Intermediate
Vocational Course
Second Year

SILKWORMING REARING TECHNOLOGY
for the Course of Sericulture

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1
HATCHING AND BRUSHING

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. Univoltine races lay only diapausing eggs. Multivoltine races lay only non-hibernating eggs while the behaviour of the eggs of the bivoltine is intermediate. Except multivoltine, uni and bivoltine race eggs are hibernating eggs which require special treatment to make them hatch. These eggs 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 egge 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 posses 5-6 leaves. It is better to tap the shoots 25-30 days prior to the date of brushing.

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

The desire race of silkworm DFLs (Diseased Free Layings) are procured from grainage. The eggs are protected from ants, rats. They are incubated well and later kept in black box. The process of brushing and methods are explained in this chapter.

1.2. HATCHING

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

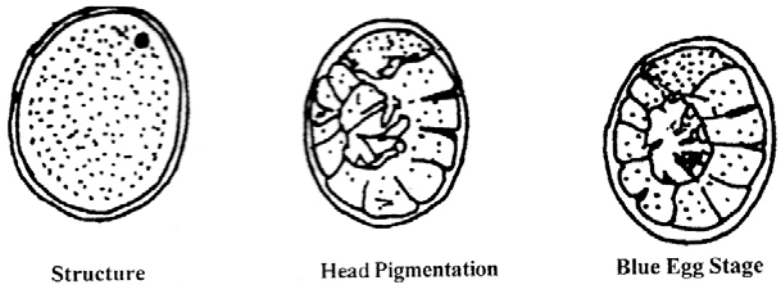


Fig. 1.1 Bombix Embryonic Stages

responce to phototropic stimulus. This mehod favours hatching more than 90 percent. If hatching is not uniform and only 50-60 percent of eggs hatch on the first day, brushing can be postphoned to next day as well. If necessary hatched worms can be separated and kept in tissue paper and stored in fridge at 10^0C.When the second batch hatch our the refrigrated eggs are mixed and brushed together. Even blue egg stages can also be preserved at 50C for 2-3 days.

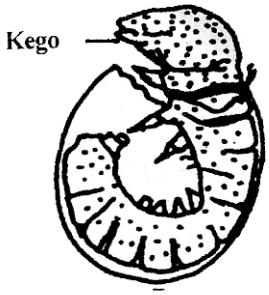


Fig. 1.2. Hatching

Silkworm eggs are available loosely and on egg cards. The newly developed larvae breaks out the egg shell and comes out, and is called hatching. The hatched larvae are collected and reared. The newly hatched larvae are black, hairy and look like small ants and are called “ants” or “kego” (Fig. 1.1). Is is always better to brush the larvae in the morning. Th eggs exposed in early hours or hot hours results in irregular hatching. Generally brushing should not be delayed. If necessary, can be postphoned to next day whne hatching is irregular. Brushing should be completed in the morning/ cool hours of the day. Freshly emerged larvae can also be preserved at 7-10^0C for one day.

1.3. HATCHING PERCENTAGE

The ratio between hatched eggs and total eggs in a laying is called "hatching percentage". The hatched eggs, unfertilized or dead egg number is counted individually for calculating the percentage. This can be done using a colour ink pen and later it is calculated using the following formulae and method.

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

$$\text{Unfertilised egg percentage} = \frac{\text{Total No. of dead / unfertilised eggs}}{\text{Total No. of eggs}} \times 100$$

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

MODEL PROBLEM :

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

Total eggs = 445

Hatched = 415

Unfertilised eggs = Total eggs - hatched eggs

= 445 - 415

= 30

Dead/unfertilised eggs = 30

$$\text{Hatching percentage} = \frac{415}{445} \times 100 = 93.25\%$$

$$\text{Unfertilised egg percentage} = \frac{30}{445} \times 100 = 6.74\%$$

EXAMPLE - 1 :

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

Total eggs = 475

Dead eggs = 20

Good eggs = Total eggs - dead eggs

= 475 - 20

= 455

$$\text{Hatching percentage} = \frac{445}{475} \times 100 = 95.78\ \%$$

$$\text{Dead egg percentage} = \frac{20}{475} \times 100 = 4.21\ \%$$

EXAMPLE - 2

In a rearing centre 2620 eggs hatched and 70 eggs did not. Find out hatching and dead eggs percentage.

Hatched eggs = 2620

Dead eggs = 70

Total eggs = hatched eggs + dead eggs

= 2620 + 70

= 2690

$$\text{Hatching percentage} = \frac{2620}{2690} \times 100 = 97.39\ \%$$

$$\text{Dead egg percentage} = \frac{70}{2690} \times 100 = 2.6\%$$

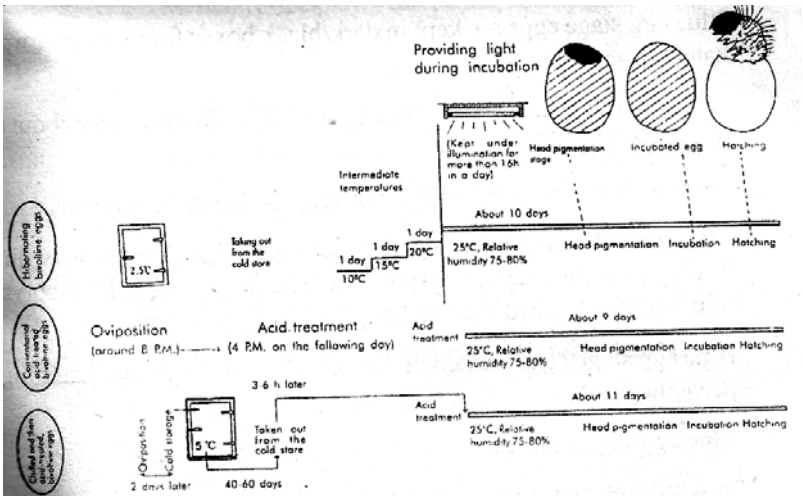


Fig. 1.3. Incubation Process

1.4. BRUSHING

When the eggs hatch, the emerged larvae are to be collected for rearing. This process of separating kego/ants from egg shell is called “brushing”. It means placing of mulberry leaves on a frame to attract the larvae so that they will be separated from their shells. The optimum time for brushing is around 10am when the humidity is 85-90% and temperature 27^0C.

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 hatching worms develop appetite and begin to crawl. Thus the suitable time for brushing would be 10am 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 into the tray worm bodies should be disinfected for disease prevention by using a fine-mesh sieve to dust a fine powder of formalin (3%).

It is of two types i.e. brushing of loose eggs and brushing from egg cards.

1.4.1. BRUSHING OF LOOSE EGGS

The eggs are spread evenly in one layer in the 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 and this paper (Fig.1.3).

This covering is placed in such a way that it just touched 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 hatch out and crawl on to the paper they are collected in to rearing tray.

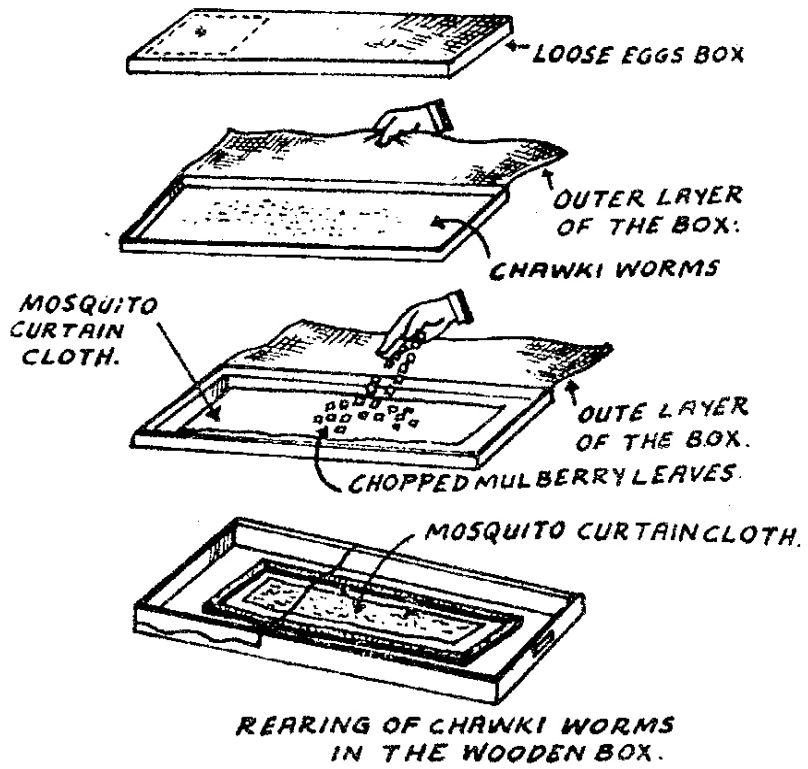


Fig. 1.4. Brushing of Loose Eggs

1.4.2 BRUSHING FROM EGG CARDS

a. Tapping method :

The hatched larvae which crawl towards the edges or corners of the egg sheet are collected into rearing tray using a feather. The egg sheet is hold upside down just above the rearing seat and tapped from above. The larvae drop on to the rearing seat. Then the dropped larvae are brushed together with feather and fed for the first time.

b. Feather method :

The hatched larvae which crawl towards the edge or corners of the sheet are collected gently with a feather. Hold the egg sheet slant wise to the rearing seat and brush off the larvae from the egg sheet to the rearing seat with the help of a feather (Fig. 1.4). Later worms are fed with finely chopped mulberry leaf.

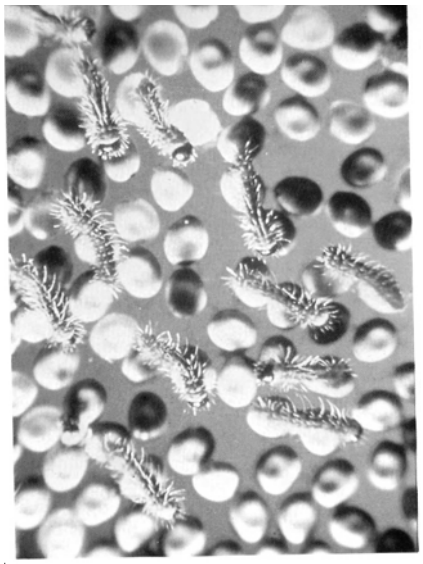
Fig. 1.5. Brushing by Feather

c. Brushing with mulberry leaves :

Mulberry leaves chopped to 0.5Sq. 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 along with mulberry leaf are transferred to rearing tray using feather.

d. Husk – feeding method :

Finely powdered paddy husk is sprinkled thinly, evenly on the egg sheet when the larvae hatch. The larvae crawl over the layer of paddy husk. Then finely chopped mulberry leaves are sprinkled on the worms and finally transferred to rearing tray using feather.



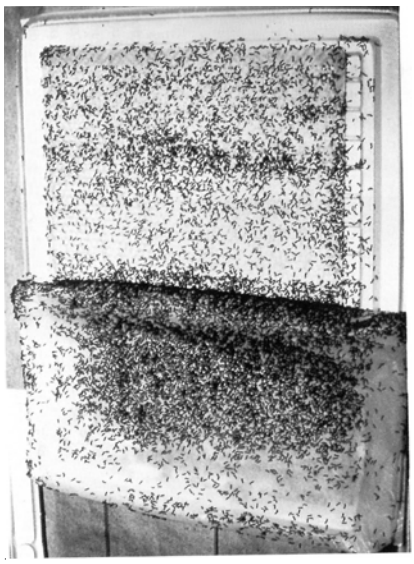


Fig. 1.6. Newly Hatched Larvae

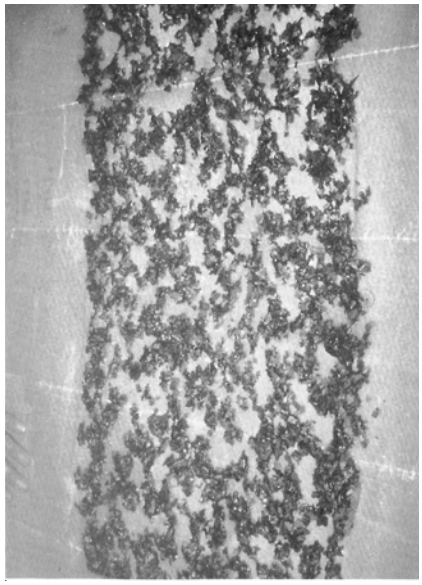


Fig. 1.7. Disinfection Newly Hatched Larvae

Fig. 1.8. Feeding of Hatched Larvae

SUMMARY

- Incubation of silkworms eggs favour maximum hatching.
- Incubation room, chamber must be clean and should possess required chemicals, disinfectants, equipments.
- Non-hibernating eggs and after acid treatment requires 80-85% humidity and 24-25^{0}C temperature right from the beginning.
- Cold stored eggs are gradually brought to normal room temperature.
- Temperature, humidity, light are equally important during incumbation of eggs.
- Eggs are kept under a photoperiod of 16 hours daily until 30-40% of the eggs reach blue egg stage.
- Blue egg stage eggs are kept in dark/black boxes for more uniform hatching on the next day.
- Hatching can be delayed at blue egg stage by cold storing for about a week at 9^{0}C.
- Incubated eggs are handled properly for good hatching percentage.
- The eggs before (48) hours hatching reach head pigmentation or pin head stage and are called eye spot stage. On the following day embryo turns black and called blue egg stage.
- Blue egg stage are kept in black boxes for maximum hatching percentage.
- Blue egg stage eggs can be preserved at 5^{0}C for 2-3 days.
- Newly developed larva breaks the egg shell and comes out, the process is called hatching.
- Newly hatched larva is called and or kego.
- The larvae are to be brushed in cool hours of the day,
- Calculation of hatching percentage is carried after brushing.
- Prior to brushing the rearing room and required equipment is kept ready.
- Brushing is important and first activity in rearing.
- It is a process/activity ensures to separate newly hatched worms from the egg shells.
- This activity starts in the early hours of the day and decreases as the daylight increases.

