Selection of Silkworm Races/Breeds for Rearing

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The silkworm rearing programme in a farm is determined by the following considerations.

1. Conditions of mulberry growth, yield of mulberry leaf, quality of mulberry leaves and time of availability.
2. Availability of labour for leaf harvesting and rearing of silkworms.
3. Facilities for rearing silkworms *i.e*., type and size of rearing house, rearing equipments, disinfection and hygiene.

Selection of silkworm breeds for rearing:

Silkworm hybrid varieties are preferred for commercial rearing to pure breeds. This is naturally so, because hybrids are more vigorous and productive than their parental pure stock. Cocoon quality in hybrids is superior in respect of cocoon weight, shell weight, shell percentageand raw silk percentage. Different types of hybrids that could be exploited in tropical region are indigenous multivoltine x multivoltine, multivoltine x bivoltine and bivoltine x bivoltine. Among these, the limitation in respect of yield and quality in multivoltine x multivoltine hybrid is well known. In this respect bivoltine x bivoltine hybrids are the best. However, it's suitability in tropical belt is doubted. But, it has been proved that with appropriate rearing technology and management skill, even superior high yieldingbivoltlne hybrids can be reared in the tropics successfully. Tropical bivoltine races will bemore suitable for such exploration. However, when the ecological conditions are not favourable, multivoltine x bivoltine silkworm hybrids are chosen. The advantages of rearing various types of hybrids can be assessed from table 1. Productivity efficiency from leaf to silk is the lowest in multivoltine x multivoltine hybrids and highest in bivoltine x bivoltine hybrids.

Table 1. Cocoon and silk productivity in relation to leaf utilization in different hybrids of silkworm *B. mort* L.

Silkworm Breed	Quantity of Leaf Required	Cocoon yield/10000 larvae in kg	Leaf required to produce one kg cocoon	Renditta	Leaf required to produce one kg silk
MVxMV	600	25	24	15	360
MVxBV	800	40	20	10	200
BVxBV	1000	50	20	8	160

Silkworm hybrid combinations recommended for commercial exploitations are given in the following paragraphs.

Pure Mysore x NB_{18}/NB_4D_2→ Old Cross breed for all seasons under irrigated mulberry garden conditions. Since it has low shell weight, shell % and high renditta, new cross breed Pure Mysore x CSR_2 has been introduced.

Pure Mysore x CSR_2 → New Cross breed for all seasons under irrigated mulberry garden conditions. It is superior to the old cross breed.

Pure Mysore x C.nichi→ Another Cross breed for rain fed mulberry garden.

BL 23/24 x NB_4D_2; CSR_2x CSR_4; CSR_2x CSR_5; CSR_{18}x CSR_{19}→ These are the productive Bivoltine hybrids for all seasons under irrigated mulberry garden.

Differences between Multivoltine, Bivoltine and Hybrids:

Multivoltine	**Bivoltine**	**Hybrids**
1. Multivoltine silkwormbreeds are resistant to fluctuating/varied environmental conditions and poor quality leaves	1. Bivoltine silkworm breeds are susceptible to fluctuating environmental conditions as well as poor quality leaves.	1. Hybrids exhibit mid parental values with respect to fluctuating environmental conditions as well as poor quality leaves.
2. Multivoltine breeds are Poor Yielders in general i.*e*., less cocoon weight, shell weight, filament length, denier *etc*.,	2. Bivoltine breeds are Good Yielders in general *i.e.*, more cocoon weight, shell weight, filament length, denier *etc*.,	2. Hybrids shows average yield i.e., average cocoon weight, average shell weight, average filament length, average denier etc.,
Eg., Pure Mysore, Nistari, *etc*.,	*Eg.* NB_4D_2, CSR_2*etc*.,	*Eg*., Pure Mysore X CSR_2

INCUBATION

Incubation is an important process by which the activated silkworm eggs are maintained under proper environmental conditions to get hatching or preparation of eggs for hatching.

Purpose

1. To get uniform hatching with high percentage.
2. To ensure the hatching on the required day.
3. To ensure healthy and robust silkworms.

Environmental conditions for incubation: For healthy development and uniform hatching eggs are to be incubated under optimum conditions of temperature, relative humidity, light and air.

Temperature: During incubation maintenance of temperature is extremely important. Too high a temperature, though it makes the eggs hatch earlier, results in a large proportion of eggs dying or becomes weak. They do not hatch at all. The hatched worms are also lighter that what they should be and remains below the normal size throughout the rearing. The cocoons spun by them are small and poor in silk content. In short, a high temperature leads to loss of eggs, under sized worms and poor harvest. Too a low temperature on the other hand prolongs the incubation period. Many eggs do not hatch at all and hatching is very irregular. It is therefore, very necessary to find out the most ideal temperature for incubation of the eggs so as to achieve the best possible hatchings. Fortunately, alot of scientific studies have gone in to this aspect and very useful information is readily available regarding suitable temperatures for incubation of different varieties *i.e*., Univoltines- 24-25 °C, Bivoltines – 24-26 °C and Multivoltines 21-24 °C. Hibernated or refrigerated silkworm eggs, after removal from refrigerator are kept at 15°C for three days and later kept in incubation temperature. This method helps in protecting the eggs from sudden shock of violent change in temperature from 2.5°C to 25°C. It also helps in uniform development of all eggs.

Humidity: The regulation of humidity during incubation is equally important. Too high or low humidity is very bad. Too high humidity makes the worms easily susceptible to diseases and also producestrimoulters. Too low humidity during summer and dry seasons causes low hatchability due to embryonic death. Therefore, it is very essential that during incubation period, humidity is maintained in the range of 75-85%.

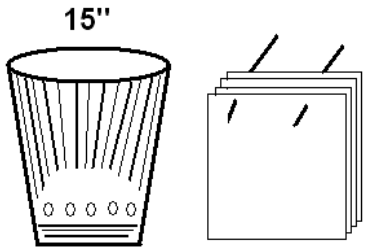
Light: Light at incubation affects the hibernating character of the eggs at succeeding generation in bivoltines. The suggested duration is 16 hours per day light is essential at incubation.

