UNIT 1

Hatching and Brushing

Structure

1.1 Introduction
1.2 Incubation
1.3 Handling of Eggs
1.4 Black Boxing
1.5 Hatching
1.6 Hatching Percentage
1.7 Brushing
1.8 Methods of Brushing

Learning Objectives

After studying this chapter students will be able to

• Understand how to handling the silkworm eggs, how to conduct incubation and black boxing of the eggs
• Identify the embryonic changes during incubation
• Distinguish the Head pigmentation stage and Blue egg stages
• Calculate the good and bad egg percentage.
1.1 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. Uni voltine races lay only diapausing eggs. Multi voltine races lay only non-diapausing eggs while the behaviour of the eggs of the bivoltine is intermediate. Except multi voltine, uni and bi voltine race eggs are hibernating (diapausing) eggs which require special treatment to make them hatch. These eggs are 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 a desired day. This can be achieved by exposing the eggs to certain range of environmental conditions. The incubation of eggs is one of the essential parameter in silkworm rearing.

Silkworm rearing requires care and skill. Since various rearing operations are important which finally reflect on cocoon quality and quantity. The rearing room activity starts with brushing of newly hatched silkworms. Since silkworms are susceptible for any kind of diseases and cannot withstand to any changes in the environmental conditions. The rearing room should be prepared in such a way not to hamper the growth of the worms. On the other hand mulberry garden should possess 5-6 leaves. It is better to tap the shoots 25-30 days prior to the date of brushing.

The equipment such as foam rubber strips, chawki rearing trays, feather (white), paraffin paper, chopping board and knife, mats are kept ready for rearing.

The desired race of silkworm DFLs (Disease Free Layings) are procured from Grainage. The eggs are protected from ants, rats. They are incubated well and later kept in black box at blue egg stage. The process of brushing and methods are explained in this unit.

1.2 Incubation

The quality of eggs plays a vital role in silkworm rearing. The eggs are to be incubated properly which ensure maximum hatching percentage. Incubation is a phase in protecting the activated silkworm eggs before rearing. Incubation means to provide suitable environmental conditions i.e. temperature 25°C ± 1°C and humidty 70 to 80% for uniform development of embryo to achieve good hatching percentage. The environment influences the stored eggs in the development of the embryo, uniform hatching of the worms, health of the larvae, mortality and 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. The cold preservation treatment, acid treatment (artificial incubation) and followed by ideal incubation process are keen factors for achieving good quality cocoon crop.
The incubation room, chamber must be clean. The required chemicals, disinfectants, equipments are to be kept available. Room heating and cooling arrangements must be prefect so as to maintain uniform temperature throughout the incubation process. 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 per cent and temperature for non-hibernating eggs and eggs after acid treatment for immediate hatching is 24\(^0\)-25\(^0\)C right from the beginning.

Over-wintered eggs taken out of cold storage are to be first kept at a temperature of 15\(^0\)C for three days. Then these eggs are exposed to incubation temperature of 24\(^0\)-25\(^0\)C. This avoids sudden violent change of temperature and helps in uniform development. Eggs stored after acid treatment should be kept at 15\(^0\)C for 12 hours and exposed to incubation temperature (Table 1.1). High temperature though 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 process. Many eggs do not hatch and hatching would be very irregular.

**Table 1.1 Conditions for Incubation**

<table>
<thead>
<tr>
<th>No. of Days in Incubation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature ($^0$C)</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illumination</td>
<td>0–</td>
<td>16hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Humidity also plays vital role in incubation, lack of optimum humidity result in poor hatching. High humidity makes the worms easily susceptible to diseases and also produces tri moulters.

Light intensity during incubation hastens embryo growth, development and hatching. It is possible to stimulate and synchronize the hatching dates of all the eggs. Silk worm 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 any unexpected reason, for which the 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 egg 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°C.

1.3 Handling of Eggs

The incubated eggs are handled properly to get good hatching percentage, otherwise harmful effects may result in poor or ununiform hatching.

Silkworm eggs are produced in central places, viz., by the Government grainages or private licensed seed producers. Rearers have to purchase the eggs from egg producing centers only. The eggs being exposed to live environmental conditions, which will result unhealthy development of embryos. Hence, there is a need to transport eggs properly to ensure healthy and uniform development of the eggs.

Live silk worm eggs are transported from egg producing centers (grainages) to the rearer’s rearing places or chawki rearing centers (young silkworm rearing centers) with proper care, because during transport also it is important to maintain optimum temperature and humidity.

Fig 1.1 Transport of Eggs
The silk worm eggs are live mererial. The developing embryo inside the egg shell delicate handling. The embryos need oxygen which should be made available by proper circulation of air in the cotainer used for transportation. Non-supply of air results in suffocation which affects the healthy development of the embryo. The developing embryo needs 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. 1.1).

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 rottening of eggs before head pigmentation. Rotten eggs are dead eggs 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 eggs shell but death occurs before hatching stage.

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

1.4 Black boxing

Fig 1.2 Incubation Box
Black Boxing
When the eggs are incubated (Fig 1.2) 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. 1.3).

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 percent 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 refrigerator later batch hatched are mixed with refrigerated eggs and brushed together. Even blue egg stages can also be preserved at 5°C for 2-3 days.

1.5 Hatching

Silk worm eggs are available loosely or on egg cards. The newly developed larvae break out the eggs shell and come out, and is called hatching.

The hatched larvae are brushed and reared. The newly hatched larvae are black, hairy and look like small ants and are called “ants” or “kego”. It is always better to brush the larvae in the morning. The eggs exposed in early hours or hot hours results in irregular hatching. Generally brushing should not be delayed. If necessary, can be postponed to next day when hatching is irregular.

Brushing should be completed in the morning/cool hours of the day. Freshly emerged larvae can also be preserved at 7-10°C for one day.

1.6 Hatching Percentage

The ratio between hatched eggs and total no. of eggs in a laying is called “hatching percentage”. The hatched eggs, unfertilised or dead egg number is counted individually for calculating the percentage. This can be done using a different coloured ink pens usually red and later it is calculated using the following formula and method.

\[
\text{Hatching percentage} = \frac{\text{Total No. of eggs hatched}}{\text{Total No. of eggs}} \times 100
\]

\[
\text{Unfertilised egg percentage} = \frac{\text{Total No. of dead eggs}}{\text{Total No. of eggs}} \times 100
\]

Total no. of eggs = Good eggs + dead eggs.

Model Problem

In a laying, total eggs are 445, out of which 415 hatched. Find out hatching and dead eggs percentage.

Total eggs = 445
Hatched = 415
Unfertilized eggs = Total eggs – hatched eggs
Dead/unfertilised eggs = 30

Hatching percentage = \( \frac{415 \times 100}{445} = 93.25\% \)

Un fertilised egg percentage = \( \frac{30 \times 100}{445} = 6.74\% \)

**Example - 1**

In a laying total eggs are 475 out of which 20 eggs did not hatch. Find out hatching and dead eggs percentage.

- Total eggs = 475
- Dead eggs = 20
- Good eggs = Total eggs - dead eggs = 475 - 20 = 455

Hatching percentage = \( \frac{455}{475} \times 100 = 95.78\% \)

Un fertilised egg percentage = \( \frac{20 \times 100}{475} = 4.2\% \)

**Example - 2**

In a laying total eggs are 444 out of which 70 eggs did not hatch. Find out hatching and dead eggs percentage.

- Hatched eggs = 444
- Dead eggs = 70
- Good eggs = Hatched eggs - dead eggs = 444 - 70 = 374

Hatching percentage = \( \frac{374}{444} \times 100 = 84.23\% \)
110

Sericulture

When the eggs hatch, the emerged larvae are to be collected for rearing. This process of separating kego /ants from egg sheet or egg shell is called “brushing”. Which involve sprinkling of thinly chopped mulberry leaves on just hatched larvae to attract them to feed. The larvae which crawl on to leaves will be separated and transferred to rearing tray from their shells by using f optimum time for brushing is around 10 am when the humidity is 83 – 90% and temperature is 27*c.

Normally hatching starts at 5 – 6 am when the eggs are exposed to early sun rays. Uniform hatching can be expected by 7-8 am. After 2 hours the newly hatched worms develop appetite and begin to crawl. Thus the suitable time for brushing would be 10 am but once again it depends upon the weather conditions.

Before brushing, rearing facilities should be prepared according to the number of silkworms to be reared. Tender mulberry leaves should be chopped to 3-5 mm size. When the worms crawl over in to the tray worm bodies should be disinfected for disease prevention by using a fine-mesh sieve to dust a fine powder of formalin (3%).

1.8 Methods of Brushing

Brushing of eggs is of two types depending on type of eggs.

1. Brushing of loose eggs.

2. Brushing of egg cards.

1.8.1 Brushing loose eggs

The eggs are spread evenly in one layer in the egg box and kept in black box at blue egg stage. On the next day when all eggs reach blue egg stage they are removed from black box and covered with a thin perforated cloth or a fine mesh or finely perforated paper (Fig.2.1).

This covering is placed in such a way that it just touches the upper surface of the eggs. Then just before brushing, chopped mulberry leaves are sprinkled on the top of the net or cloth or paper. This mulberry leaf attracts the hatched worms to crawl on to the upper surface. When maximum number of worms hatches out and crawls on to the paper they are transferred to rearing tray.
There are four methods

(a) **Tapping method**

The hatched larvae which crawl towards the edges or corners of the egg sheet are collected in to rearing tray using a feather. The egg sheet is held upside down just above the rearing seat and tapped. The larvae fall on to the rearing seat. Then the dropped larvae are brushed together with feather and fed with mulberry leaf which are already chopped.

(b) **Feather method**

The hatched larvae which crawl towards the edge or corners of the sheet are collected gently with white feather. Hold the egg sheet slantwise to the rearing seat, transfer larvae with the help of a feather. (Fig. 1.7). Later worms are fed with finely chopped mulberry leaf.

(c) **Brushing with mulberry leaves**

Mulberry leaves chopped to 0.5 sq.cm size are sprinkled on the egg sheets when larvae hatch out. The mulberry leaf attracts the larvae. After 10 minutes the egg sheet is turned upside down and larvae on mulberry leaf are transferred to rearing tray using feather.
(d) Husk - feeding method

Finely powdered paddy husk is sprinkled, evenly over the eggs sheet when the larvae hatched. Then finely chopped mulberry leaves are sprinkled over the worms which crawl on to leaf are transferred to rearing tray by using feather.
(e) Net and feeding method of Brushing

In this method spread a net on the hatched larvae then sprinkled chopped leaves over the net. The leaves attract the larvae. After 30 minutes leaves, worms along with net transferred to another rearing tray.

Summary

- Incubation is aims to secure the uniform growth and development of embryo.

- Incubation room, chamber must be clean and should possess required chemicals, disinfectants, equipments.
• Non-hibernating eggs and eggs after acid treatment requires 80-85% humidity and 24-25°C temperature right from the beginning.

• Blue egg stage eggs are kept in dark/black boxes for uniform hatching.

• 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.

• “Black boxing is a process of the blue egg stage are kept in a black boxes to ensure uniform hatching 90-95% of eggs at a time”.

• Newly hatched larva is called ant or kego.

• Brushing is the process/activity, which the separation of newly hatched worms from the egg shells.

• While brushing loose eggs, perforated, thin cloth is spread and later chopped mulberry leaf is sprinkled over the cloth, then worms are by feather in to clean tray.

• While brushing care must be taken not to damage the silkworms.

**Short Answer Type Questions**

1. Define incubation.

2. Define blue egg stage.

3. Define black boxing.

4. Define ‘kego’ or ‘ant’.

5. What is handling of eggs?


7. Define Brushing.

8. List out methods of brushing.

9. Define D.F.L.

**Long Answer Type 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). Hatching. (b). Blue egg stage. (c). Brushing.

5. Calculate hatching percentage using these values
   
   Total eggs = 530, Hatched eggs = 512, Dead eggs = 10, Un fertilized eggs = 15

6. Detail the process of brushing of loose eggs.

7. Describe methods of brushing from egg card.

8. Write shot notes on
   (a). Hatching (b). Blue egg stage (c). Feather method.
UNIT 2

Chawki Rearing

Structure

2.1 Introduction
2.2 Quality of Leaf
2.3 Leaf Selection
2.4 Feeding Schedules
2.5 Bed Cleaning
2.6 Spacing
2.7 Moulting
2.8 Chawki Rearing Method
2.9 Chawki Rearing Centers (CRCs)

Learning Objectives

After studying this unit, students will be able to

- Understand chawki rearing methods
- Identify the moulting and out of moulting worms
- Understand the importance of chawki rearing centers
- Importance of silkworm feeding and spacing schedules
2.1 Introduction

The life cycle of silk worm consists of egg, larva, pupa (cocoon) and adult stages. Among these four stages, larval stage is the only feeding and active stage. The duration of larval period from hatching to spinning is about 26 days. During this long duration the larvae grow in size and enter cocoon (pupal) stage.

To accommodate the larval body growth the larvae undergo four moults and the complete larval duration can be clearly differentiated into five instars or stages. The first three instars (till the third moult) are known as young age or chawki and the last two instars are called as late age worms.

2.2 Quality of mulberry leaf

The mulberry leaf is the exclusive food of the silkworm *Bombyx mori*(L.) The growth of the silk worm very much depends on the quality of leaves fed to them. The leaf quality is influenced by various factors such as soil, pruning, fertilizer, rainfall, irrigation etc., with these conditions mulberry grows luxuriously with rich contents of proteins and carbohydrates. Further the leaves are also succulent due to high nutrient content. These types of leaves are edible for silk worms for better growth and to produce good cocoons, leaves of Mulberry grown on loamy soil contain more water, protein and less carbohydrate and fibre, further the leaves mature slowly.

Mulberry leaves from trees grown in sandy or gravel soil mature quickly becoming rough and coarse. These leaves contain less moisture, protein and more carbohydrates and fibre. Application of balanced fertilizers with major elements required by the plants improves both physical and chemical properties of the leaves. In well distributed rainfall or irrigated conditions the mulberry growth is vigorous. Leaves of these plants are rich in nutritive value and are soft and succulent.

In areas where temperature varies during day and nights are high the leaf quality becomes superior. The nutrients synthesized during the day are least utilized during the cool night hours. Therefore the nutrients are better preserved in the leaves.

Mulberry raised under ideal agronomic conditions are better for rearing silkworms. The conditions are as follows.

1. Good soil, neither too clayey nor too sandy, but not acidic.
2. Application of optimum and balanced fertilizers.
3. Suitable cultural operations.
4. Assured irrigation or rainfall.