- ❖ The required humidity and temperature favours brushing.
- ❖ Brushing is done in two methods i.e. loose egg brushing, brushing from egg cards.
- ❖ While brushing loose eggs, finely perforated, thin paper is spread and later finely chopped mulberry leaf is sprinkled. Crawled worms are collected.
- ❖ Brushing from egg cards has different methods. Among them feather method is popular.
- ❖ While brushing care must be taken not to damage the silk worms.

QUESTIONS

I. SHORT QUESTIONS

1. Define blue egg stage
2. Define black boxing
3. Define 'kego'or 'ant'
4. Mention incubation temperature and humidity.
5. What is handling of eggs ?
6. What is eye spot stage ?
7. Mention principle for calculating hatching percentage.
8. Define Brushing
9. What is the best time for brushing ?
10. Mention required temperature and humidity for brushing.
11. Mention brushing equipments.
12. What is the popular method of brushing ?
13. List out methods of brushing ?
14. Define D.F.L.

II. ESSAY QUESTIONS

1. Write about black boxing of silkworm eggs. ?
2.. Write short notes on
   a) Hatching b) Blue egg stgage
3. Calculate hatching percentage using these values
   Total eggs = 530, Hatched eggs = 512.
4. Detail the process of brushing of loose eggs.
5. Describe methods of brushing from egg card.

2
CHAWKI REARING

2.1. INTRODUCTION

The life cycle of silkworm 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 form hatching to spinning is about 26 days. During this long duration the larvae grow in size and enter cocoon (pupal) stage. To accommodatate the larval body growth the larvae undergo four moults and thereby he complete larval duration can be clearly differentiated into five instars or stadia. 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 IMPORTANCE OF CHAWKI REARING

Young age or chawki rearing and late age rearing techniques are different. Both nutritional and ecological requirements during these two stages are different. The essential point in rearing of young silkworms is to get strong and sturdy silkworms. The success of sericulture depends to a large extent on the successful rearing of young worms. Young age worms are more resistance to high temperature and humidity and grow healthier, ensuring success of cocoon crop. The first character of young silkworms is that, they grow extremely fast. To support their fast growth, they must be given highly nutritious sufficient mulberry leaves. Undergrown mulberry makes silkworms susceptible to disease growth becomes uneven, reflects on rearing resulting in poor cocoon crop.

Therefore young silkworms are fed with tender and succulent mulberry leaves. The leaf eating time is shorter in earlier stages then later instars. However the total leaf requirement of silkworm larva in only 6.33 percent, during chawki rearing upto III moult. But body weight increases by 400 times, while 300 times increase in body size and 500 times increases in silk gland weight are achieved during young stage provided the conditions and methods of rearing are ideal. Further the rate of increase in body weight of larva per given time is more in the first instar and it decreases with the age. The effects if insecticides disinfectants, injurious gases etc, on the larvae are more in the earlier instars than in the later instars. Keeping in view of above points the young worm rearing must be carried out with maximum care.

2.3. ENVIROMENTAL CONDITIONS

Since silkworms have been domesticated for many centuries, they are by nature quite delicate and are very sensitive to environmental conditions. The ecological factors chiefly temperature, humidity, light and air during rearing have a significant in influence on the growth of larva and ultimately on cocoon crop quality. Of course the other factors like quality and quantity of leaf supply and techniques of rearing adopted such as feeding, cleaning, spacing etc, are also to be considered. The influence of environmental conditions is not the same throughout the rearing period, but varies in different stages of larval growth depending upon the physiological condition and voltinism of the silkworm.

2.3.1. TEMPERATURE :

Temperature plays a vital role on the growth of the silkworms. As silkworms are cold blooded animals, temperature will have a direct effect on various physiological activities. Rise in temperature increases various functions and with a fall the activities are decreases. Increased temperature accelerates larval growth and shortens the larval period. On the other hand at low temperature the growth is slow and larval period is prolonged. The optimum temperature for normal growth of silkworms is between 20°C and 28°C and the desirable temperature for maximum productivity ranges from 23°C to 28°C. temperature above 30°C directly affects the health of the worm. If the temperature is below 20°C all the physiological activities are retarded, especially in early instars, as a result worms become too weak and susceptible to diseases. The temperature requirements during the early instars (I,II,III) is high and the worms feed actively and grow very vigorously. Such vigorous worms, can stand better even at adverse conditions in later instars. Optimum rearing temperature for rearing is 24° – 28°C. In general the early instar larvae are resistant to high temperature and it also helps in improving survival rate and cocoon characters.

The temperature has a direct correlation with the growth of silkworms and wide fluctuation of temperature is harmful and as for as possible it should be avoided. The optimum temperature required for rearing silkworms of different early instars are as follows.

Stage of Worms	Optimum Temperature
I	26°C - 28°C
I	26°C - 28°C
III	24°C - 26°C

2.3.1.1. Regulation of Temperature

Generally the room temperature is low during winter and rainy day which should be regulated by heating with electric heaters or charcoal fires. Electrical heaters are best since they do not emit any injurious gases. When electricity is costly and not available, properly dried charcoal and can be used. In this case however the live cinders should be covered with a layer of ash for more regulated room to raise the temperature should be avoided. Because the carbondioxide and other gases emitted in this process are injurious to silkworms. Besides the above processes the doors and windows should be kept closed. During nights to keep out the cold. Late in the day, as the outside temperature goes up doors and windows should be opened to allow warm air in to the room. In Andhra Pradesh, Karnataka and West Bengal except for a few days of winter and rainy days, the temperature is often above the optimum level. Thus it is problem for the rearer to lower the temperature rather than heating up of rearing room. This sort of temperature is adverse to silkworms. This adverse effects to a certain extent be mitigated through proper designing of the rearing house and by ensuring adequate ventilation and free circulation of air.

During summer season when the day temperature is high, all the windows should be kept open during night, to bring down the temperature. And early in the morning all the windows and doors should be opened so that the cool air from outside is allowed into the rearing room to bring down the temperature. When the sun rises and the temperature goes up, doors and windows should be closed. Besides this windows and doors are covered by wet gunny cloth on a hot day to reduce the temperature. Otherwise air coolers can also be used for this purpose.

2.3.2. Humidity

It plays a vital role in silkworm rearing. The combined effect of both temperature and humidity largely determines the satisfactory growth of the silkworms and production of good quality cocoons. Its role is both direct and indirect. It directly influences the physiological functions of the silkworm. The young age silkworms can withstand to high humidity conditions better than later age worms and under such condition the growth is vigorous. The humidity conditions for different early age worms are as follows.

Age	Relative Humidity %
I	85
I	85
III	80

Humidity indirectly influences the rate of withering of the leaves in the silkworms beds. Under dry conditions the leaves wither very fast and become unsuitable for feeding. This effects growth of the larvae and also results in wastage of leaf fed. Retorded growth of young larvae makes them weak and susceptible to disease. At a humidity of 90 percent or higher, if temperature is kept at $26^0 - 28^0$C, they can grow without being greatly affected. Therefore the humidity is kept high to prevent mulberry leaf withering.

2.3.2.1. Regulation of humidity

Like temperature, humidity also fluctuates widely not only from season to season but also within the day itself during any season. Therefore it is a must for the rearer to regulate it. For this purpose paraffin paper is used for rearing beds during chawki rearing to raise humidity. Other wise wet foam rubber pads or paper pads soaked in water can also be used to increase humidity in the beds. However it is important to lower humidity to 70 per cent or below during the moulting in each instar to facilities uniform and good moulting. Otherwise it results in

a. silkworms remain under the net
b. uneven growth
c. become susceptible to disease
d. bed cleaning requires much labour
e. missing worm number increases

Therefore rearer must remember the drying and disinfection of bed during moulting without fail. Removal of paraffin paper during moulting raises the drying effect.

2.3.3. Air

Like other animals silkworms also require fresh air. By respiration of silkworms carbon dioxide gas is released in the rearing bed. Besides this carbon monoxide, ammonia, sulphur dioxide etc., are also released in the rearing room by burning of charcoal to raise temperature. These gases are injurious to silkworms. Therefore care should be taken to allow fresh air through proper ventilation to keep the toxic gases at a low level. If CO_2 exceeds to 2 per cent concentration, the growth of silkworm is retarded. Insecticides and disinfectants are also avoided in the rearing room.

Air plays an important role in regulating room temperature and humidity.Artificial air circulation is useful for bringing down high temperature and humidity.

2.3.4. Light

Silkworms are photosensitive. They have a tendency to crawl towards dim light. They do not like either strong light or complete darkness. The larval moult is uniform when silkworms are reared in 16 hours light and 8 hours darkness.

2.4. QUALITY OF MULBERRY LEAF

The Mulberry leaf is the exclusive food of the silkworms ***(Bombyx mori).*** The growth of the silkworm 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. This type of leaves are edible for silkworms 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 form 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 fluctuations during night and day 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 two clayey nor too sandy, but not acidic.
2. Application of optimum and balanced fertilizers
3. Suitable cultural operations
4. Assured irrigations 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. This 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 too soft leaves are not suitable for the worms.

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 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 nature leaf containing less moisture. This can be achieved when leaves required for 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.These leaves have better quality, optimum moisture and better feed value. This type of leaves neither wither nor increase bed humidity leading to successful crops. Morning time is the proper time for picking the mulberry leaves, planning the total leaf requirements of the day.

2.5. Leaf Selection

Mulberry 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 your 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 glossy leaf method is adopted.

2.5.1. Glossy leaf method

For the identification of glossy leaf, hold the upper part of shootr 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 shooter lightly between fingers, and bend it horizontally. Then a lead stands up right is identified as largest glossy leaf (Fig.2.1c).

Now the first instar are fed with 4th and 5th leaves downward from the base of glossyleaf, for secon instar 5th - 7th leaves, for third instar 7-8 leaves to downward are plucked.

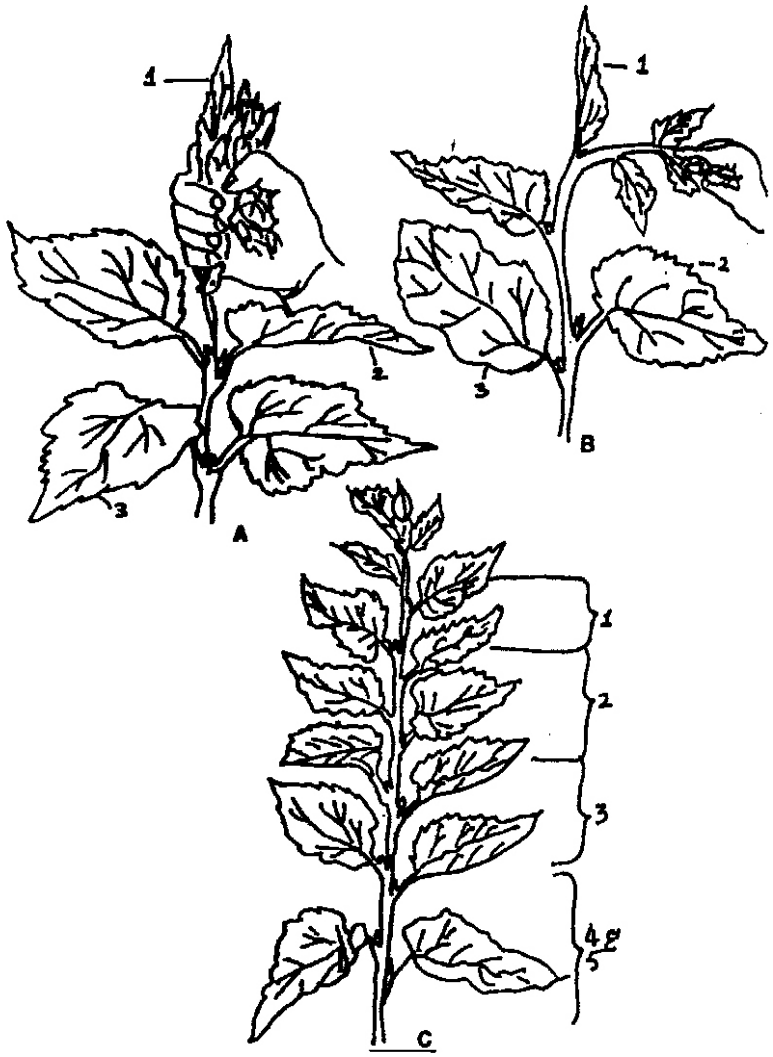


Fig. 2.1 Glossy Leaf Selection (A,B,C)

