle, and harvest the cocoons.

(6) Bottle Brush Mountage:

This recently introduced mountage consists of a thick coconut or jute fibre rope into which 6-9" sticks (midrib of coconut leaves) are inserted very closely.

These are used by the worms as support. The worms spin their cocoons in the space between the sticks. This mountage is very cheap; can be made easily and occupies little space compared to Chandrika.

Spinning, Harvesting and storage of cocoons

Process of Spinning: As the mature worms are mounted on the mountages they pass out the last excreta in semi-solid condition. During rains when the humidity is high, excess body moisture is also eliminated as liquid urine at the time of mounting. After defecation, the worm starts spinning the cocoon. It anchors itself first to the mountage by oozing a tiny droplet of the silk fluid which immediately hardens and sticks to the mountage. Then by swinging the anterior part of the body continuously, the silkworm draws out the silk fluid from the two silk glands which lie on either side of the body of it. Silk fluid is excreted in minute quantities and hardens to form the long continuous silk filament. At first, however, the worm spins a loose hammock which provides it with necessary foothold to start spinning of the cocoon proper. The filament is spun in the shape of ∽ or ∞ and the former type is common in the outer layers of cocoon shells while the latter type is usual in the middle and inner layers. In this way layers after layers of filament are laid to form the compact shell of the Cocoon.

The hammock though formed of a continuous filament forms a labyrinth of highly tangled network and this constitutes the floss of the cocoons which is not reelable. Quantity of floss is comparatively less in uni and bivoltine varieties of silkworms and is about two per cent of the weight of cocoons. In the case of multivoltine races, however, it is high and may amount to as much as ten per cent or even more.

After the compact shell of the cocoon is formed, the shrinking larva finally wraps itself in a gossamer layer and detaches itself from the shell to transform into the pupa or chrysalis. This last layer is only a body sheath of the worm and does not form part of the main shell and as such is not reelable just like the floss layer.

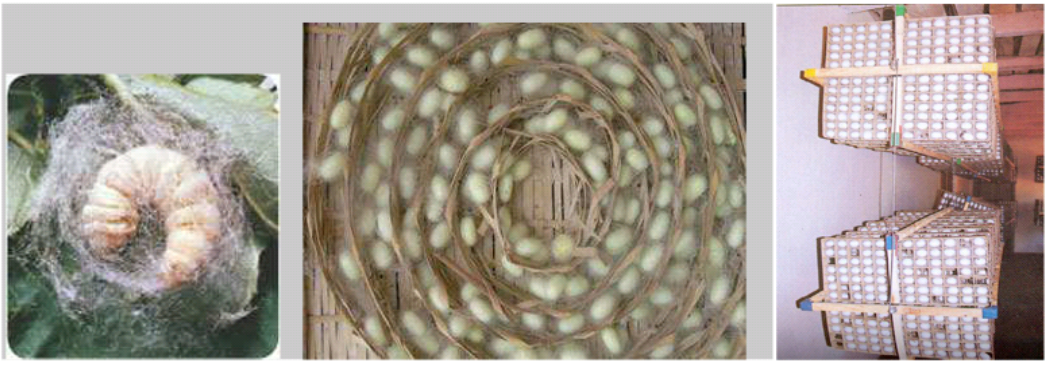
The process of spinning the cocoon by the worms takes about 1 to 2 days in the case of multivoltines and 2 to 3 days in the case of uni/bivoltine worms. It is necessary to keep the silkworm larvae undisturbed during this period, because shaking during cocoon spinning causes suspension of spinning and even breaking of the thread. It is also very necessary to provide good ventilation, as the worms have to get rid of a good deal of moisture in the process of spinning; the silk, though it is solid, is still wet, and needs to dry to set into a firm cocoon.

Mounting of worms: Collecting mature silkworms and mounting is a laborious job which requires a great deal of labour. Normal practice is to hand picking the mature worms by skilled labour who can identify the ripe worms. The ripe worms are collected in hand trays and later put on the mountages. As mentioned earlier, "chandrike" is the most popular type of mountage in Karnataka and West Bengal. As this entire process is carried out with manual labour it is possible to ensure uniform distribution of

mature worms on the mountages and thus reduce the incidence of double cocoons. In this method it is also possible to eliminate the diseased larvae and thus achieve a fair measure of uniformity of cocoons.

In order to save labour involved in picking mature worms, some simple techniques have been evolved involving the use of green branches or nets. I n the "branch method", branches with green leaves are placed over the rearing bed and when the worms crawl into them they are taken out and shaken off over a mat to dislodge the worms which are later collected and put on the mountages. Similarly, in the case of "net method" also, a net is spread on the bed after feeding and the mature worms which do not feed any more will come up and crawl on to the net which are taken out and shaken off the net over a mat and mounted as in the case of branch method.