Air: The incubation area should be avoided from stagnant air. If the CO_2 content in the air increases more than 0.5% it affects development of embryo. Hence good ventilation should be maintained during incubation. The air flow in the incubation room should be 0.3m/sec, which not only brings the fresh air but also maintain the temperature and humidity to some extent.

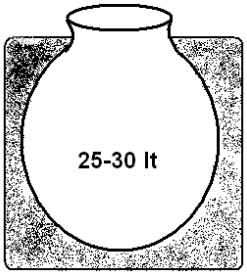
Silkworm seed before incubation should be washed in 2% formalin for 15min. The eggs are dried under shade and spread in single layer in trays.

Incubation Devices:

1. **BOD incubator:** Biological Oxygen Demand Incubators are ideal for precise maintenance of temperature, humidity, light intensity and duration as well as air current. However, it is not in much use because of high initial and maintenance cost in addition to electricity dependency.
2. **Earthen Flower Pot Method:** Earthen flower pot of wide mouth about 15 inch diameter is required. This pot is filled with a layer of 2-3 inch clean sand and made wet. This pot is provided with a row of holes about 0.5 inch diameter and 2-3 inch above the sand level. The egg sheets ate tied to rod and hung inside. Loose eggs in boxes are piled up using a base support material. It is covered with clean cloth.



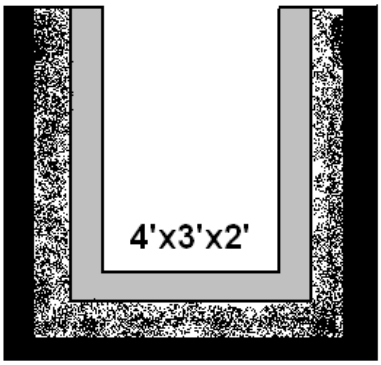
3. **Buried Earthen Pot method:** Round earthen pot (20-25 lt) with a wide mouth buried (up to neck) in clean wet sand can be used for this purpose. Sand is kept wet one day prior to incubation (pre-conditioning). The layings in sheets are tied to a rod and keeping inside the pot, loose eggs in boxes can be piled up on the base support and the pot is covered with a wet cloth. Periodic wetting of the sand and cloth should be monitored using clean water. This method provides optimum temperature, humidity and accommodated up to 200 dfls and suitable for individual farmers. This is highly effective in dry and high temperature areas.



The buried earthen pot can further be used for the preservation of the chawki leaves during young age silkworm rearing.

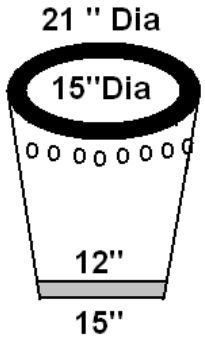
4. **Double Walled chamber Method:** The chamber is constructed by using burnt mud/cement bricks and cement mortar that is filled with loose and clean sand. While constructing, wire meshmay be fixed to avoid rodent and predators. The standard size of the outer wall is 6'x4'x3'. The inner wall is 4'x3'x2' with a gap of 3" between them. This chamber accommodates 50,000 to 60,000 dfls, suitable for large scale farmers, CRCs and grainages.

Egg sheets are tied to a rod with sufficient gap between sheets and are hung in the chamber. The same chamber can be used for loose egg incubation also. Periodical wetting of sand by water helps in maintaining required temperature and humidity. Eggs incubated by adopting this method hatch uniformly, larvae are healthy and grows better.



Low Cost Incubation Chamber: Mainly consists of two chambers (outer and inner), the outer chamber of 18 inches height and opening at one end is made of clay, of diameter of 21 inches at top opening and 15 inches at the bottom closed end. The inner chamber is 16 inch in height and also made up of mud. The top open end is having a diameter of 15 inch that tapers to 12 inch to the closed bottom end. The walls of both the chambers are provided with 5 mm diameter holes on top half portion of the chamber, in rows in longitudinal pattern. Cleaned and formalin

disinfected sand bed of 1” depth is kept at the bottom of both the chambers. Sand in the chamber is kept moist sufficiently and conditioned at least 12 hours before keeping eggs for incubation. The egg sheets are aligned vertically with the help of thin bamboo strips (with enough space for air circulation between sheets) and the mouth of both the chambers are covered with loosely knit gunny cloth and the eggs are preserved till black boxing. The system is found to be very effective as it ensures optimum conditions for the growth/development of silkworm eggs thereby hatching is optimized.



Black Boxing:

Providing total darkness for a day or two before egg hatching is called black boxing. This helps in uniform hatching in a single day. During black boxing those embryos in advanced stage of development will wait for light to hatch and developing embryos will continue their development and when exposed to light, all eggs will hatch uniformly. It helps in synchronized brushing. Simple black sheet of paper (thick craft paper) or cover, which gives total darkness, is good enough.

Eggs are pin head stage are wrapped (25 or 50 dfls each) in a tissue paper and transferred to black boxes. Such black boxes are placed under required humidity and temperature conditions. The eggs are to be exposed to light between 7 and 8 AM on the expected day (10^{th} or 11^{th} day) to enable maximum hatching.

Stages of Embryonic development:

Soon after copulation and within 10 min of entry of sperm in to the egg, the egg nucleus undergoes maturation division and prepares itself for fertilization with the sperm nucleus. Within two hours of egg laying the sperm nucleus fertilizes the egg. Soon after fertilization the embryonic development starts by zygote nucleus dividing into a number of nucleus , blastoderm is formed in about 10 hours of oviposision and germ band is about 20 hours. By 30 hours of oviposition, the embryo develops the head and the tail. By 3^{rd} day the embryo reaches the longest

embryo stage (enters diapauses in case of diapausing eggs). In non diapausing eggs there is no diapause and embryo continues to grow further to reach blastokinesis stage on 5th day of egg laying, egg spot stage on 8th day and blue egg stage on 9th day. Larva hatches out on the 10th day.

