Silkworm Rearing Technology

Early Age and Late Age Rearing, Types of Mountages, Spinning, Harvesting and Storage of Cocoons

ENVIRONMENTAL CONDITIONS FOR SILKWORM REARING

The environmental factors influencing silkworm rearing are temperature, humidity, light and air current.

a) ***Temperature:*** plays a vital role directly influencing the life process of all organisms. Temperature changes with season and also within the day. Silkworms can be reared successfully within a range of 20-28°C. The optimum temperature required for late age silkworms are 23-25°C. The larval duration increase by one day if the temperature goes below 23°C. Similarly, when the temperature goes above 36°C, it affects the survival of larvae and cocoons reared at high temperature are inferior in quality.

b) ***Humidity:*** also plays a vital role in late age silkworm rearing. Comparatively, low humidity in the range of 65 -70 % gives superior quality cocoons. High humidity and high temperatures are predisposing factors for infection by various pathogens. Humidity also indirectly influences driage of leaves in rearing bed. Hence, during feeding, high humidity is maintained and it has to be reduced during moult to facilitate easy removal of skin.

c) ***Air Current:*** has a tremendous effect on late age silkworm rearing. The air which gets polluted in the rearing house through various activities has to be removed. This is possible only when there is good ventilation. Better ventilation also helps in regulation of rearing temperature and humidity. The recommended air current during late age rearing is 1.0 m/sec for 30 minutes before feeding.

d) ***Light***: has indirect effect on silkworms. Silkworms are photosensitive and prefer dim light (15-30 lux) and avoid strong light and darkness. Light does not affect their survival rate but affects the distribution of larvae in the rearing bed. The late age silkworms shows optimum uniform growth at a photoperiod of 16 hours of light and 8 hours of darkness.

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.

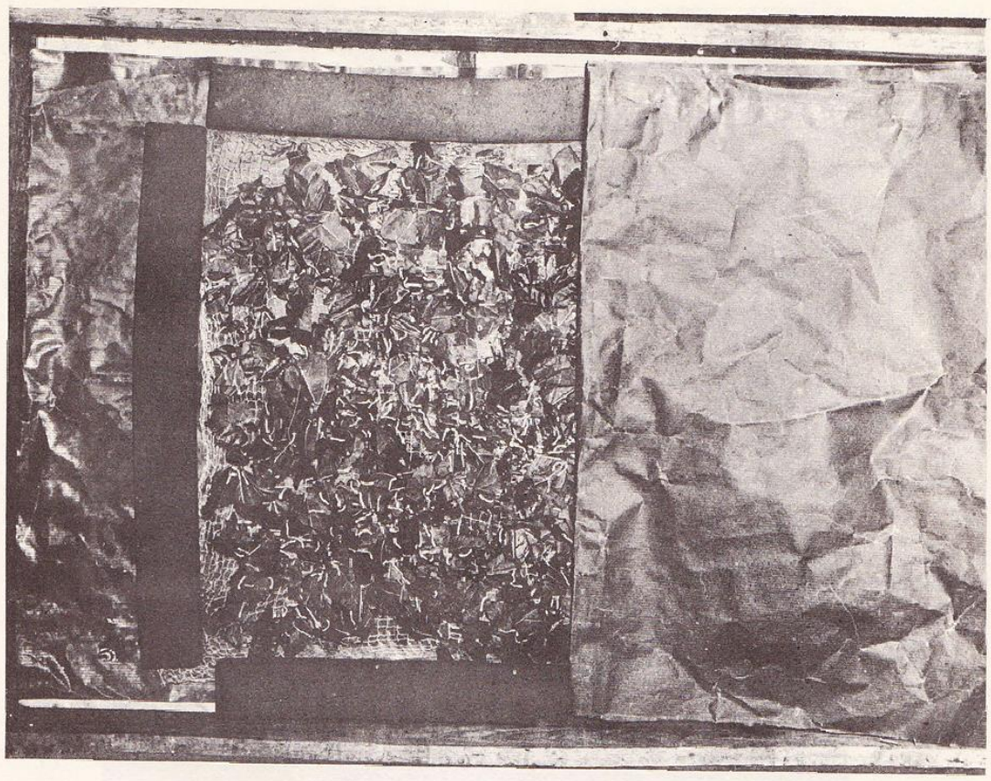
Therefore, the rearing of the young silkworms must be carried out diligently. At the time of brushing, suitable tender leaves should be chopped into 0·5 to 1 cm. squares and sprinkled over the egg sheet of the hatching worms. After the worms have crawled on to the leaves they should be gently brushed 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.

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

LATE AGE SILKWORM REARING

The rearing of third, fourth and fifth stage is called "late age or adult silkworm rearing". The late age silkworms moult or shed their skin two times, the third and fourth moult to facilitate the growth of the larvae. The late age silkworms consume large quantity of leaf. Out of the total consumption of leaf, 94% of the leaf is consumed during the late ages and the body volume increases by 29 times, weight by 25 times and silk gland by 200 times. Late age rearing needs almost 50% of the total labour in fifth stage alone. A separate rearing house with adequate rearing space and sufficient ventilation and light are essential for effective disinfection and maintenance of required environmental conditions during late age silkworm rearing.

The characteristics of late age silkworms are:

- Low tolerance to high temperature, high humidity and poor ventilation.
- Requires coarser and matured leaves rather than tender leaves. Amount of mulberry leaves ingested and digested greatly increases.
- Reduction in feeding affect the cocoon size and larval duration is prolonged.
- More resistant to disinfectants and other chemicals. Also susceptible to pests because of increased larval size.