In shoot rearing method, larvae maturing early which constitute 10 to 20 per cent of the total larvae can be picked by hand as they ripen. Later on when the remaining larvae mature uniformly and almost simultaneously, these can be collected by shaking off the larvae from the upper layers of mulberry branches to mats. They are then mounted on the mounting frames.



Methods of free mounting: In this process no hand picking of ripe worms is involved. The mountages, which in the case are made of straw, are placed directly over the trays containing the ripening worms. The mature worms crawl on to the mountages and commence spinning of cocoons. In the Soviet Union, dried weeds are placed on the trays of ripening worms as mountages. While these methods are no doubt economical, uniform distribution of spinning worms cannot be achieved and this is to be deemed as a disadvantage.

In Japan, where straw cocoonages are popular, the general practice is to spread a layer of cut straw over the rearing bed. The ripe worms crawl through the layer of cut straw to the mountages. The mountages with the worms in the process of spinning are later on transferred to trays covered with sheets of newspaper which absorb the urine and fecal matter excreted by larvae.

Revolving mountages, made of cardboard are also in use in Japan and they facilitate the free mounting of ripe worms directly from the trays. The revolving mountages should be removed from

the tray when a very thin layer of the cocoon shell has been formed and should be kept suspended, undisturbed for the worms to complete the formation of the cocoons.

Population density in mounting: A good rearing can to a great extent be spoiled by bad mounting. In India, it is very common to find that the rearer perforce resorts to over crowding of silk worms on mountages, leading to such undesirable results like double cocoon. This is indeed a sad waste of silk. This is by no means the worst result of over-crowding. The worms soil and stain the cocoons of other worms with their excreta; and as in a crowded cocoonage, deficiency of ventilation will hinder rapid driving of the moisture: damp, stained and inferior cocoons will be the result.

The proper density of mounting in the case of chandrike could be taken as 50 worms for a space 30 cm x 30 cm i.e. roughly one sq. foot or about 2 sq. cm for each worm. On this basis a chandrike of standard size of 1.8 m x 1.2 m could be used for mounting about 1,000 to 1,100 larvae. In the case of revolving mountage the number of cubicles in each mountage will be 13 x 12 or 156. Ten such cocoonages are combined to make a revolving frame. It will, therefore, be evident that the mounting capacity of a revolving frame will be 1560 or about 50 per cent more than a standard chandrike. As each worm gets a cubicle to spin a cocoon, a revolving mountage is to be deemed as an ideal cocoon age.

Care during spinning: The worms require attention during spinning of cocoons as the quality of cocoons is to a great extent determined by the environmental conditions that obtain when the worms are on the mountages. It may, in general, be stated that dry weather is good for spinning.

Generally, worms during spinning require a slightly higher temperature than during rearing; but too high a temperature is to be avoided as it will compel the worms to spin in haste and thus waste a lot of silk. The worms which are in too great a hurry to spin waste a good deals of silk in. the preliminary processes and spin irregularly shaped cocoons of poor reeling quality. This is especially the case with over-ripe worms, of which there are always a certain number. Too low a temperature on the other hand, causes delay in the spinning and injuriously affects the colour and lustre of the cocoons and their texture. The cocoons spun in a low temperature will not be so compact as those spun in a higher temperature. The delay occurs not only before the larva commences spinning, but the process of spinning itself takes longer duration.

The effect of too high a temperature on the filament is to make it thicker than the normal size, and of too low a temperature, to make it thinner. If there is violent fluctuation of temperature during the process of spinning, it leads to ununiformity of the filament spun and a flaccid cocoon results which is a source of serious trouble in the cocoon reeling· leading to wastage of silk. Abnormally high

or low temperatures affect the health of the worms and make the resultant cocoons unfit for seed purposes. A temperature around 24°C is to be deemed quite ideal for spinning.

Humidity plays an equally important role in determining the quality of cocoons spun. It would be ideal if the relative humidity could be maintained in the range of 60 to 70 per cent. Too much moisture in the air has a directly injurious effect on the quality of the cocoons and affects the lusture of the filament. From the point of view of reeling, drier the air during mounting the better it will be, but too great a dryness debilitates the worms and is to be avoided. Ventilation is an essential point for attention as a good deal of moisture has to be got rid of and there is also a good deal of excreta-solid, liquid and gaseous. Insufficient ventilation will spoil the health of the worms and the quality cocoons, and produce the worst effects of dampness. While there should be free ventilation at the time of spinning/it is however to be remembered that the spinning worms should not be exposed to violent draughts. The practice in Karnataka and West Bengal to place the chandrikes in the open has much in its favor. It is however necessary in this case not only to avoid draughts of wind but also direct sunlight which distorts the spinning process by the worms.