On the above said conditions the leaves are rich in protein, and carbohydrates besides high leaf moisture. The leaves are soft and succulent. These type of leaves are easily digested and best utilized.

From the quality point of view the requirements of young worms are completely different from those of late age worms. The chawki worms require tender, soft and succulent leaf having higher contents of moisture, protein, sugars and less starch and fibre. However tender and soft leaves are not suitable for the Silk worm.

The quality of leaf may vary considerably from season to season. In summer the leaves grow and mature fast, but wither quickly. Its life in the rearing bed becomes short favouring to increase number of feeds per day. In rainy and winter season, the leaves grow and mature fast and contain more moisture. Hence the life is longer therefore reduces the number of feeds per day. Because of high moisture content, humidity of the beds increases. Therefore it is necessary to keep down the humidity of the bed under control through feeding of reduced quantity of leaf and more mature leaf containing less moisture.

This can be achieved when leaves to the second age are fed to first instar larvae and the normal third age leaves to the second instar larvae and so on. In cold season the mulberry growth is slower and leaves mature gradually. This type of leaves neither withers nor increase bed humidity leading to successful crops. Morning time is the proper time for picking the mulberry leaves by planning the total leaf requirement of the day.

### 2.3 Leaf Selection

Mulberry leaf for young silkworms has a great effect on the growth and health of silkworm. Therefore selection of leaves should be done carefully. The leaves for young silkworms must be soft, tender, rich in water content, protein, carbohydrates etc.,. There is high correlation between moisture content in the top tender leaves and chawki worm growth and moulting. Therefore for plucking the correct leaves for young worms, the largest leaf method is adopted.

#### 2.3.1 Glossy leaf method

For the identification of glossy leaf, hold the upper part of shoot lightly, and move the hand upward gently. Then appears a large leaf which stands out at the top (Fig.2.1.a,b). This is identified as largest glossy leaf. Otherwise holding the upper part of the shootlet lightly between fingers, and bend it horizontally. Then a leaf stands up right is identified as largest glossy leaf (Fig.3.1c).
Now the first instar are fed with 4th and 5th leaves downward from the base of glossy leaf, for second instar 5th-7th leaves, for third instar 7-8 leaves to downward are plucked.

**Fig 2.1 Glossy Leaf Selection**

For 2nd instar

Leafage for 3rd instar

Border between green and brown brach colours

Young first leaves for 1st feeding of newly hatched worms

Light green shoots for the 2nd instar

Buds turn browish

Dark green

Brown

Dark green and brown colours indicate the maturity of leaves for the 4-5th instar feeding

**Fig 2.2 Lenticel and Bud Method**

2.3.2 Lenticel and Bud (LB) Method

In this method the colour of the lenticel and auxiliary buds are used to harvest good leaves corresponding to the stage of worms.
The colour of auxiliary buds changes from the top to the bottom of the branch. From top to bottom is green, apical buds are brownish, striped, non-accomplished and accomplished buds. (Fig. 3.2).

The leaf with yellowish lenticel at the base of leaf petiole found above the apical brownish buds is used for first instar. Leaves from the brownish lenticel through the apical brownish lenticel through the non-accomplished bud are used for third instar.

### 2.4 Feeding Schedule

#### 2.4.1 Feeding

Silkworms are fed to satisfy their appetite. Thereby uniform and healthy growth of silkworms can be achieved. For this, quality leaves are to be preserved and rearing beds are kept clean. Feeding with too much leaves is not economical.

**The main objectives of feeding are**

1. To satisfy the appetite of larvae
2. To promote eating and digestion of leaves by larvae
3. To keep the quality of leaves during eating.
4. To keep rearing beds clean
5. To avoid wastage of leaves and labour

**Fig 2.3** Feeding Silk Worm

Generally early age silkworms eat leaves from the surface, while late age worms from the edge. The feeding activity of each instar silkworm can be conveniently divided into seven stages.
1. First feeding stage
2. Sparse eating stage
3. Moderate eating stage
4. Active eating stage
5. Pre moulting stage
6. Last feeding stage
7. Moulting stage.

2.4.2 Growth of Silk worms

Silk worms show high rate of growth. The growth by weight, between hatching and final spinning of cocoons stage is 10,000 times which is achieved in a matter of 24 to 25 days. For achieving full growth of silkworm new techniques of rearing are followed by which worm grows to a weight of 4-5 gr. These worms are healthy and produce cocoons of 1.75-2.0 gr. and above in weight. The growth of the worms mainly depends upon the amount of mulberry ingested and digested (Table-2.3). The growth rate of silkworm varies with meteorological conditions. When the temperature is high the silkworms grows fast, but low temperature slows down the growth rate. The weight of worms increases 15 times from hatching to the end of I age, 4-5 times at I age, 5 times at III age, 5 times at IV age and 5 times at V age (Table 2.3).

![Fig 2.4 Ingestion and Percentage of Digestion](image)

Thus the weight of full grown larvae will be from 8,000-10,000 times that of newly hatched larvae which is about 0.0003 to 0.0005 gm (Table 3.2).
The quantity of leaf required for rearing 50 layings or a box of 20,000 eggs, upto III instar are given in Table 2.4.

**Table 2.2** Amount of mulberry ingested and digested by silkworms.
(per 1000 larvae in green weight)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Age of the worm</th>
<th>Quantity of Leaf to be fed</th>
<th>% of Ingestion</th>
<th>% of the Total Amount Ingested (gr)</th>
<th>Amount of Leaves Digested (gr)</th>
<th>% of Total Amount Digested</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>I</td>
<td>2-2.5 kgs</td>
<td>24.4</td>
<td>0.06</td>
<td>7.7</td>
<td>53.4</td>
</tr>
<tr>
<td>II</td>
<td>II</td>
<td>6-7.0 kgs</td>
<td>39.7</td>
<td>0.37</td>
<td>45.3</td>
<td>51.0</td>
</tr>
<tr>
<td>III</td>
<td>III</td>
<td>25-30 kgs</td>
<td>55.7</td>
<td>87.55</td>
<td>7,655.1</td>
<td>39.1</td>
</tr>
<tr>
<td>IV</td>
<td>IV</td>
<td>59.8</td>
<td>14.4</td>
<td>223.4</td>
<td>480.4</td>
<td>970.0</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>150.0</td>
<td>55.7</td>
<td>2,419.7</td>
<td>19,610.5</td>
<td>35,150.0</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
<td>41,736.2</td>
<td>22,613.8</td>
<td>41.000</td>
<td>8,861.6</td>
<td>39.2</td>
</tr>
</tbody>
</table>

**Source**: Synthetic Sericulture

**Table 2.3** Silkworms body weight and size, during different instars.

<table>
<thead>
<tr>
<th>When weighed</th>
<th>Increase in Weight (No. of times)</th>
<th>Increase in size (size of newly brushed worms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediately after hatching</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>2nd instar after moult</td>
<td>10-15</td>
<td>10-12 times</td>
</tr>
<tr>
<td>3rd instar after moult</td>
<td>75-100</td>
<td>50-80 times</td>
</tr>
<tr>
<td>4th instar after moult</td>
<td>350-500</td>
<td>300-400 times</td>
</tr>
<tr>
<td>5th instar after moult</td>
<td>1,800-2,200</td>
<td>1500-1800 times</td>
</tr>
<tr>
<td>At the height of growth</td>
<td>8,000-10,000</td>
<td>8800-9000 times</td>
</tr>
</tbody>
</table>

**Table 2.4** Leaf requirements
2.4.3 Preparation of leaves for feeding young worms

Depending on the size of the worms complete leaves can’t be used for chawki worms. Further leaf quality can also be influenced by the process of chopping. However the cut surfaces of leaf leads to loss of moisture. Therefore it is essential to adjust the chopping of leaf so as to protect the quality of leaf. The withering of leaf in rearing bed can be prevented using paraffin paper and foam rubber OR paper soaked in water. This induces to raise humidity in the rearing beds.
The main advantage of chopped leaf is to facilitate even distribution of feed to the worms. In cold conditions chopped leaves prevent the silkworm bed from dampness. Leaves do not curl up when the air is not dry. However a greater amount of leaves are wasted beside labour expenses.

Depending on the shape of the chopped leaves there are three methods of chopping. They are square, oblong and triangular. The square method is best of all which prevent leaf drying due to the drying proceeds from edge to center is prolonged. Long thin strips of oblong shapes are suitable when the season is wet. Chopping of leaves must be regulated according to the condition and size of the worms. Thus the surface of the chopped leaf is equal to the square of the length of the worms. The size of the chopped leaf for chawki worms are given below.

<table>
<thead>
<tr>
<th>Instar</th>
<th>Leaf size (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To start with</td>
</tr>
<tr>
<td>I</td>
<td>0.5</td>
</tr>
<tr>
<td>II</td>
<td>2.0</td>
</tr>
<tr>
<td>III</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Chopping of leaves is carried using chopping board and knife. Leaf is arranged in regular layers and cut to the required size depending on the age of the worm. All the chopped leaves are collected in a clean mat and loosened. Then the chopped leaves are sprinkled in the tray. While cutting the leaves care is taken not to crush or bruise the leaves.

2.4.4 Frequency of Feeding

The frequency of feeding for chawki worms depends again on the season. Generally these worms are fed four times a day. However the rearing beds are kept covered with paraffin paper. For maintenance of humidity in the rearing bed foam rubber pads of paper pads soaked in water are used.

2.5 Bed Cleaning

Silk worms are fed with large quantity of mulberry leaves than their eating capacity. Thus unconsumed leaves which are unfit for food remain in the tray at the end of each feed. Besides these excreta of worms forms a thick bed. Out of the total weight of leaf has taken as food, three fifth is excreted and only two-fifth is being assimilated by the silkworm. The piling of litter makes the beds...
moist. This releases process of fermentation liberating injurious gases and also favours multiplication of pathogens.

All these above factors are harmful to the worms. Therefore removal of old (unused) mulberry leaves, fecal matter of silkworms, exuviate, dead or unhealthy worms etc., from the rearing bed is called bed cleaning.

### 2.5.1 Frequency of Cleaning

Cleaning involves labour and frequent cleaning is not advisable as it cuts the economics of rearing. While cleaning loss of worms is inevitable especially in chawki rearing. The frequency of cleaning for young worms is as follows.

<table>
<thead>
<tr>
<th>Instar</th>
<th>Frequency of Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Instar</td>
<td>Once</td>
</tr>
<tr>
<td>II instar</td>
<td>Twice i.e. one just after the 1st moult and again before setting for 2nd moult.</td>
</tr>
<tr>
<td>III instar</td>
<td>Thrice i.e. once after moult, once in the middle of 3rd age and once just before setting for 4th moult.</td>
</tr>
</tbody>
</table>

### 2.5.2 Method of Cleaning

For cleaning of beds husk, nets, cut straw are used. There are three methods of cleaning.

1. Cleaning with husk
2. Cleaning with Net.
3. Cleaning with husk and net.

#### 2.5.2. (a) Cleaning with husk

For this method charred husk or paddy husk is sprinkled evenly over the bed of silkworms. This sprinkling of husk is carried just prior to first feeding early in the morning. The worms crawl through the husk layer to reach the leaves. During the second feeding the bed is ready for cleaning. All the worms are collected together by a brush and transferred into another fresh tray.

The natural paddy husk is too big and too thick for two ages. Thereby the worms cannot come up. For these ages, husk should be broken into small pieces before it is used. Care should be taken to avoid dust of husk as it spoils the leaves fed to the worms. Formalinized charred husk helps to avoid attack of Muscardine disease.
2.5.2. (b) Cleaning with net

In this process a net with mesh suited to the size of the worms are used. During the process of cleaning the net is spread over the bed just prior to the first feeding early in the morning. Then it is cleaned after second feeding. It is very simple method and requires little labour. However it is not convenient for the purpose of spacing. The mesh sizes of different cleaning nets are

First and second instar .................. 2mm²

Third instar ............................. 10mm²

2.5.3. (c) Combined husk and net method

In the process of cleaning both husk and net are used. First a thin layer of paddy husk is sprinkled over the bed and a suitable net is spread. Then after two feedings the worms are transferred along with the net into another tray. This process is more expensive and not suitable for spacing.

2.6 Spacing

This is an important aspect which needs maximum care. Overcrowded bed does not permit free and complete growth of the worms. It is very important for the vigorous and full growth of worms. As the worms grow in size and weight, the bed density increases leading to crowding.

Therefore the population density in the rearing bed should be regulated to ideal condition. In rearing most of the failures are because of improper spacing in the bed. As the age of the worms increases the length and breadth increases (Table 3.5).

<table>
<thead>
<tr>
<th>Stage</th>
<th>Increase in length</th>
<th>Increase in breadth</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>21/2 times that of newly hatched worms.</td>
<td>2 times that of newly hatched worms.</td>
</tr>
<tr>
<td>II</td>
<td>4-5 times that of newly hatched worms.</td>
<td>4 times that of newly hatched worms.</td>
</tr>
<tr>
<td>III</td>
<td>7-10 times that of newly hatched worms.</td>
<td>6-7 times that of newly hatched worms.</td>
</tr>
</tbody>
</table>

Over crowding of worms means insufficient space for the movement and free feeding of the worms. Crowding condition favours to increase gases, heat and fermentation of fecal matter. Fermentation process particularly happens
Paper - II  Silkworm Rearing Technology

during early stages when temperature and humidity are high. In this condition
worms do not feed freely. This results in unequal and unhealthy growth of larvae.
The worms become weak and easily susceptible to various diseases. The
commercial characters are also severely affected. The Table 2.6 indicates the
need to expand the rearing beds from time to time. Thereby orderly growth of
silkworm can be expected.

Table 2.6.2 Schedule of Spacing

<table>
<thead>
<tr>
<th>Age of worms</th>
<th>Area required for rearing</th>
<th>Increase in spacing during each instar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To being with</td>
<td>At the end</td>
</tr>
<tr>
<td>1st Instar</td>
<td>4 sq.ft</td>
<td>14 sq.ft</td>
</tr>
<tr>
<td>2nd</td>
<td>15 sq.ft</td>
<td>45 sq.ft</td>
</tr>
<tr>
<td>3rd</td>
<td>45 sq.ft</td>
<td>90 sq.ft</td>
</tr>
<tr>
<td>4th</td>
<td>90 sq.ft</td>
<td>180 sq.ft</td>
</tr>
<tr>
<td>5th</td>
<td>180 sq.ft</td>
<td>360 sq.ft</td>
</tr>
</tbody>
</table>

The above in terms of bamboo trays may be stated as follows.

