

**Intermediate
Vocational Course
Second Year**

**NON MULBERRY
SILKWORMS AND
MULBERRY REARING
REQUIREMENTS
for the Course of Sericulture**

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NON MULBERRY SILK WORMS

1.1 INTRODUCTION

The natural silks are broadly classified as mulberry and wild or non-mulberry. Non-mulberry sericulture is universally known as forest or wild sericulture. Tropical and temperate tasar, eri, muga and anaphe are the principle non-mulberry silks. Other varieties i.e. fagara, coan, mussel and spider silks are limited interest, Nearly 95% of the global production of non-mulberry silks is tasar.

All branches of sericulture require food plants and manpower. In mulberry sericulture over 60% of the cost of production goes into raising and maintaining the food plants, besides a heavy initial investment is necessary for rearing houses, rearing appliances and other essentials. Like wise, among the non-mulberry varieties, eri has the disadvantage of higher production costs. Tasar is endowed by nature with vast potential. But continuous deforestation resulted in depletion of non-mulberry food plants. One should not forget that non-mulberry sericulture holds great promise for the world forestry as a supplementary activity.

Non-mulberry sericulture is a forest-based industry uniquely suited to the economy and social structure of developing countries because of its minimum investment requirement, high employment, and foreign exchange earning potential.

In India about 12,43 million hectares of unexploited tasar food plants in the tropical and temperate belts could be put to use without investment. Moreover, unlike large industries in which heavy investment is indispensable and the employment potential is limited, tasar culture requires a very low investment for net high returns. Various operations of tasar production can be carried out even in remote forest villages as they do not require electricity, complex machinery, specialized skills etc. Non-mulberry production offers rural population an attractive source of income, arrest their migration to urban areas, thereby preserving their traditional skill and way of life.

In view of the advantages, important non mulberry silks are detailed in this chapter.

1.2 Distribution

A large number of species (400-500) are used in the production of non-mulberry silks. But only eight have been commercially exploited in Asia and Africa tribal communities. They are Tasar silk, Muga silk, Eri silk, Anaphe silk, Fagara Silk, Coan silk, Mussel silk and Spider silk.

Non-mulberry silks are commercially produced mainly in China and India. However major share of production (80%) goes to China. Climate and vegetation provide India with an abundance of non-mulberry sericigenous fauna. India produces significant amounts of all the important varieties of non-mulberry silks, tropical and temperature tasar, eri and muga (Fig. 1.1).

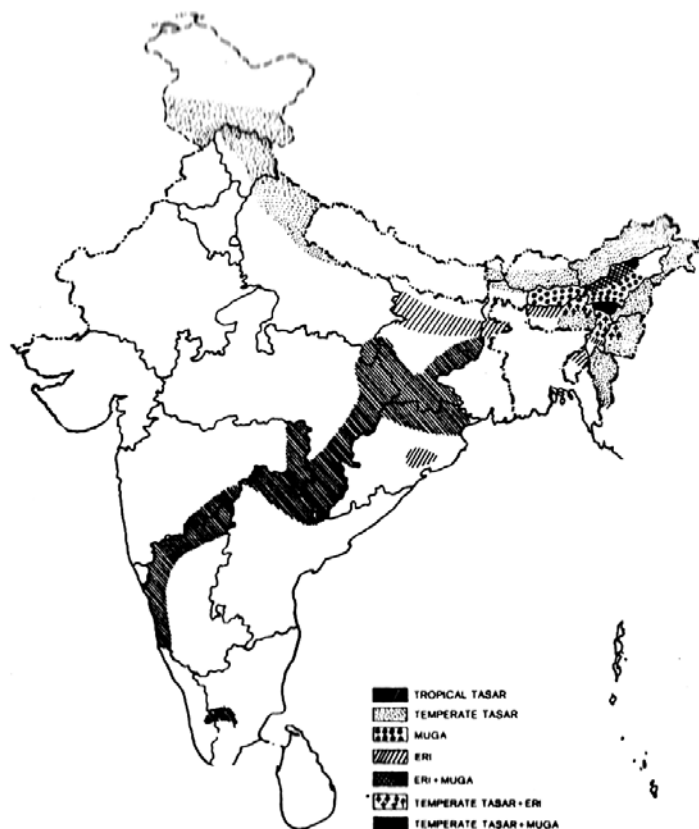


Fig. 1.1. Non mulberry silks in India

1.3. SALIENT FEATURES OF NON-MULBERRY SILKWORMS

1.3.1 Tasar Silk

These are reared in the tropical and temperate zones. Four species of the genus *Antheraea* (Hubner) are used for commercial production. They are as follows.

Tropical tasar silkworm	<i>A. Mylitta</i> , D (India)
Temperate Silkworm	<i>A. Proyli</i> , J. (India)
	<i>A. Pernyi</i> , G.M. (China, USSR)
	<i>A. Yamamai</i> , (G.M. Japan)

Antheraea comprises more species than any other genus of sericigenous insects. So far thirty five species have been recorded (31 in the Indo-Asutralian biogeographic region, 3 in Palearctic region, one in USA). These are uni or bivoltien types.

1.3.1.1. Tropical Tasar (*A. mylitta*)

These are in dense, humid tropical forest of central and southern plateau of India. The major cocoon-producing districts are Sginghbhum and Santhal Pargana in Bihar, Raigarh and Jagdampur in Madhya Pradesh; Mayurbhanji and Keonjhar in Orissa; Purulia and Bankura in West Bengal; Bhandra in Maharashtra; Adilabad, Warangal, Karimnagar, Khammam, Mahaboobnagar, Visakapatnam of Andhra Pradesh; Belgaum in Karnataka.

A. mylitta feeds on Terminalia and produces a special type of silk. The life cycle and rearing is as follows.

LIFE CYCLE

Eggs are oval, dorsoventrally flattened and bilaterally symmetrical along the enteroposterior axis. Each measures 3mm in length and 2.5mm in diameter, weighing 10mg. Eggs are white, light yellow or creamy. Two brownish parallel lines along the equatorial plane of the egg divide the surface into three zones (disk, streak, edge). Eggs hatch in 3-5 days (Fig. 1.2).

Larvae are eruciform and possess a hypognathous head with biting and chewing mouth parts. Newly hatched larva is dull brownish yellow with black head, measures 7 x 1 mm and weighs about 8 mg. after 48 hrs. larval body turns green and head becomes brown. Occasionally yellow, blue and almond coloured larvae are also found. Mature larva weighs 50 grams and measures 13 x 2.1 cm. each larva passes five instars. The larval duration is 26-28 days (first crop); 42-45 days (second crop); 55-60 days (third crop). The prothoracic hood of the first instar larvae dorsally bears an oval black spot, which early in the second

instar becomes M-shaped, later on V-shaped with two dots. These are absent in third instar, but appear in the fourth and fifth instars as two semilunar red markings. The anal flap has a triangular black mark early in the first instar, which becomes V-shaped and brownish from second instar onwards. Sexual marking appear late in the fifth instars as milky white spots on the ventral surface of the eighth and ninth abdominal segments (Fig. 1.2). In all instars the larvae possess five types of tubercles (dorsal, upper lateral, lateral, lower lateral, caudal). They are black in the first instar, orange red in the second and violet in the third to the fifth. White, minute hairs are distributed irregularly all over the body. Setae are of two kinds. Silver shining spots appear during the third instar of second to seventh abdominal segments.

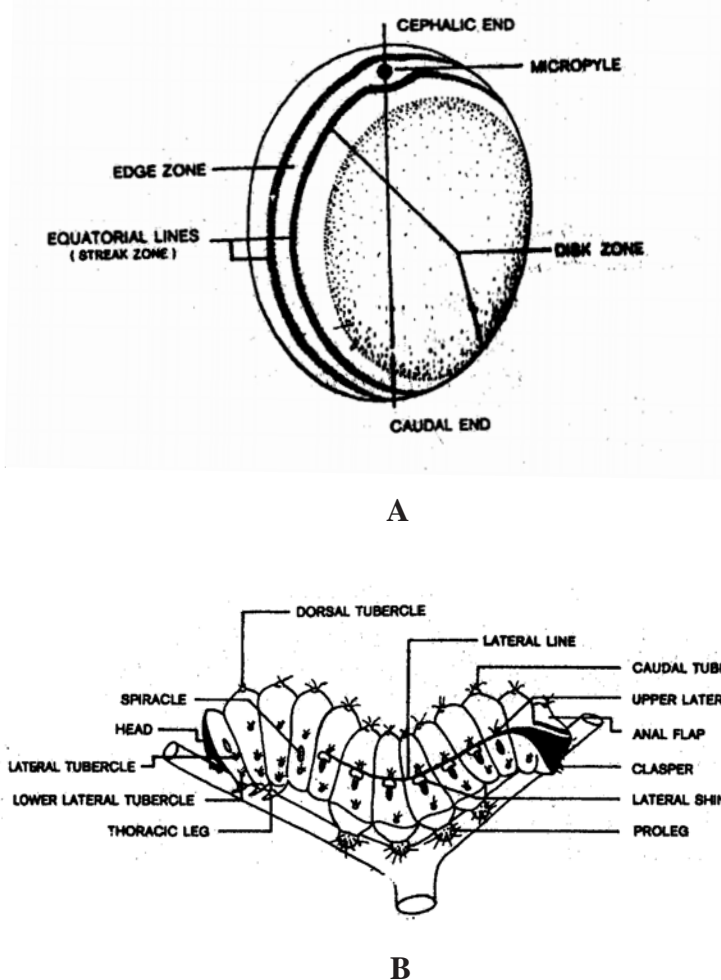
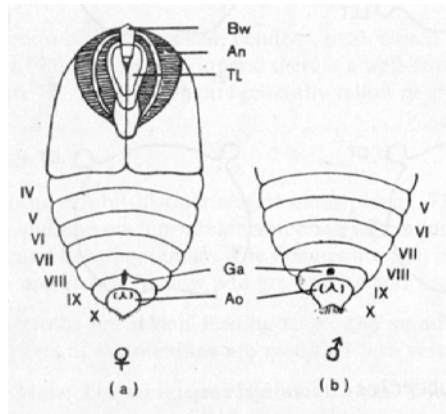


Fig. 1.2. *A. mylitta* (A) egg (B) larva



Abdomen Segments

(a) Female; (b) male

Key : bw = brain window, An = antenna
TL= thoracic leg, Ga - genital apperture
Ao = anal opening

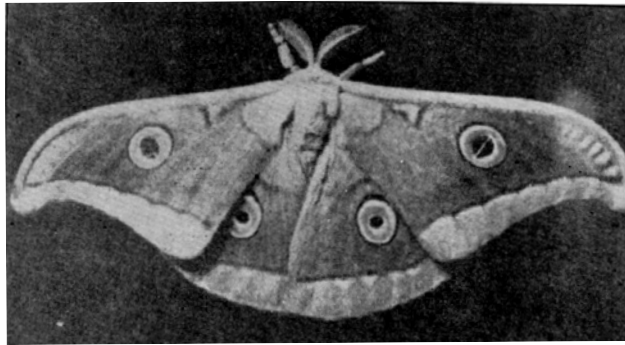
Fig. 1.3. *A. mylitta* (A) Pupa (B) Cocoon

Pupa is obtect adectious with segmented, dark brown colour body measuring 4.5x2.3 cm and weighs 10.3 grams. The sexual markings are on eighth and ninth segments. (Fig 1.3).

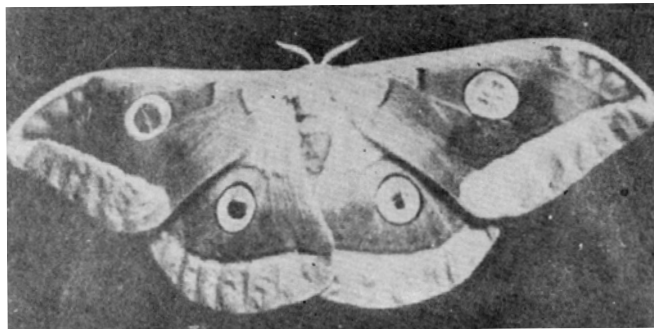
Cocoon is single shelled, pendent, oval, closed and reelable, non-flossy with fine grains (Fig. 1.3). the anterior end has dark brown peduncle with a ring at the distal end. Cocoons are yellow or grey.

Moths exhibit sexual dimorphism. The females are bigger (4.5cm) with a bipectinate antennae (1.5cm long) and broad abdomen. Males are smaller (4.0cm) with broad antennae and narrow abdomen (Fig. 1.4). Male wing span is about 16 cm. the area of fore wing is about 2121 mm² with a centrally positioned ocellus (70mm²). While hind wing is about 1584 mm² with an ocellus of 50mm². Female wing span is 18 cm. The fore wing is about 2350 mm² with ocellus (85mm²). The hind wing is 1850mm² size with ocellus (25mm²)

The colour of ocelli is same in both sexes. Wing scales, wing venation are specific. The last four abdominal segments (7-10) are modified to form the genitalis (Fig. 1.4).



Male



Female

Fig. 1.4. *A.mylitta* Moth

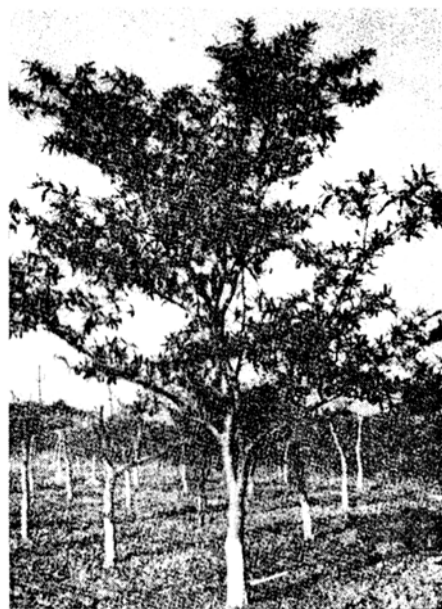
REARING

Tasar silkworm is polyphagous. The primary food plants are eight types. Besides more than two dozens of secondary food plants.

1. *Terminalia tomentosa*, W & A (Fig. 1.5).
2. *T. arjuna*, W&A (Fig. 1.5).
3. *Shorea robusta*, Roxb
4. *Lagerstroemia parviflora*, Roxb.
5. *L. Speciosa*, Pers.
6. *L. indica*, Linn.
7. *Zizyphus mauritiana*, Lam.
8. *Hardwickia binata* Roxb



T. tomentosa



T. arjuna

Fig. 1.5. Food Plants

Outdoor rearing causes 50-5% (during early instars) loss besides 35-40% loss due to diseases, pests. Hatched larvae are placed on the Terminalia leaves. Since the larvae are exposed to natural conditions, the fate of the crop largely depends on choice of rearing site and food plants, brushing, supervision and maintenance of larval population and other rearing operations (Fig. 1.6).

The cocoons are collected from the branches of food plants and marketed. The produce is measured in “**kahans**” (1 kahan=1280 cocoons) and sold in local numerical lots, which are as follows.

Ganda (4 cocoons)

Pan (80 cocoons)

Kahan (1280 in Bihar, 1600 in Orissa, 1000 in MP)

Khandi (4000 in Maharashtra)



A



B

Fig. 1.6. A) Outdoor Rearing B) Grainage

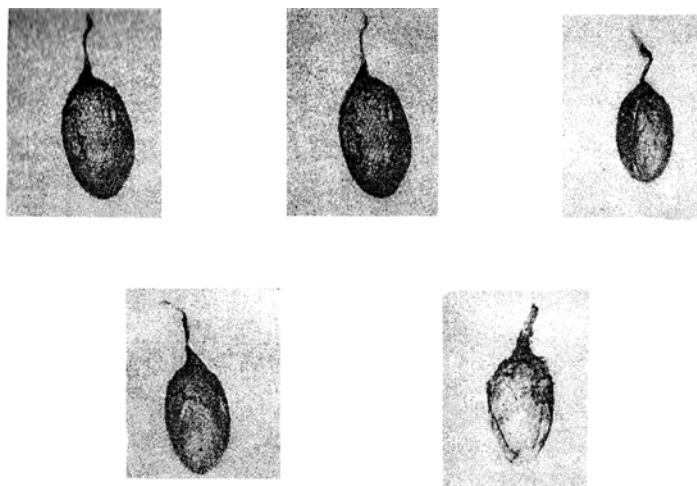


Fig. 1.7. Cocoons of Temperate Tasar

1.3.1.2. Temperate TAsar (*A. Proylei*)

This is an hybrid worm. The oak tract extending from Jammu and Kashmir in the West to Manipur in the east, embracing Himachal Pradesh, Uttar Pradesh, West Bengal, Sikkim, Assam, Arunachal Pradesh, Meghalaya, Mizoram and Nagaland inhabits the temperate tasar silkworm. The food plants is oak plant. There are five species in temperate tasar.

1. *A. proylei*, Jolly (Fig. 1.7.a)
2. *A. roylei*, Moore (Fig. 1.7.b)
3. *A. pernyi*, Guerin-Meneville (Fig. 1.7.c)
4. *A. yamamai*, Guerin-Meneville (Fig. 1.7.d)
5. *A. polyphemus*, Cramer (Fig. 1.7.e)

The primary food plants are

1. *Quercus incana*
2. *Q. Serrata*
3. *Q. delabata*
4. *Q. himalayana*
5. *Q. semiserrata*

The morphological features of life stages and rearing aspects are similar to *A. mulitta*.

1.3.2. Muga Silk

The golden yellow silk is secreted by multivoltine silkworm *A. assamensis*, distributed in Assam. The popular items made from this silk are 'dhoti', 'chaddar', 'chapkan', 'pugree' and 'mekhala'. Commercial rearing is practiced in Sibsagar, Lakhimpur, Nowgong, Darrang and other districts. If the larvae are fed on mejankori leaves (*Litsea citrate*)/ *A. assamensis* produces mejankori silk. This silk is very much admired for its durability, luster and creamy white shade. The muga reeling and weaving are done at Sualkuchi village.

LIFE CYCLE

The eggs are brownish measuring 2.8x2.5 mm in size and 9mg in weight.