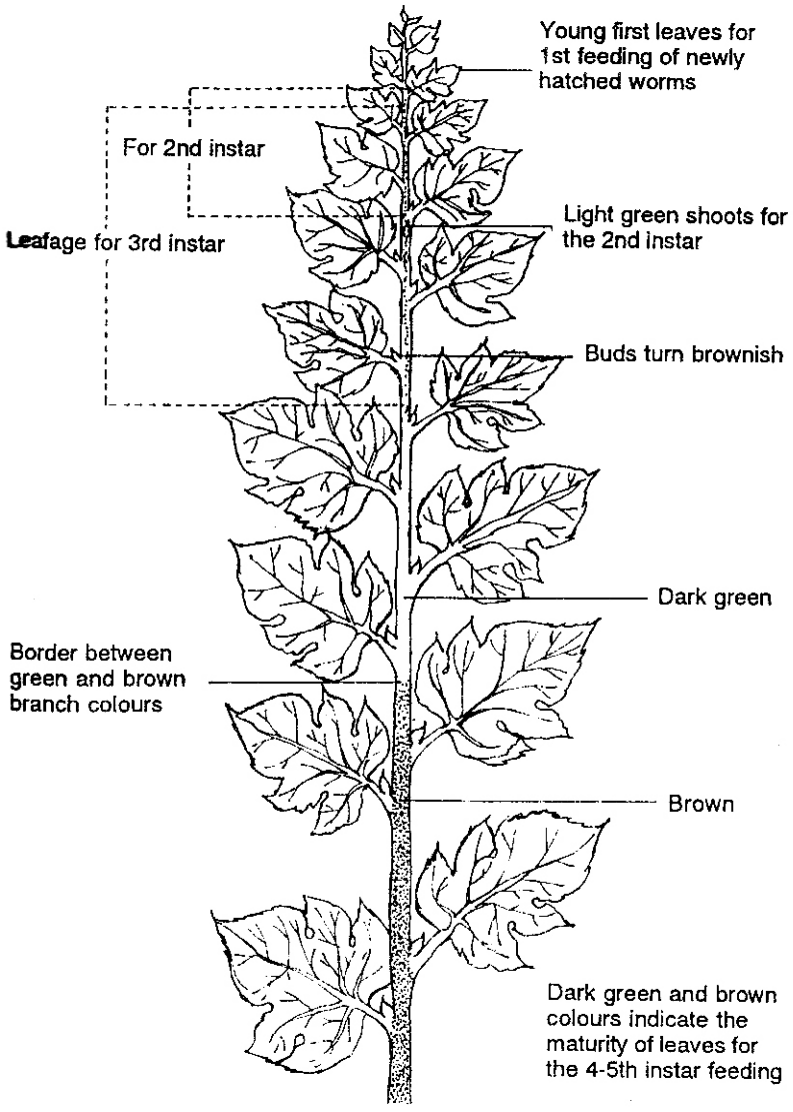


Fig. 2.2 Lenticel and Bud Method

2.5.2. 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 go worms. The colour of auxiliary buds changes from the top to the bottom of the branch. The colours from top to bottom are green, apical brownish, striped, non-accomplished and accomplished buds (Fig. 2.2)

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

2.5.2.1. Leaf Preservation

It is important not only to produce highly nutritious and succulent leave but also to preserve them after harvest till they are consumed by the worm. The freshly harvested succulent leaves undergo nutrient changes following harvest. In not day the loss of moisture affects the edibility or palatability of the leaves for silkworms. For this relative humidity is maintained in the rearing room to prevent withering of the leaves. Silkworms do not feed on withered leaves. The consumption of the worms changes in accordance with the moisture content the leaves. When large quantity of leaf is required for rearing it requires mush time for leaf harvest. Thus harvested leaf may dry quickly if not collected in proper baskets covered with wet gunny cloths or put in leaf chamber. During leaf storage high humidity and low temperature are maintained in the preservation room and periodic turning of leaves is suggested to avoid fermentation and to release the repiratory heat. In this conditions, leaves absorb more moisture and remain fresh for a longer time in the rearing beds. Generally preserved leaves show higher moisture content and protein. This high moisture content helps digestibility of worms. Large quantity of leaf can be stored on a clean floor, over gunny cloth in loose layers with adequate air pockets and covered with wet gunny cloth. In summer sprinkling of water on the leaves and frequent wetting of gunny cloth covered are required (Fig. 2.3.a,b,c).

In general mulberry leaves should be preserved in a moist and clean place. The tender leaves meant for young worms can be preserved in boxes, baskets or jars covered with clean wet cloths. In India leaves for young worms are preserved in earthemed pots covered with wet cloths and places in moist sand.

Preservation of leaves as fresh as possible helps to reduce the number of feeds, there by cuts down the labour cost involved in rearing.

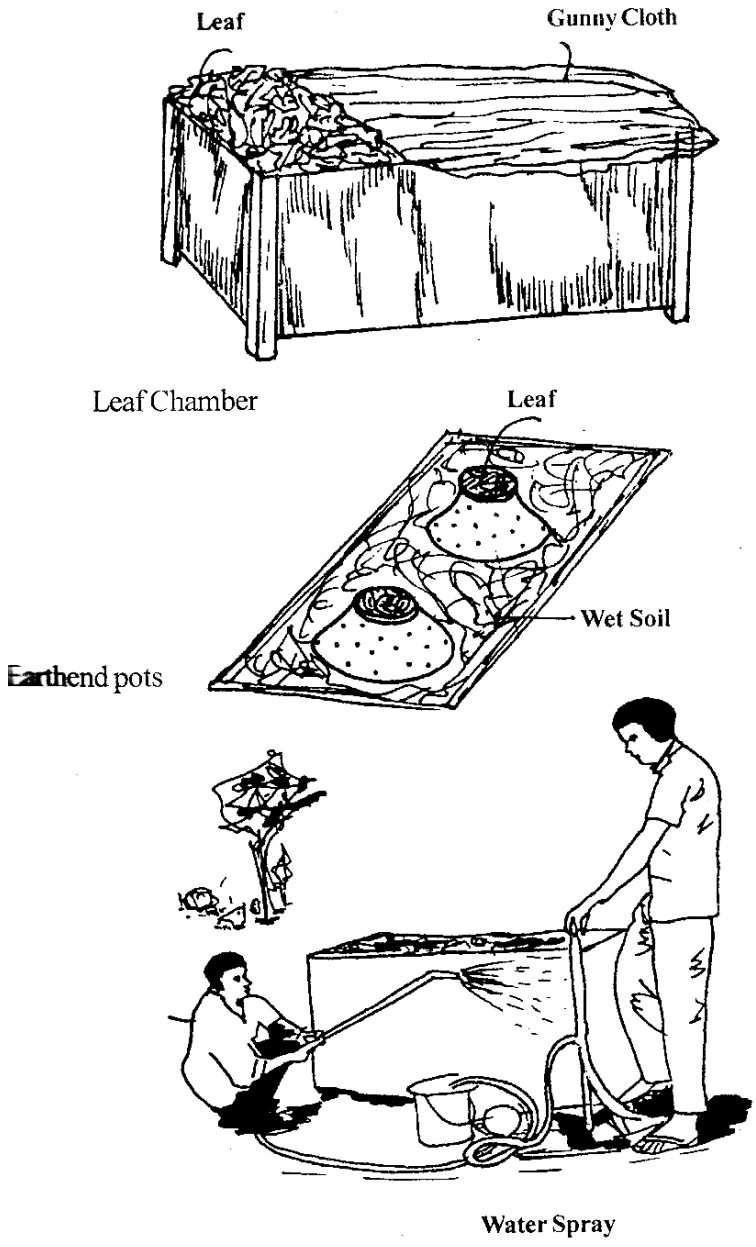


Fig. 2.3. Leaf Preservation

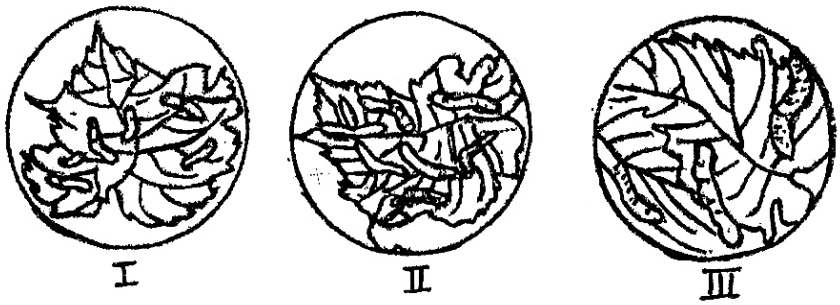


Fig. 2.4. Chawki Worms

2.6. FEEDING SCHEDULES

2.6.1. Feeding

Silkworms are fed to satisfy their appetites. Thereby uniform and health growth of silkworms can be achieved. For this, quality leaves are to be preserved and rearing beds are kept clean. Feeding with too many leaves in not economics. The main objectives of feeding are;

1. to satisfy he 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.

Generally early age silkworms eat leaves the surface. While late age worms form the edges. The feeding activity of each instar of silkworm can be conveniently into seven stages.

1. First feeding stage
2. Sparse eating stage
3. Moderate eating stage
4. Actively eating stage
5. Premoulating stage
6. Last feeding stage
7. Moulting stage

Fig. 2.5. Feeding

At the beginning of each stage the worms have a great appetite. The larvae have good appetite at the first feeding stage, and comparatively little appetite at the sparse eating and moderate eating stages. They eat much at the active eating stage. Afterwards appetite increases till last feeding stage after which eats nothing and enters moulting stage. This appetite falls very rapidly in the early part of the age and then gradually increases to the end of the age as the worm reach moulting time. If the worms are active in their movements, their appetite is keen and requires more food. On the other hand of the worms are dull feeding is not required.

When the worms are of a rusty colour, having come out of moult will be very hungry.As the rust colour decreases the appetite declines. Later a blue tint appears at the segments which gradually spreads over the worms. This blue tinge is an indication of returning to appetite which grows steadily. When appetite reaches its maximum, whitish body colour mixes with the blue. Then worm turns to light amber colour and prepares to moult appetite falls.

The main idea of feeding is to nourish all the worms simultaneously and equally to ensure uniform growth. In this process the worms are given enough time to eat and also prevent wastage of leaves in any way, to increase their body weight and size in each age. The weight of leaves required for food during each age is 2½ times their increase in weight from the first to the growth age. In the fifth stage the leaf consumption is 4½ times of their developments in body.The increase in the weight of worms during the rearing varies with season and race.

2.6.2. Growth of worms

Silkworms 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 following by which worm grows to a weight of 4-5 gms. 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 2.1, 2.2). The growth rate of silkworm varies with meteorogical 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 1 age, 4-5 times at II age, 5 times at III age; 5 times at IV age and 5 times at V age (Table 2.3)

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 2.2). the quantity of leaf required of rearing 50 layings or a box of 20,000 eggs, upto III instar are given in Table 2.4.

Table 2.1 Ingestion and Percentage of Digestion

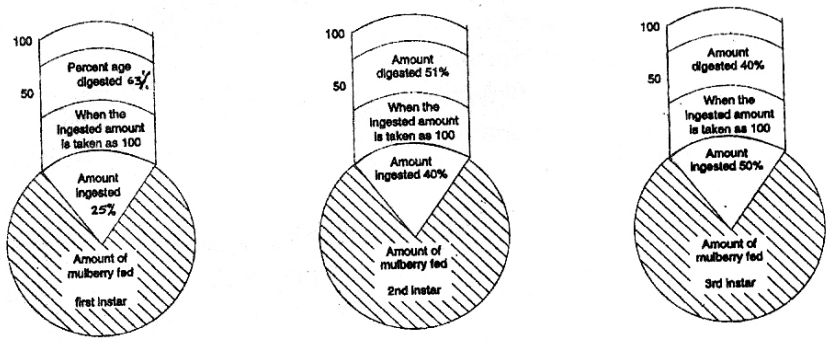


Table 2.2 Amount of mulberry ingested and digester by silkworms. (per 1000 larvae in green weight)

Stage	Amount of leaves supplied (gr)	Amount of Leaves Ingested (gr)	% of Ingestion	% of the Total Amount ingested (gr)	Amount of Leaves digested (gr)	% of Digestion	% of Total amount Digested
I	59.8	14.4	24.4	0.06	7.7	53.4	0.08
II	223.4	88.8	39.7	0.37	45.3	51.0	0.48
III	970.0	480.4	49.5	1.86	192.3	40.0	1.90
IV	5,333.0	2,419.7	45.4	10.16	961.2	39.7	10.30
V	35,150.0	19,610.5	55.7	87.55	7,655.1	39.1	87.24
Total	41,736.2	22,163.8	54.2	100.00	8,861.6	39.2	100.00

Source: Synthetic Sericulture

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

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

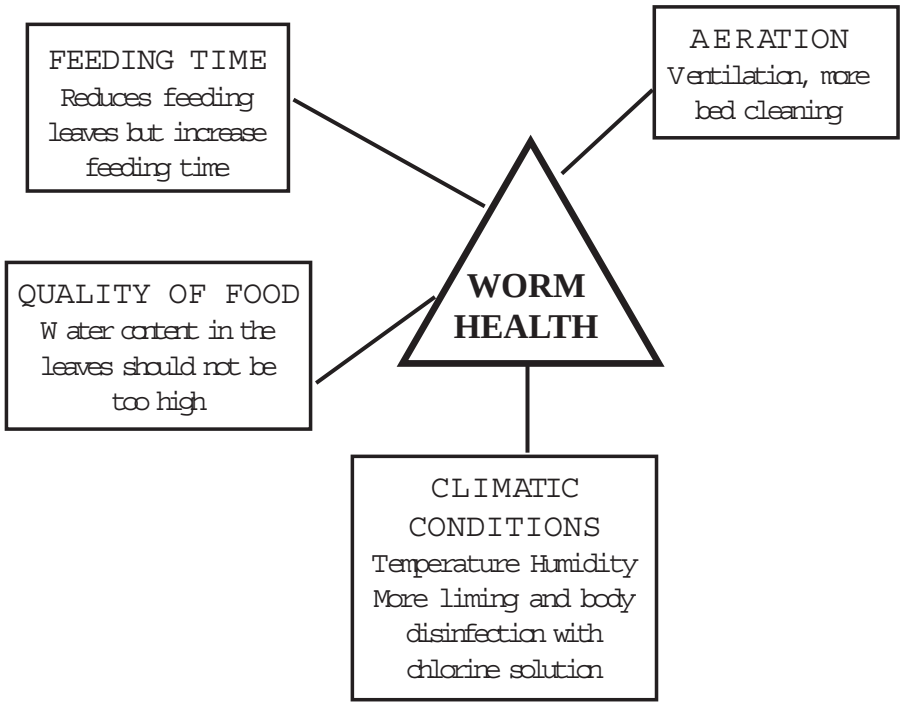


Table 2.5. Care for nearing of silkworms during rainy season

Table 2.4 Leaf Requirements

Age of the Worms	Quantity of Leaf to be Fed	
	Multivoltine X New Bivoltine Hybrid	Bivoltine X Bivoltine Hybrid
I	2 - 2.5 Kgs.	2.5 - 3 Kgs.
I	6 - 7.0 Kgs.	8.0 - 9 Kgs.
III	25 - 30.0 Kgs	35.0 - 45 Kgs

2.6.3. 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.