Schedule of Spacing (B)

<table>
<thead>
<tr>
<th>Age of Worms</th>
<th>Trays of 3½ diameter</th>
<th>Trays of 4 diameter</th>
<th>Trays of 4½ diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trays</td>
<td>Area of seat In each tray</td>
<td>Trays</td>
</tr>
<tr>
<td>1st Instar</td>
<td>Brush in :</td>
<td>2</td>
<td>1 ½’ x 1 ½</td>
</tr>
<tr>
<td></td>
<td>Increase to :</td>
<td>2</td>
<td>2¼’ x 3’</td>
</tr>
<tr>
<td>2nd Instar</td>
<td>Increase from:</td>
<td>2</td>
<td>2½’ x 3’ (or to fill almost the entire tray)</td>
</tr>
<tr>
<td></td>
<td>to:</td>
<td>5</td>
<td>‘’</td>
</tr>
<tr>
<td>3rd Instar</td>
<td>Increase from:</td>
<td>5</td>
<td>Full tray</td>
</tr>
<tr>
<td></td>
<td>To:</td>
<td>10</td>
<td>‘’</td>
</tr>
</tbody>
</table>
Sparse spacing of worms is not desirable as it leads to wastage of leave. In normal condition the space is doubled or tripled from first instar to third instar. On the whole the space has to be increased by 80-100 times from brushing to ripening of worms for spinning.

2.6.1 Time and frequency of spacing

Spacing should go simultaneously with continues development of worms. Therefore worms are spaced at each feeding. The development of worms is most rapid in first age. Thus spacing is done frequently, and it is always advantageous to combine spacing with cleaning. This saves labour also. In further instars spacing is combined with cleaning. When the humidity and temperature are higher than optimum the worms are spaced. The trays are kept in alternate shelves for free circulation of air.

2.6.2 Method of spacing

The spacing can be done separately or in combination with bed cleaning. Among these two the latter method is convenient and satisfactory. It helps in less handling less disturbance of worms.

2.7. Moulting

The silkworm larval life has five instars and four moults. The larva casts of its skin to accommodate the body growth. This is called moulting. The silkworm larvae attain their maxi-mum body growth of particular instar and as a result body becomes stout, and shiny and amber coloured. These two characters are seen in larva at the approach of moulting. In relation to the size of the body, the head of the worm appears small and dark. This is time for bed cleaning and wide spacing. After then worms are about to settle for moult are given one or two feeds which helps to reduce the humidity and favours uniform moulting.

In high humid conditions a thin layer of lime powder is dusted this prevents early moulted larva form eating leaf, favouring uniform growth. Feeding is stopped when all larvae settle for moult. The moultin period for first age is 20 hrs second and third age larvae require one day. Moulting is a very sensitive process in the life cycle of silkworms (Fig. 2.9 a & b).

After moulting fresh larvae of next instar come out by casting their old skin. The worms head is bigger in relation to the body size. It is rusty in colour, less shiny because of loose skin. The first feeding of the new instar starts only after almost all worms pass moult. Newly moulted worms are dusted with cerasine lime prior to first feed to prevent muscardine.
Any irregularity in setting for moult is noticed; all such late larvae are segregated by net feeding and reared as second batch. Care should be taken to keep the bed dry during moult. This facilitates the larvae to wriggle out of the old skin.

![Mouling Before](image1)

![Mouling After](image2)

**2.8 Chawki Rearing methods**

There are three methods of rearing but in all methods importance is given to the maintenance of leaf quality, humidity, temperature so as to ensure vigorous and healthy development.

**The rearing methods are**

1. Paraffin paper rearing

2. Box rearing
3. Co-operative rearing

2.8.1. Paraffin paper rearing

A good quality paraffin paper is used in this method. It should be divided 30 minutes prior to feeding. This allows supply of fresh air to the silkworms and eliminates toxic gases accumulated in the bed. When the worms settle for moult, paraffin paper is not necessary. Further the bed must be dry during moult. A thin layer of lime powder is sprinkled over the bed which helps to keep the bed dry. This also prevents Muscardine.

![Paraffin Paper Rearing](image)

Rearing in Wooden box, Bamboo tray

Specing with chop sticks

Second in Star Worms

Fig 2.9 Chawki Rearing

2.8.2 Box rearing

In this method specially made boxes are used for rearing. The boxes may be with or without lids.

(a). Rearing boxes with lids.

It completely resembles the paraffin paper method. After preparation of bed a lid is placed on the box and later arranged in the shelves. In third instar lids
are not necessary. When the larvae settle for moult, the paraffin paper, wet foams and the lids are removed to keep the bed dry.

(b). Rearing in Boxes without lids.

This rearing again resembles paraffin method. The wooden boxes of uniform size with 10-15cm deep are used. After preparing the rearing bed the boxes are piled one over the other for rearing first instar. For rearing second and third instar larvae, a space of 2-3 cm between the boxes is made for ventilation. The boxes are kept open for at least 30 minutes prior to each feeding. It must be completely open when larvae start settling for moult. Care must be taken to disinfect the worms to prevent Muscardine.

2.8.3 Co-operative rearing

Rearing of silkworms requires technical skills. These skills are lacking in most of rural farmers. If the silkworms are not reared properly in the young stages they are prone to diseases in later instar, resulting in crop failures. Besides this rearers are not able to afford the necessary equipment for silkworm rearing under ideal conditions. In order to overcome all these problems co-operative rearing have been organized to provide technical assistance, ideal conditions etc. The rearing is conducted up to second or third moult.

These are also called as chawki rearing centers. These centers are provided with ideal rearing houses with all the necessary equipment. The total
rearings are supervised by technical experts. Mulberry leaf rearing is provided from a single garden which ensures uniform quality of leaf.

Because of ideal conditions and quality leaf silkworm growth is vigorous and healthy. This ensures good crop results and income to the rearer. The silkworms are reared in large scale reducing the expenditure which is charged to the rearer. Further the rearer need not bother about chawki rearing and is free for a fortnight period. Generally co-operative rearing centers have a capacity to rear 200 to 500 boxes (each box contains 20,000 eggs) up to third moult or double the size up to second moult. It is popular in Japan and 90 percent rearings up to third moult are carried in co-operative centers. After then, worms are distributed to individual rearing farmers.

![Fig 2.11 Co-Operative rearing advantages](image)

(a) Stage wise labour requirement
(b) Breakup of the cost of rearing
(c) Types of cooperative rearing

**Advantages**

1. It ensures stable rearing conditions and high cocoon quality.
2. It saves labour and leaves time for other work.
3. It reduces expenditure and lowers cost of production.
4. Disease control can be carried out more effectively.

Fig 2.12 Co-operative rearing

2.9 Chawki Rearing Centers (CRCs)

The success of silkworm rearing and productivity depends on technology practiced in rearing particularly the young age silkworms. The young age silkworms are also known as “chawki worms”

I, II, III instars are reared in chawki rearing centers. Central Silk board (CSB) has initiated setting up of chawki rearing centers in the 7th plan and by end of 1987-88 a total no. of 303 CRCs established, played a major role in improving productivity at farmer level. During the 8th plan a large number of CRCs under State Govt. and Central Silk Board have been established under the National Sericulture Project (NSP).
Promotion of CRCs through the private sector is one of the objectives of NSP. It is assumed that the supply of good quality chawki worms to the farmers would go a long way in reducing mortality rate of silkworms, in improving their vigour and ensuring better yield such as:

1. On an average it facilitates an incremental yield of about 3-7 kg per 100 DFL’s.
2. It saves cost on recurring equipments and disinfectants.
3. The risk factor involved in chawki rearing is eliminated.
4. It saves labour, time up to 8 days per crop to attend other activities by the farmers.
5. A sufficient time gap is made available to the rearer for carrying out disinfection of the shed and the equipments.

2.9.1 Methodology

The list of CRCs in Mysore District was obtained from the Dy. Director of Sericulture, Mysore. There were totally 250 CRCs working under 32 technical Service Centers (TSCs). In Mysore district out of which 53 CRCs were under Government and 197 CRCs were under private sectors. Basing on these 8 Government CRCs out of 53 and 23 out of 197 private CRC fewer than 26 Technical Service Centers (TSCs) were selected for sample study in 8 taluks of the Mysore district. (Mysore, Kollegal, Chamarajanagar, Yelandur, K.R. nagar, H.D. Kota, T. Narasipura and Naniangud taluks).

Two seri culturists under each CRC ie., One CRC beneficiary and one direct brushing sericulturist were selected. Thus total sample size consists of 41 CRC beneficiaries and 41 direct brushing sericulturists in Mysore district were are very adjacent to Hindupur taluk such as Madakasira, Dharmavaram and Penukonda taluks were also selected for the study.

In Hindupur division totally there were 43 States Government CRCs and 4CSB CRCs working under 15 TSCs out of which data from 37 CRCs comprising 5 Government CRCs (CSB 4CRCs, States 1CRC) and 30 private CRCs and 2 NGO CRCs were collected. Thus the sample size consists of 84 CRC beneficiary and 74 direct brushing Seri culturists.

The targets and incentives pattern followed for CRCs for 3 years. As per the target fixed by the Department first year it was 20,000, Second year 40,000, and third year 60,000 in Mysore area. The incentives fixed were Rs.15,440/- Rs. 10713/- and Rs. 5510/- for 1st , 2nd and 3rd year respectively. It can be noted from that while target was increased by 20,000 every year
incentives were reduced by about Rs.5000/- per year. This was with an objective to establish self-reliant CRCs by private entrepreneurs. Provision was also made to collect reasonable service charges from the Seri culturists.

Similar pattern was observed in case of Hindupur where a target fixed for 1st year was 24,000 with a steep increase of 12000 per year.

**Facilities available at CRC’s**

It was observed that only 50% of the Govt. and private CRCs were having own rearing houses in Mysore area while only 20% in Hindupur area. It was observed that most of the private CRCs were having separate room for CRC. Such separate rearing house was found in very few private CRCs. As the rearing equipments were supplied by the department all the CRCs were equipped with sufficient rearing equipments.

**Summary**

• Rearing of first 3 instars is called chawki rearing. These larvae are resistant to high temperature and humidity and grow well ensuring good cocoon crop.

• Silkworms do not eat withered leaf. Leaf preservation is necessary to protect the nutritive values from time to time. Leaves are to be stored in leaf chamber or earthen pots.

• The aim of feeding worms is to satisfy their appetite. Proper feeding enables healthy growth of worms. However growth depends on the amount of mulberry ingested and digested.

• The worms are fed with chopped leaves according to their age. Feed is given four times a day.

• Bed cleaning enables to remove waste leaf and excreta.

• Cleaning nets of 2 and 10 mm² are used for bed cleaning.

• Spacing of worms facilitates proper growth.

**Short Answer Type Questions**

1. Define chawki rearing.

2. Which mulberry leaves are suitable for chawki worms.

3. What is glossy leaf?

4. What is the frequency of feeding chawki rearing?
5. Define bed cleaning.
7. Define spacing.
8. Define moulting.
10. What is the use of paraffin paper?
11. How many instars are there in larval stage.

**Long Answer Type Questions**

1. Discuss about the importance of quality leaf in chawki rearing.
2. How do you select mulberry leaves for chawki worms.
3. Describe feeding aspects of chawki worms.
4. Describe different methods of bed cleaning.
5. Write about the importance of spacing in chawki rearing.
6. Describe methods of chawki rearing.
7. Write short notes on
   (a) Spacing  (b) Leaf chopping (c) Moulting

**Practice Methods**

1. Identify the glossy, tender leaves and preserve it (or) prepare herbarium.
2. Collect the moulting and out of moulting worms and preserve it.
3. Prepare co-operative Rearing Model by thermocol.
4. Prepare a chart for care of rearing silkworms during rainy seasons.
5. Determine the percentage of digestion and percentage of indigestion of mulberry leaves by silkworms.
# UNIT 3

## Late Age Rearing

### Structure

- 3.1 Introduction
- 3.2 Quality of Leaf
- 3.3 Leaf Selection
- 3.4 Feeding Schedules
- 3.5 Bed Cleaning
- 3.6 Spacing
- 3.7 Moulting
- 3.8 Late Age Rearing Methods

### Learning Objectives

After studying this chapter you will be able to

- Understand Late age rearing methods
- Identify the Ripening worms
- Dissect and mounting of silk glands
- Explain and adopt the shoot rearing method
3.1: Introduction

Rearing of fourth and fifth instar worms is called as late age worm rearing. These worms require less humidity and preferably low temperature. Then compare to early stages. This stage is the real feeding stage. The worms consume about 90 to 95% of the total feed. When chawki worms are reared perfectly, late age rearing is comparatively easy. As this is the final stage of rearing, worms are fed properly with quality leaves to get good crops.

3.2 Quality of mulberry leaf

The details of quality of mulberry leaf described in chapter 3.4. From the quality point of view late age worms are fed with bottom mature (dark green) leaves which are thick, soft and rich in protein, comparatively low moisture leaf. Too tender or over matured leaves are not fit for feeding. However they feed on wilted, dusted, bad leaves and over matured and less nutritive leaves. But this results in slow growth and become susceptible to diseases.

If they reach spinning stage, it results in poor quality cocoons. From the 3rd day of the 5th stage the silk glands of the worm develop vigorously. Therefore they are fed with abundant good quality mulberry leaf. In the late age worms the amount of mulberry leaf ingested and digested increases. However the ratio of digestion is lower than young worms.

In the spring, when air temperature falls suddenly at night, silkworms fell ill and cannot digest the mulberry. Therefore it is necessary to raise the temperature. The dose of feeding mulberry is increased slightly in the morning feed in the day time when it is warm. But feed dose is decreases in the evening.

3.3 Leaf Selection

Mulberry for late age worms are also selected by largest glossy leaf method which is described in chapter 2.5.

In glossy leaf method selection, the mature leaves remained on the mulberry twigs after chawki rearing are fed to IV and V instar worms plucking from top to bottom.

3.4 Feeding Schedules

3.4.1 Feeding

The importance of feeding and growth of the worms are detailed in chapter 2.6
3.4.2 Preparation of leaves for feeding late age worms

Chopping of leaves for feeding is not essential to late age worms. Feeding of leaves depends on leaf harvest. In case of leaf plucking whole leaf can be given to IV and V instars. However in rainy season depending on the humidity, leaf can be cut into two bits before feeding the worms. In case of shoot harvest is cut into convenient size shoots to accommodate in the rearing tray. The quantity of leaf required for rearing 50 layings of 20,000 eggs from IV to V instar are given in table 1.

Table 3.1 leaf requirements.