REARING OF YOUNG AGE SILKWORMS (Chawki Rearing)

The success of a rearing depends in great measure, upon the care and skill bestowed in the earlier age's*viz*., first and second ages. If the worms have been spoiled by carelessness or ignorance in the earlier ages, no amount of subsequent effort can ensure a complete success of the rearing. On the other hand, worms which have received good attention in the early ages are comparatively well able to withstand adverse conditions in the later stages of rearing. The worms of early ages are very delicate and susceptible to maladroit management. They are, moreover, so tiny that individuals do not appeal to the sympathy born of distinct sight and touch, and the rearing consists of mass treatment. The tiny worms are also more liable to be lost than the more grown ones-indeed a good many are, as a matter of fact, lost in spite of normal care and skill. Roughly about half of the total loss of worms occurs during the first age. Based on all these facts rearing of young age worms become very significant.

The concept of chawki rearing is not new. In sericulturally advanced countries like Japan, the importance of young age silkworm rearing to raise healthy stock has been fully appreciated. The entire quantity of eggs used for raising cocoon crops is first raised in fully equipped young age rearing centers specially organized for the purpose under expert technical supervision. Although the sericulturists' place their indents for eggs, the indents are supplied as worms after the second moult.

In India, particularly in Karnataka, chawki rearing centers (CRCs) have been organized by the state department of sericulture to fulfill the demands of the sericulture industry.

Preparation:

The rearing of young age silkworms should be commenced only after disinfection of the rearing house and all the rearing equipments with 2% formalin solution.

The Egg: The quality of eggs to be used in rearing is very important factor determining the success of rearing. Quality silkworm seed may be defined as one which

1. Is entirely free from diseases.
2. Has maximum number of viable eggs
3. Gives good uniform hatching
4. Is prepared from healthy and robust parents
5. Assures a stable and successful cocoon crop.

Once quality eggs have been procured, it should be incubated so that best results of hatching and final harvest are obtained. For details of Incubation please refer the earlier topic INCUBATION.

Every care should be taken to see that the eggs are not exposed to excessive heat or dryness during transit. For safe protection and preservation of eggs, ideal conditions required are about 25°C temperature and about 80% relative humidity.

BRUSHING

Brushing is the process of separating the newly hatched worms from the shells of their eggs, and collecting them for convenience of rearing.

Newly hatched silkworms are black and hairy and look like black ants. Hence they are referred to as 'ants'. There are many methods of brushing, according to the condition in which the eggs are obtained, as eggs may be loose grains purchased by weight or layings on egg cards or sheets. Silkworms generally start hatching early in the morning and this progress till noon, and after that with a few stray exceptions, the eggs that are left un-hatched remain so till the next morning. The result is that on any day, by far the largestpart of the day's hatchings will have taken place before noon and it would be unwise to allow these newly hatched larvae to remain unfed to avail of the scanty afternoon hatchings. The most suitable time for brushing silkworms could,therefore,be taken as around 10 a.m.

In order to obtain uniform hatching, eggs at "blue egg" stage are kept in black boxes on the previous day of hatching. By this the early maturing embryo is prevented from hatching and the late embryos are given time to develop and catch up with the early maturing ones. The next day they are exposed suddenly to diffused light so that the larvae hatch out most uniformly responding to the phototropic stimulus. By this method hatching percentage of 90 and above is attained.

If,however,hatching is not uniform and only 50 to 60 per cent of the eggs hatch on

the first day, brushing can be done on the following day as well. If need be the first batch of hatched worms can be separated by a feather and kept in tissue paper in a refrigerator at 10°C till the next day and combined with the second day's brushing to form a common batch.

A somewhat crude and slightly cumbersome process is in vogue among sericulturists' to achieve uniform hatching. In this the egg sheets are kept thinly spread out in trays. On a day prior to their reaching the "blue egg" stage, they are lightly and evenly stroked half-a-dozen times with a soft brush or feather. This treatment is repeated throughout the day at intervals of about three hours. This method is fairly successful in achieving uniform hatching.

Brushing of loose eggs

The method of brushing the loose eggs from egg boxes is detailed below:

In this case, eggs are spread evenly in one layer in the egg box after removing the cover. At blue egg stage they are kept in black box or covered with black paper. When they change colour preparatory to hatching, black cover is removed and they are covered lightly over with a thin perforated cloth or a fine-meshed net or finely perforated thin paper (Fig.). This covering just touches the upper surface of the eggs. Just before brushing, chopped mulberry leaves are sprinkled on the top of the net or cloth or paper-not for the worms to eat, but just to attract them to crawl on to the upper surface. It is convenient to have the net or cloth or paper stretched on frame which is of a size to just fit the egg box in which the eggs are kept, in order that the active newly hatched worms might not crawl out and get lost. When a sufficient number of worms have hatched out, the rearer takes out the cloth.

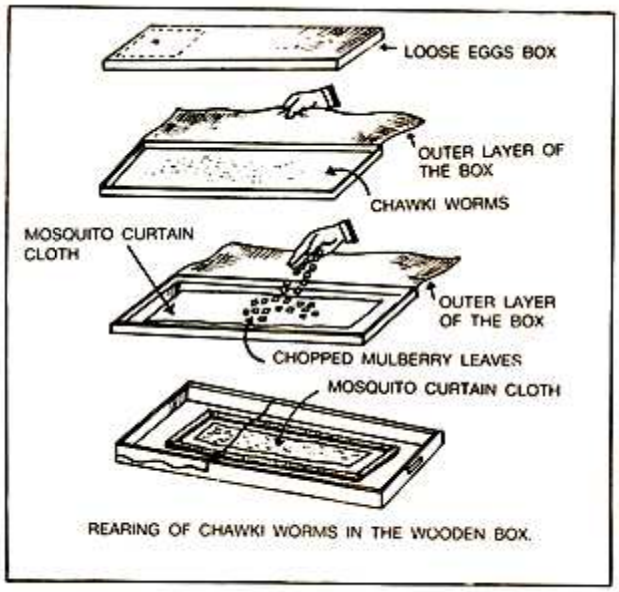


Fig. Brushing Loose Eggs

Brushing from egg cards

In the case of layings on egg cards, there are several methods of brushing. Most common ones are:

(i) Brushing by husk method;

(ii) Brushing by cloth, paper or net;

(iii)Brushing by feather;

(iv) Brushing by net and feeding.