Newly hatched larva has prominent black intersegmental markings on yellowish body and brown head. It measures 7 mm length and weights 7mg. The mature larvae measures 9X2cm in length and weighs 15 gr. In third instar the prothoracic hood markings consists of two prominent rectangular black marks which are replaced by semilunar dark brown markings in the remaining instars. The hind flap carried rectangular black mark (III instar) which becomes U-shaped in IV instar and finally changes to a 'V' (V instar).

The pupa is copper brown measuring 3.2 x 1.8 cm and weighs about 5.7 gr.

The cocoon is single shelled, light brown, oblong, closed, reelable and slightly flossy with a weak peduncle (Fig. 1.8). It is golden brown or glossy white measures 5.2 x 2.4 cm and weighs 6.3 gr.

Female moths are longer (3.5cm) than males (3 cm). the wings are brown rarely with a pinkish tinge. Wing span in males is about 13 cm and 15 cm in females (Fig.1.8).

Wing area	Male	Female
Fore wing	1662 mm ²	1857mm ²
Hind wing	1181 mm ²	1351 mm ²

REARING

The polyphagous silkworm feeds on *Machilus bombycina* King (Som) and *Litsaea monopetala*, Pers. (Scalu). Other food plants include *L. citrata* Blume; *L. salicifolia*, Roxb. Ex.Wall; *Michelia oblonga*, Wall; *Cinnamomum obtusifolium*, Nees; *Symplocos grandiflora*, Wall.

The polyvoltine is reared outdoors except for indoor cocooning. Rearing is conducted round the year (5-6 crops per annum). These crops are designated by local names based on rearing months (Jarua, Jethua, Aherua, Bhadiya Kotia). Kotia and Jethua are large scale crops for the production of reeling cocoons, other crops are stored for seed and stock.

Hatched larvae along with kharikas are tied to main trunk of the food plant. The larvae crossing the barrier are collected using bamboo sieve known as 'chaloni' (Fig. 1.10) which is hung on a leafy twig. Mature larvae are placed in a pit or bamboo basket, above which jail (cocoonage) is placed.

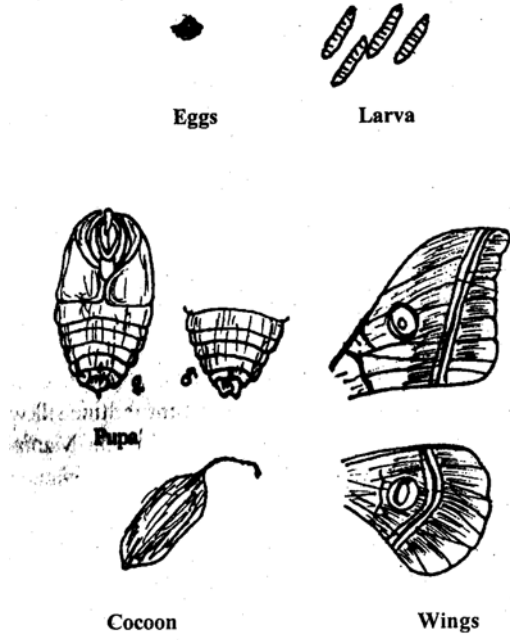


Fig. 1.8. Life Cycle of Muga

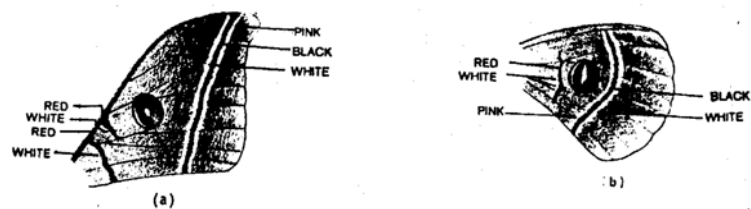


Fig. 1.9. Female Moths Wings

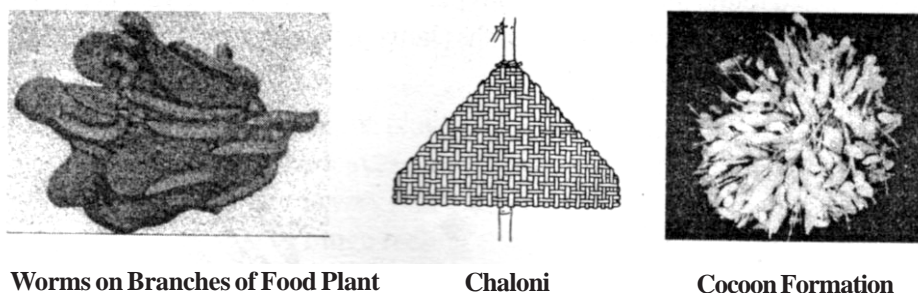


Fig. 1.10. Muga Rearing

1.3.3. Eri Silk

The white or brick – red eri silk (endi, errandi) is produced by *Philosamia ricini*, B. a domesticated multivoltine silkworm. It is widespread in Assam and also practiced in Bihar, West Bengal, Manipur, Orissa and Tripura. Among the non-mulberry varieties, eri has the disadvantage of higher production costs because it is made from domesticated silkworms.

LIFE CYCLE

The eggs are ovoid, candid white measure 1.5 x 1.0 mm and weight 6 mg.

On hatching the larva is greenish yellow measuring about 5 x 1 mm and weigh 1.5 mg. the larval body colour changes gradually to pure yellow by the end of third day. From third instar onwards the body colour segregates into yellow, cream, green, blue or white. Mature larvae measures about 7.0 x 1.5 cm and weighs 8 gr. Is translucent and covered with a white powdery substance. Spotted and unspotted larvae are found. The spots are of various types i.e. single, double, zebra and semizebra (Fig. 1.11). The prothoracic hood of the first-instar larva has a black dorsal band, which splits up into a pair of crecent shaped markings in the second and third instar. These markings disappear at the fourth instar. The planta, anal flap and claspers are light yellow throughout the larval span. The tubercles, setae are also present.

Pupa is obtect, adectious measures about 2.8 x 1.5 cm and weight about 2.6 gr.

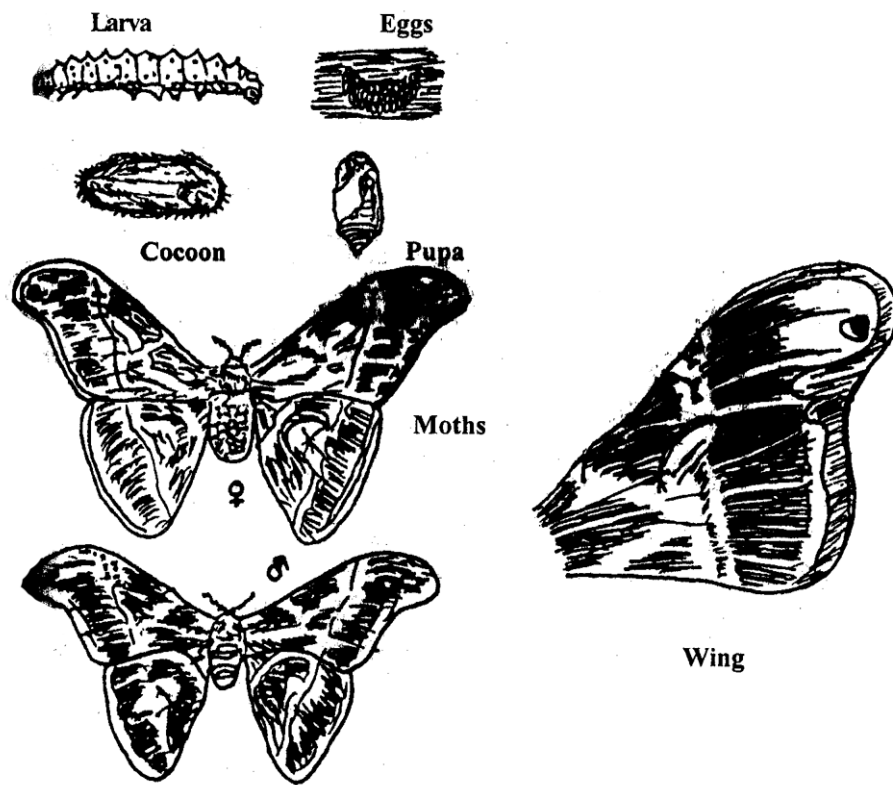


Fig. 1.11. Eri Life Cycle

Cocoons are elongated, soft, wooly, peduncleless, open mouthed and unreelable (Fig. 1.11). It measures 4.0 x 2.5 cm and weigh 3 gr.

The male moth is 2.5 cm long while female is 3 cm.

	wing span	for wing	hind wing
Male	13 cm	1242 mm ²	890 mm ²
Female	15 cm	1465 mm ²	1037 mm ²

REARING

The silkworm feeds mainly on *Ricinus communis* (Caster oil plant). Other important secondary food plants are *Heteropanax fragrans*, Seem; *Manihot utilissima*, Phol; *Carica papaya*, L; *Evodia faxinifolia*, Hook; *Ailanthus excelsa*, Roxb.

Rearing of these silkworms is entirely different from other wild silkworms. It requires a ideal rearing house and a rearing rack (Fig. 1.12). worms are mounted on split-bamboo tape (chandrika pool). Rearing of 100-125 layings from hatching to ripening requires about one metric ton of foliage.

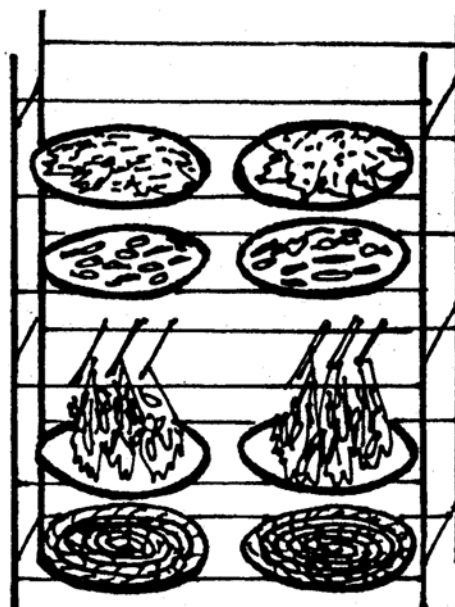


Fig. 1.12. Eri Rearing Stand

1.3.4. Anaphe Silk

Southern and Central Africa are the main source of this silkworm. It is distributed in intertropical regions of continental Africa (Nigeria, Uganda, Cameroon, the Congo, Togo). The important species used in the production of anaphe silk are *A. infracta*, Walsingham; *A. venata*, Butler; *A. panda*, Boisduval; *A. reticulate*, Walker; *A. carteri*, Walsingham; *A. moloneyi*, Druce and *A. ambrizia*, Butler.

The Anaphe are polyphagous. So far twenty two food plants are recorded (*Albizzia fastigiata*; *Sterculia tragacantha*; *S.setigeri*; *S. rhinopetala* etc., are found in Nigeria and *Bridelia micrantha*; *Cynometra alexandri*; *Triumfetta macrophylla* are in Uganda).

The freshly laid eggs are soft and creamy white, but later become hard and grey measuring 0.97x0.62 mm. the larvae are green. Pairs of tubercles present on the thoracic and abdominal segments bear short brown setae. Long tufts of white hairs are dispersed over the body. The pupae are obtect adectious and dark brown. The wings of the moth are creamy white with a span of 4-6 cm.

The anaphe silkworm is univoltine and undergoes diapause at the pupal stage. The silkworms from the cocoons communally (Fig. 1.13). the cocoon is large nestlike (spun by 1000 worms) weighs about 3.5 kg. generally 12-100 worms collectively spin cocoon for about 4 months. These cannot be reeled and looks like mulberry 7 cocoons.



Fig. 1.13. Anaphe Cocoon Nest

SUMMARY

- ⊙ Non-mulberry silk is forest based and rearing is conducted outdoors.
- ⊙ Out of large number of non-mulberry species only eight have been commercially exploited.
- ⊙ These are produced mainly in China and India.
- ⊙ In Tasar (*Antheraca*) thirty five species have been recorded. It is found in humid forests of central and southern plateau of India.
- ⊙ Tasar silkworm feeds on *Terminalia*, Oak.
- ⊙ Eggs hatch in 3-5 days. Larvae possess biting and chewing mouth parts and passes five instars and weighs 50 grams at maturity.
- ⊙ Larvae duration varies according to crop (season).
- ⊙ Larvae and pupae possess sexual markings.
- ⊙ Cocoon is big with peduncle. It is yellow or grey in colour.

- ⊙ Moths show sexual dimorphism. Females are bigger than males.
- ⊙ Because of outdoor rearing losses are heavy.
- ⊙ *A. assamensis* secretes golden yellow silk called muga silk distributed in Assam, and feeds on som and scalu leaves.
- ⊙ Brown eggs hatch and emerges a yellowish body with brown headed larva. Pupa is copper brown in colour.
- ⊙ Cocoons are brown with weak peduncle.
- ⊙ Moths exhibit sexual dimorphism.
- ⊙ It is reared outside except cocooning. A Special bamboo sieve 'chalconi' is used to collect the larvae.
- ⊙ Eri is brick red or white silk produced by *Philosamia ricini*.
- ⊙ Larvae are yellow, cream, green, blue or white in colour with spots or without spots.
- ⊙ Cocoons are without peduncle and unreelable.
- ⊙ It feeds on castor leaves. Silkworm needs a rearing house.
- ⊙ Anaphe silk is found in Africa.
- ⊙ It is univoltine undergoes diapause in pupal stage. Cocoons are spun collectively (12-100 worms) in about 4 months.
- ⊙ Cocoons cannot be reeled.

QUESTIONS

I. SHORT QUESTIONS

1. Mention non-mulberry silk varieties.
2. Write any two scientific names of non-mulberry silkworms.
3. Mention food plants of eri and muga silkworms.
4. Write tasar cocoon characters.
5. How do you identify sex of silkworm ?
6. What is kahan ?
7. What do you mean by Ganda, Pan, Khandi ?
8. What are the items made with muga silk ?

8. What are the items made with muga silk ?
9. What is chalani ?
10. What do you mean by jail in wild silk rearing ?
11. What is chandrica pool ?
12. Write the characters of eri silk cocoon.
13. What is the specialty of Anaphae silk cocoon ?
14. Write the characters of muga silk cocoon.
15. Write the characters of anaphe cocoon.

II. ESSAY QUESTIONS

1. Write about tasar silkworms.
2. Detail about eri silkworms.
3. Write about muga silkworms
4. Write short notes on
 - a) Anaphae
 - b) Life cycle of tasar worm
5. Write short notes on
 - a) Non-mulberry cocoons
 - b) Life cycle of eri

REARING HOUSE

2.1.1 INTRODUCTION

In temperate or sub tropical climates (Jammu and Kashmir, Punjab and Dehradun area of U.P) silkworm rearing is carried out twice a year (spring and autumn) or three times (spring, summer and autumn) according to the growth and production of mulberry leaves. In tropical areas (Karnataka, West Bengal, Andhra Pradesh and Tamilnadu etc.,) mulberry is full and flushy throughout the year favouring the farmer to rear silkworms five to six times in a year./ the silkworm rearing in a farm house can be achieved to the best, provided the following considerations are fulfilled i.e. conditions mulberry growth and yield of mulberry leaf, availability of labour for rearing silkworms, variety of silkworm to be reared, facilities for rearing silk worms viz. building and equipment.

2.1.1. Condition of mulberry growth and availability of mulberry leaf

The mulberry plant come to “full flush” in about six months from the time of planting. The yield and quality of leaf depends on the agronomic practices followed for the cultivation of mulberry i.e. irrigation, application of manures and fertilizers, cultural operations.

The size of the silkworm rearing depends on the availability of mulberry leaf yield. An hectare mulberry garden yields 20,000 to 25,000 kg of leaves per year under optimum agronomic practices. An hectare of irrigated mulberry yields about 30,000 kg of leaf in a year in Karnataka, W.B., A.P. and Tamilnadu. In case of pit system under rainfed condition, the yield is about 10,000 kg per year. Therefore the leaf requirements are as follows.

No.of DFL's	Breed	Required Mulberry Leaf in Kg
100	MV x BV	700
100	BV x BV	800

On the basis of seasonal availability of leaves, the number of layings to be brushed is decided. However it is necessary to avoid shortages of leaf during rearing as they lead to poor crops and also failure of rearing.

2.1.2 Labour availability

Sericulture is labour intensive industry and there has been very little mechanisation of its operations. The most ideal silkworm rearing will be one

Which is managed entirely by the family labour of the sericulturist. But practically it is not feasible in large scale economic rearing. Therefore the rearer should go in for hired labour at least in later stages of rearing, both for supplying mulberry leaf and mounting of ripe worms. Any shortage of labour or if labour costs are high, economic production costs will also increase. Agriculture and sericulture have to draw on the same surplus labour force in the rural parts, has to be ensured that the cocoon harvesting time does not clash with major agriculture operations in the village. Technologically developed sericultural countries like Japan, about three man hours are required to produce one kg, of cocoons. In India it would be safe to assume about four to five hours, where traditional methods are followed and man hours can be reduced if rational methods are followed.

2.1.3. Variety of silkworm to be reared

Depending on the voltinism the silkworms are broadly divided into univoltine, bivoltine which give one and two crops respectively in a year. Where as multivoltine worms give four or more number of crops in a year. In Karnataka “Mysore” race is very hard and gives greenish yellow cocoons with poor built. It is grown in seed areas for raising local race seed cocoons. The female parent of this is taken for hybrid seed for the preparation of reeling cocoons and to get commercial silk. In West Bengal another multivoltine race called “Nistari” which gives deep yellow cocoons are popular. However in Jammu and Kahsmir bivoltine hybrids are reared. The productivity of uni/bivoltines is better than that of multivoltines though they require more favourable temperature and humidity condition (Table 2.1)

Table 2.1. Comparative statement between different Uni/bi/multivoltine races

Sl. No.	Voltinism	No.of DFL's	Productivity in Kg	Shell Wt(g)	Silk recovery (Renditta)	Neatness	Profits
1.	Bivoltine	100	<30	0.30-0.40	1kg/10kg cocoons	high	more
2.	Pure Local Race (MV)	100	<20	0.10-0.15	1kg/16kg cocoons	less	less
3.	Hybrid BV x MV	100	<25	---	---	---	---

Bivoltine pure or local race cocoons fetch premium price than reeling cocoons. Thus large number of farmers rear commercial hybrids i.e. female local X male bivoltine or female bivoltine X male bivoltine. New breeds released by

Central Silk Board (CSB), i.e. Nandi a bivoltine hybrid is more popular in Karnataka.