Fig. 2.6. Leaf Chopping

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 donot curl up when the air is not and dry. However a greater amount of leaves are wasted besides labour expenses.

Depending on the shape of the chopped leaves there are three methods of choppings. They are square, oblong and triangular.The square method is best of all which prevents lead drying. Long thin strips or 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.

	Leaf size (cm2)		
instar	to start with	peak eating stage	preparation for moult
I	0.5	2.0	1.0
I	2.0	4.0	1.5
III	4.0	full leaf cut in to four pieces	2.0

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

2.6.4. 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 or paper soaked in water are used.

2.7. Bed Cleaning

Silkworms 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 this excreta of worms forms a thick bed. Out of the total weight of leaf taken as food, three fifth is excreted and only two-fifth is being assimilated by the silkworm. The pilling

of litter makes the beds moist. This releases process of fermentation liberating injurous gases and also favours multiplication of pathogens. All these above factors are harmful to the worms. Therefore removal of old (unused) mulberry leaves, faecal matter of silkworms, exuviae, dead or unhealthy worms etc., from the rearing bed is called bed cleaning.

2.7.1. Frequency of Cleaning

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

I instar	—	Once
II instar	—	Twice i.e. once just after the I moult and again before setting for II Moult
III instar	—	Thrice i.e. once after moult, once in the middle of III age and once Just before setting for IV moult.

2.7.2. Methods 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.

2.7.2.(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 first 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. Formalinised charred husk helps to avoid attack of muscardine disease.

2.7.2.(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 ..... 2mm^2

Third instar ..... 10mm^2

2.7.2. (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.

2.8. 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 virorous 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 2.5).

Table : 2.5 Length and breath of worms

Stage	Increase in length	Increase in breath
I	2 ½ times that of newly hatched worm	2 times that of newly hatched worms
I	4-5 times that of newly hatched worms	4 times that of newly hatched worms
III	7-10 times that of newly hatched worms	6-7 times that of newly hatched worms

Over crowding of worms means insufficient space for the movement and free feeding of the worms. Crowded condition favours to increase gases, head and fermentation of faecal matter. Fermentation process particularly happens 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 3.6 indicates the need to expand the rearing beds from time to time. Thereby orderly growth of silkworm can be expected.

Table. 2.6. SCHEDULE OF SPACING

Schedule of Spacing (A)

Age of worms	Area required for rearing		Increases spacing during each instar
	To begin with	At the end	
1st Instar	4 sq. ft.	14 sq. ft.	3 1/2 times
2nd Instar	15 sq. ft.	45 sq. ft.	3 "
3rd Instar	45 sq. ft.	90 sq. ft.	2 "
4th Instar	90 sq. ft.	180 sq. ft.	2 "
5th Instar	180 sq. ft.	360 sq. ft.	2 "

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

Age of worms	Trays of 3 1/2′ diameter		Trays of 4′ diameter		Trays of 4 1/2′ diameter	
	Trays	Area of seat in each tray	Trays	Area of seat in each tray	Trays	Area of seat in each tray
1st Instar						
Brush in :	2	1 1/2′ x1 1/2′	2	1 1/2′ x1 1/2′	2	2′ x 2′
Increas to :	2	2 1/2′ x 3′	2	2 1/2′ x 3′	2	3 1/2′ x 3′ (or to fill almost the entire tray)
2ndInstar						
Increas from :	2	2 1/2′ x 3′ (or to fill almost the entire tray)	2	2 1/2′ x 3 1/2′	1	"
to:	5	"	4	3′ ′ x 3 3/4′	3	"
3rd Instar						
Increase from :	5	Full Tray	4	3′ x 3 3/4′	3	"
to:	10	"	8	Full Tray	6	"

Sparse spacing of worms is not desirable as it leads to wastage of leaves. In normal condition the space is double 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 spinning.

(For 100 Disease free layings)

Age of Silkworm	Temperature °C	Humidity %	Size of Leaves (cms.)	Total quantity of leaf (kgs.)	No. of feeds/day	No. of cleaning/ instar	Spacing (Reaing seat for 100 dfls) (Sq. ft.)
Improved Multivoltine Hybrids							
I	27	80-90	0.5 to 2.0	2 to 2.5	3 to 4	1	4 to 14
II	27	80-90	0.5 to 4.0	6 to 7.0	3 to 4	2	15 to 45
III	26	80	0.5 to 6.0	25 to 30	4 to 5	3	45 to 90
Bivoltien Hybrids							
I	27	80-90	0.5 to 2.0	2.5 to 3	3 to 4	1	4 to 14
II	27	80-90	0.5 to 4.0	8 to 9	3 to 4	2	15 to 45
III	26	80	4.0 to 6.0	35 to 45	4 to 5	3	45 to 90

Table : 3.7. REARING SCHEDULE OF YOUNG WORMS

2.8.1. Time and frequency of spacing

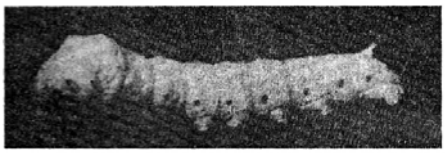
Spacing should go simultaneously with continuous development of worms. Therefore worms are spaced at each feeding. The development of worms is most rapid in first age. Thus spacing is done frequently, and it is always advantageous to combine spacing with cleaning. This saves labour also. In further instars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

2.8.2. Methods of spacing

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

2.9. Moulting

The silkworm larval life has five instars and four moults. The larvae casts off its skin to accommodate the body growth. This is called moulting. The silkworm larvae attain their maximum body growth of particular instar and as a result body becomes stout, and shiny and amber coloured. These two characters are seen in a larvae at the approach of moulting. In relation to the size of the body, the head of the worm appears small and dark. This is the time for bed cleaning and wide spacing. After them 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 time powder is dusted. This prevents early moulted larva from eating, favouring uniform growth. Feeding is stopped when all larvae settle for moult. Under proper rearing conditions all the larvae settle uniformly for moult and come out of moult uniformly (Fig. 3.8 a&b).



Before

After

Fig. 2.7 Moulting

The moulting time for first age is 20 hrs. second and third age larvae requires one day. Moulting is a very sensitive process in the life cycle of silkworms. After moulting fresh larvae of next instar comes our 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 ceresin lime prior to first feed to prevent muscardine.

Any irregularity in settling for moult is noticed, all such late larvae are segregated by net feeding and reared a second batch. Care should be taken to keep the bed dry during moult. This facilities the larvae to wriggle out of the old skin.

2.10. Rearing methods

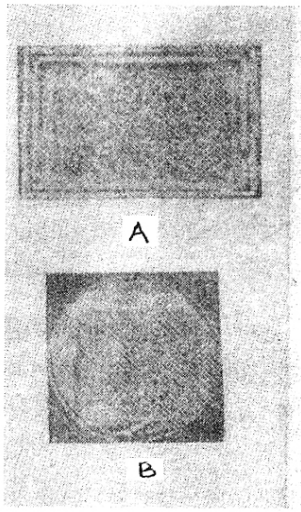
There are three methods or rearing but in all methods importance is given to, the maintenance of leaf quality, humidity, temperature so as to ensure vigorous and healthy development. The rearing methods are;

1. Paraffin paper rearing
2. Box rearing
3. Co-operative rearing

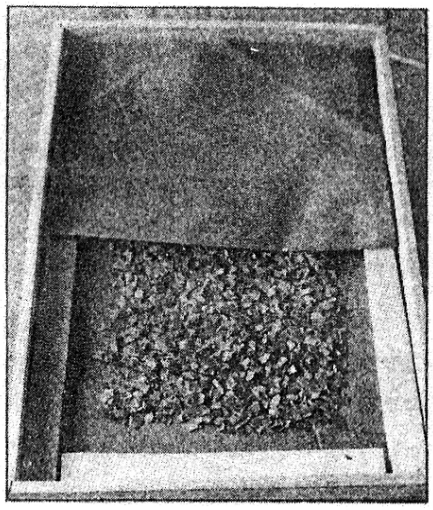
2.10.1.Paraffin Paper Rearing

A good quality paraffin paper is used in this method. It should be devoid of petroleum smell, folds, turns. It is spread as a bottom layer and as a cover for rearing beds. In between the sheets on all four sides of rearing bed, strips of wet foam rubber or news paper are placed to maintain the required humidity. Light weights are kept on the top paraffin sheet to seal the edges for better maintenance of rearing bed humidity.

While feeding the worms, the top paraffin paper sheet must be removed 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.

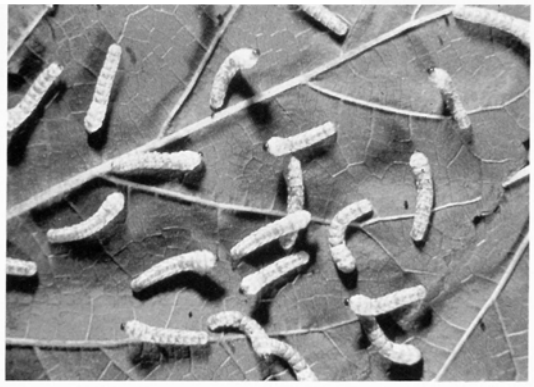


Rearing in Wooden Box, Bamboo Tray



Paraffin Paper Rearing

Spacing using Chop Sticks



Second Instar Worms

Fig. 2.8 Chawki Rearing

2.10.2.Box Rearing

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

a). Rearing in 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.

Fig. 2.9 Box Rearing

b). Rearing in Boxes without lids

this rearing again resembles paraffin method. The wooden boxes of uniform size with 10-15 cm 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 atleast 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.

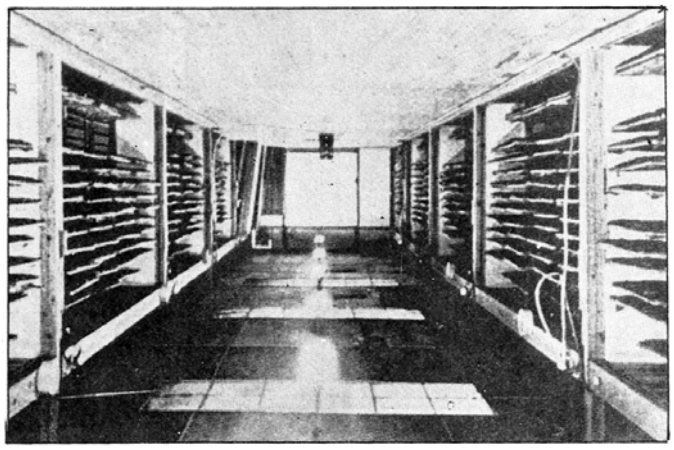


Fig. 2.10. Co-operative Rearing

2.10.3. Co-operative Rearing

Rearing of silkworms requires technical skills. These skills are laking in most of rural farmers. If the silkworms are not reared properly in the young stages they are proned to diseases in later instars, 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 orgnaised to provide technical assistance, idea conditions etc. the rearing is conducted upto second or third moult. These are also called as chawki rearing centres. These centres are provided with ideal rearing houses with all the necessary equipment. The total rearing are supervised by technical experts. Mulberry leaf for rearing is provided form 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 centres have a capacity to rear 200 to 500 boxes (each box contains 20,000 eggs) upto third moult or bouble the size upto second moult. It is popular in Japan and 90 percent rearings upto third moult are carried in co-operative centres. After then, worms are be distributed to individual rearing farmers.