METHODS OF HARVEST

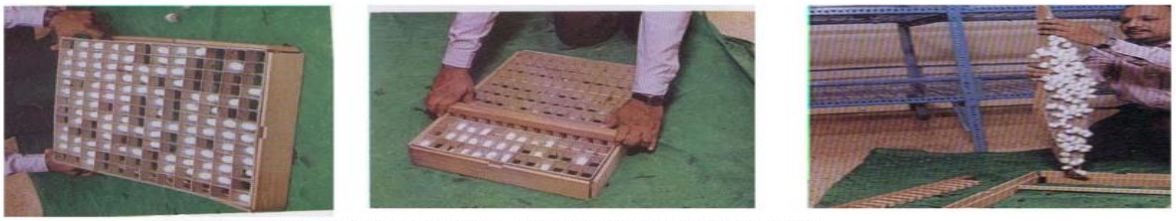
You might have realized the importance of timely harvest of silk cocoons. Now, the question comes how will you harvest?

Harvesting from Chandrika by hand

Methods for harvesting of silk cocoons varies, depending upon the mountage (spinning tray) used. Whatever the methods of harvest, first you remove litters and left-over of leaves, dead or un-spun larva, naked pupa (without cocoon), flimsy and melted cocoons from the mountage. Flimsy and melted cocoons may spoil the good cocoons by spilling stain.

Spiral bamboo mountage (Chandrika) is most commonly used in our country. You may harvest the cocoons from Chandrika by hand, simply by moving your fingers in between the ridges. In case of plastic collapsible mountages, you may harvest manually by hand picking.

In the rotary card board mountages, harvesting by hand is rather difficult and time consuming. You can use a wooden harvester for quick harvesting. It has two parts. First one is a wooden frame on which cardboard mountage can be fixed. Another is pusher, made up of wooden pegs, that fits with the hole of mountages. After removing dead worms, flimsy and stained cocoons, fix cardboard mountage on the harvester. Then, place the wooden pusher on the holes and push gently so that cocoons come out of cardboard holes. Now, you may collect the cocoons by hand by folding the mountages



Steps of harvesting from cardboard mountages by hand

1. **Placing of mountage on harvester**
2. **Pushing with pegs**
3. **Collection of cocoon**

In order to ease the process, some machines are developed by CSR&TI, Mysore for harvesting and deflossing the cocoons, the details are as follows:

a) **Cocoon Harvester:** It is made up of iron or wood. It consists of two parts and is used for harvesting cocoons from rotary mountages. Cardboard mountages are inserted into the wooden frame and cocoons are pushed out using the pusher made of the same size as the holes of the mountage

Cocoon Harvester

b) **Cocoon Deflosser:** Hand operated and motorised cocoon deflossing machines of different capacity are available for fast deflossing of the cocoons . The motorised machines have capacity to defloss 100 kg cocoons per hour.

Deflosser (Electric run)

Deflosser (Hand operated)

After harvesting, spread the cocoons in trays with maximum of two layers of cocoon. Heaping of cocoons may lead to accumulation of moisture and heat and ultimately melting of cocoons.

SORTING OF COCOONS

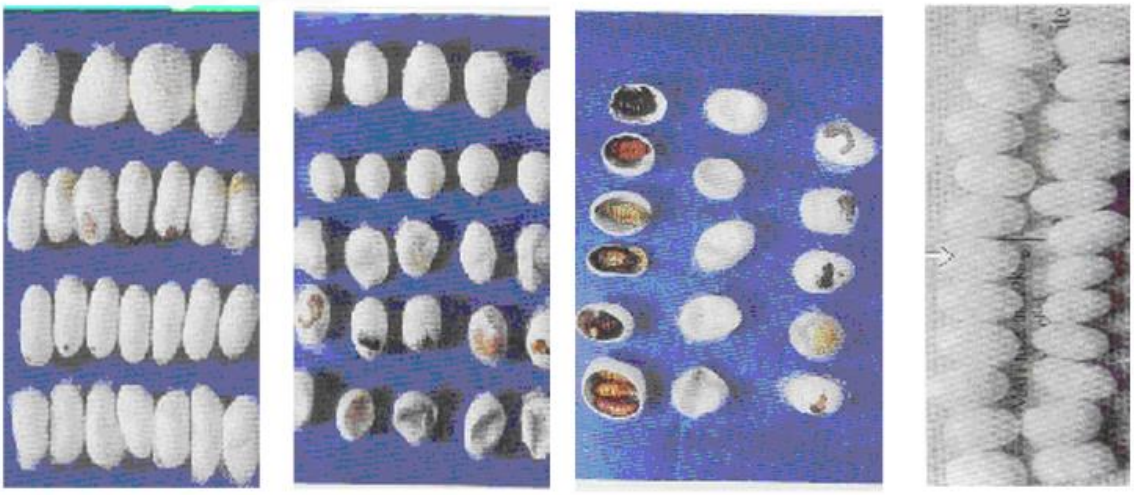
After deflossing, if you spread and look into cocoons, you will find most of the cocoons are with a particular shape and size because the shape and size are inherited racial or genetic characters, eventhough you will find some odd shaped and defective cocoons. ***Removal of odd shaped and defective cocoons from the lots is called sorting of cocoons***. Defective cocoons affect the reeling performance and quality of the silk. Therefore, unsuitable cocoons are to be sorted out from the good cocoons to get optimum result during reeling.