2.2. SITE SELECTION

Silkworms are more sensitive to environmental conditions especially to temperature and humidity. So selection of rearing house should be planned and constructed to maintain optimum environmental conditions and to get good quality cocoons. In Indian conditions the farmer is financially handicapped to build a new rearing house. But proceeds to rear in the suitable part of his existing house. However, the site of rearing house should not be water-logged, possess provision for fresh pure air, without being exposed to direct heat of the sun or draughts. If the surroundings are damp, it should be cleared by making drains or basement height should be increased. Humidity can be reduced by opening suitable windows, allowing free air. If the moisture of air is due to river or lake situated near the house, the direct current of air can be avoided by raising bushes or trees or walls or wind breaks.

If there is any stagnation of air around the rearing room, it is cleared by cutting thick vegetation.

On the otherhand violent draughts of wind, heat from the sun, cold from chill winds at night can be prevented by raising trees and suitable shelter.

2.2.1. Orientation and Construction of rearing house

Orientation of the room should be such that the interior is protected from the direct afternoon sunlight, as it is harmful to worms. The best orientation of rearing room will be north and south, the room facing north with the door open to cool breezes, with a window on the south side to aid ventilation and with the sides of the room east and west. If this direction is not possible the next best would be a north – west face, and south east back. Otherwise if a farmer is able to build a new house east is better than west face. East facing should be all right in the morning, but as the day increases the room warms up and cools at night with the cold night air. On the otherhand afternoon sun will make the room hotter and hotter, leading to drying up of leaves. West facing would be the least facing should invariably possess broad verandah or trees planted to cast a shadow. Inside the rearing room mulberry leaves and silkworms should not be kept on western side as it is hot in the afternoon. Opposite to the door, a window should always be provided to induce ventilation.

While building a new house, the width of the room should be smaller than its length or frontage and should not exceed 15 to 18 ft. A broad room leads to inequalities of temperature. On the other hand a small room leads to stagnation of air, for which windows and ventilators should be provided to admit free passage of air. Verandahs 4-6 ft. broad are provided at least on that side which is most exposed.

In any construction, roof should be of non-conducting material and amply provided with ventilators. For tropical conditions mud wall and thatched roof or a country tiled roof is always ideal. But corrugated zinc sheet roof is the worst of all. For any kind of rearing house high roof is better than a low roof and a false ceiling is desirable. It is necessary to provide doors, windows ventilators etc. with fly proof mesh.

However, all the above perfections which could be adopted by rich persons who intend to construct a new rearing room. But in India sericulture is mainly confined to marginal farmers who can not spare a new rearing house. In any case the sericulturist must remember the needs and necessities for the better growth of silkworms and working knowledge, which enables him to make the best of his limited sources.

The following are some of the important guidelines to be remembered

AVOID

1. Dampness
2. Stagnation of air
3. Direct and too strong draught of air
4. Exposure to bright sunlight and radiation
5. Narrow rearing space.

ENSURE

1. Adequate temperature and humidity
2. Good ventilation
3. To provide two shutters to the door. Further windows and doors are fitted with wire mesh.
4. rat proof building by providing a projecting edge all round at plinth level.
5. Movable stairs.

2.3. CENTRAL SILK BOARD (CSB) MODEL

A model rearing house of convenient size for shelf rearing is shown in fig. 2.1. It is a rat-proof building with a ledge all around to prevent rats entry into the building. The building has a verandah all around and glass windows and doors to provide good ventilation and light. The ceiling of the rearing house is generally made of wood, if made of concrete or tiles a false ceiling must be constructed. Ventilators must be installed to ensure free circulation of air.

The rearing house is partitioned into four convenient rooms in one of which high temperature and humidity are maintained for the young age silkworms rearing. The rooms are provided with an adequate number of windows and doors top ensure good ventilation for rearing late age silkworms.

The rearing houses should be located in such a manner so as to maintain as possible ideal temperature and humidity conditions inside the rearing rooms. In temperate and sub-tropical regions they should be constructed in north-south direction so that maximum sunlight and heat is available to adequate warm up of the rearing rooms. In tropical regions, however the building should be sited east-west so that too hot, direct sunlight is avoided and cool room temperature are maintained.

Recently there has been a tendency to use improvised rearing sheds with roof and side walls made of plastic sheets or taurpaulins which prevent direct draughts of cold air entering from outside the sheds. This type of shed is usually used to shoot or floor rearings.

In certain countries such as India, where mostly shelf rearing is practiced there are no separate rearing houses as such, but the rearing is done in the dwelling houses only. Similarly in Jammu and Kashmir of India, where most floor rearing is practiced in the rearers own houses.

A sketch of modern and model rearing house is given in Fig. 2.1. Further the following are different rearing houses suitable for different regions.

1. CSB model rearing house (Fig. 2.1 a,b)
2. Two rack capacity rearing room (Fig. 2.2)
3. Double wall and mangalore tile roof model (Fig. 2.3)
4. Mudwall and country tile roof model (Fig. 2.4)
5. Mudwall and mangalore tile roof model (Fig. 2.5)
6. Mudwall and thatched rood model (Fig. 2.6)
7. Bamboo mat wall and thatched roof model (Fig. 2.7)
8. Plankwall and thached roof model (Fig. 2.8)

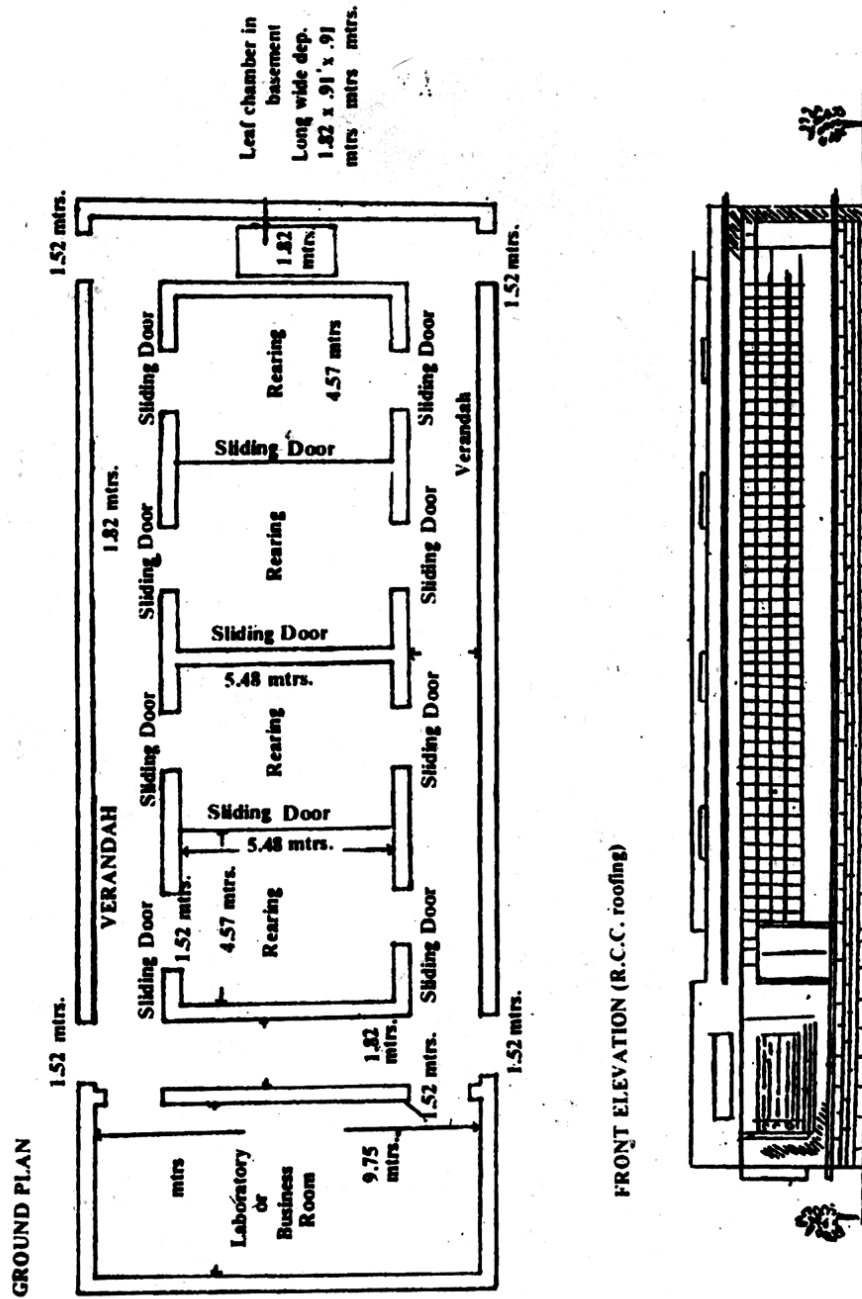


Fig. 2.1 A) CSB Model Rearing House

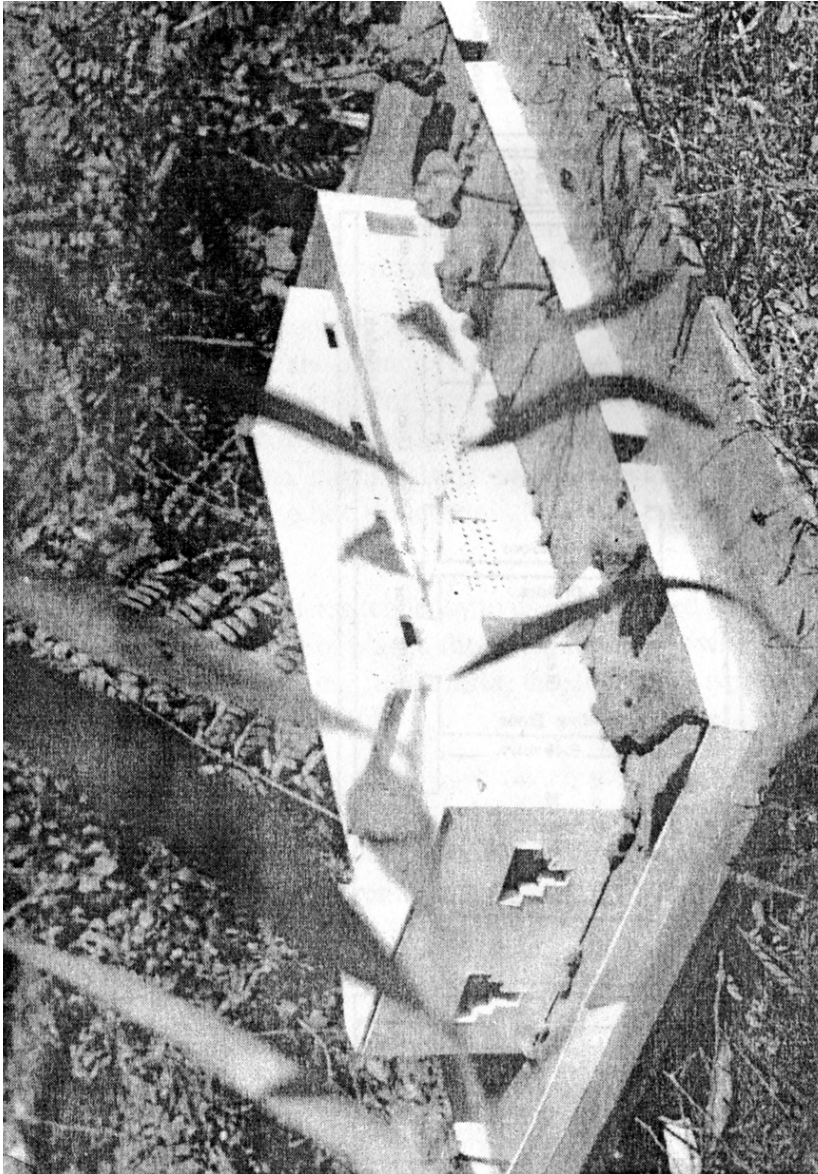


Fig. 2.1 B) CSB Model Rearing House

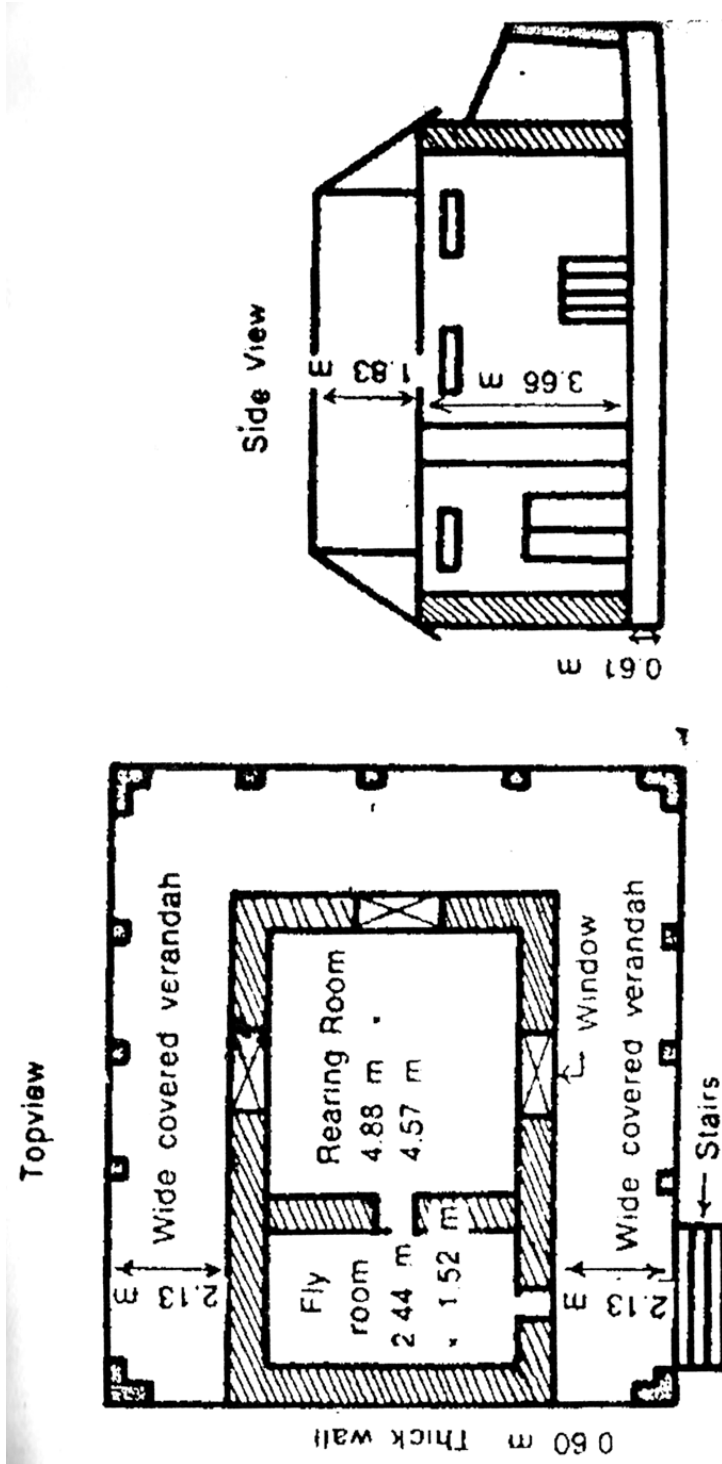
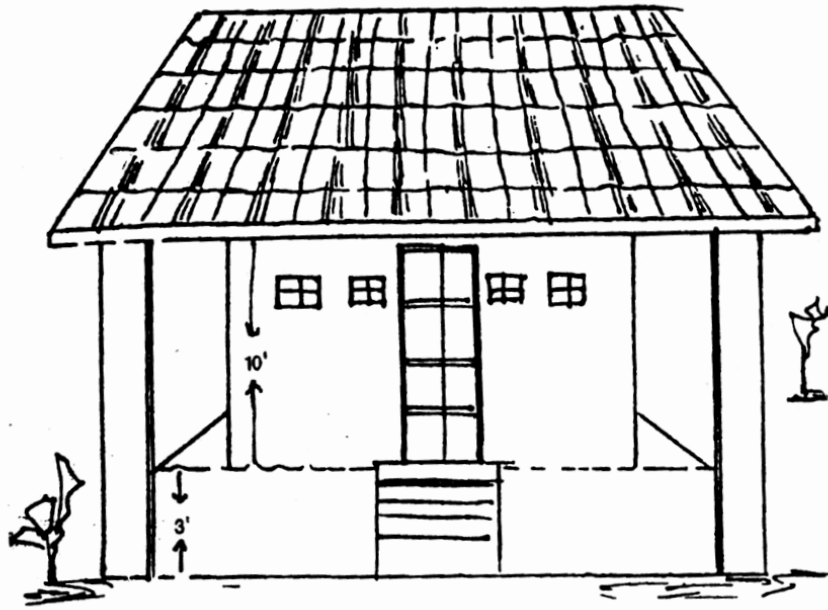
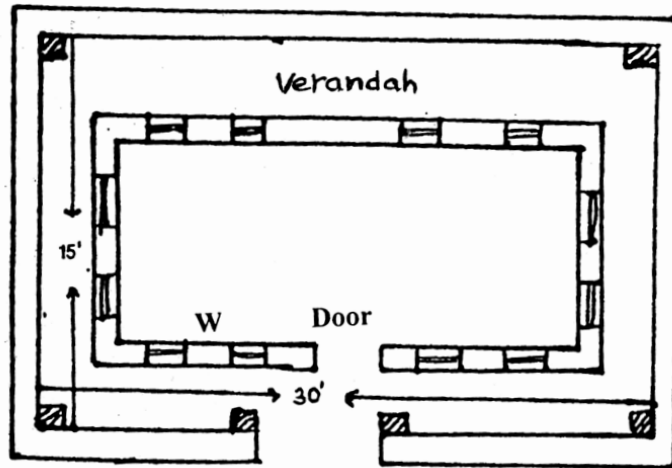