To start with, the egg cards, when the eggs reach the 'blue egg' stage, should be covered with a large sheet of paper to prevent the active young worms from crawling out and getting lost. It must be noted that the newly hatched multivoltine worms do not display the same aptitude to stray as worms of bivoltines.

Brushing by husk method: This is a very popular method of brushing is vogue in India. In this method, charred powdered husk is spread on the newly hatched worms. Laterchopped mulberry leaves are spread on the card. The newly hatched worms crawl on to the top of the feed. After half an hour of feeding, the silkworms are brushed off to the rearing tray with a feather.

Brushing by cloth, paper or net: This is only an adaptation of the method described in relation to loose eggs. The layings are covered over with paper or net or cloth and the worms which crawl on to the underside are collected by tapping or transferring the paper

with worms to the rearing tray.

Brushing by feather: In this the egg card or paper is held vertically by one end over the rearing tray and the hatched worms are separated by gentle strokes with a feather. This method is simple and easy but is apt to injure the worms which at this stage are tiny and delicate(Fig.).

Fig. (Brushing of worms by a feather

Brushing by net and feeding: In this, instead of husk, a fine meshed net in employed. In other respects it resemble method described above.

After brushing the silkworms, the bed is prepared by collecting the worms and mulberry leaves together by using a feather. The bed is spread uniformly using chopsticks. After about two hours of brushing, the first formal feed is given to the silkworms. Prior to the first feeding, as a precaution against muscardine the larvae may be treated with one per cent "DithaneM_{45}" or "Capton".

Different methods of rearing early age silkworms have been evolved in recent years, all of which seek to prevent the driage of mulberry leaves and also maintenance of proper temperature and humidity in the rearing beds, and thus secure vigorous and healthy development of silkworms. The different methods are given below.

1. Paraffin paper method:

In this method,paraffin paper is used both as a bottom layer and also as a cover for the rearing beds in the usual rearing trays. The paraffin paper for this purpose should be of a good quality, without the smell of petroleum. Care must be taken to see that the paraffin paper is not torn or over-wrinkled or soiled.

A sheet of paraffin paper is spread on the base of the rearing tray over which the

rearing bed of silkworm is formed. A second sheet of paraffin paper is placed loosely over the silkworm bed. In between the two sheets, on all four sides of the rearing bed, strips of wet foam rubber pads or ordinary newspaper folded into strips are placed to maintain the required humidity. Thin sticks are placed at the periphery of the cover sheet to keep it down and thus prevent the ingress of air (Fig).

Fig. Covered rearing with paraffin paper

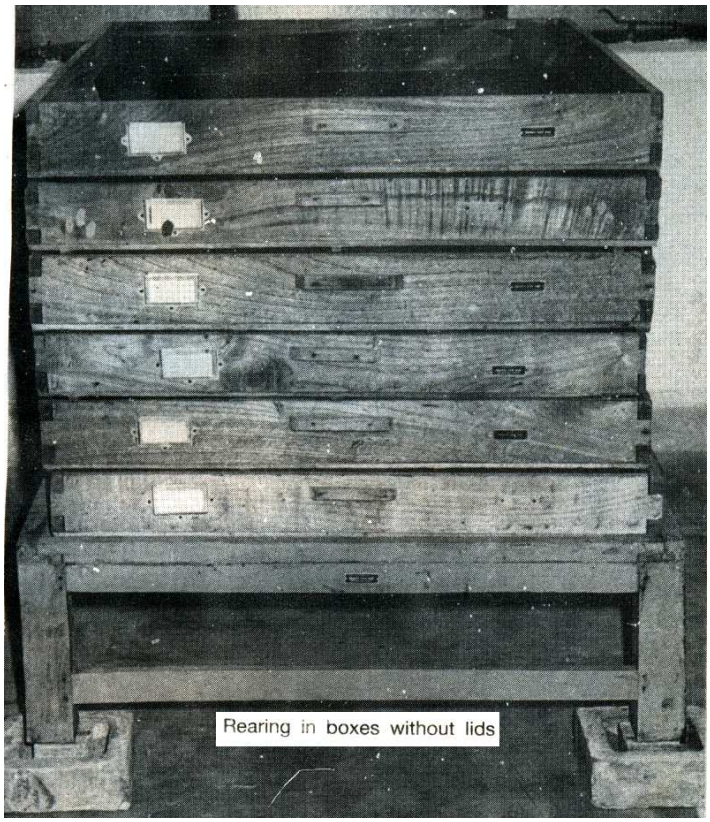
Care should be taken to see that the cover sheet is removed at least 30 minutes before each feed so that supply of fresh air to-the silkworms is received and simultaneously the expulsion of the accumulated toxic gases on the rearing beds is also achieved. When the worms begin to settle for moultparaffin paper cover is not necessary as the rearing beds should be dry to facilitate moulting of the larvae.

In paraffin paper method of rearing, particularly in humid places, there is fear of incidence of muscardine disease. To prevent this, a thin layer of ceresan lime or dithane M_{45}or captonkoalin mixture is spread over the bed as a prophylactic measure at the time of hatching, at each moult and in the middle of each age

2. Rearing In boxes without lids:

In this case also the rearing beds are prepared as in paraffin paper method of rearing (Fig.). The boxes are piled, on top of another for rearing first age larvae. For rearing second and third age larvae a space of 2 to 3 cm is provided between each two boxes by keeping wooden strips for ventilation. The boxes are kept open for atleast 30 minute prior to each feeding, and completely when the larvae start to settling for moult. In this method

also chances of incidence of muscardine are quite high and as such prophylactic measures as detailed under paraffin paper method of rearing should be adopted.