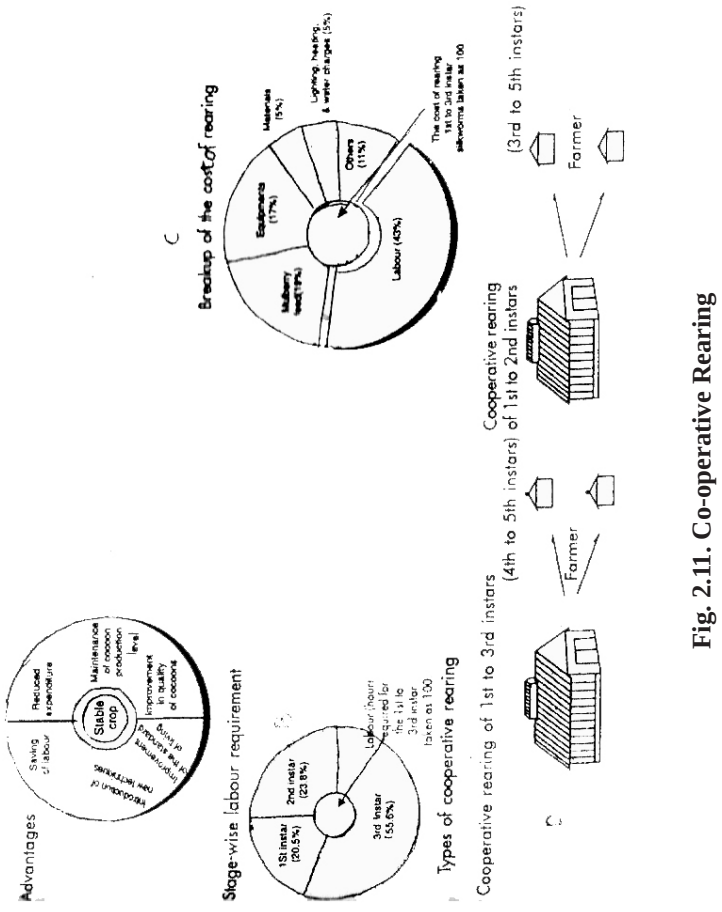


Fig. 2.11. Co-operative Rearing

A. Advantages
B. Stagewise labour requirement
C. Breakup of the cost of rearing
D. Types of Co-operative rearing

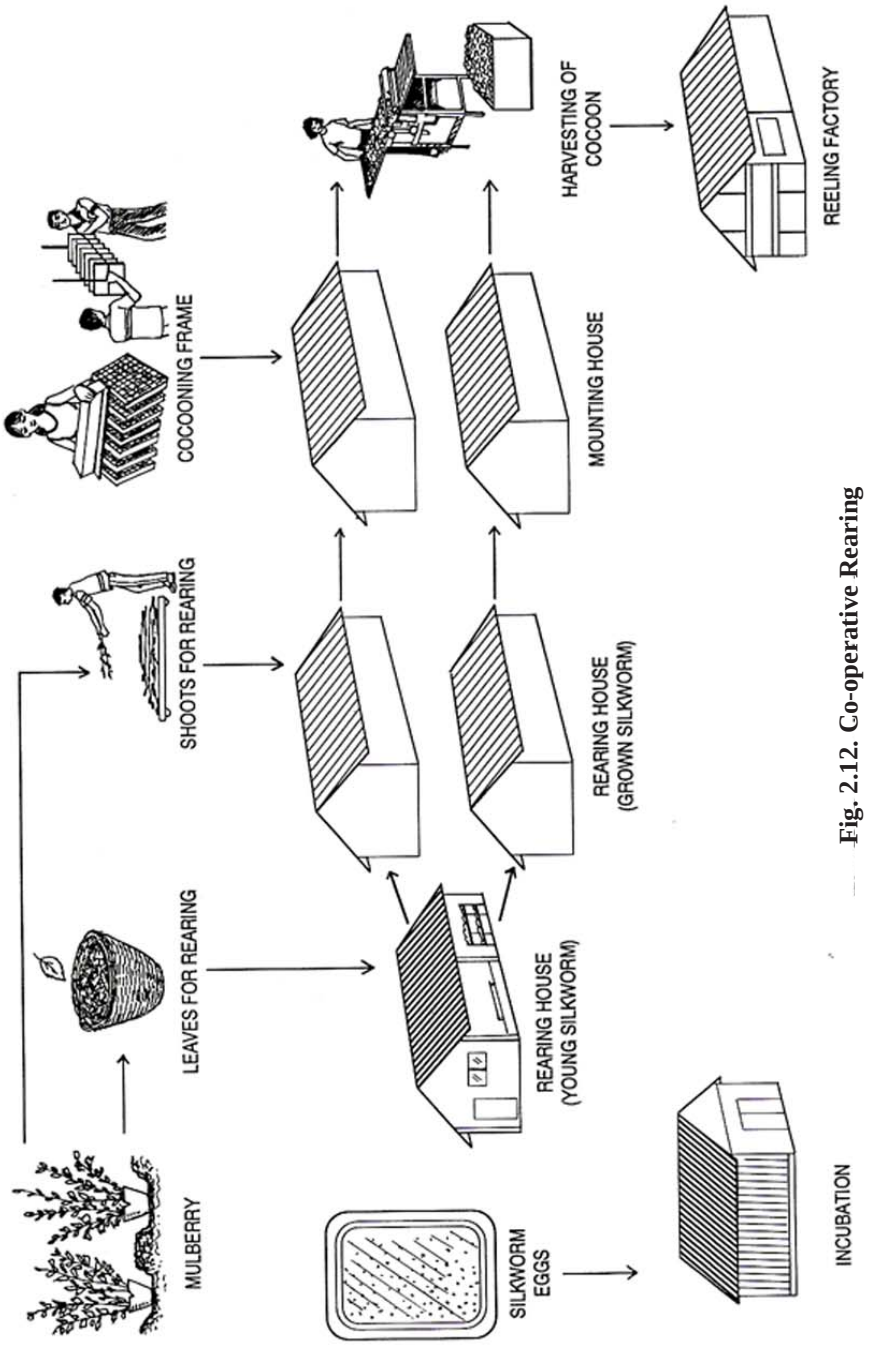


Fig. 2.12. Co-operative Rearing

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.

SUMMARY

- Rearing of first three instars is called chawki rearing. These larvae are resistant to high temperature and humidity and grow well ensuring good cocoon crop.
- The worms grow very fast and requires nutritious leaves. The total weight of the worm is attained in chawki rearing.
- Larvae are very sensitive to diseases and requires to be reared carefully.
- Chawki worms are fed with quality leaf.
- There are two leaf selection methods. They are glossy leaf method, lenticel and bud method.
- 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 earthinned 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.
- Bed cleaning is carried using husk, net,husk & net.
- Cleaning nets of 2 and 10mm^2 are used for bed cleaning.
- Spacing of worms facilities proper growth.
- Care should be taken during moulting of worms as it is an important stage of larval development.

- Chawki rearing is carried in three methods. i.e. covered rearing with paraffin paper, box rearing, co-operative rearing.
- Depending on the available conditions the method of chawki rearing in adopted. However the best method is co-operative rearing.

QUESTIONS

I. SHORT QUESTIONS

1. Define chawki rearing
2. Mention temperature and humidity requirements of chawki worms.
3. Which mulberry leaves are suitable for chawki worms ?
4. What is glossy leaf ?
5. Mention popular method of leaf selection.
6. Mention leaf selection methods.
7. Mention leaf preservation equipments.
8. What are the methods of leaf chopping ?
9. What is the frequency of feeding chawki worms ?
10. Define bed cleaning.
11. What is the frequency of bed cleaning in chawki rearing ?
12. Mention methods of bed cleaning.
13. When do you clean silkworm beds ?
14. Define spacing.
15. Define moulting
16. How do you identify moulting worm ?
17. What is the use of paraffin paper ?
18. Name methods of chawki rearing.
19. How many instars are there in larval stage ?
20. What is the food of silkworms ?

II. ESSAY QUESTIONS.

1. Discuss importance of chawki rearing
2. Discuss the environmental conditions required for chawki rearing.
3. Discuss about the importance of quality leaf in chawki rearing
4. How do you select mulberry leaves for chawki worms ?
5. Describe the importance of leaf preservation.
6. Describe feeding aspects of chawki worms.
7. Describe different methods of bed cleaning.
8. Write about the importance of spacing in chawki rearing
9. Write about the care during moulting.
10. Describe methods of chawki rearing.
11. Write short notes on

    a. Spacing b. Leaf chopping

12. Write short notes on

    a. Leaf preservation b. Moulting

3
LATE AGE REARING

3.1. INTRODUCTION

Rearing of fourth and fifth instar worms is called as late age worm rearing. These wroms require less humidity and preferable low temperature. This stage is the real feeding stage. The worms consume about 90 to 95 percent 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 proper with quality leaves to get good crops.

3.2. IMPORTANCE OF LATE AGE WORM REARING

The fourth and fifth instars of silkworms are more delicate and require rigid conditions of temperature and humidity. During these stages the worms activity and develop silk glands and secrete silk, but also stores the food for coming series of metamorphosis. Therefore these worms are fed with quantity leaves. These worms eat mature leaves which contain less moisture. During this period silkworm body volume increases by 29 times, body weight by 25 times and silkgland weight by 200 times. Thus rearing at these stages influences quality and quantity of cocoon crop production.

3.3. ENVIRONMENTAL CONDITIONS

The ecological and nutritional conditions required for late age are completely different from young age. The ecological factor greatly influences the growth of the worms.

3.4. Temperature

The adult silkworm is susceptible to high temperature. The larval mortality increases when young worms are reared in low temperature (24^0C) and late age rearing in high temperature (28^0C). temperature influences to alter various physiological aspects which intern reflects on silk characters and production. Therefore wide fluctuations of temperature should be avoided. The optimum temperature required for late age worms are;

Stage of Worms	Optimum temperature
IV	24^0 - 25^0C
V	23^0 - 24^0 C

3.3.1.a. Regulation of Temperature

When the temperature in the rearing room rises to 30^{0}C and above, it affects the survival rate, pupation and commercial characters. In tropical areas it is very difficult to maintain ideal temperature. Therefore it is necessary to set up protective fixture from the heat. If the rearing room is roofed with zinc or tiles, it is desirable to have insulating material i.e.. foam styrol. This insulation prevents high reise of room temperature. If insulation material is not available temporary ceiling is advisable. Trees also planted around the rearing room. If there is no scarity of water, water sprinkles on the roof works well. Daily variable temperature within a range of 25± 4^{0}C is preferable over constant temperature.

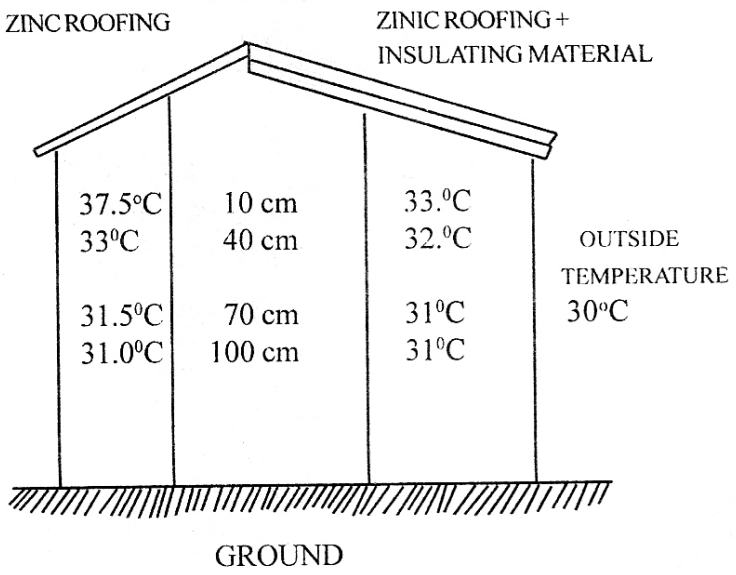


Fig. 3.1 Distribution of Temperature in rearing room

3.3.2. Humidity

Late instar worms are sensitive to high humidity. The humidity requirements during feeding and moulting are quite different in silkworm. The optimum humidity required for IV and V instars is 75% and 70% respectively. During feeding high humidity is maintained which favours to keep the freshness of leaves fed to silkworms for sufficient consumption. During moulting process maintenance of low humidity is preferable.

3.3.3. Air

The air in the rearing room is polluted by carbon monoxide, CO_2, NH_4, SO_2,. These pollutants are produced by working men, silkworms, mulberry leaves, fermentation of leaves, burning of charcoal. After finishing the daily rearing activities such as feeding, cleaning, spacing generally the room is closed, or poorly ventilated without knowing its effects. Then the injurious gases increase to a significant level and affect the worms. Therefore windows should be wide open to improve the air current. The growth of the silkworms and air current are correlate, Carbondioxide content exceeding one per cent in the rearing room is bad for silworms. During high temperature, the CO_2 released by silkworms increases in proportion to the humidity. Air current of 1.0 meter per second during V age rearing considerably reduces larval mortality. Further it improves ingestion, digestibility, larval weight, cocoon weight and pupation rate.

3.3.4. Light

Rearing of silkworms in continuous light delays growth. Further it causes pentamoulters and reduces both larval and cocoon weights. Silkworms are fond of dim light of 15 to 20 lux and avoid strong light and darkness. Late age worms thrive better in 16 hours light and 8 hours dark periods.

3.4. QUALITY OF MULBERRY LEAF

The details of quality of mulberry leaf are 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, 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 warm develop vigorously. Therefore they are fed with abundant good quality mulberry. In the late age worms the amount of mulberry ingested and digested increases. However the ratio of digestion is lower than young worms.

In the spring, when are temperature falls suddenly at night, silk worms fell ill and cannot digest the mulberry. Therefore it is necessary to raise the temperature. The dose of mulberry is increases slightly in the morning feed in the day time when it is warm. But feed dose is decreased is the evening.

3.5. LEAF SELECTION

Mulberry for late age worms are also selected by largest glossy leaf method which is described in chapter 3.5.

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.

3.5.1. Leaf Preservation

Leaf preservation is more important to prevent withering of leaves. It is suitable to preserve late age worm leaves in leaf chambers. In dry further lost by rapid evaporation after harvest. Therefore it is necessary to reinstate moisture into the leaf by sprinkling water over the leaves and preserving under wet gunny cloth or leaf chamber. However it is ensured that feeding the leaves should not carry water droplets. Withering of leaves can be prevented by increasing humidity of rearing room. But it is detrimental to the health of late age worms. Therefore it is necessary to prevent moisture loss without increasing the humidity by adopting proper method of preservation.

For other details on leaf preservation refer chapter 2.5

3.6. FEEDING SCHEDULES

3.6.1. Feeding

The importance of feeding and growth of the worms are detailed in chapter 2.6

3.6.2. 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 before feeding the worms. In case of shoot harvest they are cut to a convenient size to accommodate in the rearing tray. The quantity of leaf required for rearing 50 laying or 20,000 eggs from IV to V instar are given in table 3.

Table 3.1. Leaf requirements

Age of the Worms	Quantity of Leaf to be Fed	
	Multivoltine X New Bivoltine Hybrid (CB)	Bivoltine X Bivoltine Hybrid
I	75 - 85 Kg	105 - 125 Kg
II	600 - 625 Kg.	700 - 725 Kg

3.6.3. Frequency of Feeding

It mainly depends on the season. Generally the late age worms are fed four times per day i.e. 5 am, 11 am, 4 pm and 10 pm. Further it is necessary to reduce the frequency in rainy season and to increase in summer. However care should be taken to reduce or increase much to the total quantum of feed.