The cocoons are sorted into:

a) Good b) Double c) Uzi pierced d) Flimsy or thin shelled e) Melted or stained and f) Thin-end cocoons.

Sorting will improve the product image and marketability. Reelers always prefer uniform shape in a lot. Uniform shape improves reeling performance and silk quality. Sorted out defective cocoons can be sold in different rates.

Among sorted out cocoons, you will find different defective cocoons indicated below



Defective Cocoons

1. ***Melted and Stained Cocoons:*** If spinning larvae or pupae die inside the cocoon during spinning or transportation, it causes melting or inner soiling. Sometime, inner melted material ooze out and cocoon gets stained. Staining of cocoons may be due to urination also.

2. ***Flimsy or Thin Shelled Cocoons:*** Weak or undernourished silkworms spun loose or less compact cocoons. These become flimsy or thin shelled. Reelability of these cocoons is poor.

3. ***Deformed Cocoons:*** Weak larvae or improper mountage causes deformed cocoons. These cocoons affect reelability and quality of raw silk.

4. ***Thin-end Cocoons:*** Thin end cocoons may be due to genetic character of the silkworm races or may be due to improper rearing and spinning environment. These cocoons affect reeling performance.

ASSESSMENT OF COCOONS

Cocoons produced are to be marketed. Following points/ characters are generally considered to assess the cocoons in fixing the price.

1) ***Cocoon Weight:*** Cocoons are being sold on weight basis. You will find that the weight of the cocoons gradually decreases due to moisture loss and consumption of the fat till the pupa transform into moth and emerge out. So, immediately after harvest, defloss, sort, and weigh the good cocoons. This will be the weight of green cocoons. Make a label indicating race or combination, date of spinning, green weight, etc. while taking to the market.

2) ***Assessment of Cocoons for Defective Cocoon Percentage:*** If the lot is not sorted properly, you can assess percentage of defective cocoons in a lot. For this, take one kg of cocoon from the lot at random. Sort out defective cocoons like double, flimsy, melted, pierced etc. Count and weigh good and defective cocoons separately. Assess defective cocoon percentage by the following formula:

$$\text{Defective cocoon}(\%) = \frac{\text{Wt. of defective in one kg}}{\text{Wt. of cocoon taken (1kg.)}} \times 100$$

Activity 2

One kg. of cocoon contains 250 gm of defective cocoons. Calculate defective cocoon percentage.

3) ***Rendita:*** It represents the quantity of green (fresh) cocoons required to produce 1 kg. of raw silk. If 10 kg. of green (fresh) cocoon of a lot is required to produce 1 kg raw silk, then *Rendita* of that lot is 10. It is an indicator of price fixation of the cocoon when purchased for reeling.

4) ***Shell ratio (%):*** It indicates the quantity of silk shell in terms of cocoon weight and expressed in percentage. This value gives a clear indication of quantity of raw silk that can be reeled from a lot of fresh cocoons. It is used for estimating *Rendita* and ultimately helps in price fixation.

To find out weight of a single cocoon, take 50 cocoons randomly from the sorted out good cocoons, calculate single cocoon weight using the following formula:

$$\text{Average single cocoon weight (g.)} = \frac{\text{Weight of the 50 good cocoons}}{50}$$

Then, cut the cocoons and record the shell weight. Calculate ***shell ratio percentage*** by using the formula:

$$\text{Shell ratio (\%)} = \frac{\text{Shell weight}}{\text{Cocoon weight}} \times 100$$

In multi X bi-hybrids, generally it ranges between 12 and 16 whereas, it is between 18 and 23 in bivoltine hybrids.

Activity 3

If 50 nos. of good cocoons weighs 75 gm. and their empty cocoon shell weighs 8 gm., calculate average single cocoon weight and shell ratio percentage.