Rearing in boxes without lids

Environmental Conditions for Rearing

The ecological factors, chiefly temperature, humidity, light and air during rearing, have a significant influence on the growth of larvae and ultimate cocoon crop quality. The influence is not the same throughout the rearing period, but varies in different stages of growth. The conditions ideal for the young age rearing and the principles of how they affect the health and growth of silkworms are discussed below.

Temperature

Silkworm being a poikilotherm, the body temperature is changeable according to the environmental temperature. The physiology of silkworm viz., metabolic rate, activity of enzymes, nutrients conversion, assimilation *etc*., is influenced by environmental temperature. Though silkworms are capable of growing in temperature range from 15°C to 40°C, from the physiological point of view the ideal one is from 20°C to 30°C and the one desirable for maximum productivity is from 23°C to 28°C. The

temperature requirement during the early (I, II &III) and late (IV &V) instars are differenthigh during the early and low during late age, within the optimum range (23-28°C). Optimum rearing temperature during early instars (I to III) as obvious from many reports, range from 25°C-27°C. Generally, the early instar larvae are resistant to high temperature and it also help in improving survival rate and cocoon characters. The principles of rearing technology as presentlypracticed in India have taken into consideration all these observations. The standard rearing temperature recommended for first, second and third instars are 27°C, 27°C and 26°C, respectively (Table).

Maintenance of optimum temperature

If the rearing room temperature is below the optimum, the simple way is to heat up the rearing room and raise the temperature. Electric room heaters or charcoal stove can be used for this purpose. Under South Indian conditions, such situations are limited to night times, especially in winter. The temperature, more often, is above the optimum. Airconditioning is costly. Proper designing of rearing building, use of thick walls and roof, free circulation of air, *etc*.,are required.

Humidity

Humidity plays a vital role in silkworm rearing. The effect is both direct and indirect. It directly influences the physiological functions of silkworms. For example, the amount of ingestion, digestion and metabolism increased with the rise in relative humidity. The pHvalue of the blood is remarkably lower at high humidity (RH 80-90%) than at low humidity (60% RH) conditions. Expiration of CO_2also increases with the rise in relative humidity. Indirectly, humidity affects the rate of drying of leaves in rearing bed, it's suitability as a feed,consumption etc. Low humidity' causes, fast drying of mulberry leaves in the bed, lesser consumption, retarded larval growth and larvae become weak and easily susceptible to diseases.

It is clearly understood that early instar larvae are more resistant to high humidity and it supports better survival rate and maximum growth. Considering the overall effect, humidity ranges of 85 to 90% in first and second instar and 80% in third instar, are recommended (Table).

Table: Temperature and humidity requirement during young age silkworm rearing

Particulars	Instars		
	1	2	3
Temperature	27ºC	27ºC	26ºC
Humidity	85-90%	85-90%	80%

The humidity requirement duringfeeding and moulting stage in silkworm is different. Comparatively high humidity is maintained during feeding. Low humidity (10%RH) is preferable during moulting.

Humidity maintenance during young age silkworm rearing

Regulation of humidity for young age silkworms is achieved through the use of paraffin paper as cover for the rearing bed and the wet foam or paper pads. It should be understood that rearing humidity above 90% is not at all desirable. In rainy seasons, when the room humidity is high, it is not necessary to use the wet foam pads. Even piling of trays can be avoided, when room humidity is extremely high. Paraffin paper seat or cover also can be dispensed with judicially when humidity is very high.

Light:

Silkworms are fond of dim light of 15 to 30 lux and avoid very strong light and darkness. Light has little influence on the health and survival ability of silkworms, but it influences distribution of larvae in rearing bed. It is more crowded and distributed in several layers in dark condition compared to thin and even distribution in light condition. There is a profound influence of photoperiod on the early instars on the type of eggs produced (hibernating/non- hibernating) by the resulting moth. But, this is of no importance in commercial rearing. The effect of light during rearing on appearance of trimoulters and nonspinning larvae is yet to be proved conclusively. A photoperiod of 16 hours dark and 8 hours light is considered ideal for young age rearing.

Air:

The composition of air and its circulation in the rearing room are important,considering the effect on silkworm growth and in regulation of room temperature and humidity. In the rearing room, the air is polluted by CO_2 from silkworm rearers and mulberry leaves, formaldehyde gas from disinfectant, ammonia from silkworm excretaand sulphur dioxide from burning of coal. The safe limit for

silkworm rearing is 1 to 2% of CO_2formaldehyde gas up to 1 %, 0.02% of sulphur dioxide and 0.1 % ammonia, in the air in rearing room. Most of these gases when excess in rearing room, affect the health and survival rate of silkworm. The young age silkworms are less resistant to toxic gases, though comparatively resistant to CO_2. However, these substances are produced, during young age rearing, in comparatively far less quantity than in later age rearing. Accordingly, aeration for the purpose of letting in fresh air dispelling foul air, is also of less importance during young age rearing. Though it is less important to ventilate the room during younger stages, care shouldbe taken to remove paraffin cover and keep the rearing bed open, before each feed, for adequate period.

Feeding:

The purpose and key points of feeding of silkworms are as follows:

(i) To satisfy the appetite of larvae.

(ii) To promote eating and digestion of leaves by larvae.

(iii) To keep the quality of leaves good during eating.

(iv) To keep rearing beds clean.

(v) To avoid wastage of leaves and labour.

Generally the early age silkworms eat leaves from the surface while late age worms from the edges. At the beginning of each age the worms have a great appetite. This appetite falls off very rapidly in the early part of the age and then goes on gradually increasing till close to the end of the age, when it again declines as the worms reach the moulting time.