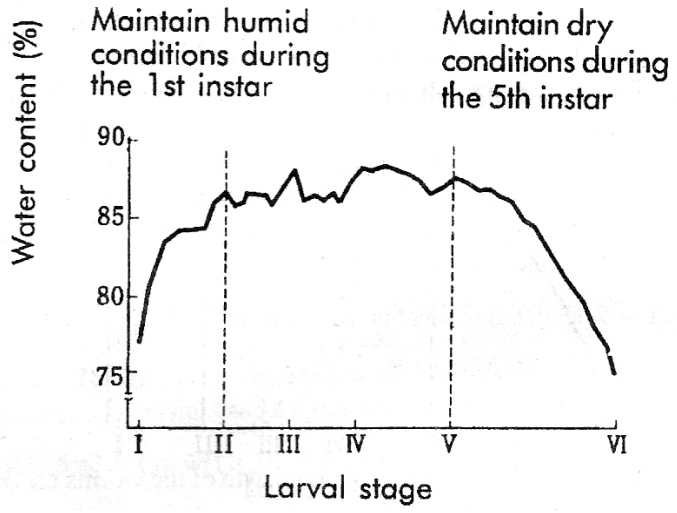
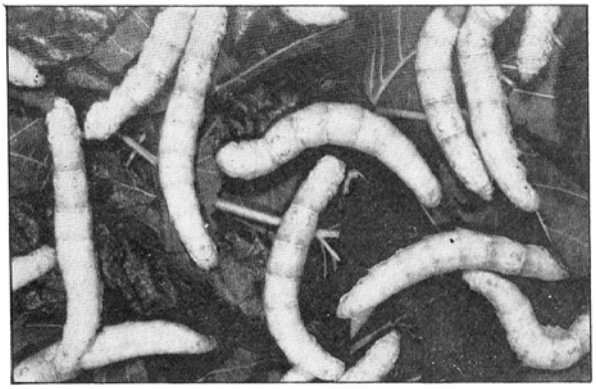


Fig. 3.2. Change in larval body water content

Fig. 3.3. Feedung of late age worms

IV Instar



V Instar

Fig. 3.4. Late age Worms

3.6. 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 $20mm^2$ is spread prior to feeding. The bed cleaning is done before the second feeds where the worms alont with net and leaves are transferred into afreahs tray. The faecal material and left over laeaf 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.

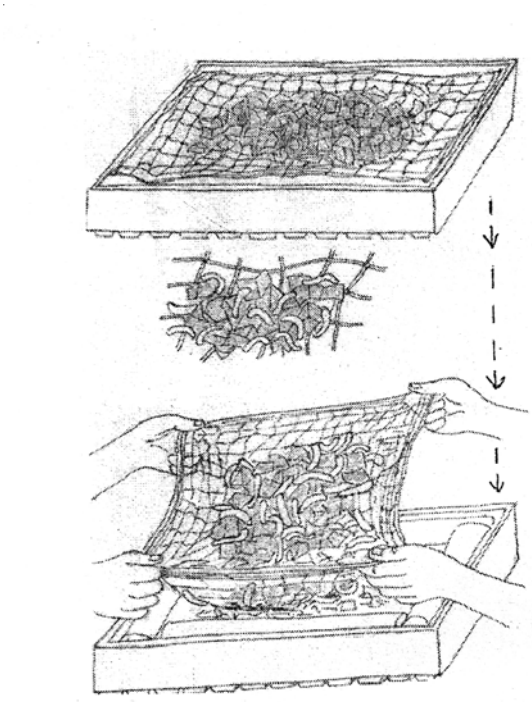


Fig. 3.5. Bed Cleaning

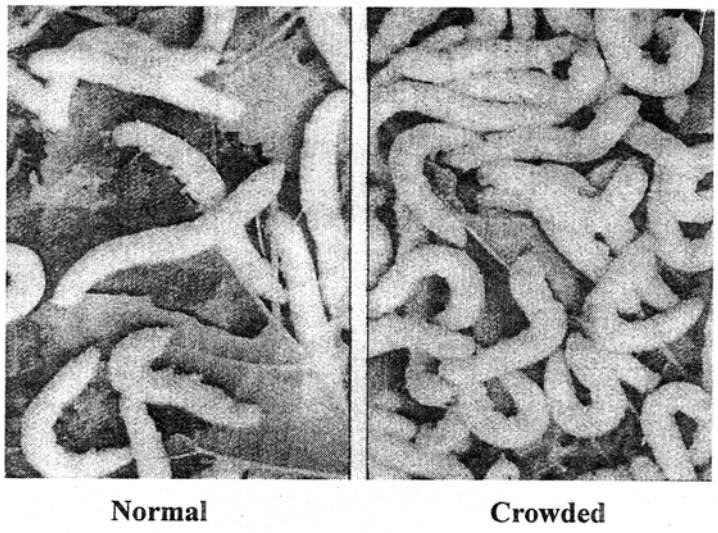


Fig. 3.6. Spacing

3.8. SPACING

Spacing of worms in he beds play a vital role for the success of silkworm crop and improvement of cocoon quality. Buding IV and V instars more than 93 per cent 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 incident of disease and yield of inferior quality cocoons (Fig. 3.6.).

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

Table 3.2.a. Length and breadth of the worms.

Stage	Increase in length	Increase in breath
IV	13 - 15 Times that of newly hatched worms	10 - 13 times that of newly hatched worms
V	23 - 27 - do -	17 - 22 -do-

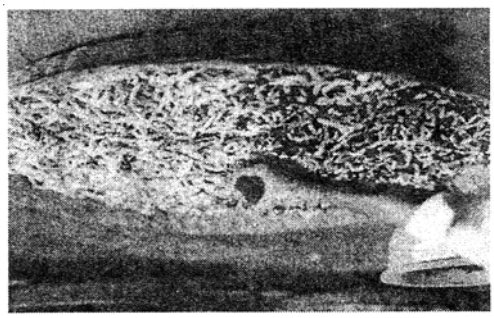
Table 3.2.b. Schedule of spacing

Age	Trays of 31/2' dia		Trays of 31/2' dia		Trays of 31/2' dia	
	Tray	Area of seat in each Tray	Trays	Area of seat in each Tray	Trays	Area of seat in each Tray
IV Increase						
from	10	Full Tray	4	3'x33/4'	3	2'x2'
to	20	Full Tray	8	Full Tray	6	$3^{1/2}$'x2'
V increase						
from	20	Full Tray	15	Full Tray	12	$3^{1/2}$'x2'
to	40	Full Tray	30	Full Tray	25	$3^{1/2}$'x2'

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

V Instar

Feeding



Disinfection

Fig. 3.7. Late Age Rearing

3.9. 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 hours. 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.

3.10. REARING METHODS

There are three methods of rearing

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

3.10.1. Shelf Rearing

Bamboo rearing trays are arranged in tiers on rearing stand for rearing and is called shelf rearing. The stands are arranged in rows leaving a convenient space for attending cleaning, feeding. Generally round bamboo trays are used for this method. In each stand ten trays are arranged. The worms are fed with individual leaves. Four or five 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.

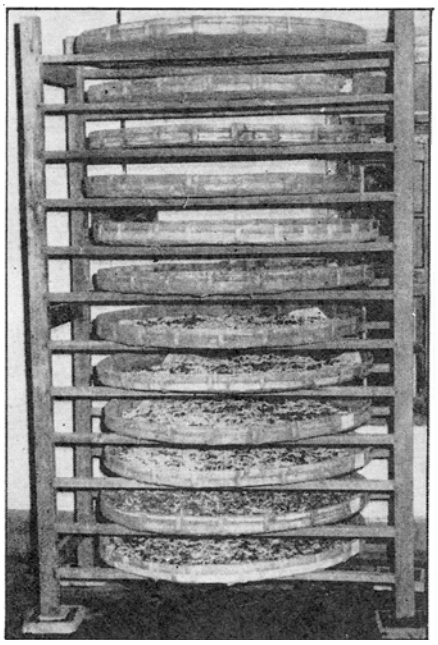


Fig. 3.8. Shelf Rearing

3.10.2. Floor Rearing

The rearing is carried on fixed rearing seats. The seats are arranged in two or three tiers. Three seats can accommodate as many worms as possible. Rearing seat should measure 1-1.5 m, width and 5-7 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 suffiecent 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.

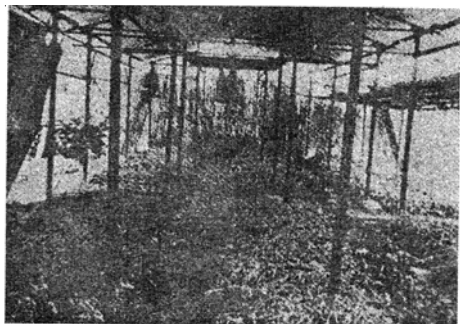
Advantages

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

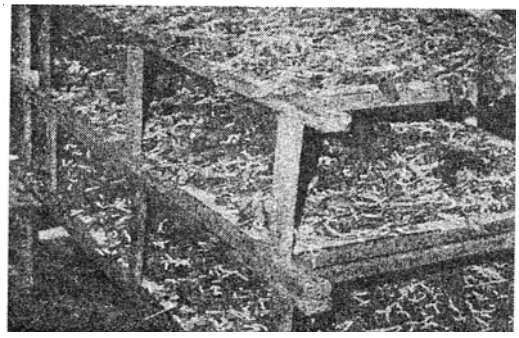
3.10.3. Shoot Rearing

It is the 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 tiers can be arranged with a gap of one meter in between the tiers. This method of rearing can be carried outdoor. When the environmental conditions are favourable, especially temperature.

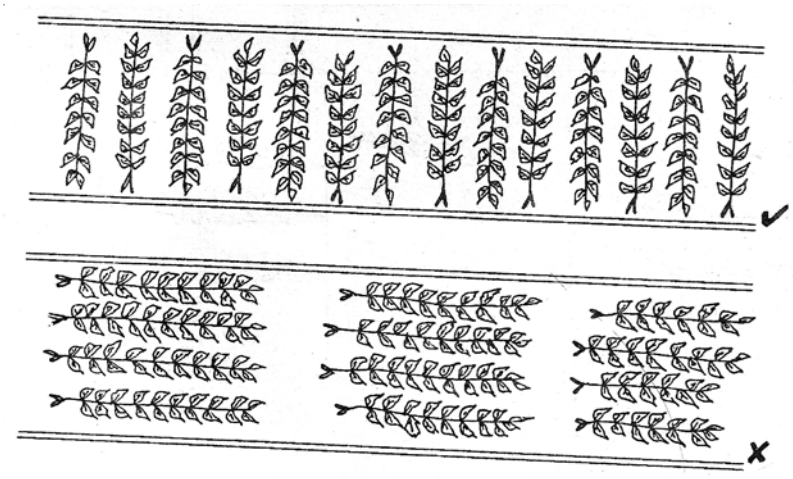
The worms are supplied with big shoots. In every feed the larvae keep moving upwards consuming mulberry leaves. Due to shoot feeding the food is distributed in three dimensions favouring better aeration of rearing beds. Thus it is possible to accommodate 50% more worms per unit area. The rearing activities 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 2 mts. After cleaning rolled bundles are spread on to the rearing beds. Thus labour requirements for cleaning and feeding are minimized.



A. Floor Rearing



B. Shoot Rearing



C. Arrangement of Mulberry Twigs in Shoot/Branch Method

Fig. 3.9. 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
4. Better aeration of rearing beds.
5. Three dimensional feeding reduces leaf wastage
6. Accommodates 50% more worms per unit area.
7. Cleaning and feeding time is minimum
8. Rearing activities are made easy.

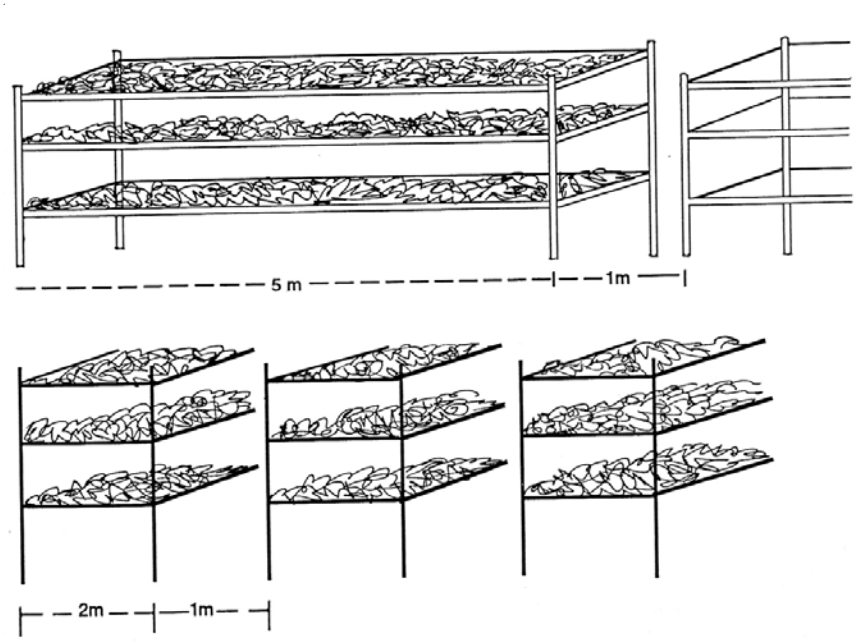


Fig. 3.10.Spatial Arrangement of Branch Rearing

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

Note : Ensure circulation of air if too warm and humid

Table. 3.3. Rearing Schedule of Late Age Worms (for 100 DFL's)

SUMMARY

- ❖ Rearing of IV, V instar worms is called as late rearing.
- ❖ Late age worms eats activity and develop silk glands (gland weight) increases to 200 times).
- ❖ These worms require low temperature and humidity levels. Care should be taken to avoid injurious gases in the room.
- ❖ Worms are fed with bottom mature, thick, rich in protein, low moisture leaves.
- ❖ Leaves are preserved in leaf chamber to protect nutrients.
- ❖ Full leaves are fed four times a day
- ❖ Bed leaves are fed four times a day.
- ❖ Worms are spaced based on the growth of late age worms. Because bad spacing favours the incidence of the disease and yields inferior quality cocoons. On the other hand over spacing leads to wastage and higher lead 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.
- ❖ Late age worms are reared in three methods. They are shelf rearing, floor rearing, shoot rearing.
- ❖ Out of all, shoot rearing has lot of advantages. The food is distributed in three dimension and favours to consume complete leaf. Bed cleaning spacing is very easy.