Fig. 2.2 Two Rack Capacity Rearing House

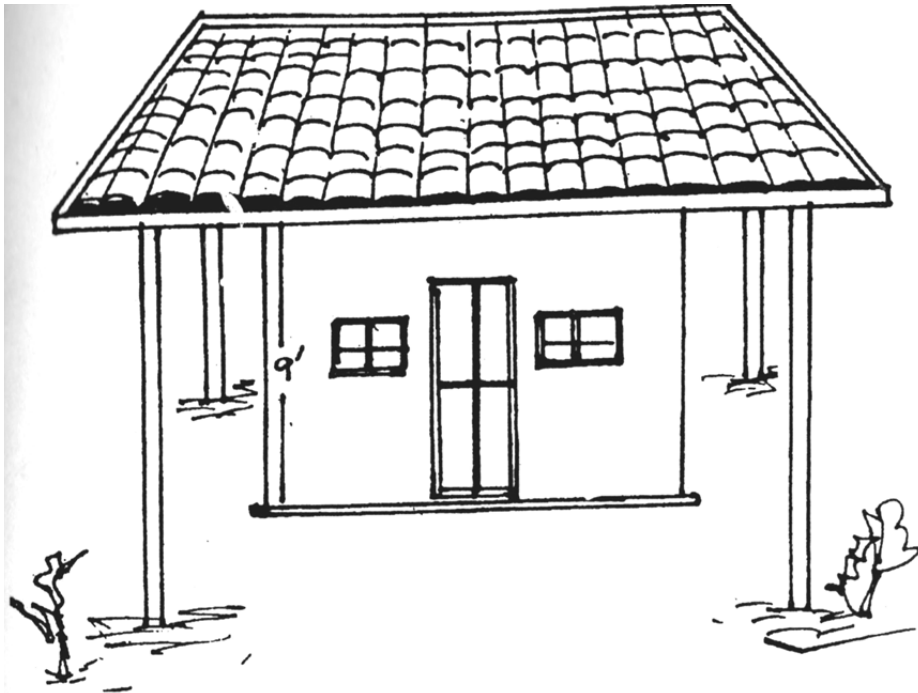


Front Elevation

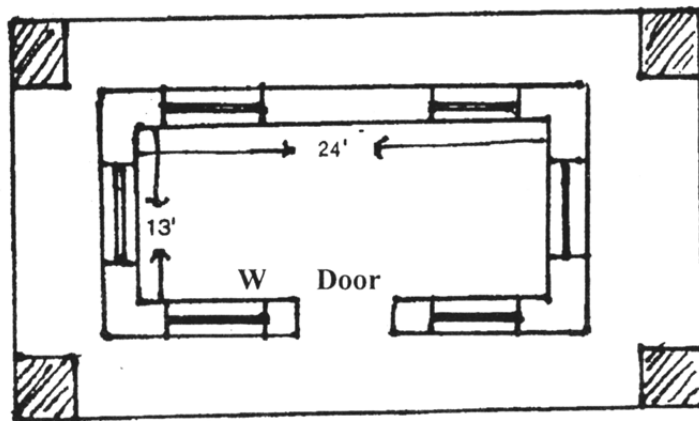


Ground Plan

Fig. 2.3 Double Wall and Mangalore Tile Roof Model

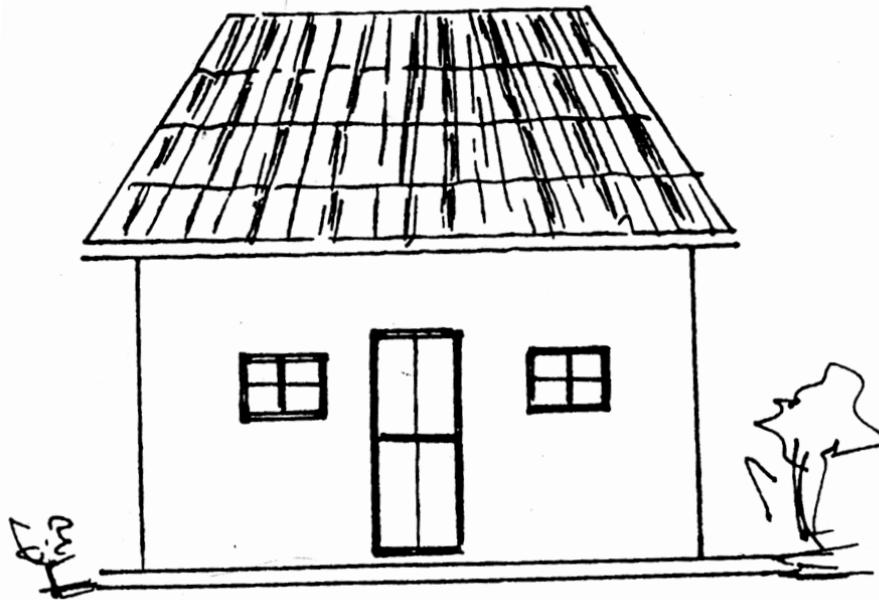


Front Elevation

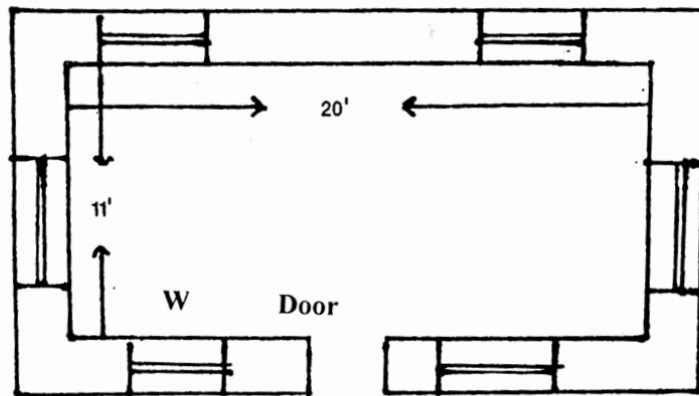


Ground Plan

Fig. 2.4 Mud Wall and Country Tile Roof Model



Front Elevation

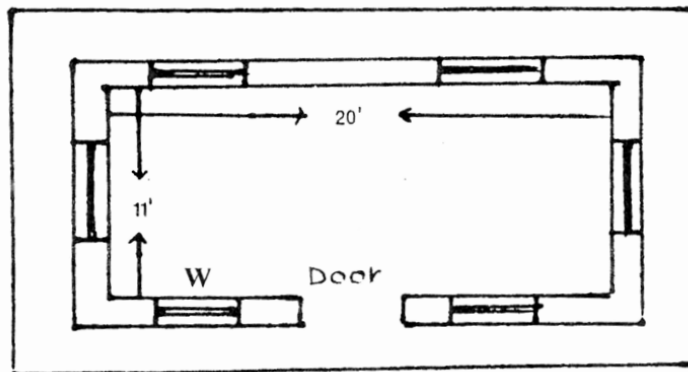


Ground Plan

Fig. 2.5 Mud Wall and Mangalore Tile Roof Model



Front Elevation

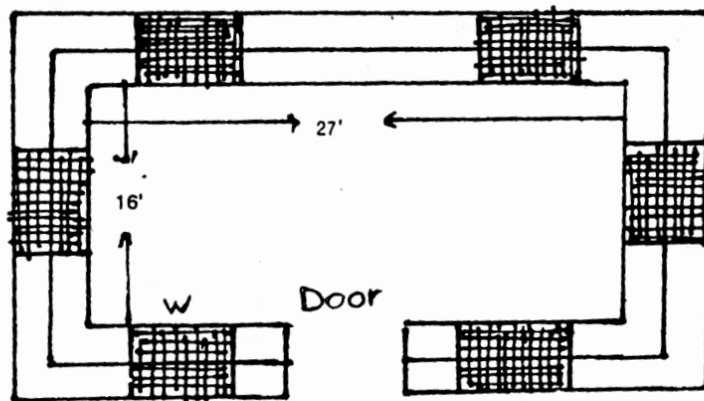


Ground Plan

Fig. 2.6 Mud Wall Thatched Roof Model



Front Elevation



Ground Plan

Fig. 2.7 Bamboo Wall and Thatched Roof Model

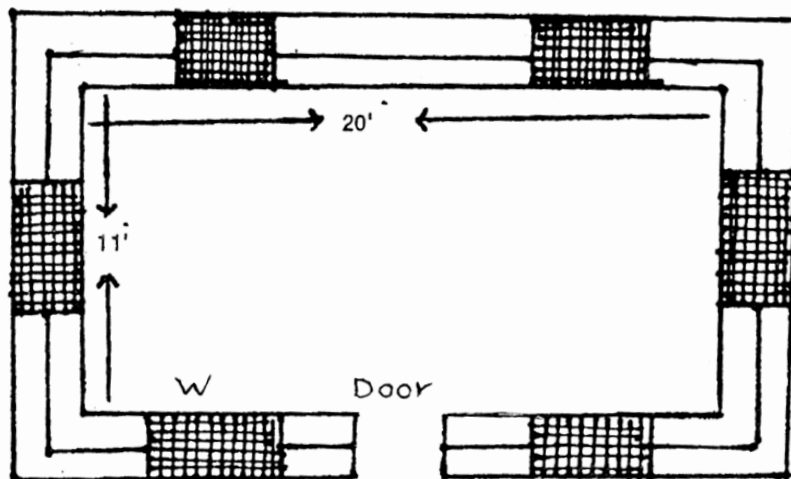
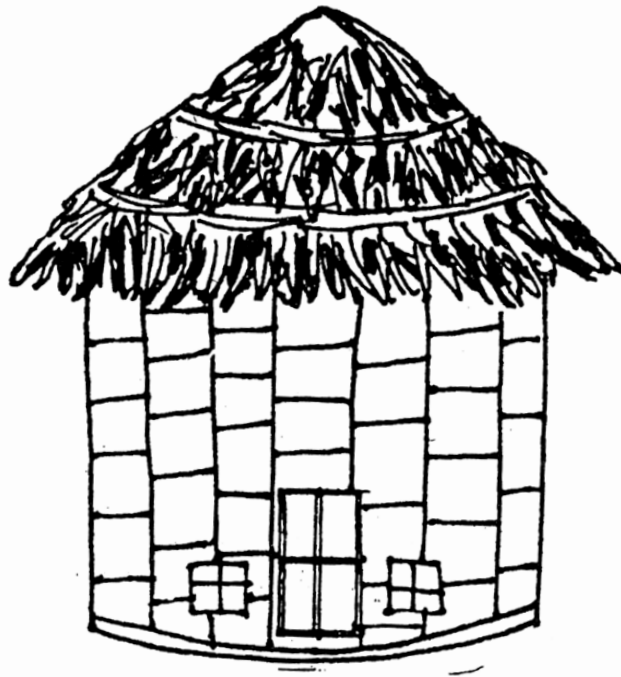


Fig. 260 Rearing House

SUMMARY

- ⊙ The rearer should think about favourable conditions for mulberry growth labour availability and decide about variety of silkworms to be reared.
- ⊙ There are multovoltine, bivoltine varieties which are better suitable Indian conditions.
- ⊙ Silkworm rearing requires a suitable rearing house and favourable environmental conditions.
- ⊙ Rearing room surroundings should be healthy and neat.
- ⊙ Rearing room should not allow direct sunlight.
- ⊙ While building a new house, the width of the room should be smallest than its length.
- ⊙ Rearing room roof should be of non-conducting material and rooms provided with ventilators.
- ⊙ Mud wall and thatched roof or a country tiled roof is always ideal for tropical conditions.
- ⊙ Besides CSB model, different types of rearing houses (plans) are available.

QUESTIONS

I. SHORT QUESTIONS

1. Define rearing
2. What is the best orientation of rearing house ?
3. Which silkworm race is popular in Karnataka and West Bengal
4. What are the advantages of CSB model rearing house ?
5. Mention any four rearing houses.
6. What is the best option for rearing house.

II. ESSAY QUESTIONS

1. Selection of rearing is important-justify
2. Discuss about the orientation and construction of rearing house.
3. List out kinds of rearing houses and draw the lay-out of any one kind.
4. Draw lay-out for any two kinds of rearing houses.

REARING EQUIPMENTS

3.1. INTRODUCTION

The size of the silkworm rearing and number of equipment required depends on the availability of mulberry leaf. An hectare mulberry garden yields 20,000 to 25,000 kg of leaves per year. An hectare of irrigated mulberry yields about 30,000 kg of leaf in a year in south and west areas of India. In case of pit system under rainfed condition, the yield is about 10,000 kg per year. Keeping in view of rearing conditions, labour availability the variety of silkworm to be reared is decided. The rearing equipment especially rearing stands, leaf chamber are to be placed at proper place. The space available in the rearing room has to be completely used for rearing stands and trays so that maximum possible rearing can be achieved.

3.2. EQUIPMENTS AND USES

1. Rearing stands

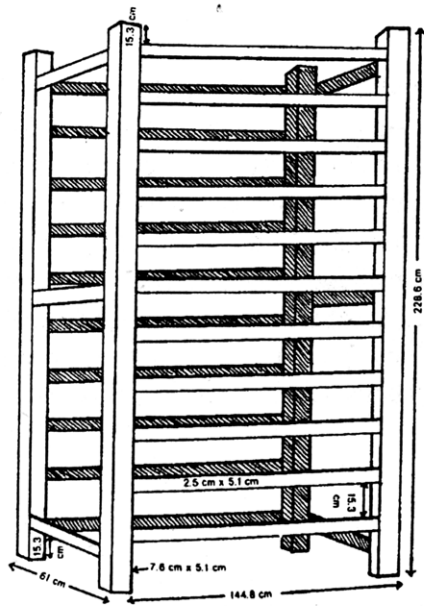
These are frames on which rearing trays containing the silkworms are placed. These stands are made up of wood or bamboo. The bamboo rearing stands are very much popular in Karnataka and West Bengal. It measures 2.25m. height, 1.5m. length and 0.65m, width. It should have ten to twelve tiers spaced at a distance of 0.15m. between the two tiers. Six stands are needed for each rearing room (Fig. 3.1.a).

2. Ant Wells

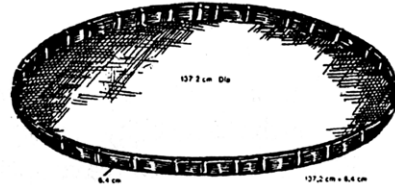
Ant are serious pests of silkworms. They are to be prevented before they crawl on the stand. It is possible by resting the rearing stand legs on ant wells. The simplest ant well is an enameled plate (12 cm wide, 4-5cm deep). Cement ant wells (21x21x8cm size with a groove of 4 cm) can also be used. The groove is filled with water to prevent ants (Fig. 3.1.a). on the otherhand a piece of cloth dipped in kerosene can be placed around the legs of rearing stand. Dusting of BHC also serves the purpose.

3. Rearing Trays

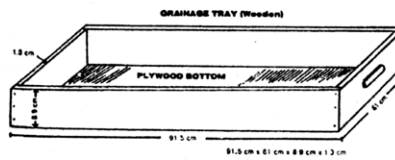
Rearing trays are portable equipment for keeping silkworms during rearing. There are many kinds of trays differing from one another in materials, shape and size. The selection of the material should not be costly as sericulture is poor man's industry and luxurious equipment are quite out of place. however the material should not be very flimsy and perishable as it would become costly in long run.