Selection of mulberry leaves for the young age silkworms

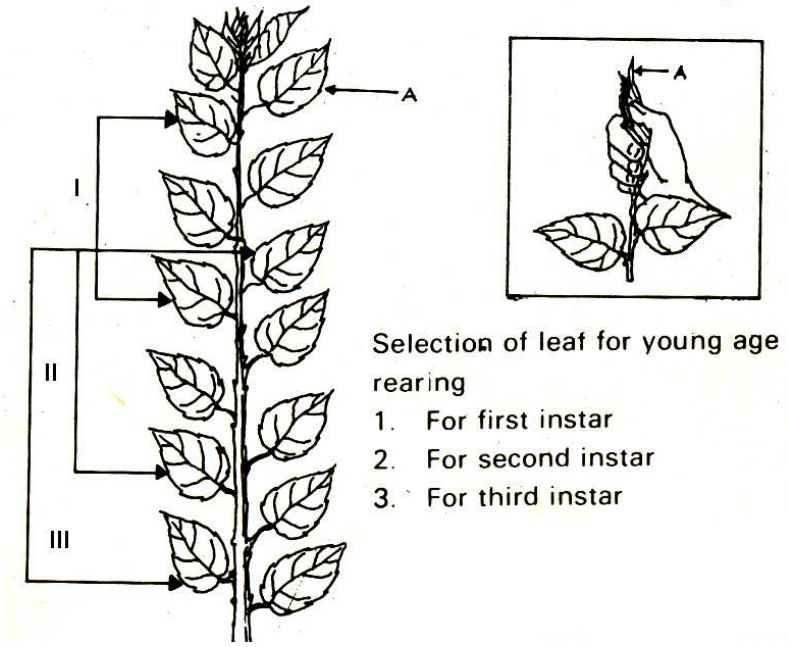
Mulberry leaves for young silkworms must be soft and rich in water content, protein, carbohydrates, *etc*.,. The high correlation of the moisture content in the top tender leaves and the young age silkworm growth rate and moulting ratio is known. For plucking the correct leaves for young age rearing, the largest glossy leaf method is adopted. The largest glossy leaf is the one light green and glossy, being the largest among the first few leaves on the top of the shoot. This can be identified in a fully grown shoot, by scooping the top leaves and marking the largest leaf by its tip (Fig.). From the one below the largest glossy leaf, 5 or 6 leaves for I instar, 6-7 1eaves for II

instar and 7-8 leaves for III instar are used in young age silkworm rearing.

Generally there are two methods are used for leaf harvesting

1. Individual leaf harvesting
2. Shoot lets harvesting

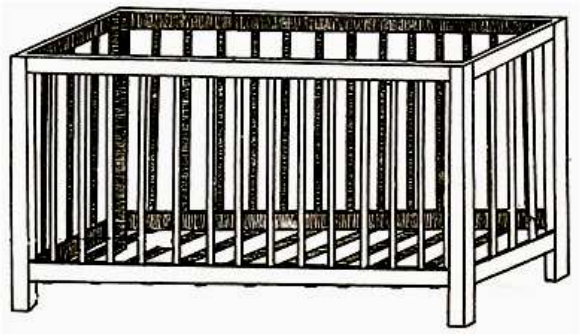
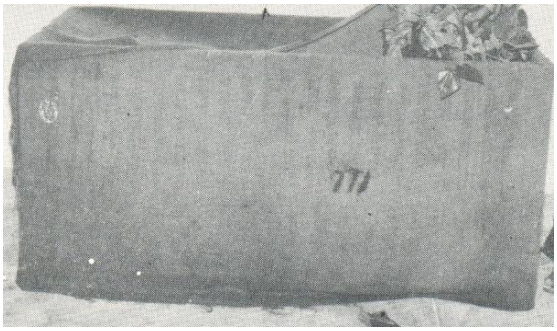
In both the methods same type of leaves are selected for feeding the chawki worms.



Selection of leaf for young age rearing

1. For first instar
2. For second instar
3. For third instar

Mulberry leaves for early age silkworms are to be harvested in the cool time of the day *i.e.*, early morning or in the late evening and should be preserved in the cool and wet condition in order to prevent them withering. Immediately after leaf harvesting, leaves are preserved in suitable containers like leaf bins (Fig.), where the humidity must be maintained close to 100 % RH by repeated sprinkling or spraying of water over the gunny or cloth surface of the container. If containers are not available they should be at least covered with wet cotton cloth or gunny cloth. The cloth used to cover leaves should be clean as far as possible.

Mulberry leaves should be chopped in order that they are supplied to silkworms evenly. The size of chopped leaves is variable according to the form of leaves, that is entire leaves or shoot lets.

The following size is an example of leaves supplied to chawki worms.

	Chopped leaves (mm square)	Chopped shoot lets (mm square)
For first instar	6-12	12-18
For second instar	12-18	18-24
For third instar	18-30	24-entire shoot lets

Generally the size of chopped leaves and chopped shootlets is smaller at the earlier age and premoulting stage of each instar, and large at the voracious age of each stadium.

For example, 0.5 – 1 cm square can be gradually raised to 1.5 to 2 cm squares by the end of first instar. Also, the leaf size started with 2 cm squares and increases to 3-4 cm squares by the end of second instar.

Regarding the amount of mulberry leaf to be supplied to silkworms and the times of feeding, they are variable according to the rearing temperature and RH, ventilation of the rearing room, area of rearing bed, form of mulberry leaves (chopped, entire leaves, chopped shootlets, entire shootlets). In general, in case of paraffin paper rearing or box rearing, the amount of mulberry leaves supplied to silkworms and the times of feeding are as follows (For one egg box *i.e.*, 20,000 eggs).

	Amount of mulberry leaves (g)	Feeding Times per day	Temperature °C	RH %
First Instar	1125-1350	3	27	90
Second Instar	2813-3375	3	27	90
Third Instar	13023-14000	4	26	80

As mentioned above, silkworms are supplied with mulberry leaves 3-4 times per day, but in this case the rearing temperature, humidity and the area of the bed (spacing) must be regulated in the range of standards.