<table>
<thead>
<tr>
<th>Age of the Worm</th>
<th>Quantity of leaf be fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV 75 – 85 kg</td>
<td>105 – 125 kg</td>
</tr>
<tr>
<td>V 600 – 625 kg</td>
<td>700 – 725 kg</td>
</tr>
</tbody>
</table>

3.1 Feeding of Late Age Worms

Maintain dry conditions during the 5th instar
Maintain humid conditions during the 1st Instar

Change in larval body water content
3.5 Bed Cleaning

It is a process to remove waste and harmful material found in the rearing bed. Bed cleaning is done daily during IV and V instars. In branch feeding, shoot feeding and individual leaf feeding they are cut to a small size before feeding. Generally bed cleaning is preferable after first feeding. The net size of 20 mm² is spread prior to feeding. The bed cleaning is done before the second feeds where the worms along with net and leaves are transferred into a fresh tray. The fecal material and left over leaf are put into manure pit. While cleaning attention should be paid to keep the rearing room, floor and premises clean and tidy. Methods of cleaning are described in chapter 2.7.
3.6 Spacing

Good pacing of worms in the beds plays a vital role for the success of silkworm crop and improvement of cocoon quality. During IV and V instars more than 93% total feed is given. Besides all precautions taken while feeding of the worms by adequate leaves, crowded condition leads to under nourishment and uneven development of the worms. Further it favours the incidence of disease and yield of inferior quality cocoons (Fig.3.6).

Wide spacing leads to leaf wastage and higher leaf cocoon ratio. Therefore optimum spacing based on the growth of different instars is necessary (Table 3.2.a,b) to get good crops.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Increase in Length</th>
<th>Increase in breadth</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV</td>
<td>13-15 times that of newly Hatched worms</td>
<td>10-13 times that of newly hatched worms.</td>
</tr>
<tr>
<td>V</td>
<td>23-27 -do-</td>
<td>17-22 -do-</td>
</tr>
</tbody>
</table>

**Table 3.2 b) Schedule of spacing**

<table>
<thead>
<tr>
<th>stage of Worms</th>
<th>Trays of 3 ½ diameter</th>
<th>Area of seat In each tray</th>
<th>Trays of 3 ½ diameter</th>
<th>Area of seat In each tray</th>
<th>Trays of 3 ½ diameter</th>
<th>Area of seat In each tray</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV Instar</td>
<td>10 Full Tray</td>
<td>4 '3'x3'4&quot;</td>
<td>3 Full Tray</td>
<td>6 '3'x2'</td>
<td>25 Full Tray</td>
<td>30 '3'x2'</td>
</tr>
<tr>
<td>V Instar</td>
<td>20 Full Tray</td>
<td>8 Full Tray</td>
<td>3 Full Tray</td>
<td>6 '3'x2'</td>
<td>40 Full Tray</td>
<td>30 '3'x2'</td>
</tr>
</tbody>
</table>

Spacing should be increased simultaneously with the growth of the larvae. It is better to apace the worm while bed cleaning. The late age worms are spaced every day.
3.7 Moulting

For the details of importance of moulting see first para of chapter 2.9

The fourth and last moult of silkworm is characteristic. The duration of moulting is prolonged when compared to first three moults. When the conditions are optimum the moulting is completed in 30 hrs. When the worms are settling for moult, the bed is spread to a thin layer. This spreading enables to dry the left over leaves and also provides low humidity. If the rearing room humidity is high, a thin layer of lime is applied after the last feed.

3.8 Late Age Rearing Methods

There are three methods of rearing

1. Shelf rearing
2. Floor rearing
3. Shoot rearing
3.8.1 Shelf rearing

Round bamboo trays are arranged in tiers of rearing stand for Silkworm rearing is called shelf rearing. The stands are arranged in rows leaving a convenient apace for attending cleaning and feeding. Generally round bamboo trays are used for this method. In each stand ten trays are arranged. The worms are fed with individual leaves. three or four feeds are given per day and nets are used for cleaning.

Advantages

1. More worms can be reared in a limited area.
2. An overall view of all the trays is possible
3. Required air and light are available.

Disadvantages

1. More labour are required
2. Care should be taken for proper spacing
3. Cost of production is more.

Fig 3.5 Shelf Rearing
3.8.2 Floor Rearing

The rearing is carried on fixed rearing seats. The seats are arranged on two or three tiers. These seats can accommodate as many worms as possible. Rearing seat should measure 1-1.5m width and 5-7m length with a space of 0.6-0.8m between the tiers. The length can be adjusted according to the length of the room. There must be sufficient space all around the seats for attending various rearing activities. The seats are made of wood or bamboo. The worms are fed with individual leaves or branches cut to small size. The number of feeds are three or four in a day are adopted and cleaning is carried using nets.

Advantages

1. Saving on labour expenses thus reduces cost of production
2. Saves times in feeding, cleaning and spacing.
3. Cost of trays and maintenance are totally eliminated.
4. More number of worms can be reared.
5. Silkworm growth and disease incidence can be observed easily.

3.8.3 Shoot Rearing

It is most economical method of all and resembles floor rearing. The rearing seats are one meter wide and length can be extended according to the size of rearing room. The rearing seats are arranged 20cm above the ground. Depending on the space available two or three tiers can be arranged with a gap of one meter in between the tiers. This method of rearing can be carried outdoor if the environmental conditions are favourable, especially temperature.

The worms are supplied with big shoots. In every feed the larvae keep moving upwards to consume mulberry leaves. Due to shoot feeding the food is distributed in three dimensions favouring better aeration of rearing beds. Thus it is possible to accommodate 50% more worms per unit area. The rearing activates especially cleaning is much reduced.

It requires only one cleaning each in fourth and fifth instar. Ropes of convenient length are spread parallel to each other lengthwise on the bed and after two, three feeds when worms have crawled on to new branches, the bed is held by ropes is rolled into loose bundles by cutting the ropes for every 2mts. After cleaning rolled bundles are spread on to the rearing beds. Thus labour requirements for cleaning and feeding are minimized.
Fig 3.6 Shoot Rearing Method

Fig 3.6(b) Floor Rearing Method

Fig 3.7 Late Age Rearing
**Advantages**

1. Labour requirements are reduced to 60% in IV age and 50% in V age.
2. Leaf saving is about 25% in IV age and 10% in V age.
3. Provision for indoor and outdoor rearing.
5. Three dimensional feeding reduces leaf wastage.
6. Accommodates 50% more worms per unit area.
7. Cleaning and feeding time is minimized.
8. Rearing activities are made easy.

*Fig 3.8 Spatial Arrangement of Branch Rearing*
Summary

- Rearing of IV, V instar worms is called as late age rearing.
- Worms are fed with bottom mature, thick, rich in protein and low moisture leaves.
- Worms are spaced based on the growth of late age worms. Because bed spacing favours the incidence of the disease and yields inferior quality cocoons. On the other hand over spacing leads to wastage and higher leaf cocoon ratio. Thus spacing is carried along with bed cleaning.
- Moulting is completed in 30 hrs. When the worms are settling for moult the rearing bed is spread to a thin layer.
- Out of all, shoot rearing has lot of advantages. The food is distributed in three dimension and favours to consume complete leaf. Bed cleaning and Spacing is very easy.

Short Answer Type Questions

1. Define late age rearing.
2. What type of mulberry leaf is fed to late age worms?
3. What is the size of leaf for feeding IV and V instar worms?
4. What is the size used to clean the bed of the late ages?
5. What is the time duration for IV moult?
6. What is the time required to complete larval period?
7. Name the gases injurious to silk worms.
8. Mention the time schedule for feeding late age worms?

Long Answer Type Questions

1. Write about leaf quality required for late age worms.
2. Write about feeding of late age rearing.
3. Describe the methods of late age rearing.
4. Write short notes on
   (a). bed cleaning   (b). Moulting
   (c). Shelf rearing   (d). Floor rearing
   (e). Advantages of shelf rearing.
For student practice

- Identify the matured leaves and preserve it (or) prepare herbarium.
- Dissect the Silkworm larva (V stage) and mount the silk glands.
- Prepare a model of silk gland by using a wax (or) cotton.
- Collect the Ripening worms and preserve it.
- Prepare different types of mountages by using of bamboo sticks, thermocol (or) thick card board.
4.1 Introduction

Silk worm rearing is to be carried systematically for better crop results. Rearing activities such as incubation, brushing, feeding, leaf quality, bed cleaning, and spacing are important which reflect on the quality and quantity of cocoons. Above all maintenance of environmental conditions especially temperature and humidity are vital for the growth and health of silkworms. Any slight change may hamper the health lead to disease and finally death. The cocoons are the final product in silk worm rearing to get cash returns. Thus cocoon quality and quantity
are so important which reflect on the price fixation. Therefore it is necessary to understand about the effective on the price fixation.

Therefore it is necessary to understand about the effective rate of rearing (ERR) and to estimate the crop results. The calculation of ERR also helps the farmer to understand mistakes done to avoid in the rearing activity. In this chapter calculation of ERR by various methods utilising weight and number of cocoons are discussed along with calculation of good and bad cocoon percentage for the benefit of entrepreneur.

### 4.2 Calculation of ERR by Weight

ERR is defined as the ratio between the weight of cocoons produced and the total number of larvae at a certain instar.

**Principle for calculating effective rate of rearing is as follows.**

\[
ERR = \frac{\text{No. of cocoons harvested}}{\text{No. of larva in 3rd or 4th instar}} \times 100
\]

Effective rate of rearing is calculated on the basis of weight and number of cocoons. The following are the principles.

\[
\text{ERR by weight} = \frac{\text{Weight of cocoons harvested}}{\text{No. of larva brushed}} \times 100
\]

\[
\text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No. of larva brushed}} \times 100
\]

Now let us calculate ERR (in both methods) on the following values.

### 4.2.1. Model Problem

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Good Cocoons</td>
<td>1413</td>
</tr>
<tr>
<td>2.</td>
<td>Filmsy</td>
<td>36</td>
</tr>
<tr>
<td>3.</td>
<td>Double Cocoons</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>1491</td>
<td>2.125 kg</td>
</tr>
</tbody>
</table>
SOLUTION

ERR by number

Total No. of larvae brushed = 1610
Total No. of cocoons harvested = 1491

\[ \text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No. of larva brushed}} \times 100 \]
\[ = \frac{1491}{1610} \times 100 = 92.60 \]

For 10,000 Larvae (brushed) we can harvest 9260 cocoons.

ERR by Weight

Total quantity of cocoons harvested = 2.125
Number of larvae brushed = 1610

\[ \text{ERR by weight} = \frac{\text{Weight of cocoons harvested}}{\text{No. of larva brushed}} \times 100 \]
\[ = \frac{2.125}{1610} \times 100 = 1.319 \text{ kg} \]

We can harvest 1.319 Kg of cocoons from 1610 larvae brushed.

4.2.2 Model Problem

Calculate yield (Kg)/100 DFL’s on the basis of the following data.
E.R.R. = 80; No. of worms in 3rd instar = 300

Solution

\[ \text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No. of larva brushed}} \times 100 \]

No. of cocoons harvested /1 DFL
\[ = \frac{\text{No. of larvae in 3rd instar} \times \text{ERR}}{100} \]
\[ = \frac{300 \times 80}{100} = 240 \]

For 100 DFLs = 240X100 = 24,000 cocoons
Weight of single cocoons  = 1.5 grams
Weight of 240 cocoons  = 240X 1.5 = 360 grams.
For 100 DFL = 360 X 100  = 36,000gms.
= 36 Kg. Yield for 100 DFL’s

Weight of cocoons harvested from one DFL X 100
360X 100  = 36 Kg.

4.2.3 Model Problem

Calculate number of cocoons harvested if E.R.R. % is 90

No.of worms in 3rd instar = 350

Solution

\[
\text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No. of larva brushed}} \times 100
\]

\[
\text{Cocoons harvested} = \frac{\text{No. of Larvae} \times \text{ERR } \%}{100}
\]

ERR  = 90
Number of larvae = 350

90 = \frac{\text{Cocoons harvested} \times 100}{350}

\[
\text{Cocoon harvested} = \frac{350 \times 90}{100}
\]

= 315 coco

4.2.4 Model Problem

Calculate effective rate of rearing by number and weight using the following values.

Cocoons harvested  Number  Weight
Good cocoons  
1940  
2.210 Kg

Thin cocoons  
50  
0.051 Kg

Double cocoons  
40  
0.046 Kg

TOTAL  
2030  
2.307 Kg

Total number of larvae brushed = 2140

Solution

ERR based on number is calculated by substituting the values in principle.

\[
\text{ERR} = \frac{2030 \times 100}{2140} = 94.85\%
\]

For every 10,000 larvae 9485 cocoons are produced.

ERR based on weight is calculated by substituting the values in principle

\[
\text{ERR} = \frac{2.307 \times 100}{2140} = 1.78 \text{ kg}
\]

1.78 Kg cocoons are harvested from 2140 larvae

4.2.5 Model Problem

Calculate cocoon yield for 100 DFL with the following data.

ERR = 80; Number of worms in 3rd instar = 315

Solution

\[
\text{ERR} = \frac{\text{No. of cocoons harvested}}{\text{No. of larva in 3rd instar}} \times 100
\]

No. of cocoons produced = \[
\frac{\text{No. of larvae in 3rd instar} \times \text{ERR}}{100}
\]

\[
= \frac{315 \times 80}{100} = 252
\]

For 100 DFLs  
= 252 \times 100  
= 25200

Weight of single cocoons  
= 1.5 gr.

Weight of 252 cocoons = 252 \times 1.5  
= 378 gr.
For 100 DFL’s = 378 x 100 = 37800 gr.
= 37.8 Kg

For 100 DFL’s = weight of cocoons produced from single DFL x 100
= 378 x 100 = 37.8 Kg

Summary

- Calculation of ERR essential to understand and know the crop activity. It also helps the rearer to know the mistakes which can be rectified in the next rearing.

- Rearing activity reflects on cocoons quality and quantity. Cocoons are the final produce to get cash returns.

- ERR is the ratio between the weight or number of cocoons produced and number of larvae in a particular instar.

- ERR is calculated by weight and number.

- Calculation of percentage of good and bad cocoons also given an idea on the performance of rearing activity.

Short Answer Type Questions

1. Define ERR.
2. Write the principle to calculate ERR
3. Define the principle to calculate Leaf cocoon ratio.

Long Answer Type Questions

1. Calculate ERR = 80 : Number of worms in 3rd instar = 315

or

Calculate effective rate of rearing by number and weight using the following values.