QUESTIONS

I. SHORT QUESTIONS

1. Define late age rearing
2. What type of mulberry leaf is fed to late age worms ?
3. Mention temperature and humidity required for late age worms.
4. What are the leaf harvest methods for late age worms ?
5. What is the leaf size for feeding IV and V instar worms ?
6. What is the net size used to clean the bed of the late ages ?
7. What is the time required for IV moult ?

8. List out different methods of late age rearing.
9. Which method is economical for late age rearing
10. How many moults are there in *Bombyx* ?
11. What is the time required to complete larval period ?
12. What are the real feeding stages of larvae ?
13. What is the percent of feed consumption in late ages ?
14. Name the gases injurious to silk worms.
15. What are the light requirements for late age rearing ?
16. What is the time schedule for feeding late age worms ?

II. ESSAY QUESTIONS

1. What are the environmental conditions required for late age rearing ?
2. Write about leaf quality required for late age worms.
3. Describe about feeding of late age worms.
4. Write about spacing of late age rearing.
5. Mention methods of late age rearing. Describe shelf rearing.
6. Shoot rearing is most economical – Justify the statement
7. Write about floor rearing.
8. Write short notes on
   a) Bed cleaning b) Moulting
9. Write about the important of late age rearing.
10. Write short notes on
    a) Shelf rearing b) Leaf requirements

4
EFFECTIVE RATE OF REARING (ERR)

4.1. INTRODUCTION

Silkworm rearing is to be carried systematically for better crop results. Rearing activities such as incubation, brushing, feeding, leaf quality, bed cleaning, 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 and lead to disease and finally death. The cocoons are the final product in silkworm 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 rate of rearing (ERR) and to estimate the crop results. The calculation of ERR also helps the farmer to understand and confirm the mistakes in the rearing activity. In this chapter calculation of ERR by various methods utilizing weight and number of cocoons are discussed along with calculation of good and bad cocoon percentage for the benefit of learner.

4.2. CALCULATION OF ERR

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

Principle for calculation effective rate of rearing is as follows.

$$\text{ERR} = \frac{\text{No. of cocoons harvested}}{\text{No.of larvae in 3rd or 4th instar}} \quad \text{X } 100$$

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

$$\text{ERR by weight} = \frac{\text{Wt. of cocoons harvested}}{\text{No.of larvae brushed}} \text{ X } 100$$

$$\text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No.of larvae brushed}} \text{ X } 100$$

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

4.2.1. Model Problem

		Number	Weight
1.	Good Cocoons	1413	2.020 Kg
2.	Flimsy Cocoons	36	0.050 Kg
3.	Double Cocoons	42	0.055 Kg.
	TOTAL :	1491	2.125 Kg.

SOLUTION :

$$\text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No.of larvae brushed}} \text{ X } 100$$

Total No. of cocoons harvested = 1491

Total No. of larvae brushed = 1610

$$= \frac{1491}{1610} \text{ X } 100 = 92.60$$

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

$$\text{ERR by weight} = \frac{\text{Wt. of cocoons harvested}}{\text{No.of larvae brushed}} \text{ X } 100$$

Total quantity of cocoons harvested = 2.125

Number of larvae brushed = 1610

$$= \frac{2.125}{1610} \text{ X } 100 = 13.19 \text{ Kg.}$$

We can harvest 13.19 Kg of cocoons from 1619 larvae brushed

4.2.2. Model Problem

Calculate yield/100 DFL in Kg on the basis of the following data.

E.R.R. = 80; No. of worms in 3rd instar = 300

SOLUTION :

$$\text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No.of larvae brushed}} \text{ X } 100$$

$$\text{No. of cocoons harvestd} = \frac{\text{No. of Larvae in 3rd instar } \mathbf{X} \text{ ERR}}{100}$$

$$= \frac{300X80}{100} = 240$$

For 100 DFLs = 240 X 100 = 24,000

Weight of single cocoons = 1.5 gms

Weight of 240 cocoons = 240 X 1.5 = 360 gms.

For 100 DFL = 360 X 100 = 36,000 gms

= 36 Kg. Yield for 100 DFL's

Weight of cocoons harvested from one DFL X 100

360 X 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 :

$$\text{ERR by number} = \frac{\text{No. of cocoons harvested}}{\text{No.of larvae brushed}} \text{ X } 100$$

ERR = 90

$$90 = \frac{\text{Cocoons harvested}}{350} \text{ X } 100$$

$$\text{Cocoons harvested} = \frac{\text{No. of Larvae } \mathbf{X} \text{ ERR \%}}{100}$$

$$= \frac{350 \text{ X } 90}{100} = 315$$

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
Flimsy 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

$$= \frac{2030}{2140} \text{ X } 100 = 94.85\%$$

For every 10,000 larvae 9485 cocoons are produced.

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

$$= \frac{2.307}{2140} \text{ X } 100 = 10.78 \text{ Kg.}$$

10.78 Kg. cocoons are harvested from 2140 larvae

4.2.5. Model Problem

Calculate cocoon yield for 100 DFL with the following data.

E.R.R. = 80; No. of worms in 3rd instar = 315

SOLUTION :

$$\text{ERR} = \frac{\text{No. of cocoons harvested}}{\text{No.of larvae brushed}} \text{ X } 100$$

$$\text{No. of cocoons produced} = \frac{\text{No. of Larvae in 3rd instar XERR}}{100}$$

$$= \frac{315X80}{100} = 252$$

For 100 DFLs = 252 X 100 = 25,200

Weight of single cocoons = 1.5 gms

Weight of 252 cocoons = 252 X 1.5 = 378 gms.

For 100 DFLs = 378 X 100 = 37,800 gms

= 37.8 Kg.

For 100 DFLs = weight of cocoons produced from single DFL X 100

378 X 100 = 37.8 Kg.

4.2.6. Model Problem

Calculate cocoons product with the following data

No. of larvae in third instar 375; ERR 94.

$$\text{ERR} = \frac{\text{Total No. of cocoons produced}}{\text{No.of larvae in 3rd instar}} \text{ X } 100$$

$$\text{Total No. of cocoons Produced} = \frac{\text{No. of Larvae in 3rd instar } \mathbf{X}}{\frac{\text{ERR}}{100}}$$

$$= \frac{375 \text{ X } 94}{100} = 352.5$$

No. of cocoons produced = 352

4.2.7. Calculation of percentages of bad/good cocoons

The percentages are calculated by weight and number

$$1.\ \text{Bad cocoons\%} = \frac{\text{Weight of bad cocoons}}{\text{weight of total cocoons}} \text{ X100}$$

OR

$$\frac{\text{No. of bad cocoons}}{\text{No. of total cocoons}} \text{ X100}$$

$$2.\ \text{Good cocoons\%} = \frac{\text{Weight of good cocoons}}{\text{weight of total cocoons}} \text{ X100}$$

OR

$$\frac{\text{No. of good cocoons}}{\text{No. of total cocoons}} \text{ X100}$$

4.2.7.1. Model Problem

Calculate good and bad cocoon percentages based on weight and number with the following values.

Cocoons Types	Number	Weight (gr)
Dead cocoons	125	145
Double cocoons	22	95
Forforated cocoons	15	18
Malformed cocoons	20	35
Stained cocoons	100	150
Thin cocoons	30	50
Good cocoons	1240	1950
Total Cocoons	**1552**	**2443**

SOLUTION :

Total number of good cocoons = 1240

Total weight of good cocoons = 1950

Total number of bad cocoons = 312

Total weigh of bad cocoons = 493

Total number of cocoons = 1552

Total Weight of cocoons = 2443

$$\text{Bad cocoons \% by number} = \frac{312}{1552} \times 100 = 20.10\%$$

$$\text{Bad cocoons \% by weight} = \frac{493}{2443} \times 100 = 20.18\ \%$$

$$\text{Good cocoons \% by number} = \frac{1240}{1552} \times 100 = 79.89\%$$

$$\text{Good cocoons \% by weight} = \frac{1950}{2443} \times 100 = 79.81\ \%$$

SUMMARY

- Calculation of ERR is essential to understand and know the crop activity. It also help the rearer to know the mistakes which can be rectified in the next rearing.
- Rearing activity reflects on cocoon 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 percentages of good and bad cocoons also gives an idea on the performance of rearing activity.

QUESTIONS

I. SHORT QUESTIONS

1. Define ERR.
2. What is the importance of ERR in rearing ?
3. Write the principle to calculate ERR.
4. Write the principle to calculate good and bad cocoon percent ages.
5. Calculate percentage of good cocoons where total number of cocoons are 100 and good cocoons are also 100.

II. ESSAY QUESTION.

1. Calculate ERR where weight of cocoons harvested is 20 Kg and the number of larvae in III instar are 10,000.

5
SPINNING AND MOUNTING

5.1. INTRODUCTION

The object of rearing silkworms is to get cocoons of good quality and maximum yield. Silkworm stops feeding towards the end of fifith instar and starts building the cocoons. The larvae becomes transparent, shiny and stops feeding before spinning. Silkworm spins cocoons prior to pupation so as to protect itself from external disturbances and natural enemies. Since it is the most critical period of its metamorphosis. But man has started silkworm rearing as a profitable crop business. The rearer is intended to get quality cocoons so as to improve the income. But it mainly depends on the conditions provided during spinning and mounting. If otherwise the worms spin flimsy cocoons by wasting the silk which decreases the production, quality and increase the cost of production. 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 productivity and economics is sericulture should be calculated based on raw silk out put per unit area. The cocoon quality is the main factor that decides the cost of raw silk. Therefore farmer should select improved breeds and modern techniques of silkworm rearing. 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. The crop results are assessed by effective rate of rearing (ERR). All the factors that effect the quality and quantity of cocoons are discussed in this unit.

5.2. RIPENING OF WORMS

Fifth instar worms feeding may last from five to seven days in case of multivoltine and bivoltine worms in the topical areas, and seven to nine days in case of bivoltine and univoltine 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 becomes specific in appearance. They are translucent and yellowish and it is a clear indication that the worms are fully ripe and ready for mounting. Ripe worms should be picked in time so that 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).

Fig. 5.1. Mature Worms

5.3. SILK GLAND

Every animal in the animal kingdom possess certain adaptations or modifications of body organs to suit its mode of living. During this process some may loose certain organs fully or partially and are replaced by a different organ. Among these animals birds and insects show remarkable adaptations compared to others. The silkworm a lepidopteran insect has four life stages, one of which is totally inactive/resting/sleeping stage. The larval stage actively feeds on mulberry and grows to a maximum size by passing four moults. It is a preparatory stage where the animal stores the food material for future life stages and also develops certain organs which can protect the successive stages (pupa) by enclosing it. The larvae develops a pair of silkglands which are modified labial glands, and are capable of utilizing the haemolymph aminoacids 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 for undergoing into pupa 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. Since cocoon is the final crop yield, must be given care for better and healthy spinning by feeding the worms with good quality leaf.

5.3.1. Structure

Silkgland is also a kind of dermal gland derives from the invagination of the labial ectoderm. Silkgland 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 are situated 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 the head and connect with the spinneret of the labium. The gland is devided into the anterior, middle and posterior parts. The anterior region is a straight tube opening at the fore end into the duct and posterioly into the middle region. This parts is not twisted and unlike the middle and posterior parts, has no secretory function. The middle part is the largest, twisted in the shape of the letter 'S'. this region is again devided into three functionally different sections fore, middle and hind parts. The fore part is slender or narrow at the starting but thickens quickly backwards. The middle part is very thick while the hind part is thick at anterior portion and becomes slender at postrtior part. The posterior part is very long with many windings of uniform thickness, which are regulated by dermo visceral muscles and the tracheae (Fig. 5.2).

A pair of Filippi's glands open inside the silkgland at the joint of the anterior division of two glands. These secrete some viscous fluid.

The wall of silkgland is composed of these layers.

1. Tunica propria having gland cells.
2. Tunica intima encloses lumen of the gland.

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

The silkgland 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 remains constant (1000), with the cell division having been completed during the embryonic period. But the number of cells in silkgland of different races is not the same.

Fig. 5.2. Silk Glands

The nuclei n the cells of the silkgland undergoes much changes as the larvae develop from the young stage to the advanced stage. The nuclei is more or less circular in shape (freshly hatched larva) and gradually branches out as the age increases. According to the age the cells of the silk gland become larger and the secretory function becomes 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 coloured because the intestine of these larvae do not allow the permeation of the yellow and cocoon fibre pigments.

5.4. PROCESS OF SPINNING

When ripe worms are mounted on the mountages they passout last excreta in semi-solid condition. When the humidity is high, excess body moisture is also eliminated as urine. After defaecation the ripe worm starts spinning the cocoons by selecting a suitable place in the mountage. Each silkworm develops a pair of silkglands which synthesize silk by utilizing the aminoacids coming from mulberry leaf. The ripeworm 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 silk fluid is drawn out to form a long filament which becomes hard. The silkworm first lays the foundation for the cocoons by weaving a primary web. This web becomes the foothold for the larva to spin the compact shell. The silkworm larvae moves its head in the shape of “or” “8” to spin the cocoon. The former shape is found in the outer layers of cocoon shells while the later type is usual in middle and inner layers. 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 bivoltine races is about 2 percent of the weight of cocoon. While in multivoltine more than 10 percent floss is seen. The process of spinning continues about 1 to 2 days in multivoltines and 2 to 3 days in uni/bivoltines. After the compact shell of the cocoons is formed the shrinking larva wraps itself in palade or gossamer layer. Finally the larvae 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 not reelable and contributes to waste silk content.