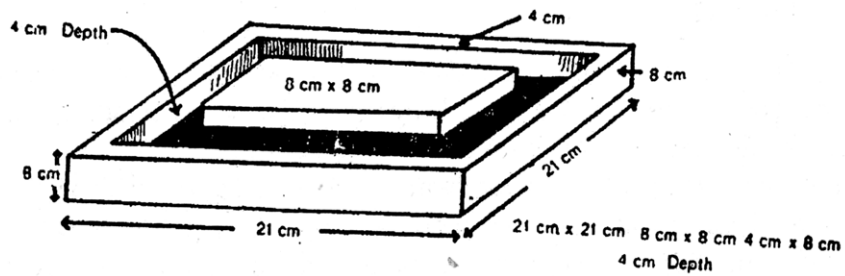
Rearing Stand



Bamboo Tray



Wooden Tray



Ant well

Fig. 3.1.A Rearing Equipments

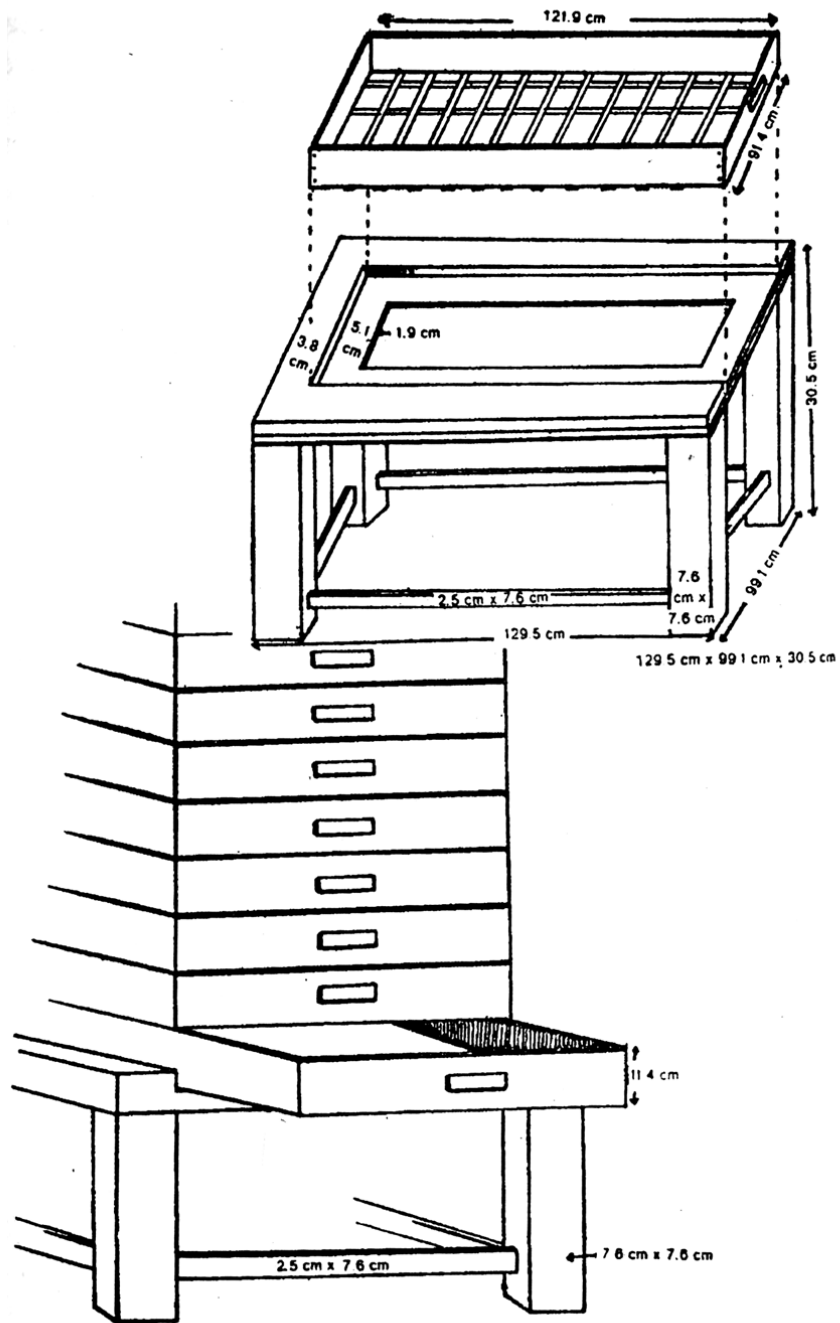


Fig. 3.1.B Chawki Rearing Set

In India bamboo round trays are popular as they are light and easy to handle and carry from place to place. It is cheap and can be prepared in every village. It measures 138 cm diameter with a depth of 6.5 cm (Fig. 3.1.a). Wooden trays (1.2m X 0.9m X 12 cm) are used for rearing young stage silkworms. Two trays are required till the end of second instar for rearing 100 DFLs. These wooden trays are accommodated in bench type young silkworm stand (wood). The trays are piled (Fig. 3.1.b.)

4. Paraffin Paper

This is a thick craft paper coated with paraffin wax with a melting point of 55°C. It is used in modern methods of chawki worm rearing. It is to cover the silkworms bed to prevent leaf withering and to maintain required humidity.

5. Foam Rubber Strips

For modern method of rearing long foam rubber strips (2.5 X 2.5 cm size) are essential. These are dipped in water and kept around the chawki worm bed to maintain optimum humidity. As a substitute, news paper folded into convenient strips are also used.

6. Chopsticks

This bamboo stick is 17.5 to 22 cm long, thin in girth and tapering at one end. These are used for poking the young larvae. This ensures hygienic handling of delicate young worms (Fig. 3.2).

7. Feather

A white quill (long) feather is most essential in the rearing room. It is used for brushing newly hatched worms and also for changing beds in the early stages. It is the most convenient and safe for brushing (Fig. 3.2).

8. Chopping Board, knives and mats

The mulberry leaf are chopped according to the age of the worm before feeding. This equipment is essential for chopping the leaf in a proper way. The board is made up of soft wood (92X92 cm with 7.6 cm thickness). Each rearing house needs two knives (small one for chawki rearing, big one for late age rearing). The knife is 0.3 to 0.5 m long blade with 4 to 8 cm breadth (Fig. 3.2).

Leaf chopping is carried on the mats to avoid dust, dirt and helps to collect the chopped leaves.

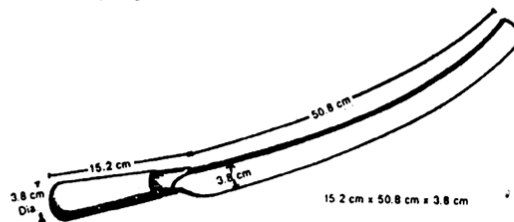
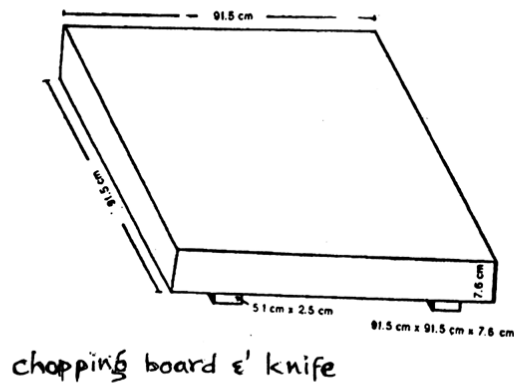
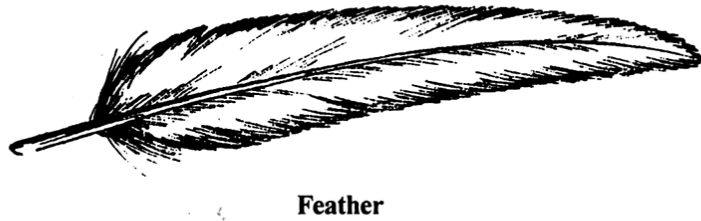
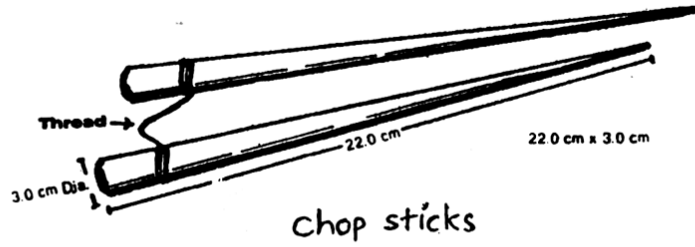


Fig. 3.2. Rearing Equipments

9. Leaf Chamber

The rearer can not go to field to get the leaf for every feeding. And it is also not advisable to cut the leaves when it is too hot or raining. The required leaf is therefore plucked by hired labour in the early hours or late in the afternoon. Thus it is necessary to preserve the nutrients of mulberry leaf till feeding. It can be achieved by preserving the leaf chamber/earthened pots/refrigerators.

A simple leaf chamber is made up to wooden strips (152 X 76 X 76 cm size; strip size is 7.5 cm fitted with 7.5 cm spacing). The chamber is covered on all sides with gunny cloth which is made wet. During summer season and dry days water is sprayed periodically on the gunny cloth (Fig. 3.3).

The leaf can also be preserved in earthened pots (Fig. 3.2). the rearer should remember that heaping of leaves in a corner is worst. Because the leaves rapidly wither owing to evaporation especially in dry season. On the other hand temperature inside the heap raises favouring the fermentation in the leaves. Besides this there is every danger of the leaves getting infected with diseased germs, dust especially during cleaning, bed changing etc. thus it is necessary to preserve the leaf in leaf chamber

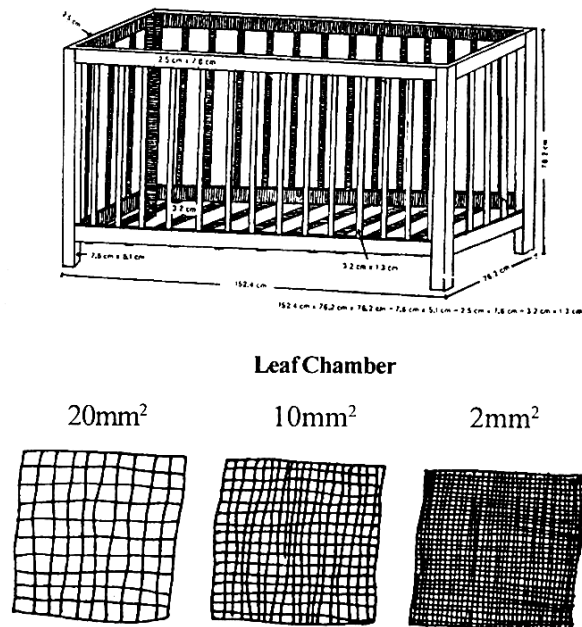


Fig. 3.3. Rearing Equipments

10. Cleaning Nets

During the course of feeding certain amount of mulberry leaf is left behind in the tray. This dried leaf together with litter of the worms accumulates in the rearing beds, owing to increase of bed size. Further it also adds to increase temperature and harmful gases in the bed. Thus the waste leaf as well as litter has to be periodically removed using nets, basing on the age of the worms.

The nets are woven using cotton or nylon thread. The mesh should be square and of the same length of the silkworm. The rearer should possess small (2mm²), medium (10mm²) and large (20mm²) nets (Fig. 3.3) for rearing chawki and late age worms.

11. Mountages

It is used to enable the ripe worm to spin cocoon. The most common form of mountage in India is "Chandrika". It is a rectangular bamboo mat on which a spiral bamboo tape is tied. The chandrika measures 1.8 m X 1.2 m. The tape is about 4-5 cm. broad and space between the spirals is about 4-5 cm. It became more popular than any other mountage because of the following advantages (Fig. 3.4).

- a. Easily manufactured in the villages by bamboo weavers.
- b. Can be stored easily.
- c. It provides easy passage of air for quick drying of excreta of spinning worms and avoids staining.
- d. Easy to transport.
- e. Easy to disinfect.
- d. Low cost and light weight.

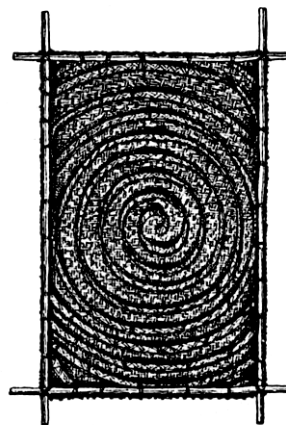


Fig. 3.4. Chandrika

Besides chandrika there are other types of mountages which are in practice i.e., zig-zag mountage, centipede mountage, rotary mountage etc.

Zig-zag mountage frame is made of plastic wire or sedge straw/mulberry branches/bamboo, usually consists of about 40 corners of about 6 cm each, and each set can mount 250-300 worms. (Fig. 3.5). In India straw mountages in Assam, mulberry branch mountages in Jammu & Kashmir are in practice. Recently P.V.C. mountages are also used. It has the same advantages like chandrika besides reducing the labour expenses.

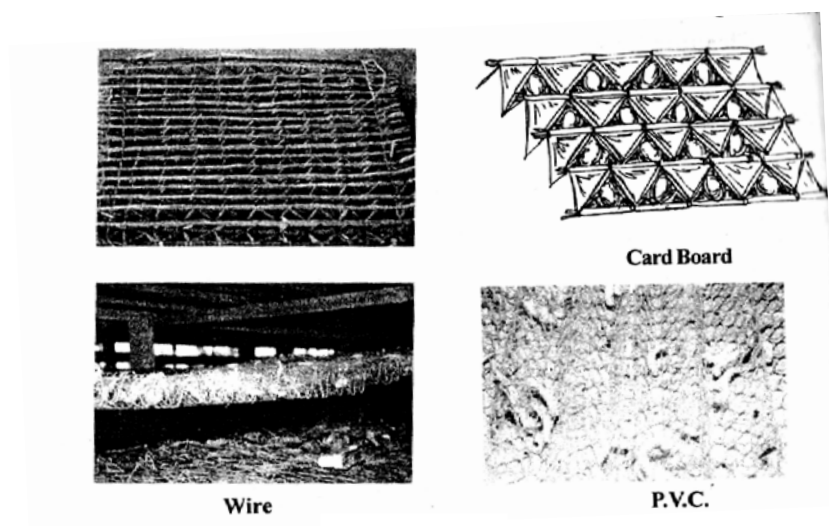


Fig. 3.5 Zig-Zag Mountages

Rotary mountage has pieces of cardboard to form 13 rows, consisting of 12 sections and each amounting to 156 sections. Ten pieces are put into frame as a set (Fig. 3.6). when this frame is hung up with wire holding at by ends, the frame can be turned around two axes. This frame produces fewer spoiled cocoons and raises the reelability of cocoons. Good cocoon percentage is more than 80. It is the best type and suitable for large scale silkworm rearing because it does not only lead to increased cocoon quality but also saves labour in mounting and harvesting.

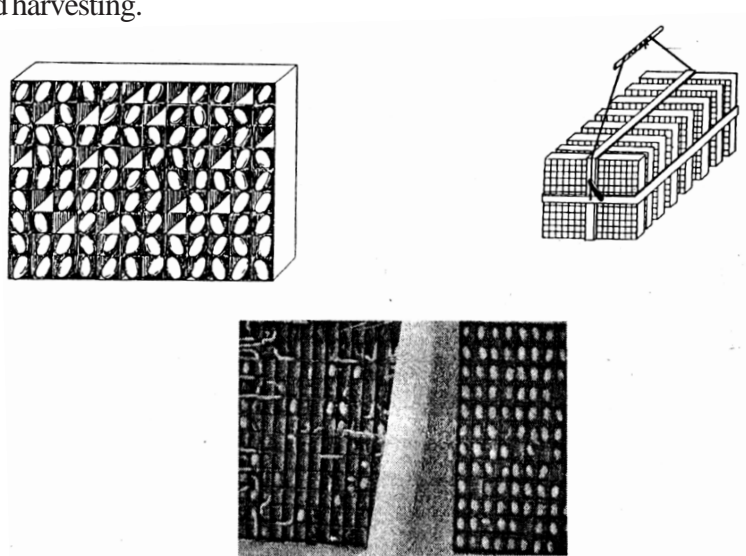


Fig. 3.6 Rotary Mountages

Centipede moutage is made using plastic or straw material. It provides for self mounting similar to rotary type. But care should be taken to avoid a high density of worms on the moutage because it may cause a higher incidence of bad quality cocoons i.e. double and deformed cocoons. It is easy to transport and low cost (Fig. 3.7).

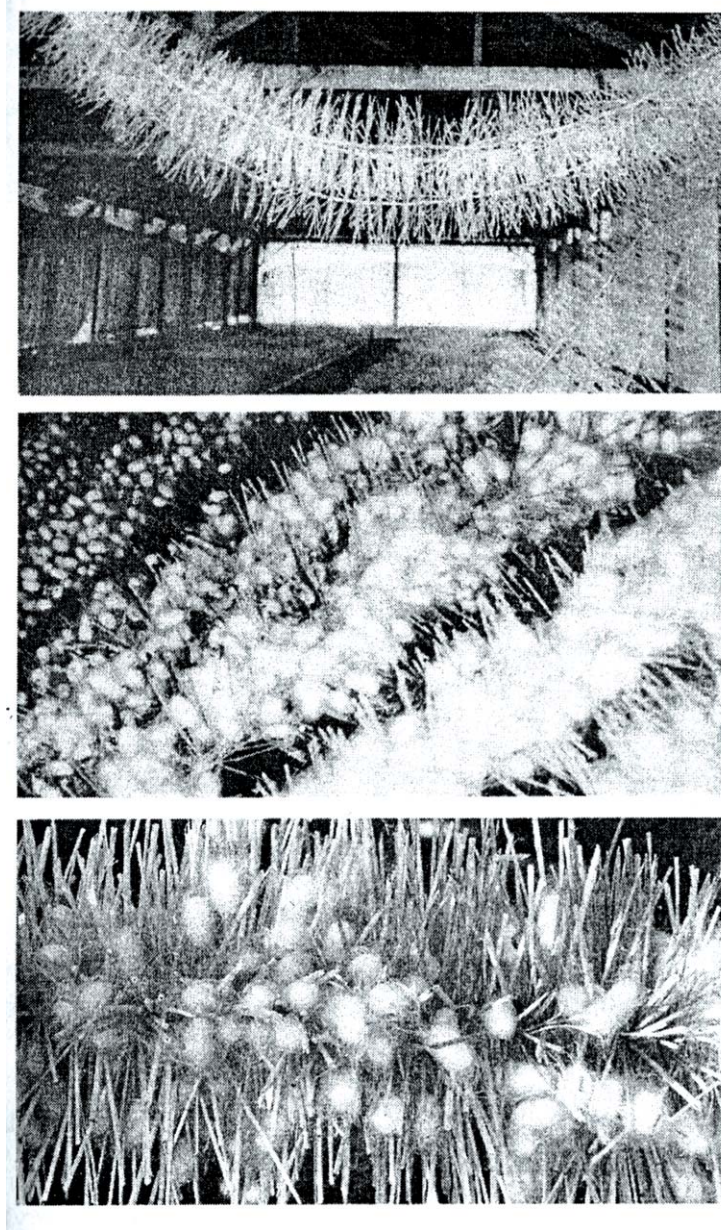


Fig. 3.7. Centipede Moutages

12. Foot Cleaning Tray

Silkworms are very sensitive to dust and micro organisms which may cause damage. Thus they are prevented prior to their entry into rearing room along with foot of rearer. This can be achieved by keeping foot cleaning tray at the entrance of the room. It measures 1.1m X 0.5m X 0.1 m with tin bottom. A pad of gunny cloth soaked in 2% formalin is kept in the tray. Thus the persons entering into the rearing room disinfect their foot (Fig. 3.8).