However, in Karnataka state, during wet weather, when the atmospheric humidity as well as moisture content in the leaf is on the higher side, only 3 feeds need be given at 6am, 1pm and 8pm. During other seasons including summer months, however 4 feeds may be found necessary, which may be given at 6am, 11am, 3pm and 8 pm. The leaf requirement for 100 layings (with average 400 eggs per laying) during first stage will be about 2-2.5kg for improved MV hybrids and 2.5- 3kg for new BV hybrids. For second age worms, the leaf requirement will be 6-7 kg for the improved MV hybrids and 8-9 kg for the new BV hybrids. Recently some of the rearers tried to feed entire leaves right from the time of brushing and succeeded. But still there is a diverse opinion about the entire leaf feeding method.

BED CLEANING

Normally a much larger quantity of mulberry leaves has to be fed than is eaten by the worms. It is obvious, therefore, that a sizeable quantity of unconsumed leaves, more or less in a state unfit for food, remains over in the tray at the end of each feed. In addition to this, there are excreta which the worms are passing, and the whole forms a thick and often damp bed which ought not to be allowed to remain. It is estimated that about three-fifths of the total weight of leaf taken as food during the rearing is thrown out again as excreta, only two-fifths being assimilated by the worm. The piling of litter makes beds moist and releases processes of fermentation, thus generating injurious gases and favouring multiplication of pathogenic micro-organisms. This imperils the health of the worms. In order to keep the silkworms healthy, the litter piled on rearing beds together with waste mulberry leaves, *etc*., should be periodically removed. This process is called "Bed cleaning".

Frequency of cleaning

From the standpoint of health and sanitation of the worms, it would appear that more frequent the cleaning, the better it would be, but in practice there are important limitations. In the first place, cleaning involves labour and the frequent cleaning will distort the economics of silkworm rearing. But the more important point weighing against

too frequent cleaning is the loss of worms which is an inevitable occurrence of each cleaning. Especially in the early stages, the loss of worms in cleaning tends to be very high. Having regard to the above, the following schedule of cleaning could be adopted profitably:

I age - Once

I age - Twice *i.e*., once just after the I moult and again before settling for I moult.

III age - Thrice *i.e*., once after moult, once in the middle of the III age and once just before settling for IV moult.

Methods of cleaning

There are three methods of cleaning; *viz*., (i) cleaning with husk; (ii) cleaning with net and (iii) cleaning with husk and net.

Cleaning with husk:A thin layer of paddy husk is sprinkled evenly over the bed so as to cover the same completely. This is done generally just prior to first feeding in the morning. The worms crawl through the layer of husk to get at the feed of leaves. After a few hours when the second feeding is given the bed is ready for cleaning. The worms are swept together by a brush and transferred to another tray. This method is advantageous in that immediately the husk is applied, the worms begin to crawl through and thus get separated from the old bed.

It is however to be noted that naturalsized paddy husk is a little too big and too thick for worms in the first two ages, and so the layer becomes very thick and solid for the free passage of the worms. For these ages, therefore, the husk should be pounded and broken into small pieces before use with the young worms. But care must be taken to ensure that it is not broken up completely into powder. In fact,husk powder should be carefully winnowed from the broken husk before use. Husk powder is just as much dirt as dust and chokes up the worms and spoils the leaves fed to them. Care should be taken, when the worms are young, that the layer of husk sprinkled is thin and not so heavy as to hindertheir movements. Of late, charred paddy husk is being used in place of ordinary husk. When the worms are in the 3rdage, there is no need to pound the husk; when they have passed the 4thage, chopped straw may be used instead of husk with advantage.

Formalinised charred husk when used for cleaning helps avoid attacks of muscardine disease.

Cleaning with net: In this a net with mesh suited tothe size of the silkworms is spread over the bed just prior to the first feeding in the morning. As in the case of husk method, cleaning is done after the second feeding is given. This method is simple besides requiring very little labour and is quite popular in West Bengal. In Karnataka, it is just being adopted by the enlightened rearers. However, it is not so convenient for purposes of spacing as the size of the bed remains restricted to the size of the net as the worms cannot be easily separated from the net (Fig.).

Generally, the following mesh sizes are used for cleaning nets:

First and Second instars --0.5 cm^2

Third instar --1 cm^2

Combined husk and net method: In this method, a thin layer of paddy husk is first sprinkled over the bed and a net of suitable mesh is superposed on it. Two successive feedings follow where after the net with the worms on it is transferred to another tray. This method combines the cleanness of the husk method, with the ease of transference of the net method and requires less of skill and care in manipulation than the former; but it is more expensive than either and has some inconvenience in regard to spacing as in the case of net method.

It is however to be mentioned that the general practice even now is to resort to the old method of cleaning. In this no husk or net is used. The worms, if in earlier stages, up to III moult, are simply swept together with a feather and transferred to another tray. The worms are then spread out using chopsticks or feather, to form a freshbed. The worms in IV and V stages are also collected by hand and transferred to new trays. This method is likely to cause injury to the worms and is perhaps one of the main causes for the "missing larvae" in our rearings which depress our cocoon yields. If the cocoon crops areto be

stabilized, the farmers must be weaned away from this antiquated and crude method of bed cleaning.

It is remembered that, under the traditional system of bed cleaning about 25-30% of worms will loses. Under the improved method of bed cleaning, the loss of worms during chawki rearing is minimum i.e., less than 10%. Again these worms being more robust, the mortality at the later stage is also considerably less and consequently, the total loss of worms is also minimum, which may be of the order of 15-20% only. Thus the ERR (effective rate of rearing) will be 80-85%.