<table>
<thead>
<tr>
<th>Cocoon harvested</th>
<th>Number</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good cocoon</td>
<td>1940</td>
<td>2.210 kg</td>
</tr>
<tr>
<td>Thin cocoon</td>
<td>50</td>
<td>0.051 kg</td>
</tr>
<tr>
<td>Double cocoon</td>
<td>40</td>
<td>0.046 kg</td>
</tr>
<tr>
<td>Melted cocoon</td>
<td>10</td>
<td>0.010 kg</td>
</tr>
<tr>
<td>Total</td>
<td>2040</td>
<td>2.317 kg</td>
</tr>
</tbody>
</table>
UNIT 5

Spinning and Mounting

Structure

5.1 Introduction
5.2 Repinning of Worms
5.3 Process of Spinning
5.4 Mounting
5.5 Types of Mountages
5.6 Environmental Conditions
5.7 Care During Mounting
5.8 Cocoon Harvesting
5.9 Transport

Learning Objectives

After studying this unit, students will be able to

• Understand the quality of cocoons, decided basing on shell weight, cocoon weight floss percentage
• Identify the ripening worms, good and bad cocoons
• Identify the influence of temperature and humidity during cocoon formation
• Identify the different types of mountages and their uses
5.1. Introduction

The object of rearing silk worms is to get cocoons of good quality and maximum yield. Silk worm stops feeding at the end of fifth instar and starts building the cocoons. The larvae becomes transparent, shiny and stops feeding before spinning. Silk worm spins cocoons prior to pupation so as to protect itself from external disturbances and natural enemies. Since it is the most critical period of metamorphosis, good mountages help the rearer to get good quality cocoons.

The cocoons are to be harvested carefully and cleaned to eliminate bad cocoons otherwise it reduces the cost of cocoons.

The quality of cocoons is decided basing on shell weight, cocoon weight, shell ratio, floss percentage, no. of cocoons per kg., number of bad cocoons, filament length, number of breaks, denier etc.

5.2 Ripening of Worms

Fifth instar worms feeding may last for five to seven days in case of multi voltine and bi voltine worms in the tropical areas, and seven to nine days in case of bi voltine and uni voltine races in sub-tropical areas. These worms stop feeding and called as mature larvae and starts spinning the cocoons. As the stomach contents become empty, the mature larvae become specific in appearance. They are translucent and yellowish with fully formed silk glands and it is a clear indication that the worms are fully ripe and ready for mounting.

Fig. 5.1 Mature Worms
Ripe worms should be picked in time so all the mature worms are enabled to spin cocoons successfully. Worms not picked in time or unduly delayed in picking can also be mistaken as diseased worms. Worms picked much before ripening may not also spin, resulting in unnecessary crop losses at the last stage of rearing. Mature worms normally crawl towards the edges of the rearing tray by raising heads, in search of suitable supports for building their cocoons. The process of picking ripe worms and putting on the mountage for spinning is called “mounting” of worms (Fig 5.1).

**Silk Gland**

Every animal in the animal kingdom possess certain adaptation or modifications of body organs to suit its mode of living. During this process some animals birds and insects show remarkable adaptations compared to others. The silkworm a lepidopteron insect has four life stages, one of which is totally inactive/resting/sleeping stage. The larval stage actively feeds on mulberry and grows to maximum size by passing through four moults. It is a preparatory stage where the animal stores the food material for four life stages and also develops certain organs which can protect the successive stages (pupa) by enclosing it.

The larvae develop a pair of silk glands which are modified labial glands, and are capable of utilising the haemolymph and amino acids for the synthesis of silk proteins. These proteins (sericin, fibroin) are utilized by the mature larvae for spinning the silk cocoons. At the end of fifth instar the larva stops feeding and starts spinning the cocoons by oozing silk from the spinneret and wraps itself or undergoing into pupal stage. The details of spinning, cocooning are given in this unit. The detailed structure of silk gland and silk synthesis along with properties are also discussed in the unit.

The development of silk gland and its growth depends on various factors such as environment, rearing method and mulberry leaf quality. Among all, the nutrient value of mulberry influences the silk production very much. Since cocoon is the final crop yield, must be given care for better healthy feeding of the worms with good quality leaf

**Structure of silk gland**

Silk gland is also kind of dermal gland derives from the invagination of the labial ectoderm. Silk gland is an important organ which produces silk as the source of cocoon fibre. A major part of this gland lies just below the alimentary canal. Glands re situtated on the ventro-lateral sides of the mid-intestine and the posterior ends are blind. The gland is tubular and cylindrical in shape. At the anterior end, the two glands unite in head and connect with the spinneret of the labium. The gland is divided in to the anterior, middle and posterior parts.
The anterior region is a straight tube opening at the fore end into the
duct and posterior into the middle region. This part is not twisted and unlike the
middle and posterior parts has no secretary function. The middle part is the
largest, twisted in the shape of the letter ‘S’. This region is again divided into
three functionally different sections as fore, middle and hind parts. The fore part
is slender or narrow at the starting but thickens quickly backwards. The middle
is slender at posterior part. The posterior part is very long with many windings
of uniform thickness, which are regulated by dermo-visceral muscles and the
tracheae (Fig5.2).

A pair of Filippi’s gland opens inside the silk gland at the joint of the
anterior division of two glands. They secrete some viscous fluid.

The wall of silk gland is composed of these layers.

1. Tunica perpuria having gland cells.

2. Tunica intima encloses lumen of the gland.

Tunica perpuria is uniform is structure. Tunica intima has a thick chitinous
layer but only anterior division is shed at the time of moulting.

Fig 5.2 Silk Gland
The silk gland grows very fast from the time of hatching to the final stage of mature larva. The growth involves swelling and increase of size of each cell but not increase in number of cells. The number of cells in the silk gland remained constant (100), with the cell division having been completed during the embryonic period. But the number of cells in silk gland of different races is not the same.

The nuclei in the cells of the silk gland undergo much change as the larvae develop from the young stage to the advanced stage. The nuclei is more or less circular in shape in freshly hatched larva and gradually branches out as the age increases. According to the age the cells of the silk gland become larger, secretary in function and become very active. Thus intensive branching of nuclei occupies most of the intracellular space. The oxygen for carrying metabolic activities is supplied from the tracheae distributed in the middle and posterior parts of the silk gland though anterior part has no tracheae.

When freshly hatched larvae start feeding on mulberry, the colour (yellow) pigment from the ingested mulberry leaves passes towards the alimentary canal and later into haemolymph. In the fifth instar the permeability of silk gland changes and the pigment permeates into its cells whereby silk glands become coloured. It is believed that the silk glands of the larvae which produce white cocoons do not become colored because the intestine of these larvae do not allow the permeation of the yellow and cocoon fibre pigments.

### 5.3 Process of Spinning

When the ripen worms are mounted on the mountages they pass out last excreta in semi-solid condition. When the humidity is high, excess body moisture is also eliminated as urine. After defecation ripe worm starts spinning the cocoon by selecting a suitable place in the mountage. Each silkworm develops a pair of silk glands which synthesize silk by utilising the aminoacids coming from mulberry leaf. The ripen worm anchors itself first to the mountage by oozing a tiny droplet of silk fluid which immediately hardens and sticks to the mountage. Then by swinging the head continuously the silkworm first lays the foundation for the cocoons by weaving a primary web. The silk worm larvae moves its head in the shape of ‘s’ or ‘∞’ to spin the cocoon. The former shape is found in the outer layers of cocoon shell while the later type is usual in middle and inner layer. In this way the larvae forms layers of silk filaments around itself and finally wrapped in a compact shell (Fig.5.3).

The first formed filament i.e. primary web constitutes the floss of the cocoons and is not reelable. The floss in uni and bi volatine races is about 2 percent of the weight of cocoon. While in multi volatine more than 10 percent floss is seen. The process of spinning continues about 1 to 2 days in multi volatines.
and 2 to 3 days in uni/bi voltines. After the compact shell of the cocoons is formed the shrinking larva wraps itself in palade or gossamer layer. Finally the larva detaches itself from the cocoons shell to transform into pupa or chrysalis. This layer (gossamer/palade layer) does not form part of main shell. It is also not reelable and contributes to waste silk content.

**Fig 5.3 Spinning Stage**

### 5.4 Mounting

Depending on the material and structure of the cocooning frames the number of bad cocoons may increase or much labour may required in mounting. The details of different mountages are given in unit -2 paper I. the features of good mountages are as follows.

- Mature worms can be easily induced to cocoon spinning
- Total mountage space can be efficiently used.
- Manufacturing can be easily and cheaply undertaken.
- Durable structures.
- Storage attached to the mountage can be easily removed.
- Material used is resistant to high moisture or wetness.

### 5.5 Types of Mountages

Mature silkworms are collected and mounted on the mountages. This laborious job requires lot of skilled labor. The ripe worms are identified and
picked by skilled labour and mounted on the mountages. This kind of mounting reduces the density of the mounted worms and incidence of double cocoons. Diseased worms can also be eliminated. Worms can also be mounted using nets or green branches.

Branches of green leaves are placed over the rearing bed and when the worms crawl on to them, they are taken out and shaken over a mat; dislodged worms are put on mountages. Similarly a net is placed over the bed after feeding mature worms, which are no longer feeding crawl upon to the nets are collected for mounting as in branch method. In shoot rearing early maturing larvae (10-20%) are picked by hand and later remaining worms are collected by shaking the branches and later mounted.

5.5.1 Proper time of Mounting

It has negative effect on cocoon quality and quantity if mounting does not take place at the right times. When immature worms are mounted, they die in the cocoon or their silk content in the cocoons will be low, resulting in bad results in thin, double, stained cocoons which contributes to reduce cocoon quality in terms of reelability, fiber strength, colour, etc. these defects can be eliminated by ensuring the following.

• Silk worm body shape should be short and fat.
• Thoracic segments should be translucent.
• Faecal should be greenish, soft and irregular in shape.
• The worms should raise their head, thorax and should ooze out silk from their mouth parts.
• They should crawl around the rearing bed to find a place suitable for cocooning.

5.5.2 Methods of Mounting

1. Picking – up for Mounting

When one third of body of the silk worm becomes transparent, worms are picked up and put on the mountages. This method helps the rearer to mount the worms at right time. But labour expenses are high. Generally silkworms mature between 10 am and 3 pm. The worms become over mature producing cocoons of poor quality if the mounting is delayed with inadequate labour.

2. By shaking the shoots

It is better for shoot rearing. When worms (5-10%) mature, they are picked up by hands for mounting. The remaining worms are left till maturity.
When 40-50% of the worms have matured mulberry shoots full of silkworms are shaked on paper, vinyl sheets placed on a mat. The remaining worms are mixed with faeces and remaining mulberry leaf. Then these are covered with 2-3 layers of straw nets. After a gap of 30-40 minutes silkworms crawl up on to the net. These worms (roughly hundreds) are mounted on selected mountages.

Rotary mountages are leaned against the wall by putting 130-140 worms on each frame. More number of worms is put on the top frame than the lower frame so as to fill all the frames evenly when suspended.

Advantages

- Even size cocoons
- Less floss
- No chance for double cocoons
- Less labour expenses
3. Net Method

A net is placed after feeding the silkworms. Mature (ripe worms) crawl onto the net while others feed. The net is separated along with worms for mounting.

4. Branch Method

It is similar to net method where only mulberry shoots are used instead of nets. When worms crawl onto shoots are mounted.

6. Self – Mounting

First mature worms are picked by hand then a self-mountage frame is hanged on the surface of silkworm beds. Ripe worms crawl onto the mountage frame, which is later hanged. It reduces labour cost.

A. Crowded

B. Normal

Fig 5.5

5.5.3 Density of Mountage

The density varies according to the size and type of mountage.
The details of density of mounting for different mountages are as follows.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of Mountage</th>
<th>Details of density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chandrika</td>
<td>50 worms per 10 X 10 cm (1100 per chandrika)</td>
</tr>
<tr>
<td>2.</td>
<td>Rotary</td>
<td>1500 worms per mountage</td>
</tr>
<tr>
<td>3.</td>
<td>Centipede</td>
<td>350-400 larvae/m2</td>
</tr>
<tr>
<td>4.</td>
<td>Square frame type</td>
<td>150 larvae per mountage</td>
</tr>
</tbody>
</table>

5.6 Environmental Conditions

Mounting and spinning are to be carried with utmost care to get good quality of cocoons. Ideal temperature of 22°-23°C and relative humidity between 60-70% are required. These conditions are important during the first 50 hrs, after mounting. Temperature of 24°-25° C and relative humidity between
60-70% are required. These conditions are important during the first 50 hrs, after mounting. Temperature above 26°C affects the cocoon quality.

5.7 Care during Mounting

1. In the mounting room old newspaper or mats put under the mounting frame. When urine and excreta falls on the paper it must be removed.

2. If the temperature raised beyond 22°C - 23°C the shell becomes very loose and folded with wrinkles and knots. It also changes the properties of sericin. This induces cohesion of silk filaments and causes difficulties in reeling.

3. Low temperature slows down the secretion of silk bave resulting in large size cocoons. Further it takes very long time for spinning.

4. Relative humidity (60-70%) induces good health, good reelability and quality cocoons. When it raises the larvae and pupae cease to death.

5. Low humidity causes double layered cocoons, loose cocoons.

6. Excessive moisture and harmful gases are released from faeces and urine of silkworms.

7. Air current speed should be less than one meter per second and fast or strong air current causes crowding of mature silkworms resulting in excessive number of double cocoons.

8. Mounting room requires moderate, even illumination. Strong light causes crowding of silkworms at one side and finally results in double cocoons or uneven thickness cocoons.

9. Complete darkness will slow down the spinning process resulting in low quality cocoons.

10. Ants crawling on to the mountages are prevented.

11. Spinning worms if disturbed increases floss percentage.

5.8 Cocoon harvesting

The silkworm larva metamorphosis into pupa after spinning the cocoons for about 48 hours from the time they are mounted. Generally pupation takes place on the 4th day of spinning. Thus the worms inside the cocoons will be still in the form of pre pupa, which has a delicate cuticular skin. Thus if the cocoons are handled before this stage, the skin may rupture and body fluid will ooze and
stain the cocoons, making it unsuitable for reeling. Thus early harvesting of cocoons should be strictly avoided.

In course of time the pupal skin hardens and turns to dark brown. The cocoons are then harvested on the 5th day in summer and 6th day in cooler season. In the case of seed cocoons, they may be harvested on the 6th day. Harvesting must not be delayed beyond the above said period because it affects the reeling activity (Fig 5.6).

Before harvesting the cocoons, the mountages are held in a slanting position with the cocoon side downwards and given a gentle shaking to dislodge the faecal material. The flimsy cocoons are taken out with forceps or chopsticks. Care must be taken not to rupture the cocoons as their body fluid or dead silkworms may stain good cocoons. The cocoons harvested are kept in thin layers in a tray or on a mat. After harvesting, the cocoons are first cleaned to remove pellets or debris sticking to the cocoons. Then they are sorted to separate bad cocoons.