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

Types of 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.

A mountage for good quality reelable cocoon should have the following minimum features:

- should have sufficient cocooning space between frameworks,
- material used for mountage should favour reelability of cocoons,
- material should be cheap, durable and easily available,
- should be convenient for the process of mounting and harvesting, and
- should be convenient to prevent faeces and urine coming in contact with cocoons.

The most commonly used mountage for spinning cocoons of silkworms are:

a) Bamboo chandrike

b) Plastic collapsible mountage

c) Rotary cardboard mountage

d) Bottlebrush mountage

e) Dried grass/straw/ twigs mountage

a) **Bamboo Chandrike:** It is the most commonly used mountage in India. It is made of bamboo spirals woven on a bamboo mat with two supporting bamboo sticks. The mat is of size 1.8 x 1.2 m (Fig. 3.4). The spirals are made of bamboo tapes on mat base with 5-6 cm width. Small holes are made on the mat base to provide ventilation. Matured silkworms are transferred to the chandrike @ 40-50 worms per sq ft. After mounting, the chandrike is kept at a slanting back position of 45° to allow the urine to fall on the ground and to prevent the staining of cocoons. During mounting, care should be taken to prevent damage to the soft skin of larvae which may result in pupal mortality. Chandrikes are also difficult to disinfect properly.

Fig. 3.4: Chandrike

b) **Rotary Card Board Mountage:** These are made of pieces of cardboard assembled in a checkered pattern consisting of 13 rows and 12 sections each providing a total mounting space of 156 sections of size 4.5 x 3 x 3 cm. Each mountage is 55 cm long, 40 cm wide and 3 cm deep and can be folded completely when not in use. Ten such mountages are fixed on a wooden rectangular frame using ten iron clamps on each of the four sides. The frame consists of two rectangular frames of size 120 x 58 cm and 115 x 44 cm and is made of square wood of size 1 x 2 cm. Both the ends of the shorter axis are fixed by an iron screw and the whole wooden frame can be hanged horizontally (Fig. 3.5). It can also revolve by the horizontal short axis. Hence, the name rotary mountage. The wooden frame can also be folded when not in use.

Fig. 3.5: Rotary Mountage

c) **Plastic Collapsible Mountage:** These are also called as *Netrikes* and are made of plastic mesh having 11 folds of 2.2" height and can be placed in a wooden tray of size 2' x 3' for mounting the larvae (Fig. 3.6). It can be stored by folding. Newspaper is spread at the bottom of the mountage for absorption of urine. Each mountage can hold 350-400 larvae for spinning. After mounting, strips of paddy straw or pieces of old newspaper are put on the mountage for providing anchorage to the spinning silkworms. Plastic collapsible mountage can also be used for self mounting. It can be directly placed on the rearing bed when the larvae start spinning by self mounting. These mountages possess several advantages. It is easy for handling, requires less space for storage and help in maintaining hygienic condition. It is also easy for harvesting cocoons.

Fig.3.6: Plastic collapsible

d) **Bottle Brush Mountage:** Different types of bottle brush mountages are available depending on the material used, like plastic, bamboo and coconut broomstick. Plastic bottle brush is a machine made plastic material with individual pieces. Normally, 50 such individual pieces are joined together by an iron rod and at the end it has an iron stopper. Each individual piece has eight branches of 1.5 cm length with two sub-branches of 9 cm length (Fig. 3.7). These branches are equally distributed at a distance of one cm at the base and 4 cm at the end in a circular fashion. Distance between two sub-branches is 3 cm. The circle formed by the branches and sub-branches is 24 cm in diameter. Each bottle brush assembled is one meter long and can mount 350-400 larvae.

Fig. 3.7: Plastic Bottle Brush

Structure of the mountage is same, but coir rope is used as support and bamboo pieces or coconut broom sticks of 15 cm length are inserted into the coir rope at a distance of 3 cm in groups of eight. A mountage of one meter length can hold 500 larvae for spinning. It is easy for mounting operation but the branches become loose in due course.

e) **Dried Grass/ Straw/ Mulberry Twigs Mountage:** When silkworm starts maturing, a thick layer of dried grass or straw is spread over the rearing bed. Matured larvae crawl through the bed on the mountage and spin cocoons. For mounting 100 dfls of larvae, 80 m^2 space is required. This method is simple, labour saving and is ideal for shoot rearing method. But, formation of floss and deformed cocoons are more in this method.

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 ᔕ 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?

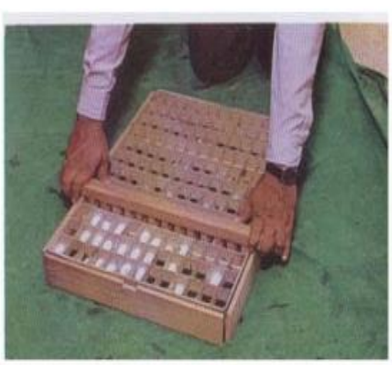


Harvesting from Chandrika by hand

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.

Storage of cocoons:

The cocoons dried to the optimum level may be conditioned for a minimum period of 7 - 10 days before taking up for reeling in order to achieve better reeling performance. The cocoons should be stored in an appropriate storage room for long duration storage. The cocoon storage should have 20°C or below temperature in the center of the room and the air inside the room should have 55% or below relative humidity so that fungus will not attack the cocoons.