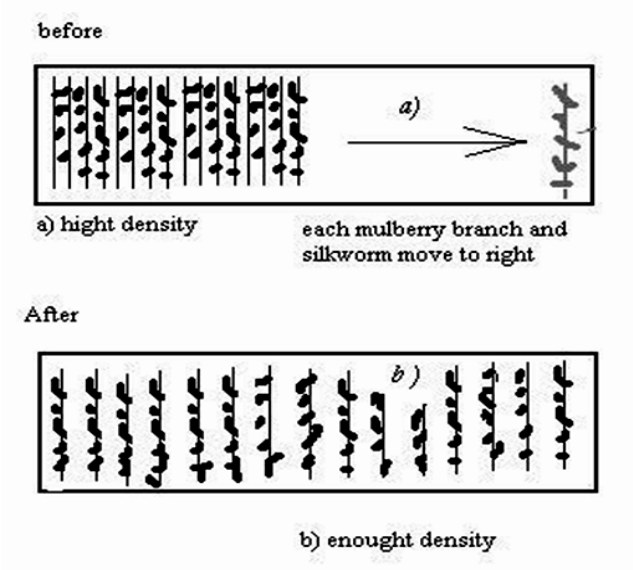
SPACING

Purpose of spacing

Silkworm is a very fast growing animal and records a 10,000 fold increase in weight and about 7,000 fold increase in size during the short span of 20 to 30 days. The above figures clearly establish the need to extend the rearing beds from time to time in order to avoid overcrowding of the worms and thus to provide for their orderly growth. The purpose of spacing is to achieve this objective. At present, however, there is a tendency among farmers to overcrowd the worms, either for want of rearing equipment or for the purpose of conserving on mulberry leaf. The latter objective is very irrational as crowded conditions of rearing lead to under-nourishment and uneven development of the worms in the bed and naturally to sub-standard harvest. Crowded conditions also increase accumulation of gases, heat and fermentation of faecal matter particularly during the early age when the temperature and humidity in the rearing beds are high. Under such unhygienic conditions, the worms do not feed freely on the leaves even though fresh and good quality leaves may be available in sufficient quantity. This results in unequal and unhealthy growth of larvae and often leads to crop losses.

Sparse spacing of silkworms is also not desirable as it leads to wastage of mulberry leaves. In later stages it also calls for larger number of rearing trays and the consequent increase in labourrequirement for handing the rearing. Optimum spacing therefore to be accomplished through experience.Normally it would be sufficient if rearing space is doubled or trebled from first instar to third instar. In the fourth instar it may be found necessary to increase the space, by two or three times and again in the fifth instar two times. Thus, the rearing space will have to be increased by 80 to 100 times from the time

of brushing till the time of ripening of the worms for spinning.



The spacing to be provided for different stages of silkworms of 50 layings or a box of 20,000 eggs is given below.

Age	At the beginning of each age (Sq.mt)	At the end of each age (Sq.mt)
For Uni and Bivoltines		
First age	0.2	1.0
Second age	1.0	2.0
Third age	2.0	5.0
For MVxBV hybrids		
First age	0.2	0.5
Second age	0.5	1.5
Third age	1.5	3.0

Time and frequency of spacing

As spacing is intended to provide room for the worms as they grow, it follows that theoretically, spacing ought to go on simultaneously with the continuous development of worms and that, at least, it should be given at each time of feeding. But in practice this is quite impossible and therefore, the method adopted is to give spacing at convenient intervals, allowing at each interval enough room to provide for the development which takes place till the time comes for the next spacing.

As already mentioned, the development of silkworms is most rapid in the first age and therefore, the spacing has to be frequent. The first spacing should be given on the day after the worms are brushed and henceforward spacing should be done every day, till the

day when the worms show signs of going into moult. It would of course be advantageous to combine spacing with cleaning as it would help save labour and also ensure more even expansion of rearing space.

In the 2nd to the 5th age, generally spacing is combined with cleaning. It may be found necessary to provide more spacing when the humidity and temperature are higher than optimum. The rearing trays are also kept in alternate shelves of the rearing stand. This enables free circulation of air in the rearing bed and thereby ensures reduction in temperature and humidity in the bed.

Methods of spacing

There are two methods of spacing *i.e.* either conducting it independently or incombination with cleaning. In the former case, where the object is just to spread out the worms over a more extended bed, a convenient way is to mark out on the tray the limits of the space desired, and to distribute worms on it by picking out worms from the parts of the bed where they are thickest, so that in the end, they are evenly distributed over the whole of the increased space. Where spacing is combined with cleaning by husk and net, the worms are taken as a whole from the old bed, and distributed evenly over a new bed of the required space. This is most convenient and satisfactory. When cleaning by net alone is done, the process becomes slightly more complicated, as it will be similar to independent spacing.

MOULTING AND CARE AT MOULTING

The silkworm casts off its skin four times during its life of 20 to 30 days to provide for its growth. This is called moulting. This is a very sensitive period in the lifeofthe silkworm, when it does not feed but just tries to wriggle out of the old skin. Unless care is taken to stop the feeds and also to resume the same after the moults in proper time, uniformity in growth of the silkworms cannot be secured.

At the approach of moulting, the silkworms attain their maximum body growth for the particular instar and as a result the body of the silkworm becomes stout, shiny and amber coloured. In relation to the size of the body, the head of the worm about to moult appears quite small and also somewhat dark. It is desirable that a bed cleaning is given just at this time and the worms are spaced out. Leaves also could be cut to a smaller size for feeds just prior to moulting. As soon as all the worms have settled down for moult, the feeding

is stopped. It is also advantageous to sprinkle lime powder after the last feed. This prevents the worms which have come out of moult early from commencing eating of leaves and thus causing uniformity in growth. Further, application of lime helps to keep the bed dry during moulting.

The larvae normally take 15 to 30 hours to complete moulting during the different instars. Worms out of moult have a rusty colour and the head also appears bigger compared to its size at the time of going for moult. From these, it becomes easy to identify the moulting as also out of moult worms easily.

The first feeding of the new instar should start only after all the worms have come out of the moult. In localities where muscardine is prevalent, it is desirable to take anti-muscardine precautionary measures by dusting ceresin lime on to the newly moulted worms prior to the first feeding.

If any irregularity in settling for moult is observed, the late larvae may be segregated through net feeding and reared as a second batch. It is however of very great importance that the rearing bed should be as dry as possible when the worms are in moult. This enables the silkworm to crawl out of the skin easily thus securing uniformity of moulting. Since the newly formed skin is thin and delicate, under more humid conditions the worms become susceptible to fungal attacks. Therefore, it is very essential that the silkworm beds are kept dry during the moult.