### 5.9 Transport

The cocoons should be put into loosely woven cotton bags each weighing about 10kg. They are loosely packed and transported in cooler hours of the day (i.e. morning or evening). If transported in larger bags, cocoons will be steamed or crushed. Strong vibration during transportation is harmful because cocoons might be crushed. While transporting cocoons are protected from direct sunlight and rain. It is also important that cocoon cost depends on the quality; they are well protected from direct sunlight and humidity.

![Fig 5.7 Good Cocoons](image_url)
Cocoons are placed in heaps samples are given for quality testing, basing on which cost is decided. Cocoons are transported to well develop areas of reeling to get good returns. The cocoon quality is based on certain aspects like hatching percentage, ERR percentages of good and bad cocoons, shell ratio, denier, filament length. All these factors influence the cost of cocoons.

**Summary**

- Ripe or mature worms are identified by translucent and yellowish colour. These are picked in time for cocoon spinning. The larvae are put on mountages by skilled labour.

- Worm passes out last excreta before it starts spinning. The worm first oozes a tiny drop of silk for anchoring and then draws a long filament by swinging the head continuously.

- Spinning takes 2-3 days, to wrap itself into a compact shell.

- The inner most layer (gossamer layer) and outer most (floss) layers are not reelable.

- Temperature (22° – 23° C), humidity (60-70%), good air current and ventilation are required.

- Cocoons are harvested after 5-6 days of mounting.

- Cocoons are transported in cooler hours of the day by packing in loosely woven bags/ baskets.

- Cocoon assessment is calculated based on shell ratio, floss percentage, denier, filament length etc., for price fixation.

**Short Answer Type Questions**

1. How do you identify ripen worms.
2. Define mounting.
3. Mention the reasons for bad cocoon formation.
4. Define spinning.
5. Define floss.
6. What is palade layer?
7. What are the temperature and humidity levels required for spinning?
8. Define cocoon harvesting.
9. Define sorting of cocoons.

10. What are the factors that influence price fixation?

**Long Answer Type Questions**

1. Write notes on structure of silk gland with neat labeled diagram.

2. Explain about mounting.

3. Write notes on requirements of spinning.

4. Detail about types of mountages.

5. Write short notes on

   (a). Transport of cocoons   (b) Ripen worms   (c) Cocoons sorting

**Student Practice Questions**

1. Identify the ripen worms and stored it

2. Make models of different types mountages by using bamboo, cardboard sheets.

3. Make models of decorative items like flower bouquets by using waste cocoons.
6.1 Introduction

The contributions made by CSR&TI Mysore, the premier sericulture research institute of the country, towards silk industry are tremendous. Our scientists have been developing suitable package of practices for the tropical conditions. Though India stand second in world silk production, next only to China, the production of bi voltine silk in India is negligible and the silk produced is not of international grade and is not suited for power looms. Hence, a large
quantity of Chinese silk is imported and utilized due to the shortage of quality silk in the country. To overcome this problem, an Indo-Japanese collaboration project on Bi voltine Sericulture technology Development (BSTD Project) was initiated at CSR&TI, Mysore in 1991.

During the first phase of JICA (BSTD Project, 1991-96), new productive bi voltine silkworm breeds, technology for rearing and controlling diseases along with improved mulberry cultivation practices and mulberry varieties were developed in CSRTI, Mysore. These technologies were fine tuned under field condition with selected farmers in association with Department of Sericulture, Government of Karnataka during the first two years of JICA second phase (PPPBST, 1997-2002). As a result, it was possible to demonstrate that bi voltine crops can be successfully reared in the field with a stabilized yield meticulously and international quality of silk of 2A-3A grade can be produced.

6.2 Bi voltine Races

Bi voltine sericulture excels in quality and productivity. The successful bi voltine crop depends on disinfection, maintenance of hygienic conditions, feeding of sufficient quantity of quality mulberry leaf, quality silkworm seed, disease management and breed.

6.2.1 Breeds for Bi voltine Silkworm Rearing:

1. Important Features of CSR Hybrids

![Fig 6.1 Bivoltine Hybrid Larvae](image)
The productive bi voltine hybrids namely CSR2 X CSR4 and CSR2 X CSR5 are suitable for rearing during favourable months (August to February) in southern states. CSR18 x CSR19 is suitable for rearing throughout the year. These hybrids are high yielding and produce quality raw silk. The hybrid characteristics in comparison with Multi voltine x Bi voltine hybrids (CB) are presented in Table 1.

2. Essential care required for rearing CSR hybrids

- Requirement of more quantity of good quality mulberry leaves which is higher than the leaf requirement of multi x bi hybrids or other bi voltine breeds.
  - Sufficient spacing in the rearing bed.
  - As CSR Hybrids are more susceptible to diseases compared to cross breeds, it is essential to maintain good hygienic conditions during rearing.
  - Good ventilation.

6.3 Bi voltine rearing Aspects

Disinfection

1. Don’t use cow dung for trays

Fig 6.2 Don’t Use Cow Dung For Smearing on Bamboo Rearing Trays
• Bi voltine silkworms are more susceptible to diseases compared to multi voltine and cross breed silkworms.

• Prevention by disinfection is the best option for avoiding the loss due to diseases in silkworm rearing.

• Disinfection is the destruction of disease causing pathogens.

**Cleaning of rearing house and tools**

![Image of cleaning process](image)

**Fig 6.3 Cleaning of rearing house and tools**

• Clean the rearing house and tools free from dust and dirt.

• Wash them with water (4-5 days before brushing).
Washing of rearing trays and others

Fig. 6.4 Washing of rearing trays and others

- Wash and disinfect the rearing trays and other tools by dipping them in disinfection tank.
Sun draying of rearing tools

- After washing the rearing tools sundry the tools.

![Disinfection by bleaching powder](image)

**Fig 6.5 Disinfection by bleaching powder**

A. Dissolve 60g of slaked lime powder in 20 lt of water (0.3%).

B. Dissolve 400g of bleaching powder in 0.5 lt of slaked lime solution and make a paste.

C. Pour the above bleaching powder paste to rest of the slaked lime solution and shake thoroughly.

**Spraying of bleaching powder solution**

![Spraying of bleaching powder solution](image)

**Fig 6.6 Spraying of bleaching powder solution**
• Spray bleaching powder solution at the rate of 2lt/sq.mt. of floor area (3 days before brushing).

• To rearing house capacity of 100 DFL s, 75-100 lt required.

• Protect the face while disinfection.

**Disinfection by 2% Formalin**

**Preparation of 2% Formalin**

• Mix 1 lt of Formalin (36% Formaldehyde) with 17 lt of water to get 2% Formalin.

• To rearing house capacity of 100 DFL s, 75-100 lt 2% Formaldehyde is required.

**Spraying of Formalin solution**

• Spray 2% Formalin at the rate of 2 lt/sq.mt. of floor area to disinfect the rearing house and equipments (3 days before brushing).

• Carryout disinfection during afternoon when temperature is more than 20o C.

• After disinfection close the rearing house for 24 hours.

• Protect the face with mask while disinfection.

---

Fig 6.6 Disinfection formula
Disinfection by 2.5% sanitech (Chloride dioxide) solution

Preparation of 2.5% Sanitech (Chlorine dioxide) solution

A. Add 50g activator in a clean container.
B. Add 500 ml sanitech solution to 50g activator crystals to activate the Chlorine dioxide.
C. Leave the preparion for 5 min to allow complete dissolution of the crystals till colour changes to yellow.
D. Mix 500ml of yellow colored sanitech solution with 19 lt of water.
E. Dissolve 100g of slaked lime in 0.5 lt of water a clean container and mix this solution with 19.5 lt of solution.
F. Stir the solution thoroughly. This solution (500 ppm chlorine dioxide + 0.5% slaked lime) can be used to disinfect the rearing house and tools.
Spraying of 2.5% Sanitech solution

Fig 6.8 Spraying by sanitech

- Spray the disinfectants at the rate of 2 lt/sq.mt floor area of the rearing house (3 days before brushing).
- To rearing house capacity of 100 DFL s 75-100 lt is required.

Disinfection of rearing house surroundings

Fig 6.9 Disinfection of rearing house
• After inside disinfection, spray the disinfect the outside walls of the rearing house.

• Dust the mixture of bleaching powder and slaked lime at the entrance of the rearing house and surroundings.

Disinfection of mountages

 Fig. 6.10 Disinfection of mountages

• Remove the floss the card boards of the rotary mountages with the help of broomstick.

• After cleaning burn the floss carefully with gass flame.

• After removing the floss, arrange the card boards randomly and pile up on vinyl sheet spray small amount of 10% Formalin solution.

2. Incubation

1. Loose egg incubation

• Spread loose egggs uniformly in outer frame which is lined with black cloth and paper. Cover eggs with tissue paper and fix them lightly with the help of inner frame.

• Whole set should be placed for incubation at 25o C with 80% humidity, 16 hours light and 8 hours dark.
Plastic incubation frame

- Plastic incubation frame is easy to use and disinfection.
• Loose egg incubation frame is made up of two frames. Inner frame correctly fits into outer frame.

3. Block boxing of Eggs

![Image of block boxing of eggs](image)

Fig. 6.12 Block boxing of eggs

• The eggs at head pigmentation stage should be subjected to black boxing by covering black paper or black cloth, 48 hours before hatching to achieve uniform hatching.

4. Exposing of eggs to light

![Image of eggs exposed to light](image)

Fig. 6.13 Exposing of eggs to light
• Four loose egg incubation frames were kept in each tray (2’ x 3’) and eggs were exposed to bright light (in morning at 6.00 am) for 3 hours for good hatching.

Covering with brushing net

- The larvae are covered fully with well disinfected brushing net (mosquito net) 30 minutes before brushing.

4. Chawki Rearing (Young age Rearing)

Tools for rearing

Fig. 6.14 Covering with brushing net

Fig. 6.15 Tools for rearing
• Rearing trays, stands, feather, chop sticks, knife, chopping board, plastic basins, well disinfected gunny and muslin cloths, paraffin paper, humidifier, heater, leaf collecting basket, ant wells and electric balance etc., are required.

Selection of mulberry leaf for first feeding

Fig. 6.16 Mulberry leaves

• Select first glossy leaf for first feeding of brushed larvae.

Leaf picking and transportation

Fig. 6.17 Leaf picking
• Select tender succulent and nutritious leaf for young age silkworm larvae.

• After picking, the leaves are brought to the rearing house during cooler hours and kept in well disinfected basket.

**Preservation of chawki leaf**

![Image of silkworm rearing]

**Fig. 6.18 Prevention of leaves**

• Preserve mulberry leaves in moist, cool, clean and relatively dark place of or chamber lined with well disinfected gunny cloth.

• In dry season or dry condition sprinkle clean water over leaves and preserve them under wet gunny cloth.

**Removal of Petiole**

![Image of silkworm rearing]

**Fig. 6.18 Removal of Petiole**
• Arrange leaves in such a way that all petioles are grouped together.

• Remove the petioles before starting the actual cutting of the leaf.

**Leaf chopping for chawki larvae**

![Leaf chopping](image1)

**Fig. 6.19 Leaf chopping**

• After removing the leaf petiole, nutrient leaves should be chopped to appropriate size (0.5 – 2.0 cm² for 1st instar and 2.0- 4.0 cm² for 2nd instar).

**First feeding to newly hatched larvae**

![Feeding to newly hatched larvae](image2)

**Fig. 6.20 Feeding to newly hatched larvae**
• Provide selected fresh young soft leaves for first feeding.

• Chopped leaves are sprinkled over the brushing net to attract the newly hatched larvae to crawl over brushing net.

**Feeding of larvae on brushing net**

- Sprinkle proper size cut mulberry leaves on the brushing net.

- After brushing, larvae are kept at 28°C temperature and 90% humidity for 3-4 hours before transferring the larvae to the rearing trays.

**Transferring of the larvae to rearing trays**

- After 3-4 hours, when all the newly hatched larvae crawl over upper net, the upper net along with mulberry leaf and worms should be lifted gently with the help of two persons.

- Use of two brushing nets helps to separate out the newly hatched larvae from unhatched eggs and shells.
Arrangement of rearing bed

After transferring the worms to rearing tray, arrange rearing bed to proposed space and some more chopped leaf may be fed if required.

Bed drying

Fig. 6.22 Arrangement of rearing bed

Fig. 6.23 Bed drying
• Keep the trays in criss-cross condition for 30 minutes before every feeding to allow fresh air and light to dry the bed.

• After bed drying fresh leaf can be fed to the larvae.

**Bed cleaning**

![Fig. 6.24 Bed cleaning](image)

• Cleaning is not required during first instar, during 2nd instar cleaning should be done twice, once after resumption and once before settling for 2nd moult.

• Put appropriate size nylon or cotton net on the bed and then feed Mulberry leaves over the net.

• After 3-5 hours of feeding, transfer larvae and mulberry leaves with net to other tray.
Identification of the moulting larvae

- When the larvae are going for moult, their appetite reduced and the body becomes shining.
- Moulting larvae are identified by the feature of head raising and pointed mouth portion.

Care during moultling
• When 70-80% worms settled for moult, stop feeding and remove top paper cover.

• After 3-4 hours of stopping feeding, dust slaked lime powder on the larvae in the bed @ 4-5g/sq.ft.

**Distribution of chawki larvae**

Fig. 6.27 Distribution of chawki larvae

• When the larvae settled for 2nd moult, distribute the larvae to farmers.

• Transport larvae during cooler hours of the day well disinfected closed type van.
Late Age Rearing

Silkworm rearing house

![Fig. 6.28 Silkworm rearing house](image)

- A separate and isolated rearing house with good ventilation is suitable for late age rearing,
- 1050 (35’ x 30’) sq. feet floor area is required for 100 DFLs rearing including virandah and shoot store room.

Shoot rearing stand

![6.29 Shoot rearing stand](image)
• The recommend systems for late age shoot rearing is 3 tier system

• To rear 100 DFLs (50,000 larvae), 350 (140 larvae/sq.ft) and 700(70 larvae/sq.ft) rearing bed area required for 4th and 5th age rearing respectively.

Hygiene maintenance

Fig. 6.30 Hygiene maintenance

• Wash hand before entering the rearing house with 2% bleaching powder in 0.3 % slaked lime or 0.25% sanitech solution.

• Keep the foot mat containing 5% bleaching powder in slaked lime at the entrance.

• Don’t dump silkworm rearing wastage around the rearing house or mounting hall. Burn them far away from rearing house.