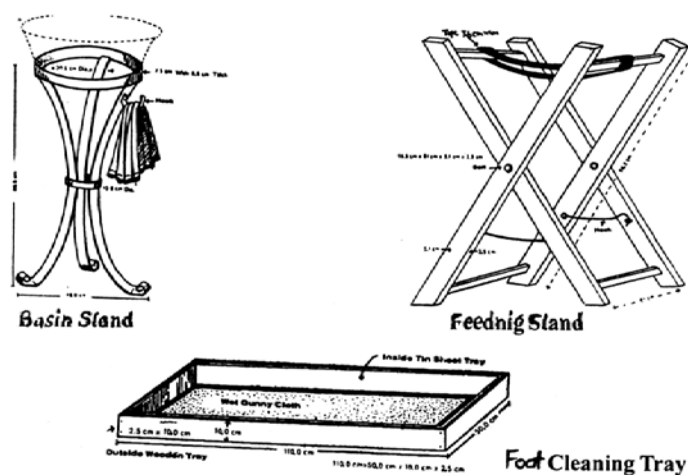


Fig. 3.8. Rearing Equipments

13. Basin & Stand

While entering into the rearing room it is advisable to disinfect hands before handling the worms. Thus basin, stand (tripod) is required to keep disinfecting solution (Fig. 3.8).

14. Feeding Stand

At the time of feeding the worms, wooden feeding stands are required for keeping the trays, (90X60 cm with 5X2 cm tape). It can be folded (Fig. 3.8).

15. Other Appliances

For reading temperature and humidity in the rearing room dry wet thermometer, hygrometer, humidity chart are essential.

During winter especially in Kashmir, West Bengal it is necessary to heat up the rearing room to increase the temperature. Thus an electric, charcoal stove is essential. On the otherhand it is necessary for fumigation process also.

Sprayer is required for disinfecting the rearing room, equipment and also spraying water on the leaf chamber.

Leaf baskets to carry leaves from the mulberry field to rearing house, litter basket to collect waste leafage, litter etc; disinfection mask for workers remaining in the rearing room for longer period for effective disinfection; black box/paper/cloth for black boxing of eggs; humidifier for increasing humidity are also required for rearing room.

For measuring chemicals/formalin and to weigh the leaf for assessment of growth a rough balance, measuring cylinder, buckets are required. Other items like gunny cloth, uzi proof net are also required.

3.3 CHEMICALS AND USES

For successful rearing of silkworm maintenance of hygienic conditions are necessary. To prevent and control the micro organisms disinfectants like formaldehyde, paraformaldehyde, bleaching powder, sodium hypochloride, slaked lime powder are necessary. Silworms are not so exception for diseases. Thus as a preparatory step Reshamket Oushadh (RKO), uzicide, China clay, dimilin and fungicides like Dithane M-45 or Captan are kept along with other chemicals.

SUMMARY

- ⊙ Summary rearing size and equipment number required depends on the availability of mulberry leaf.
- ⊙ Bamboo rearing stands are popular which have 10-12 tiers.
- ⊙ Ant wells are necessary to prevent ants.
- ⊙ Paraffin trays made up of wood, bamboo are required. Bamboo trays are cheap and light.
- ⊙ Paraffin Paper, foam rubber strips are essential to maintain proper temperature and humidity during chawki rearing.
- ⊙ Chop sticks ensure hygienic handling of delicate young silkworms.
- ⊙ White feathers are necessary for brushing.
- ⊙ Silkworms are fed with finely chopped mulberry leaf. This function requires necessary equipments.

- ⊙ The nutrients of mulberry are preserved before they are fed to silkworms. The leaf is preserved in leaf chamber, earthened pots.
- ⊙ Cleaning nets of three sizes are necessary for bed cleaning, of otherwise left over mulberry, silkworm litter accumulate in the bed and damage the silkworm crop.
- ⊙ Chandrika is a popular moutage. Besides this many kinds are in use. Rotary moutage ensures good cocoon percentage (80%).
- ⊙ Foot cleaning tray is essential to prevent the microorganisms entering into the rearing room along with foot of rearer.
- ⊙ Basin, stand is to clean hands before entering into the rearing room.
- ⊙ Other appliances like thermometer, hygrometer, stove, sprayer, leaf baskets, face mask are necessary.
- ⊙ Chemicals are essential for disinfection, disease and pest control.

QUESTIONS

I. SHORT QUESTIONS

1. What is the important of ant well ?
2. What are the advantages of bamboo tray ?
3. Name any four equipment used in chawki rearing.
4. What are the uses of paraffin paper ?
5. What is the importance of foam rubber strip ?
6. Why white feather is necessary for rearing ?
7. Name the popular moutage in India.
8. Name any four moutages.
9. What are the net sizes used in rearing ?
10. How do you measure relative humidity ?
11. Mention the equipment used in disinfection ?
12. What are the chemicals used in disinfection ?

13. What chemicals are used to control uzi fly ?
14. List out leaf storage equipments.
15. What are the fungicides used in rearing ?

II. ESSAY QUESTIONS

1. What are the equipments used in rearing ? Add a note on rearing stands and trays.
2. List out rearing equipment and write about leaf chamber and cleaning nets.
3. Write about different kinds of mountages with neat diagrams.
4. Write about disinfecting equipment and chemicals.

PREPARATION FOR REARING

4.1. INTRODUCTION

Like any other animals silkworms are also susceptible to a number of diseases. Some microorganisms like bacteria, virus, fungi, protozoan parasites attack the silkworms readily and spread the disease quickly. The optimum temperature and humidity for the silkworm are suitable for the growth of such germs and insects etc. therefore maintenance of hygienic conditions in and around the rearing room before starting rearing of silkworms enables to avoid the disease causing organisms.

4.2. CLEANING

This process has to be done prior to disinfection. After selection of rearing house before starting rearing of silkworms the rearing room and rearing equipment are to be cleaned. All the dumped materials, waste materials, dirt stones etc. in and around the rearing room are removed and cleaned using broom stick. The surroundings of the rearing house must be kept neat. If there is any stagnation of water around or near the rearing room, it becomes a reservoir for microorganisms to develop. Therefore it is necessary to clear the stagnant water. After cleaning the dust and dirt around the rearing room, water mixed with cow dung is sprinkled. The ceiling and walls of the rearing room has to be cleaned. All the crevices and holes in the rearing room should be closed using clay mixed with cow dung.

The rearing room and appliances are washed thoroughly with water and then dried in sun (Fig. 4.2 & 3).

4.3 PREPARATION OF DISINFECTANTS

For preparing required strength of formalin the following methods are used.

FIRST METHOD :

$$\text{Required strength fo Formalin} = \frac{\text{strength of original formalin} - \text{strength of formalin required}}{\text{Strength of formalin required}}$$

The required strength of formalin is prepared depending on the surface area of rearing room. A surface area of 10' x 10' requires one liter disinfecting solution. Therefore a room size of 10' x 1- ' requires roughly six liters of solution. For disinfecting rearing equipment additional two liters of solution is required.

From the above formula we get the ratio of water to be added to one part of commercial formalin to get required strength. Commercial formaldehyde available in the market is 38-40%. Disinfection by formalin can be strengthened when wetting agent like detergent (Teepol, Adibond, Sanae etc) added in 0.2% concentrations. These agents improve spreading and penpenetration of disinfectant.

MODEL PROBLEM

Calculate the required 2% formalin solution and also the required amount of commercial formalin for dinsinfection of rearing house of 6X9 m with 4 mts. Height with terraced roof.

SOLUTION :

The required of 2% formalin solution for disinfection of rearing house of 100 sq. m. area is about 5.73 litre. This is calculated as

1. Floor area = length x breadth
2. Area of 2 walls = length x height of each wall x 2
3. Area of 2 other walls = breadth x height of each wall x 2
4. Roof of terrace = length x breadth.

To disinfect 6 x 9 m with height of 4 mts size room, the required 2% formalin is calculated.

Floor area = 6 x 9 mts = 54 mts² or (20' x 30') = 600 sq.ft.

Area of 2 walls = 6x4x2 mts = 48mts² or (20' x 10.3' x 2') = 412 sq.ft.

Area of 2 walls = 9x4x2mts=72mts² or (30' x 10.3' x 2') = 618 sq.ft.

Area of roof = 6x9 mts=54mts² or (20' x 30')=600sq.ft.

Total area	228 mt.sq.ft. 2230 sq.ft.
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$$\text{Requirement of 2\% formalin solution} = \frac{228 \times 5.73}{100} = 13.06 \text{ liters}$$

For disinfecting the rearing room 13.06 liters of 2% formalin is required. Additionally equal amount of solution is required for spraying rearing equipments..

Total requirements of 2% formalin is 26 liters.

$$\frac{40 - 2}{2} = \frac{38}{2} = 19 \text{ liters}$$

One liter of commercial formalin is to be added to 19 liters of water to get 20 liters of 2% formalin.

to get 26 liters of 2% formalin.

$$\frac{26}{20} = \frac{13}{10} = 1.3 \text{ liters}$$

About 1.3 liters of commercial formaldehyde is required to disinfect rearing equipment and rearing house (6x9 mts with 4mts height) which can accommodate 250 - 300 DFL's.

SECOND METHOD :

$$\text{Quantity of formalin required} = \frac{\text{required concentration X required quantity of solution}}{\text{availabler concentration of commercial formaldehyde}}$$

SOLUTION :

$$\frac{2 \times 100}{40} = \frac{2000}{40} = 50 \text{cc of commercial formalin}$$

for disinfecting rearing room (6x9mts with 4mts height) and rearing equipment 26 liters of 2% of formalin is required.

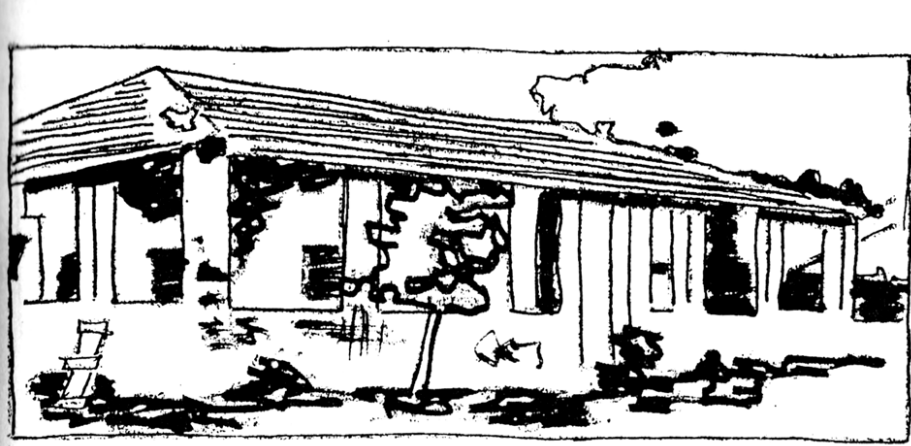
To calculate quantity of formalin requires is

$$\frac{2 \times 26}{40} = \frac{52}{40} = \frac{13}{10} = 1.3 \text{ liters}$$

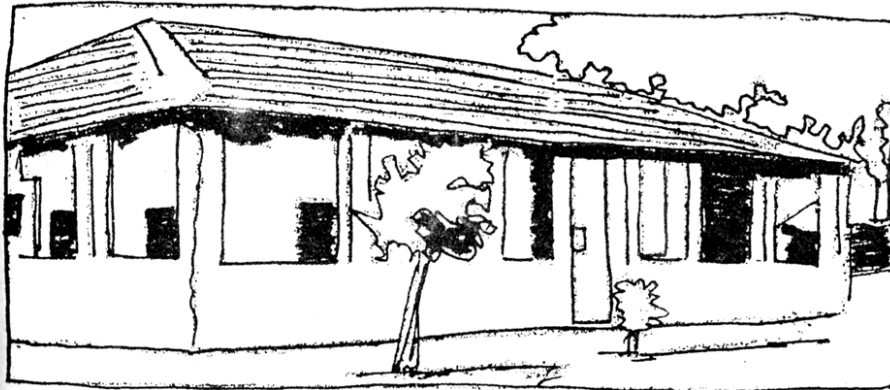
1.3 liters of commercial formalin is required



Fig. 4.1. Disinfection of Rearing House & Equipments



Before Cleaning



After Cleaning

Fig. 4.2. Cleaning of Rearing House

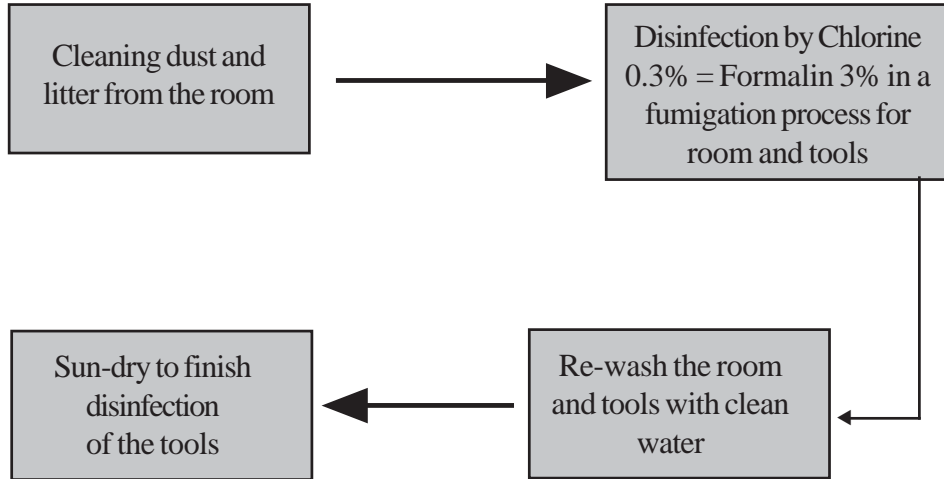


Fig. 4.3.a. Disinfection Procedure

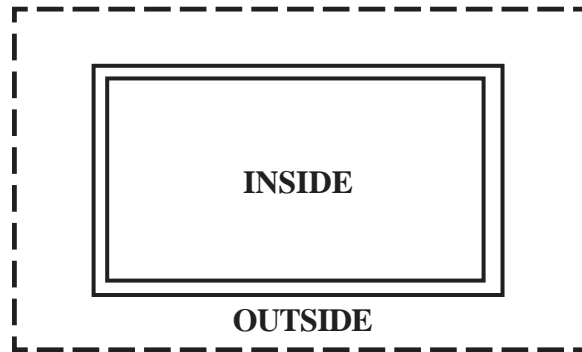
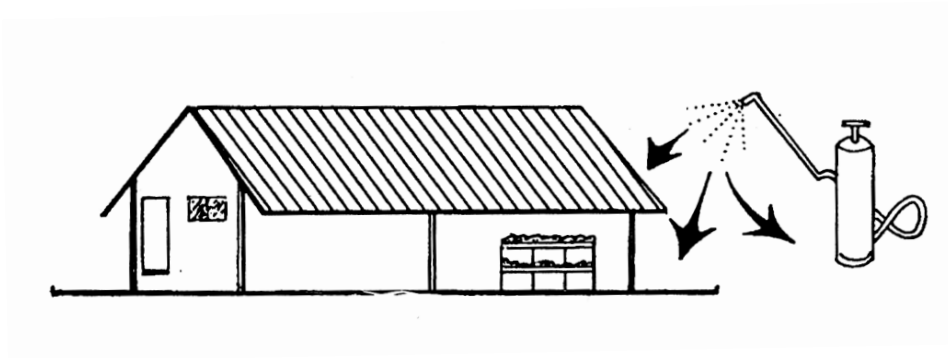


Fig. 4.3.b. Disinfection of Rearing House

4.4. DISINFECTION

The destruction and extermination of disease causing germs is known as disinfection. The most effective and simple method of disinfection is by using various chemicals and disinfectants. For the selection of disinfectant the following points have to be considered.

- Effectiveness against different pathogens.
- Simplicity, ease and swiftness of its application
- Harmless nature to human beings and domestic animals
- Easy availability
- Cheap cost.
- Harmless to buildings equipments.

The commonly used disinfections which are effective against various pathogens in sericulture industry are.

1. Formalin
2. Paraformaldehyde
3. Bleaching powder
4. Sodium hypochloride
5. Slaked lime powder etc.

However the effectiveness of disinfectants depends on the concentration, duration of contact ambient temperature and humidity.

The rearing room and equipments have to be prepared in advance for ensuring effective and easy disinfection. This involves;

1. Collection of dead larvae, pupae, cocoons used paper bits, other debris etc, and burning them.
2. Taking out of rearing equipments and washing with either 5% bleaching powder solution or 0.5% sodium hypochlorite solution.
3. Scrubbing and washing the floor and walls of the rearing room with 5% bleaching powder 0.5% sodium hypochlorite solution.
4. Drying of equipments in the sun.
5. Sealing of cracks and crevices in the rearing room.
6. Making the room air tight by closing windows and doors.

Rearing stands and chandrikas are to be cleared of dead larvae, cocoons and floss before washing. The equipments and the rearing rooms should not be washed with only water as disease causing pathogens, get washed out and are deposited outside the rearing room. Thus they may be carried into the rearing room again and become source of infection.

Rearing rooms and instruments (except for those made up of cloth or paper) are washed with water carefully before they are disinfected. After washing they are dried in the sun. sun drying is a kind of disinfection. The articles made up of paper or cloth are dried in the sun sufficiently. During sterilization if 1/500 high power bleaching powder is added to water, increases the sterilizing power.

4.4.1. Disinfecting methods

Disinfecting methods are two kinds-physical and chemical. In physical method steam or boiling water is used while in the later method various kinds of chemicals are spread. Physical disinfection is only for wood or metal made equipments. It is not suitable for a wide area or for the rearing room.

4.4.1.1. Disinfection of rearing equipments.

The rearing equipments such as rearing trays, feeding stands, basins and wells etc., which are smaller in size and easy to handle are first disinfected. These are dipped in a tank containing 0.5% sodium hypochlorite or 5% bleaching powder solution for at least 10 minutes followed by sun drying. Cleaning nets, gunny cloth, towels, foam pads etc/ are soaked in 2% formaldehyde solution. The bigger equipments such as stands, leaf chamber, chandrikas etc., are disinfected by spraying either 2% formalin or 5% bleaching powder solution. Articles which can not be soaked or sprayed with a liquid disinfectant are disinfected by fumigation.

In India it is a common practice among the rearers to smear the bamboo trays with cow dung to increase durability. It is also suggested that cow dung is made to slurry with 5% bleaching powder or 2% formalin and smeared. This improves the durability as well as disinfection simultaneously. An alternate method of the above is to use a paste made out of soaked menthol seeds and news papers. The chandreka's having floss after cocoon harvest will be disinfected through burning of floss using a burner.

4.1.2. Disinfection of rearing house

Before disinfection the rearing house is made airtight and 2% formalin solution is sprayed using sprayer. All the rearing equipments, walls and floor are thoroughly made wet by drenching spray. The spray should be uniform with sufficient pressure. For this a power gator rocker sprayer is suitable. A strong spray boom and a solid cone spray nozzle may be used. Spraying of formalin solution makes metallic machines and equipments rust. So care should be taken not to spray the formalin directly on them.

Ideal room temperature should be maintained at 25°C during disinfection for quick diffusion of formaldehyde gas. When the temperature after disinfection is low, the sterilizing power falls. If the temperature is low, room is to be heated. The proper time for disinfection is around 11 A.M.. As the day increases the raised temperature in the afternoon helps in better disinfection. After spraying the room should be kept closed for at least a day. More efficacy of formalin disinfection against virus, a mixture of 2% slaked lime is advisable (Fig. 4.4).

Formalin causes irritation in nasal mucosa and eyes, further the skin hardens. Therefore care should be taken during spraying by keeping nasal mask and gloves.

Chlorine compounds such as bleaching powder or sodium hypochlorite solution can be used as disinfectants. Bleaching powder is dissolved in water to get 5% solution. After shaking well supernatant solution is used for spraying. When bleaching powder is used as disinfectant it is always better to choose freshly prepared or properly packed powder. The chlorine available in bleaching powder is unstable thus stored powder loses its disinfection capacity. This powder is good against cytoplasmic polyhedrosis virus (CPV), nuclear polyhedrosis virus (NPV), flacherie fungus causing muscardine and pebrine spores.

Disinfection in the gaseous form is called fumigation. However this process of disinfection is effective only in air tight rearing houses. This method is convenient and easy to disinfect rearing houses and equipment at a time.

For fumigation process formalin can be used. The quantity of original formalin solution required for disinfection is calculated according to the room size. Then the quantity is diluted – times. The solution is allowed to evaporate in a pan, by heating from beneath using electric or charcoal stove. Slowly the formalin gas comes out. This process should be conducted in the air tight rearing room. Care should be taken that the chemical does not catch fire, which will nullify the disinfecting effect.

In any case it is necessary to fumigate for 4-5 hrs. the temperature of 20°C or higher and 70 percent or above humidity is preferable for disinfection. Disinfection of metallic instruments can be better achieved by fumigation process.

Paraformaldehyde can also be used for fumigation process as it releases formaldehyde fumes on heating. The quantity of paraformaldehyde required to fumigate an area of 10 cubic meters is about 60 grams.

Rearing house should be closed after disinfection at least for one day. All the doors, windows are opened 1-2 days before use of rearing house to allow free circulation of fresh air.

4.5. MAINTENANCE OF HYGENIC CONDITIONS

Maintenance of good hygienic conditions during rearing results in better crop production. As this process not only helps in preventing the entry of disease causing pathogens from outside, but also checks the spread of various diseases. During the process of rearing only a few members are allowed into the rearing room. While entering into the rearing house, they are advised to wipe their feet on a foot cleaning tray and wash their hands in wash basin. Disinfectants like formalin, detol or cresolor soap is added to the water in wash basin. Bleaching powder or a freshly prepared slaked lime is sprinkled on a gunny cloth placed on the foot mat at the entrance of the rearing house. Freshly prepared lime is also sprinkled all round the rearing room.

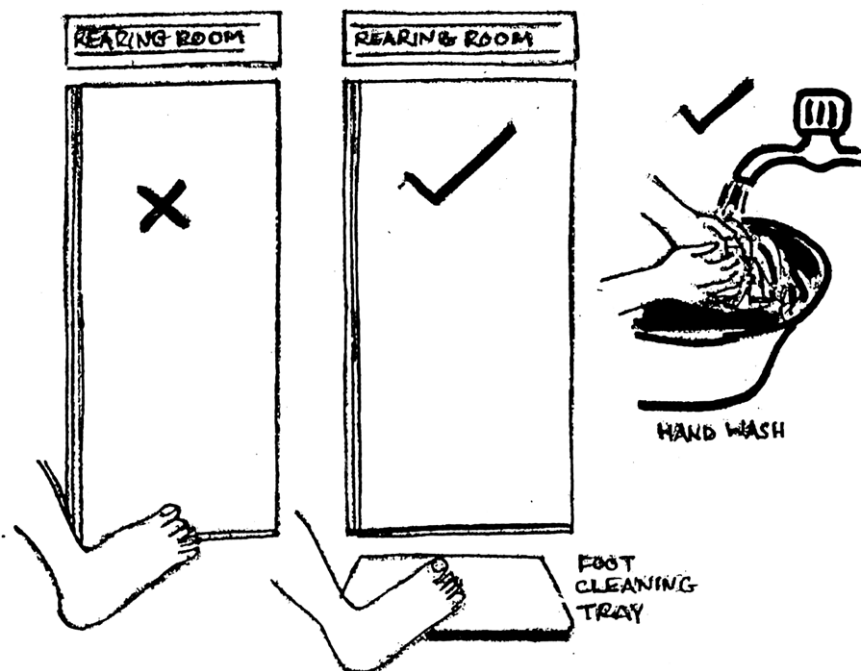


Fig. 4.4. Ideal Entrance

On the other hand diseased and dead worms collected during rearing should be put in lime vats or containers. The concentration of formalin solution in the basin stand should not increase one percent. The silkworm litter compost pit should be far away from the rearing house. While bed cleaning care must be taken to prevent dropping of litter on the floor of rearing house. Immediately after cleaning, the room should be swept and the rearer should wash hands and feet. Holes and crevices of rearing room should be closed to check the entry and accumulation of litter in them along with disease causing organisms. Therefore cleaning of rearing bed should be done preferably with nets. If the incidence of disease is more the worms are immediately shifted in to disinfected trays. Rearing equipments should not be borrowed or lend to prevent the transfer of pathogens from rearing house to the other. The rearing articles such as paraffin paper, old news paper are used for only one rearing. In any case overlapping of rearings should be avoided to maintain proper hygienic conditions and also to get good cocoon production.

SUMMARY

- ⊙ Maintenance of proper hygienic conditions is an important aspect in silk worm rearing.
- ⊙ Cleaning of dust and dirt in and around the rearing room is ensured. All the crevices, holes and room, equipments are cleaned properly before disinfection.
- ⊙ Disinfection includes elimination of various harmful microorganisms using various chemicals i.e. formalin, bleaching powder etc.
- ⊙ The equipments have to be washed with water, dried and disinfected.
- ⊙ There are two methods of disinfections – physical and chemical.
- ⊙ For disinfection 5% bleaching powder/ 2% formalin/0.5% sodium hypochlorite is used.
- ⊙ During disinfection 25°C temperature is maintained for quick diffusion of formalin gas. Room should be closed one day after disinfection.
- ⊙ The required strength and amount of disinfectant is calculated according to the room area.
- ⊙ Fumigation method of disinfection is effective in air tight rearing houses. Fumigation is continued for 4-5 hours, where disinfecting solution is warmed using stove.
- ⊙ Maintenance of hygienic conditions checks the spread of diseases.

QUESTIONS

I. SHORT QUESTIONS

1. Define cleaning
2. Define disinfection
3. Define fumigation
4. Name any four disinfectants used in sericulture
5. What are the methods of disinfection ?

6. How do you disinfect small rearing equipments ?
7. What is the ideal temperature and time for disinfection ?
8. Write the principle to calculate required strength of formalin ?
9. What is the use fo wettnig agents in disinfection process.
10. What chemicals and equipments are required for fumigation ?
11. State the importance of hygienic conditions.

II. ESSAY QUESTIONS

1. Write about disinfection of rearing equipment. Add a note on disinfection.
2. Detail the process of disinfection of rearing house stating the importance of disinfection.
3. How do you claculate the required strength of formalin. Explain with suitable example.
4. Write about cleaning and fumigation process.
5. Maintenance of hygenic condition in rearing are important eloborate the statement.

ENVIRONMENTAL CONDITIONS

5.1. INTRODUCTION

Silkworms are other domesticated insects for many centuries, as silk played an important role in the economic life of man. The silkworms are by nature quite delicate and very sensitive to environmental conditions. Silkworm rearing is aimed to produce good quality cocoons of very high silk content utilizing the available optimum environmental conditions. The ecological factors chiefly temperature, humidity, light and air during rearing show a significant effect on the growth of larvae and finally cocoon crop quality. However, the other factors such as quality and quantity of leaf supply and the techniques of rearing adopted. Such as feeding, cleaning, spacing etc., also influence the rearing activity. The silkworm behavior in relation to various environmental conditions varies with different stages of growth. Bad environment affects the growth of the worm. There by reducing the quality and quantity of silk as growth of the worm is directly correlated to the development of the silk gland. So based on the above responses, suitable environmental conditions have to be adopted for obtaining the best results. The importance of various environment at conditions and their effects on various aspects of rearing and silkworm development in particular are detailed in this chapter.

5.2. TEMPERATURE

Silkworms are poikilotherms/cold blooded animals, thus they change their body temperature according to the environmental temperature. Temperature has direct effect on the various physiological activities of living organisms. Like other animals (poikilotherms) the physiology of silkworm viz, metabolic rate, activity of enzymes, nutrients conversion, digestion, assimilation, excretion, nervous stimulations, hormonal actions are influenced by environmental temperature. The silkworms are capable of growing in temperature ranging from 15°C to 40°C. But from the physiological point of view the ideal temperature ranges from 20°C to 30°C. The silkworm rearing is aimed to produce good quality cocoons for which an ideal and desirable temperature ranges from 23°C to 28°C for getting maximum productivity. The effect of temperature on the physiology of silkworm during rearing can be divided into the groups which are as follows.

- ⊙ The temperature, which is harmless to the growth of silkworms.
- ⊙ The temperature, which is favourable for the healthy growth of silkworms.

The temperature, which is favourable for making good quality cocoons.

With the rise in temperature, the metabolic activities of the worm are increased while they are slackened when the temperature is low. Therefore at higher temperature the growth of the larvae is fast and consequently the duration of larvae period is shortened. On the other hand growth becomes slow at low temperature and it favours to prolong the larval duration. Therefore, to keep the temperature range within the limit is absolutely essential for rearing silkworms. The optimum temperature for normal growth in silkworms is between 20°C and 28°C. Temperature above 30°C is positively harmful to worms. If the temperature is below 20°C, the growth is considerably retarded owing to very low rate of physiological function. This temperature problem especially in the early stages results to make the worms weak and susceptible to diseases.

The chawki worms are comparatively stronger and more resistant to humidity temperature than late age worms. Thus the young worms feed very actively and grow very vigorous under high temperature and humid conditions. Such resistant and vigorous worms can feed and thrive better even under adverse conditions at later instars. Further, the resistance attained by early instar larvae improves the survival rate in various stages of development and finally they get good quality of cocoons.

As it is said earlier, that the temperature has a direct correlation with the growth of silkworms, wide fluctuations are avoided as they are harmful. The maximum temperature for rearing silkworms in different instars are as follows.

Age of worms		Optimum Temperature (°c)
I	---	26 - 28
II	---	26 - 28
III	---	24 - 26
IV	---	24 - 25
V	---	23 - 24

In case silkworms are reared in such a temperature in respective stadium, it is necessary that they are fed with rich nutrient sufficient leaves. So that maximum possible growth can be achieved. If insufficient amount of leaf is supplied expecting sufficient nutrition, it would be better to lower the rearing temperature at least to some extent. Moreover, regarding the rearing temperature in

the former period of the stadium is higher and it is lower in later period of stadium. The rearing room temperature can be recorded using a thermometer.

5.3. HUMIDITY

The role of the rearing humidity upon the growth and health of silkworm is similar to that of rearing temperature. That is high humidity makes to decrease the length of growing period of silkworms by accelerating the activity of physiological functions. The pH value of the blood is remarkably lower at high humidity (RH 80-90%) than at low humidity (60% RH) condition. Expiration of CO₂ increases with rise in humidity. On the contrary, low humidity makes to prolong the length of growing period of larva. The combined effect of both temperature and humidity largely determines the satisfactory growth of silkworms and production of quality cocoons. In this way both temperature and humidity are complementary to each other. The role of humidity is both direct and indirectly. It directly involves to influence the physiology of silkworm larva while indirectly influences the rate of withering of leaves in the larval beds. Therefore suitable rearing must be determined while considering the following points.

- a. The optimum humidity for the growth of silkworm is about 75% relative humidity. The early instars are resistant to high humidity with relatively little or no effect of change in the moisture. On the contrary the late age instars are weak against high humidity, suffering badly from the damage of humidity.
- b. In an extremely desiccated rearing room, silkworms cannot eat mulberry leaves owing to the withering of leaves. Then they become malnourished especially this problem occurs in the early instars.
- c. If the air of rearing room is too moist, it becomes favourable to grow the pathogenic microbes thus silkworms are apt to suffer from diseases.

Considering the above factors, different humidity conditions for different instars should be provided as follows.

Age of worms		humidity %
I	---	85
II	---	85
III	---	80
IV	---	75
V	---	70

For knowing the humidity percent of rearing room a hygrometer /wet & dry thermometer and humidity chart are required.

Keeping in view of the above considerations it is advisable that young silkworms are reared in a moist condition by covered box rearing. Because of high rearing temperature mulberry leaves are liable to wither and increase of feeding frequency is not advisable. On the other hand late age larva are reared in dried condition. Because the rearing room is apt to be wet with mulberry shoots with leaves. This realizes large amount of mulberry leaf supply, withering becomes slow, which introduces a wet climate in the rearing room. Moreover late age worms are weak to high humidity. At a humidity of 90 percent or higher, if the temperature is kept at 20°C – 28°C, the worms can grow without being affected.

5.4. Air

Silkworms breathe through eighteen spiracles on both sides of the body, supplying the blood with oxygen through the tracheae. These tracheae distribute the oxygen to the body and at the same time unnecessary substances i.e., CO₂ or water produced in the body are exhaled through tracheae. Therefore it is need less to say that the fresh air is necessary for the life of silkworms.

The air of rearing room is contaminated by carbon dioxide, sulfuric acid gas, carbon monoxide, ammonia, formaldehyde gas etc., produced by the breath of man, silkworms or mulberry leaves, the fermentation of litter, burning of coal. These gases are injurious to silkworms. When the gases increase in the beds and rearing room beyond the tolerance limits the worms become sluggish and do not feed..

The safe limit for silkworm rearing is 1 to 2% of CO₂, 1% of formaldehyde gas, 0.02% of sulphur dioxide and 0.1% of ammonia in the air of rearing room. Young worms are less resistant to toxic gas though comparatively resistant to CO₂. the production of these gases are far less in early instars than in late age instars.

The effect of sulfur dioxide cause prothetely in the cocoons, and makes the cocoon quality worse and worsening the reliability of cocoon filaments. Ammonia gas (0.1%) in the room makes the sericin insoluble while reeling.

5.5. Light

There is no correlation between light and survival rate of silkworms. However, silkworms are photosensitive and generally tends to crawl towards dimlight. They do not like either strong light or complete darkness.

to produce heavier cocoons than those of silkworms reared in dark condition. The appetite of silkworm is more in a light place than in a dark place. The larvae come up to the upper surface of the bed more quickly under light condition than in a dark condition. However it is not advisable to rear either in complete light or complete darkness. Silkworms are fond of dim light of 15 to 20 lux and avoid strong and darkness. The late age worms thrive better in 16hrs. light and 8hrs. dark period. Light helps in uniform distribution of larvae in rearing bed. They are crowded and distributed in several layers in dark condition compared to thin and even distribution in light condition. Photo period influences on the early instars on the type of eggs produced by the resulting moth.

5.6. Regulation of environmental conditions

5.6.1. Regulation of Temperature

The temperature varies from season to season. Generally the rearing practice starts in the month of September depending on the leaf availability. The room temperature is considerably low during winter and rainy seasons, thus it becomes a hurdle for rearing. For providing required optimum temperature the room has to be heated with electric heater or charcoal fires. Electric heaters are however costly and a marginal farmer is not expected to get that. But it is the best since it does not emit any smoke. When electricity is costly or not available, charcoal stove can be conveniently used. Care should be taken while using charcoal stove, as it should not emit smoke. It is better that the live clinders are covered with a layer of ash for better, more regulated and uniform dissemination of heat. In any case open fire using firewood as fuel should be avoided as it induces to generate obnoxious gases in the rearing room which in turn become harmful to worms. Besides this the doors and windows are kept closed during nights to keep out the cold and later in the day, as the outside temperature goes up, they should be opened to allow warm air to get in. This is another better way of temperature regulation without any expenses. In general, among the states Andhra Pradesh, Karnataka and West Bengal the temperature is often above the optimum level except for a few days of winter and rainy seasons. Therefore it is a problem for the farmer to bring down the raised temperature rather than to boost up. Such adverse effects of higher temperature to a certain extent be mitigated through proper designing of the rearing house and by ensuring adequate ventilation and free circulation of air inside the rearing house.

The temperature reading is quite opposite in summer when compared to winter and rainy seasons. This is again a problem to cut down the raised temperature. For this all the windows should be kept open during night. Further

all the doors are opened early in the morning so that cool air from outside flows into the rearing room and favours to bring down the temperature. When the day temperature increases with the day all the opened doors and windows have to be closed. Further the doors and windows are covered by wet gunny cloth to bring down the room temperature. Otherwise use of air cooler will serve the purpose. On the other hand problems of high and low temperature can be solved by air conditioning which is very costly and not affordable by many sericulturists.

5.6.2. Regulation of Humidity

The functions of humidity are very wide and frequent not only from season to season but also within the day itself during any season. The regulation of humidity during chawki rearing is achieved using paraffin paper, foam rubber pads, covered box rearing to get optimum levels. The humidity requirement during feeding and moulting of silkworm is different. It is necessary to lower the humidity to 60 per cent during moulting in each instar for uniform moulting. If this is neglected silkworms remain under the net, show uneven growth, become susceptible to disease, bed cleaning requires much labour, missing worms increases. Further removal of paraffin paper increases the drying effect. On the contrary high humidity is maintained during feeding which prevents leaf withering.