• Keep the surroundings clean and neat.
Harvesting of mulberry shoots

• Harvest shoots for 4th and 5th instar larvae during cooler hours of the day with sharp knife.

• A bundle of shoot of 10-20 kg is made for easy transportation.

Transportation of mulberry shoots
• Farmers are using bullock cart or head load transport the mulberry shoot from field to rearing house.

• Carry mulberry shoots during cooler hours of the day.

Preservation of mulberry shoots

![Image of mulberry shoots preservation](image)

*Fig. 5.34 Preservation of mulberry shoots*

- The mulberry shoots are preserved properly by wrapping with wet gunny cloth and arranged vertically in upward direction.

Shoot rearing

![Image of shoot rearing](image)

*Fig. 5.35*
• Shoot rearing is effective for labor and time saving. It is a hygienic way of late age silkworm rearing. Chances of secondary contamination will be reduced considerably.

**Arrangements of shoots**

![Image of mulberry shoot in rearing bed](Fig. 5.36)

- Arrange mulberry shoot in rearing bed in such a way that apical buds of shoot be kept alternatively.

- Watch the condition of rearing bed and if any small or unequal worms are there, it should be removed and disposed hygienically.

**Nylon net for prevention of Uzi Fly**

![Image of nylon net](Fig. 5.37)
• Nylon net can be used to prevent the entry of Uzi Fly.

• Keep nylon net at a minimum distance of 2-3 feet from the rearing stand.

**Sufficient spacing for good growth**

![Image of silkworms](image1)

- Rear larvae in the bed should be with sufficient spacing.
- 50-70 larvae per square feet is recommended density for rearing. Sufficient spacing is effective to reduce the secondary contamination, and to support enough growth better cocoon yield and quality improvement.

**Unsuitable type of shoot rearing stand**

![Image of unsuitable rearing stand](image2)
• Shoot rearing stand should have three tier system not the five tier as shown in the picture. More than three tier it is difficult to provide the mulberry shoots and to observe the worms.

• Prepare 5ft. width shoot rack and arrange lowest tier at minimum 1ft. above the ground.

Applying of bed disinfectants

Fig. 5.40 Applying of bed disinfectants

• For prevention of silkworm diseases, when all the worms come out of moult take the bed disinfectant in a thin cloth and dust over silkworm @ 5g/ square feet area after every moult and once on 4th day of 5th instar.

• Don’t dust the bed disinfectant to under moult larvae or eating stage.

• Start feeding after 30 minutes of dusting.
Mounting

Separate mounting shed

Fig. 5.41

• A separate mounting hall constructed with thatched roofing and open from all sides is good.

• Mounting space for 100 dfls required 30’ x 12’ to hang 38-40 rotary mountages sets.

Varandah type mounting house

Fig. 5.42
• A verandah type mounting house constructed attached to rearing house.

Open verandah for mounting

![Fig. 5.43](image1)

• The open verandah is also recommended to farmers for mounting.
• Prepare enough space for mounting.

Identification of matured larvae

![Fig. 5.44](image2)
• Matured larvae show translucent body, slightly decreased body size, soften feaces, stop eating and they start moving around lifting the head, abdomen and thorax and start climbing up vertically.

• When more than 40% worms mature, mounting can be done by “Jabarai” method.

**Jabarai method” for collection of larvae**

![Jabarai method](image1)

Fig. 5.45

• Take eight to ten mulberry shoots at a time for “Jabarai”.
• Shake mulberry shoots gently from appropriate height on a news paper.
• Fallen mature worms are collected for mounting.

**Rotary mountages**

![Rotary mountages](image2)

Fig. 5.46
• Rotary mountage, consists of 10 card boards and a wooden frame with plastic stoppers, is an excellent mountage for production of quality cocoons.

• A rotary mountage consists of 10 card board frames, and a wooden frame (1.2 x 0.5 cm). Each cardboard has (12x13) 156 cells and can accommodate 1560 worms. On both sides there are hooks to suspend the mountages from ceiling for free rotation.

• Keep wooden frame in such a way that hooks should face upwards.

• Card boards are fixed one by one in all four hooks in such a way that mid point of card board attach to the hooks.

**Loading of larvae to Rotary mountage**

• Spread news papers on floor.

• Put rotary mountages on news papers horizontally.

• Spread 1200 to 1300 larvae uniformly on a wooden board of same length of rotary mountage.

• Put the wooden board with mature larvae on the mountages and put larvae gently in the rotary mountages.

• Put remaining worms inside the mountages by hand gently.
• This operation should be done carefully and gently to avoid larval injury.

• Place Rotary mountages vertically on news paper.

• 1200-1300 mature worms can be mounted by had in between the cardboard gently and uniformly.

• Tie the upper hook of the rotary mountages with rope to the ceiling in such a way that mountage should be 2 to 3 inches above the ground level.

• Mount the larvae in between the cardboard gently and uniformly with the help of hand.

**Keeping Rotary mountages on floor**

![Image of mountages on floor]

Fig. 5.48

• After loading matured worms in rotary mountages, mountages may be kept for 4-6 hours as such on floor for climbing of the larvae.

• When almost all larvae climb the mountage, the mountage can be suspended from ceiling.
Carrying of Rotary mountages

Fig. 5.49

• Carry Rotary mountages after 4-6 hours with the help of two persons for hanging.

Hanging of rotary mountages

Fig. 5.50
• Hang rotary mountages after loading larvae parallel from the ceiling for free rotation. Strong steel rod with iron rings can be used. If ceiling is not of RCC strong nails (4’ length) can be put with strong wooden reapers used in tiled/thatched roofing. Distance between two nails should be about 1.4m. With these nails mountages can be hung.

**Hanging of second rotary mountage**

![Hanging of second rotary mountage](image)

Fig. 5.51

• By taking the support of first hung rotary mountages, second mountage can be hung gently using two steel rods.

• Similarly based on the height of the ceiling two or three tiers of rotary mountages can be hung.

**Hanging hook**

• Place or put hooks of the rod for hanging second mountages is such as way that outer part of hook should face outside so hook will not create hindrances for free rotation.

• After hanging mountages, the rotation of mountages should be stopped by rotation stopper for 2-3 hours. Then, open the stopper and make the rotation free.
Nylon net below the hung mountages

- After hanging all mountages, a nylon net can be tied above the ground level as swing. This protect the falling worms from getting injured.
- Fallen worms can be remounted.

Removal of diseased larvae

![Image](image.jpg)

**Fig. 5.52**

- Don’t allow diseased larvae to crawl to the floor.
- Collect the diseased larvae and burn them.

Ideal mounting and spinning of the larvae

- Keep mountages in well ventilated place.
- Mountages should rotate freely.
- Remove dead or un spun worms after 48 hours of spinning.
Harvesting of Cocoons

Removal of cardboard from frame

![Fig. 5.53](image)

- Place mountages vertically in such a way that all the hooks face downwards.
- Open plastic frame stopper gently.
- By pressing, the cardboard should be removed one by one gently without damaging it.

Cocoon harvester

![Fig. 5.54](image)
• To harvest the cocoons from rotary mountages, wooden harvester is recommended.

• It has two parts once is the wooden frame in which card board can be fixed.

• Another is pusher with thirteen pages which can fix in card board holes.

Removal of flimsy cocoons and diseased larvae

![Removal of flimsy cocoons and diseased larvae](image)

Fig. 5.55

• Before harvesting the cocoon each frame should be watched thoroughly and remove all the flimsy or thin shelled cocoons or dead worms by hand.

Fixing of card board into harvester

![Fixing of card board into harvester](image)

Fig. 5.56
• After removing all the thin shelled and flimsy cocoons, fix the card board in the wooden harvester.

Harvesting of cocoons

[Image]

Fig. 5.57

• After fixing the card board in harvester, place wooden pusher exactly on the holes over cocoon and push it gently so that cocoons come out of card board.

Removal of cocoons from card board

[Image]

Fig. 5.58
• After folding the card board, collect cocoons from holes of card board.

• Remove cocoons with the help of hand as it is shown in the picture.

**Removal of defective cocoons**

![Fig. 5.58](image)

• Collect harvested cocoons and remove all the defective cocoons such as de shaped, malformed, flimsy and double etc before marketing of the cocoons.

**Cocoons deflossing**

![Fig. 5.59](image)
- Removal of loose and outer floss from cocoons is the deflossing.
- After harvesting and before taking the cocoons to market, cocoon should be de flossed.

**Cocoons deflossing by hand machine**

![Image of cocoons deflossing by hand machine]

**Fig. 5.60**
- Before bringing the cocoons to market remove loose and outer floss from cocoon.
- A small transportable de flossing machine is effective to remove floss from cocoon.

**Disinfection After Rearing**

**Burning of contaminated materials**

![Image of burning contaminated materials]

**Fig. 5.61**
• After the completion of rearing collect the waste materials diseased larvae, flimsy and melted cocoons and burn them.

Spraying of disinfectant

Fig. 5.62

• Spray bleaching powder/sanitech/Formalin solution at the rate of 2 Lt/sq.mt floor area (after cocoon harvest).

6.4 Advantages of Bivoltage Rearing

1. The selected farmers have been able to get better crop by the technical advises and financial supports from JICA, CSB and DOS and also with the joint cooperation of JICA with CSB and DOS.

2. As CSB and DOS are aiming to produce much a amount of the quality silk with CSR-Hybrids, we not only have to diffuse the new Bi voltage Sericulture Technology to the selected farmers but also to other general Sericulture farmers of other areas who are located in suitable place for introduction of new Bi voltage CSR – Hybrids with this objective.

3. The Tropical bivoltage Sericulture technology developed has given an unprecedented success in the three southern states of Karnataka, Andhra Pradesh and Tanil Naidu, stability in production has been achieved with an average yield
of 60-70kg/100 DFLs for selected farmers. The renditta ranged from 5.5-6.0 and silk graded 2A-4A and could meet the demand of quality silk for both domestic and export market.

4. It is envisaged that the successful large scale practicing of these technology fulfill the requirement for production of quality silk in the country.

Summary

- Ideal mulberry varieties for chawki rearing are V 1 and S 36.
- Well disinfected with 2% formalin solution and 5% Bleaching powder solution.
- Eggs are incubated at 25° C and 70% RH.
- During moulting slaked lime may be dusted.
- Shoot rearing is preferable at late age rearing.
- Special required features of Bi voltine is A, B,C,D, E and F
  (A) Disinfection
  (B) Quality Mulberry Leaf
  (C) Pathogen free young or chawki larvae
  (D) Adequate spacing in the bed
  (E) Mounting in ventilated place with good mountages
  (F) Better Silkworm races and quality seeds
- Don’t use cow dung for trays. Disinfect the rearing room and equipments with 2.5% Sanitech solution and 2% Formalin solution.
- Incubate the eggs at 25° C with 80% humidity, 16 hours light and 8 hours dark.
- Loose eggs are incubated in a two frame (25" x 12") incubator.
- 48 hours before black boxing the eggs
- Brushing the larvae by brushing net
- Glossy leaves are preferable for chawkie worms, Matured leaves leaves for late ages.
- Rotary mountages are used for mounting the worms keep mountages in well ventilated place
Short Answer Type Questions

1. Define C R C.

2. What are the disinfectants are used during disinfection of chawkie rearing rooms?

3. How to black box the Bivoltine eggs.

4. In “Jobarai method” how to collect the ripening worms.

5. Advantages of Rotary Mountage.

6. How to transport mulberry shoots.

7. How to de-floss the Bivoltine cocoons.

Long Answer Type Questions

1. Write notes on disinfection of Bi voltine Rearing Room and equipments.

2. Write notes on Bi voltine Rearing.
UNIT 7

Economics

Structure

7.1 Introduction
7.2 Economics of Rearing
7.3 By products

Learning Objectives

After completing this unit, the student will be able to

- Understand the importance economics of rearing
- Reduce the cost of production by controlling unnecessary expenditure
- Understand the utilization of byproducts to add up additional income

7.1 Introduction

The economics of any holding depends on various activities. Sericulture is not an exception. No doubt all the aspects right from Moriculture to Silk reeling have good commercial value. Silkworm rearing is to be conducted systematically. All the aspects directly or indirectly influence the rearing and reflect on cocoons production. On the other hand cocoons quality and quantity also depends on various activities of rearing. In other words the crop economics is influenced by the rearing activities. The crop expenses are much less for disease control and labour. However the rearer should know the economics of silkworm rearing and the factors that hamper the cocoons production.
The byproducts of silkworm rearing can be used for various purposes. Some of them (excreta) are very good source for production of important chemicals used in industries like pharmaceuticals, chemical industries, fertilizers. In this chapter economics and by products of silkworm rearing is discussed.

7.2. Economics of rearing 300 DFLs or one acre

From economic point of view the improved techniques of rearing are more important, for achieving good crop results. The profits are nearly 50% more than normal rearing process. The new techniques of rearing are to be followed right from the selection and cultivation of Mulberry. Hybrid variety of Mulberry i.e., M5 & V 1 yields more quantity of leaf/acre when compared to local varieties. Further by adopting various latest cultural and irrigation processes the yield can be still increased.

Selection of proper seed for rearing is more important as diseased layings yield poor crops and low quality of cocoons. For this purpose better to procure third instar worms from chawki rearing centers. The third, fourth and final instars are so important part of silkworm rearing. The rearing of worms should be conducted in a methodical way. Thereby the no. of cocoons per crop (ERR) per acre increases when compared to normal process of rearing.

The improved techniques of rearing includes selection of rearing house, provision of proper environmental conditions, shoot rearing method for third to fifth ages, hygienic conditions, proper disinfection, quality of leaf and leaf preservation methods. Depending on the growth of the worms they are to be properly spaced. Further the worms are given quality leaf depending on the age of worms. Care should be taken during moulting, feeding, bed cleaning, mounting, harvesting. During the process of rearing disinfection (dusting of vijeta and lime) of rearing bed is advisable so as to prevent incidence of the diseases and also to maintain proper hygienic conditions.

By adopting chawki method of rearing and late age rearing separately, helps the farmer to maintain proper environmental conditions. Further the equipment also differs in both rearings. It is also advised to rear chawki worm in co-operative rearing centers or procure worms from CRC’s. This enables to reduce the expenditure and also to ensure proper growth and the healthy worms under the supervision of technicians.

Maintenance of optimum environmental conditions during spinning and mounting also increases the quality of cocoons. Thus by adopting the above mentioned new techniques more profits can be achieved instead of following old traditional methods of rearing. Now by following above advanced rearing techniques, the bi voltine hybrid silkworm rearing instead of multi voltine hybrids
producing best quality cocoons and fetching good prices in the market leading
to increased profits.

Table. 7.1 Investment on equipment for rearing 300 DFL’s in one acre
of mulberry under irrigated conditions (Model).

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Equipments</th>
<th>Required NO</th>
<th>Cost per Item Rs.</th>
<th>Total Cost Rs.</th>
<th>Utility (Yrs)</th>
<th>Value Per Yr. Rs.</th>
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<tbody>
<tr>
<td>1.</td>
<td>Rearing stands</td>
<td>4</td>
<td>500/-</td>
<td>2,000/-</td>
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<td>2.</td>
<td>Rearing trays</td>
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<td>80/-</td>
<td>2,400/-</td>
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<td>240/-</td>
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<td>3.</td>
<td>Round bamboo trays</td>
<td>100</td>
<td>25/-</td>
<td>2,500/-</td>
<td>3</td>
<td>840/-</td>
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<td>4.</td>
<td>Leaf chopping boards</td>
<td>2</td>
<td>150/-</td>
<td>300/-</td>
<td>10</td>
<td>30/-</td>
</tr>
<tr>
<td>5.</td>
<td>Chopping knives</td>
<td>2</td>
<td>40/-</td>
<td>80/-</td>
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<td>6.</td>
<td>Feeding stands</td>
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<td>30/-</td>
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<td>7.</td>
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<td>10</td>
<td>30/-</td>
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<td>Sprayer</td>
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<td>250/-</td>
<td>10</td>
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<td>10.</td>
<td>Foam pads</td>
<td>1 Kg</td>
<td>150/-</td>
<td>150/-</td>
<td>4</td>
<td>38/-</td>
</tr>
<tr>
<td>11.</td>
<td>Chandrikas (bamboo)</td>
<td>60</td>
<td>50/-</td>
<td>3,000/-</td>
<td>3</td>
<td>1,000/-</td>
</tr>
<tr>
<td>12.</td>
<td>Cleaning nets</td>
<td>300</td>
<td>5/-</td>
<td>1,500/-</td>
<td>3</td>
<td>500/-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>13,530/-</strong></td>
<td></td>
<td><strong>3,035/-</strong></td>
</tr>
</tbody>
</table>

12. Building (rearing house)
Plinth area 1053 sq.ft. cost of Construction @ Rs.125/- per sq.ft.

1,31,625/-
50
2,633/-

The silkworm rearing capacity and crop pattern mainly depends upon
the leaf yield. The full impact of the yield and economics will be seen from third
year onwards only. During the first year, two crops can be taken and the leaf
yield and rearing capacity is limited to about 325 DFL’s under irrigated condition.
From second year onwards the leaf yield increases to 14,000 kg per acre with
a rearing capacity of around 1625 DFL’s (five crops in a year). From second
year onwards the net profit per acre is about Rs.25,660 per five crops. Now
profit is further increased by using new varieties like Mulberry (V 1) and advanced
rearing technology.
### Table 7.2: Expenditure on rearing 300 DFL’s (Model)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item</th>
<th>Total cost Rs. Ps.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cost of DFL’s @250/- per 100dfls so 1625 DFL’s</td>
<td>4,062 = 50</td>
</tr>
<tr>
<td>2.</td>
<td>Cost of labour wages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Young age 14 days, 3 men/day = 42 days</td>
<td>2,560 = 00</td>
</tr>
<tr>
<td></td>
<td>Late age 14 days, 5 men/day = 70 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spinning and harvesting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 days, 8 men/day = 16 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total = 128 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labour charges @ 20/-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>= 128 x 20 =</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Misc. ie. recurring expenditure on rearing</td>
<td>1,000 = 00</td>
</tr>
<tr>
<td>4.</td>
<td>Non-recurring expenditure on rearing Equipoments and Moriculture equipments</td>
<td>4,316 = 00</td>
</tr>
<tr>
<td>5.</td>
<td>Building value</td>
<td>2,633 = 00</td>
</tr>
<tr>
<td>6.</td>
<td>Leaf production (14,000kg per year) @ 0.78ps. per kg.</td>
<td>10,956 = 00</td>
</tr>
<tr>
<td></td>
<td><strong>Grand Total</strong></td>
<td><strong>25,527 = 50</strong></td>
</tr>
</tbody>
</table>

Cost of production of cocoon is Rs.44.88ps./kg green cocoons.

### Table 7.3: Net profits from one acre of Mulberry / year

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item</th>
<th>Total cost Rs. Ps.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Returns through sale of cocoons of 568.75kg. @Rs.90/- per kg. @ 35kg cocoons for 100 DFL’s. For 325 DFL’s/ 5 crops amounts to 568.75kg.</td>
<td>51,187 = 50</td>
</tr>
<tr>
<td>2.</td>
<td>Expenditure per one acre per year</td>
<td>(-) 25,527 = 50</td>
</tr>
<tr>
<td></td>
<td><strong>Net Profit</strong></td>
<td><strong>25,660 = 50</strong></td>
</tr>
</tbody>
</table>

**Note:** Above data may change from time to time according to cocoon market, grainages/etc.
7.3 By Products

Sericulture is an agro based industry which includes various aspects such as Mulberry cultivation, Grainage, Silkworm rearing and Reeling. These different aspects are very much associated with each other as one depends on the other. One has to be a successful Sericulturist, he must have a planned approach.

The most important factor of the planning would be adoption of new technology to get more profits, further a proper planning to add additional income, with an integrated approach where sriculture can be combined with an intercropping, dairying/sheep/goat rearing and poultry farming. The project could be undertaken taking account of waste products or by-products in the sericulture and their utilization.

Like other crops sericulture also leaves some by-products at every level, which can be utilised in many ways. We can proudly say that “Nothing is waste in Sericulture”. Further this aspect also gives lot of scope for self employment where many persons are involved in processing, collecting and transporting of by-products.

The sources of by-products are Mulberry garden, Grainage, Silkworm rearing and Reeling.

The mulberry crop has to be well manured, which includes cattle manure, manure of sheep/goat and silkworm faeces. It may be suggested that an effective, modified recycling procedure would be followed to dump silkworm faeces along with other leaf waste, which can be converted in to good manure after proper decomposition.

Silkworm litter is a good fertilizer as it contains more amounts of nitrogen. It is also used in bio-gas production. Excess of harvested leaves and left over leaves in the rearing bed (accounting for 10-20% of harvest) along with larval litter (60% of ingested food), and exuvia of the moulted larvae are the major wastes generated in the rearing activity. They are collected daily during bed cleaning. Apart from these, rejects of worms, rejected because they are weak, diseased unhealthy and dead larvae also constitute wastes. The following uses have been found for them.

7.3.1 Uses of leaf and litter as compost

The amount of nitrogen, phosphorus and potassium present the left over mulberry leaf is 3.1, 0.55 and 1.5% respectively and that present in the silkworm litter is 1.4, 0.4 and 0.8% respectively. These can be added to the soil and they are converted into compost.
For preparing compost from the mixed sericulture farm wastes, they are collected in pits of convenient size, (4.5 X 1.5X 1m³). Each day’s collection of silkworm litter, left-over leaves in the bed and weeds (grasses etc) are spread in a thin layer. A mixture of fresh cow dung solution (4-5 kg cow dung in 100 liters of water) or biogas slurry, ashes (140-170g) and water (18-22liters) is sprinkled on the layer to make it compact and 150-200 gm lime powder is also added to the mixture to create a buffer effect.

At the end of the rearing the left-over leaves in the garden along with the young mulberry twigs are also added to the pit. Some amount of chemical fertilizer, preferably, single superphosphate of lime is added to enrich the nutrient value of the compost. When the pit is completely filled, it is plastered with a 25 cm layer of a mixture of mud and cow dung. This prevents flies from collecting on the garbage and creating nuisance. A shed of asbestos or thatched roof prevents the pit from being soaked with rainwater. Compost of manure can be dug and used from it after three or four months.

By this method, about 5-6 Mt of well-decomposed and nutritionally rich compost with 30% moisture will be available for one acre of Mulberry farm. The resulting compost contains 1.6%N, 0.7%P and 0.3%K, in addition to various micronutrients. Use of compost as fertilizer enriches, maintains and restores the health of low-humus-containing tropical soil. It not only increases the productivity of soil and improves yield, but also checks soil erosion by enriching the binding properties of the soil by improving soil structure, drainage and its base-exchange capacity. It destroys harmful pathogens that may grow on the garbage and also helps to prevent environmental pollution.

7.3.2 Use of larva as Animal feed

Rejects and dead larvae can be used as poultry feed. Chicks fed on them lay bigger and more number of eggs because the silkworm contains high protein content. Cast larval skin is also good food for poultry.

7.3.3 Use of silk gland as suturing material

Mature silk glands from dead worms can be used as the source of guts which are used for surgical suturing. This can be done by treating the silk glands with acetic acid and then drawing them into fine filament.

7.3.4. (a) Uses of litter as Biogas

Silkworm litter can be effectively used as raw material in the biogas plant along with cow dung to produce fuel. It is better to use litter for fuel production than for fertilizer as it may contain spores or other resistant stages which may remain in the soil and may be transferred to the next generation.
The quantity of cattle manure available with small and marginal farmers may not be sufficient to feed a small 2m3 bio-gas plant. Silkworm larval litter with a better biogas yield (96.20% more than cow dung) can be used as a supplement to cow dung in the biogas plant. Experiments have revealed that silkworm larval litter incorporated treatment increases the biogas generation (from 56.97 to 96.20%).

The quantity of gas produced per gram of total solid dissolved was also high in cow dung silkworm litter incorporated treatment. The manurial value of the bio digested slurry was also increased due to its incorporation with the litter. Nitrogen, phosphorus and potassium were all high in the slurry obtained by using dung with litter than dung alone.

The reduction of microorganisms pathogenic to both Mulberry and Silkworm are also possible in the bio digester, since the environment in the digester is not conducive to the survival of these pathogens. This leads to break in the perpetuation of pathogens and reduces the loss in cocoon crops due to diseases.

7.3.4. (b) Pharmaceutical uses:

In China silkworm litter was used as manure, feed for fish during 1950. Pharmaceutical and perfumery compounds are produced from silkworm and its litter in China. In 1970 paste chlorophyll, copper chlorophyllin sodium was produced from silkworm litter. In 1975 Phytol, Kerotine, Triactinol, Pectin was produced to utilize them in food, chemical, pharmaceutical, cosmetics industries. Being the largest producer, of raw silk in the world, it accumulates large quantities of silkworm excreta (4,00,000 tons a year) and converts it into raw material for synthesizing many new product of which chlorophyll (C55H72MgN4O5RCH3) is worth mentioning because it is in demand internationally for pharmaceutical and food processing industries.

Chlorophyll extracted from pine needles and forage grass are used as a colouring matter of chlorophyll soaps, food, waxes and toothpastes. It is also used as a deodorant, healing agent and are medicine for stopping bleeding of teeth and gums during dental and gum diseases. It is estimated that 20 tons of silkworm excrement can produce one ton of chlorophyll or 30 kg of sodium iron chlorophylline and that too with less expenditure than the conventional process of manufacturing it from dried alfalfa leaves. They have also developed a technique for producing fructose from silkworm litter.

The Zhejiang Academy of Traditional Chinese Medicine has developed ganxuebao, a medicine for hepatitis and leukemia, made from chlorophyll extracted from silkworm excreta. According to the chief of the
research group that studied the use of silkworm excrement, this medicine has an efficiency rate of 95.6% for cancer patients suffering from loss of white blood cells caused by chemotherapy and radiotherapy.

Table 7.4 Other by products and their uses.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Product</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Paste chlorophyll</td>
<td>Chemical industry.</td>
</tr>
<tr>
<td>2.</td>
<td>Copper chlorphillin sodium</td>
<td>Pharmaceutical industry (for Human stomach, liver Pancreas, chronic renal diseases), for wine, fruit concentrate preparation, Toothpaste, Shampoo preparation.</td>
</tr>
<tr>
<td>3.</td>
<td>Phytol</td>
<td>To produce vitamins (K &amp; A)</td>
</tr>
<tr>
<td>4.</td>
<td>Triactinol</td>
<td>As growth regulators in rice, wheat, maize, Groundnut, vegetables.</td>
</tr>
<tr>
<td>5.</td>
<td>Kerotine</td>
<td>To produce K vitamin, medicine for stomach, lung disease. To prevent cancer to these organs.</td>
</tr>
<tr>
<td>6.</td>
<td>Pectin</td>
<td>For preparing Jam, fruit juice concentrates, ice creams, medicins to control blood pressure and cholesterol.</td>
</tr>
</tbody>
</table>

7.3.5. Pierced cocoons

Pierced cocoons produced in rearing are categorized as grade I waste. These cocoons and cut-open cocoons are the raw material for hand spinning industry to form silks like ghicha and katia which are used for producing fabrics like gent’s chaddar, lady’s scarves, curtains, table cloth and caps. It is also used for producing spun silk in mills. These are also used for garland and other decorative items.

7.3.6. Uses of waste moth

The moths unused for seed purposes, dead moths, and the discarded eggs are dumped in pits and allowed to form compost without any commercial motive. But as some these discarded moths and eggs are pebrinized, they may spread pebrine to the seed cocoons reared unless special care is taken to burn
The silmoths, which are discarded after emergence or after mating, are now used to brew medicinal wines in accordance with ancient Chinese prescriptions. The best known is a male silkworm moth wine produced by Shaanxi Sericultural Technology Station. According to Wang Xinhua, a senior agronomist, the liquid can be used to treat impotence, abnormal menstruation and menopausal symptoms.

Summary

- Improved techniques of rearing are more important, for good crop results.
- All the aspects of silkworm rearing are carried with lot of care.
- The byproducts of sericulture are used for various industrial purposes.
- Excess leaf, litter is used for compost preparation containing 1.6% N, 0.7% P and 0.3% K besides many micronutrients.
- Dead larvae are used for animal feed. Silk glands of dead larvae are used for preparing suturing material.
- Silkworm litter can also be used in biogas production.
- Waste moths are used for compost, to treat impotence, abnormal menstruation and menopausal symptoms.

Short Answer Type Questions

1. Mention the factors that influence economics of rearing.
2. What are the reasons for poor cocoon crop?
3. Mention by products of silkworm rearing.
4. What are the uses of waste mulberry leaf?
5. Mention the chemicals extracted from silkworm litter.
6. What are the uses of Silk gland?
7. Mention the uses of pectin.
8. What are the uses of waste moth?

Long Answer Type Question

1. Detail about the economics of silkworm rearing.
2. Explain the uses of silkworm litter and other byproducts of Sericulture.
3. Brief about by products of rearing and their uses.