In tropical areas the temperature is usually higher than the optimum for late age rearing. Therefore humidity should not be high as both these parameters can prove highly detrimental to late age worms.

If the leaf withering is due to high temperature and low humidity it is better to give more water to the leaves by sprinkling while they are in storage. It is not advisable to raise the humidity of room by sprinkling water inside the rearing house, where the temperature is already high.

5.6.3. Regulation of Air

It is more important from the point of physiology of silkworm. Care should be taken to allow free circulation of air through proper ventilation to keep the toxic gases at low levels. Insecticides and disinfectants i.e. DDT, BHC, tobacco are harmful to the worms are more highly susceptible to these chemicals than late age worms. Thus care must be taken in handling such agricultural chemicals. Air current of 1.0 meters per second during V age rearing considerably reduces larval mortality by improving ingestion, digestion, larval weight, cocoon weight and pupation rate. Though it is less important to ventilate the room during, younger states, care should be taken to remove paraffin cover and keep the rearing bed open before each feed for free circulation of fresh air. Moreover it is

one of the important factor for rearing silkworms that the temperature and humidity of rearing room can be controlled by ventilation. Therefore artificial circulation of air helps to cut down the temperature and humidity.

Therefore, considering all the above facts, it is advisable to rear silkworms in the dim light during the day time and in the dark at night.

SUMMARY

- ⊙ The ecological factors chiefly temperature, humidity light and air during rearing have a significant influence on the growth of larva and ultimately on cocoon crop quality.
- ⊙ The influence of these factors on rearing varies in different stages of larval growth.
- ⊙ Temperature directly influences the growth of the worms. The optimum temperature for normal growth of silkworm is between 23°C and 28°C.
- ⊙ Regulation of temperature is summer, winter and rainy days is more important. This can be achieved by air cooler, hanging wet gunny cloth to the doors and windows in summer seasons. While in winter and rainy seasons it is to heat up the room using stoves.
- ⊙ The effects of humidity are direct and indirect.
- ⊙ The optimum humidity ranges from 70 – 85% for better growth of worms.
- ⊙ Young age worms require high humidity, this is possible when paraffin paper, wet foam pads and box rearing is adopted.
- ⊙ High humidity generally helps to prevent leaf withering
- ⊙ Silkworm require fresh air. Care should be taken to avoid the injurious gases such as CO, NH₄, SO₂ etc, by allowing fresh air through proper ventilation.
- ⊙ Silkworms are fond of dim light of 15 to 20 lux and avoid strong and darkness.

QUESTIONS

I. SHORT QUESTIONS

1. Define poikilotherms
2. What is the ideal temperature for silkworm rearing ?
3. How do you regulate high temperature during summer ?
4. How do you regulate low temperature during winter days ?
5. What are the indirect effects of humidity ?
6. What do you require to measure humidity ?
7. List out toxic gases produced in the rearing room.
8. What is safe limit of CO₂, NH₄, SO₂ in rearing ?
9. How much air current is useful in V instar ?
10. How much light is required for rearing ?

II. ESSAY QUESTIONS

1. What are the environmental conditions ? Discuss about temperature and its regulation.
2. Discuss in detail about various environmental factors.
3. Discuss about light and air required for rearing.
4. Detail about temperature, humidity required for rearing.

EQUIPMENT REQUIRED FOR REARING 300 DFLS

6.1. INTRODUCTION

After selection of rearing house the next phase is to consider proper rearing equipment. Sericulturist must use the space available in the room for maximum possible advantage of rearing. The rearer has to utilize all the resources available in the field for procurement/preparation of equipment. Locally available material will be cheap and reduces transport charges. Metallic equipments are to be prepared locally utilizing the skills of blacksmith and suggestion of sericulture technicians.

6.2. EQUIPMENT

The following articles constitute the rearing equipment.

1. Wooden trays (Rectangular)
2. Bamboo trays (Round)
3. Rearing stand
4. Ant wells
5. Leaf chopping knives
6. Leaf chopping board
7. Leaf chopping mat
8. Bed cleaning nets
9. Leaf Chamber
10. Feeding stand (wooden or metal)
11. Feeding mat
12. Leaf basket
13. Chopsticks, feathers
14. Dry-wet bulb thermometer
15. Hygrometer

16. Charcoal Stove or Electric heater
17. Foot cleaning tray
18. Paraffin papers and rubber foam strips
19. Wash basin – stand
20. Foot cleaning tray
21. Sprayer
22. Nylon nets against UZI fly
23. Rough Balance
24. Litter basket
25. Humidity chart
26. Air cooler (optional)

Chemicals

1. Formaldehyde
2. Bleaching powder
3. Paraformaldehyde
4. Benzoic acid
5. Uzicide
6. Lime Powder
7. China clay
8. R.K.O.
9. Dimilin
10. Dettol or cresol

The above listed equipment is useful for rearing, cleaning, feeding, disinfection, regulation of environmental conditions, leaf storage, pest control, brushing activities.

The details description and time of using different equipment listed in this chapter have already been discussed in the earlier chapter of this book. Students are advised to review them for further understanding of this chapter.

Equipments required for rearing 300 DFL's in a single batch

S.No.	Particulars of the equipment	No. Required
1.	Wooden trays for young age rearings (Rectangular)	6
2.	Bamboo trays (Round)	90-96
3.	Rearing Stands	9
4.	Ant wells	36
5.	Leaf chambers	2
6.	Leaf chopping knives	2
7.	Leaf chopping board	1
8.	Leaf chopping sticks	12
9.	Leaf chopping mat	1
10.	Leaf Basket	5-10
11.	Feeding stand (Wooden or iron)	1
12.	Basin with stand	1
13.	Bed cleaning nets, each size 1, 1x3=3	3
14.	Foot cleaning tray	1
15.	Hygrometer	1
16.	Dry-wet bulb thermometer	1
17.	Mountages	90
18.	Paraffin paper and Foam Rubber Strips	20sheets 1 kg.
19.	Charcoal stove or Electric heater	1
20.	Leaf feeding mat	1
21.	Sprayer	1
22.	Nylon nets against UZI fly to cover the rearing stand	1
23.	Litter basket	1
24.	Humidity chart	1
25.	Rough balance	1

Chemicals

1. Formaldehyde Solution
2. Bleaching powder
3. Paraformaldehyde
4. Benzoic acid
5. Uzicide
6. Lime Powder
7. R.K.O.
8. Dimilin
9. Dettol or cresol
10. China clay



Fig. 6.1. Basic Rearing Equipments

SUMMARY

- ⊙ Rearer should procure good, suitable equipments.
- ⊙ As far as possible locally available material and equipments are used
- ⊙ Various equipments such as rearing, brushing, leaf storing, cleaning, disinfecting, feeding, pest controlling are necessary for rearing.
- ⊙ Disinfecting chemicals are compulsory for rearing activity.

QUESTIONS

I. SHORT QUESTIONS

1. Mention some feeding equipments.
2. Mention disinfecting equipments.
3. Mention leaf storing equipments.
4. What are the equipments used for regulation of environmental conditions ?
5. Mention pest controlling equipments ?

II. ESSAY QUESTIONS

1. List out equipments and chemicals required for rearing.
2. What are the equipment requirements for rearing 300 DFL's ?

INCUBATION OF EGGS

7.1. INTRODUCTION

Silkworm eggs are of two types i.e. hibernating and non-hibernating eggs. Further processing of the eggs depends upon whether they are of the diapausing or the non diapausing type. Univoltine races lay only diapausing eggs Multivoltine races lay only non-hibernating eggs while the behavior of the eggs of the bivoltine is intermediate. Except multivoltine, uni and bivoltine race eggs are hibernating eggs which require special treatment to make them hatch. These eggs stored till the next season or awakened from diapause artificially. The eggs stored are taken out and subjected to incubation to achieve uniform hatching on desired day. This can be achieved by exposing the eggs to certain range of environment conditions. The incubation of eggs is one of the essential parameter in silkworm rearing.

7.2. INCUBATION

The quality of eggs play a vital role in silkworm rearing. The eggs are to be incubated properly which ensures maximum hatching. Incubation is a phase in protecting the activated silkworm eggs before rearing. The environment influences the stored eggs in the development of the embryo, uniform hatching of the worms, health of the larvae, mortality, yield of cocoons. Thus the silkworm eggs are kept under proper incubation process to get high and uniform rate of hatching, on the desired date, good larval health and high cocoon quality. Acid treatment (artificial incubation) followed by ideal incubation process.

The incubation room, chamber must be clean. The required chemicals, disinfectants, equipments are to be kept available. Heating or cooling arrangements must be perfect so as to maintain uniform temperature throughout the incubation room. The eggs cards are arranged in such a way to expose all the eggs to the temperature and room humidity. Optimum humidity in the incubation room should be 80-85 percent and temperature for non-hibernating eggs and eggs after acid treatment for immediate hatching is 24^o-25^oC right from the beginning.

Over-wintered eggs taken out of cold storage are to be first kept at a temperature of 15°C for three days. Then these eggs are exposed to incubation temperature of 24^o-25°C. This avoids sudden violent change of temperature and helps in uniform development. Eggs stored after acid treatment should be kept at 15°C for 12 hours and exposed to incubation temperature (Table 1.1). High temperature makes the eggs hatch earlier, results in a large proportion of the eggs dying or becoming weak. They do not hatch at all. Hatched worms are lighter and remain well below the normal size resulting in forming poor silk cocoons. Too low temperature prolongs incubation process. Many eggs do not hatch and hatching would be very irregular.

Table 7.1. Conditions for Incubation

Items	No. of days in incubation											
	1	2	3	4	5	6	7	8	9	10	11	12
Temperature (°C)	25-----											
Humidity (%)	85-----											
Illumination	0 ----- 16 hr ----- 0											

Humidity also plays vital role in incubation. Lack of optimum humidity results in poor hatching. High humidity makes the worms easily susceptible to diseases and also produce trimoulters.

Light intensity during incubation hastens embryo growth, development and hatching. It is possible to stimulate and synchronize the hatching dates of all the eggs. Silkworms eggs may be kept under a photoperiod of 16 hours daily until 30-40% of the eggs reach blue egg stage (three days before hatching). At this stage eggs are kept in dark black boxes for more uniform hatching on the next day.

If for any unexpected reason hatching has to be delayed after incubation has started, can be done to a limited extent by cold storing the eggs at 5°C on the second or third day of incubation for about a week. Hatching can be delayed at blue eggs stage by cold storing for about a week. Hatching can be delayed at blue eggs stage by cold storing for about a week at 5°C. Brushing can also be delayed by cold storing the newly hatched larvae for about three days at 7.5^o-10°C.

7.2.1. HANDLING OF EGGS

The incubated eggs are handled properly to get good hatching otherwise harmful effects may result.

Silkworm eggs are produced in central places, viz, by Government grainages and or private licensed seed producers. Readers have to purchase the eggs from egg producing centres. The eggs being live material should not be subjected to adverse environmental conditions, which will result in unhealthy development of embryos. Hence, there is a need to transport eggs properly to ensure healthy and uniform development of the eggs.

Live silkworm eggs are transported from egg producing centers (grainages) to the rearer's rearing places or chawki rearing centres (young silkworm rearing centres).

The silkworm eggs are live material. The development embryo inside the egg shell need delicate handling. The embryos need oxygen which should be made available by proper circulation of air in the container used for transportation. Non-supply of air results in suffocation which affects the healthy development of the embryo. The developing embryo need optimum temperature and humidity. If the temperature is more than the optimum, it affects the development and physiological activity of the embryo. The eggs require about 75% humidity, as otherwise they dessicate (Fig. 7.1).

Eggs exposed to high temperature (above 28°C) and humidity (over 90%) during egg-laying and incubation; storage of hibernating eggs at 25°C for too long period or under dry and high temperature conditions; stimulation of eggs in acid treatment; contamination of eggs by pesticides, nicotine, mosquito repellent, glue or gum causes rotten eggs before head pigmentation. Rotten eggs are dead which perish after the colouring of the serosa and before head pigmentation with sunken shell and deep cavity. Too high temperature (over 28°C) during incubation; too low relative humidity (less than 50%); contact with pesticides or other harmful chemicals causes dead eggs after head pigmentation. In this embryo is normally formed in the egg shell but death occurs before hatching stage.



Fig 7.1. Transport of Eggs

Thus keeping in view of the above dangers the eggs are to be handled carefully till hatching so as to ensure uniform and more hatching.

7.3. Blue Egg Stage

When the eggs are incubated (Fig. 7.2) under suitable conditions reach to pin head or head pigmentation stage in 7-8 days (48 hours before hatching). This first pigmentation can be seen through the egg shell as a blue spot and this stage is called "eye spot" stage. On the following day the whole body of the embryo turns black due to the development of body pigments and appears bluish-black through the egg shell and called as "blue egg stage". These blue egg stages hatch out in all hours (Fig. 7.3).

7.4. Black Boxing

Eggs after reaching blue egg stage are kept in black box/paper/cloth and kept in dark. In this way early maturing embryos are prevented from hatching and late maturing embryos are given time to develop and catch up with the early maturing ones. Thus all the eggs reach to blue egg stage. The eggs hatch out in response to phototropic stimulus. This method favours hatching more than 90 per cent. If hatching is not uniform and only 50-60 per cent of eggs hatch on the first day. Brushing can be postponed to next day as well. If necessary hatched worms can be separated and kept in tissue paper and stored in fridge at 10°C. when the second batch hatch out the refrigerated eggs mixed and brushed together. Even blue egg stages can also be preserved at 5°C for 2-3 days.



Fig. 7.2. Incubation Box

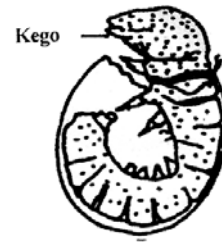
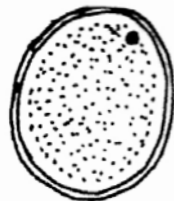


Fig. 7.4. Hatching



Structure



Head Pigmentation



Blue Egg Stage

Fig. 7.3. *Bombix* Embryonic Stages

SUMMARY

- ❖ Incubation of silkworms eggs favour maximum hatching.
- ❖ Incubation room, chamber must be clean and should possess required chemicals, disinfectants, equipments.
- ❖ Non-hibernating eggs and after acid treatment requires 80-85% humidity and 24-25°C temperature right from the beginning.
- ❖ Cold stored eggs are gradually brought to normal room temperature.
- ❖ Temperature, humidity, light are equally important during incubation of eggs.
- ❖ Eggs are kept under a photoperiod of 16 hours daily until 30-40% of the eggs reach blue egg stage.
- ❖ Blue egg stage eggs are kept in dark/black boxes for more uniform hatching on the next day.
- ❖ Hatching can be delayed at blue egg stage by cold storing for about a week at 9°C.
- ❖ Incubated eggs are handled properly for good hatching percentage.
- ❖ The eggs before (48) hours hatching reach head pigmentation or pin head stage and are called eye spot stage. On the following day embryo turns black and called blue egg stage.
- ❖ Blue egg stage are kept in black boxes for maximum hatching percentage.
- ❖ Blue egg stage eggs can be preserved at 5°C for 2-3 days.

QUESTIONS

I. SHORT QUESTIONS

1. Define incubation
2. Define blue egg stage.
3. Define black boxing.
4. Mention incubation temperature and humidity
5. Define 'kego' or 'ant'.

5. Define 'kego' or 'ant'.
6. What is handling of eggs ?
7. What is ey spot stage ?
8. Mention principle for calculating hatching percentage.

II. ESSAY QUESTIONS

1. Detail incubation process of silkworm eggs.
2. What is the importance of handling of eggs ?
3. Write about black boxing of silkworm eggs.
4. Write short notes on
 - a) Black Boxing
 - b) Blue egg stage.

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GLOSSARY

CLEANING and DEBRIS	It is a process to remove and eliminate dust dirt It is an unward waste product
COCOON	Protective covering of eggs, larvae etc. eggs of some annelide are fertilized and developed in a cocoon. Larvae of many insects spin cocoons in which pupae develop.
DFL's	Disease Free Layings.
DISINFECT	The destruction and extermination of disease causing germs.
INSTAR	Stage in development of an insect, between two ecyses or the final adult stage.
LARVA	The Pre-adult form in which same animals hatch from the egg; capable of feeding for itself though usually in a way different from adult; but usually incapable of sexual reproduction; and distinctly different from sexually mature adult in form. Changes into adult, usually by a rather rapid metamorphosis.
CHAWKI REARING	Rearing of I, II instar silkworms.
LATE AGE REARING	Rearing of IV and V instar silkworms.
HYGIENE	It is a state where total healthy conditions are available.
COCOON	Protective covering of eggs, larvae etc. eg. Eggs of some annehdfs are fertilized and developed in a cocoon, Larvae of many insects spin cocoons in which pupae develop.
BLEACHING	It is a Chemical process involved in eliminating harmful micro-organisms.
HYGROMETER	An instrument used to measure humidity of the environment.

STERLIZE	It is a process to get rid of microbes by boiling or other means.
TASAR SILK	A wild type silk spun by <i>Antheraea</i> species feeding on <i>Terminalia</i> or <i>Quercus</i> leaves.
MUGA SILK	The golden yellow silk spun by multivoltine <i>Antheraea</i> species feeding on castor oil plant.
KAHAN	It is one of the unit of measure in vogue in tasar industry. It varies from State to State. It reads 1280 cocoons in Bihar, 1600 in Orissa, 1000 in Madhya Pradesh, 4000 in Maharashtra.
CHALONI	It is a bamboo cocoonage used for spinning of muga silkworms.
JALI	It is a term used for cocoonage in wild silkworm rearing.
FUMIGATION	It is a type of disinfection in the gaseous form.
HUMIDITY	It indicates the percentage of water vapour present in the air.