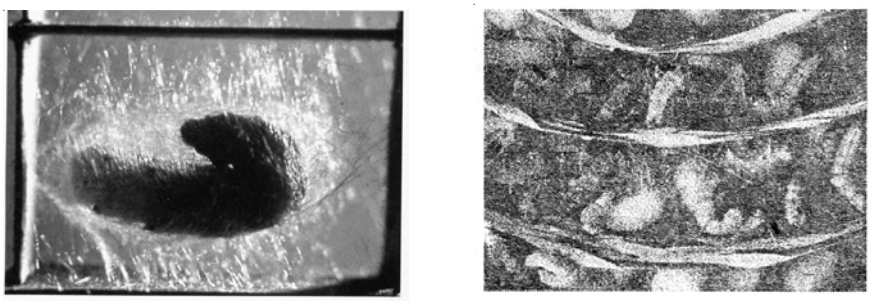


Fig. 5.3 Spinning Stage

5.5. MOUNTAGES

Depending on the material and structure of the cocooning frames the number of bad cocoons may increase or much labour may be required in mounting. The details if different mountages are given in chapter-3 of paper I. the features of good mountage are as follows.

-- Mature worm can be easily induced to cocoon spinning

-- Total mountage space can be efficiently used.

-- Manufacturing can be easily and cheaply undertaken.

-- Durable structures.

-- Storage requires little space.

-- Floss attached to the mountage can be easily removed

-- Material used is resistant to high moisture or wetness.

5.6. MOUNTING

Mature silkworms are collected and mounted on the mountages. This laborious job requires lot of skilled labour. 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.

5.6.1. Proper time of mounting

It has a 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 reliability. If the worms are over mature, silk will be wasted. All these cases results in thin, double, stained cocoons which contributes to reduce cocoons quality in terms of reliability, fiber strength, colour etc.. These defects can be eliminated by ensuring the following.

-- Silkworm body shape should be short and fat.

-- Thorasic segments should be translucent.

-- Faeces 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.

5.6.2. Methods of mounting

1. Picking-up mounting

When one third of body of the silkworm 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 30 pm. The worms become overmature producing cocoons of poor quality if the labour is inadequate.

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 per cent of the worms have matured paper, vinyl etc. may be placed on a mat and mulberry shoots full of silkworms are shaked. These worms are mixed with faeces and remaining mulberry leaf. Then these are covered with 2-3 layers of straw nets. After a lap of 30-40 minutes silkworms crawl upon 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 are put in the top frame than the lower frames so as to fill all the frames evenly when suspended.

In another method news paper is spread on the floor, lying the cocooning frame on one side with the entrance horizontally placed. A certain number of silkworms are put into each frame. The silkworms first fall on to the new paper but crawl on to the frame within 30-40 minutes. Then frames are lifted to hang (Fig 5.4.a,b).

--- Even size cocoons

--- Less floss

--- No chance for double cocoons

--- Less labour expenses

3. Net Method

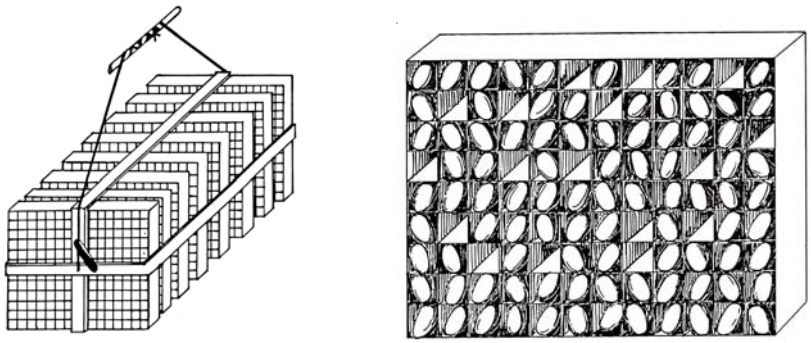
A net is placed after feeding the silkworms. Mature (ripe worms) crawl onto the net while others feed. The net is taken along with worms for mounting.

4. Branch Method

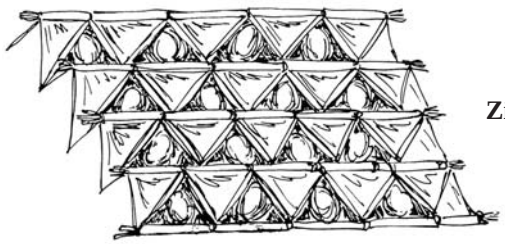
It is similar to net method where only mulberry shoots are used. When worms crawl onto shoots are mounted.

5. Self-Mounting

First mature worms are picked by hand then a self-mountage frame is hanged very near to silkworm beds. Ripe worms crawl onto the mountage frame. Which is later lifted to hang. It reduces labour cost.

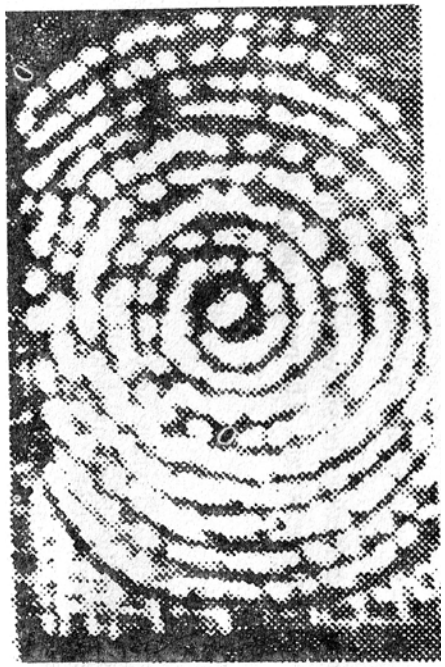


Set of Rotary Mountage

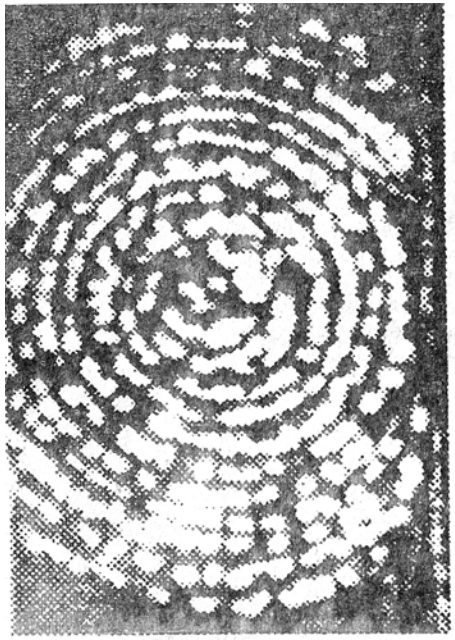


Zig Zag Mountage

Fig. 5.4. Mountages



A. Normal



B. Crowded

Fig. 5.5. Density of Mounting

5.6.3. Density of Mounting :

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

S.No.	Mountage	Details of Density
1.	Chandrika	50 worms per 10 X 10 cm (1100 per chandrika)
2.	Rotary	1500 worms per mountage
3.	Centipede	350-400 larvae/m^2
4.	Square frame type	150 larvae per mountage

Fig. 5.6. Cocoon Harvesting

5.7. ENVIRONMENTAL CONDITIONS

Mounting and spinning are to be carried with atmost care to get good quality of cocoons. Ideal temperature of 22^0-23^0C and relative humidity between 60-70 per cent are required. These conditions are important during the first 50 hrs. after mounting. Temperature above 26^0C affects the cocoon quality.

5.8. CARE DURING SPINNING

1. In the mounting room old news papers or mats are put under the mounting frame. When urine and excreta falls on the paper it must be removed
2. If the temperature raises beyond 22^0-23^0 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. Low temperature slows down the secretion of silk bave resulting in large size cocoons. Further it takes very long time for spinning.
3. Relative humidity (60-70%) induces good health, good reelability and quality cocoon. When it raises the larvae and pupae cease to death. Low humidity causes double layerd cocoons, loose cocoons.
4. Excessive moisture and harmful gases are released from faeces and urine of silkworms. Air current speed should be less than one metre per second and fast or strong air current causes crowding of mature silkworms resulting in excessive number of double cocoons.
5. 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. Complete darkness will slow down the spinning process resulting in low quality cocoons.
6. Ants crawling on to the mountages are prevented.
7. Spinning worms if disturbed increases floss percentage.

5.9. COCOON HARVESTING

The silkworm larva metamorphose into pupa after spinning the cocoons for about 48 hours from the time they are mounted. Generally pupation takes place on the 4^{th} day of spinning. Thus the worms inside the cocoons will be still in the form of prepupa, 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 or 7th day. Harvesting must not be delayed beyond the said period. Because it affects the reeling activity (Fig. 5.6.).

Before harvesting the cocoons, the mountage is 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.

Fig. 5.7. Transport of Cocoons

5.10. TRANSPORT

The cocoons should be put into cotton bags each weighing about 10kg. They are loosely packed and transported in cool hours of the day (ie. Morning or evening). If transport 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 is also important.

Cocoon cost depends on the quality. Thus they are well protected from direct sunlight and humidity. Cocoons are placed in heaps and samples are given for quality testing, basing on which cost is decided. Cocoons are transported to well developed 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.

5.11. TRANSPORT OF COCOONS

Transportation of cocoons is a crucial step in marketing. During transportatiojn of the live cocoon, if care is not taken, the live pupa inside the cocoon will be deformed, thereby oozing out the body fluid inside the cocoon. This damages the silk fibre and discolours the inner portion of cocoon. The inner silk layer of the cocoon gets hardened, making the cocoon unreelable and increasing the silk waste.

Improper method of transportation often causes pressure on cocoons and crushed cocoons get stained (Black colour) and stain the surrounding cocoons which are not crushed. All these cocoons become unfit for reeling and adds to wastage.

Transportation the live cocoons in a heap or in a closed bag or container, the pupae often suffocate, resulting in perspiration. The perspiration, being alkaline in nature affects the sericin layer of the cocoon filament which results in poor reelability.

Transportation of good cocoons along with melted, flimsy, stained cocoons. The damage is much more as the pupae inside the cocoon are easily susceptible to melting. Finally good cocoons are stained and thereby reducing the cost.

-- Improper transportation of live cocoons results in low percentage of recovery of silk
-- Increase in the percentage of recovery of waste
-- Affecting the quality of silk
-- Increase in renditta
-- Increase in cost of production
-- Lower price

Immediately after harvest the cocoons are cleaned and sorted to reduce the percentage of defective cocoon. This also reduces the damage of good cocoon during transport. However the cocoons are transported safely to get good price. The following points are adopted for safe transportation.

1. Cocoons are filled in suitable containers
2. Container should be so designed to provide enough aeration, prevent jolting and crushing of cocoons, prevent damage to the pupa inside the cocoon.
3. Cocoons are filled in container at a minimum level to minimize the pressure on the bottom layer of cocoons.
4. Perforated containers are suitable which allows good air circulation.
5. Good air circulation prevents absorption of moisture by the cocoons and denaturation of the sericin on the filament.
6. The container is covered properly so that the cocoon are not subjected to the sun light.
7. Cocoons are transported in cool hours of the day.
8. Avoid delay in transportation after filling the containers.
9. Avoid transport of cocoons in an heap or in a container without perforations.

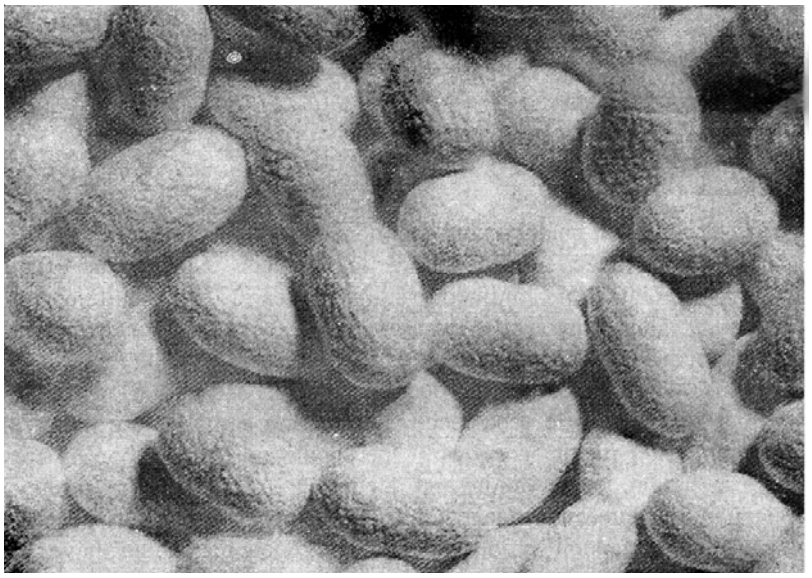


Fig. 5.8. Good Cocoons

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 moutages by skilled labour.
- Crowed worms on mountages results in double cocoons.
- Selection of moutages is very important. In India chandrika is popular and cheap mountage.
- Worm passes out last excreta before it starts spinning. The worm first oozes a tiny drop of silk for anchoring and then draws along filament by swinging the head continuously.
- Spinning takes 2-3 days, to wrap itself into a compact shell.
- The inner most layer (gossamer) and outer most (floss) layers are not reelable.
- Temperature (22^0-23^0C), humidity (60-70%), good air current and ventilation are required.
- Cocoons are harvested after 5-6 days of mounting.

- Sorting of cocoons (bad and good) improves the cocoons price.
- Cocoon are transported in cool hours of the day by packing in very loose bags/baskets.
- Cocoons are protected from direct sun light and humidity.
- Cocoon assessment is calculated based on shell ratio, floss percentage denier, filament length etc., for price fixation.

QUESTIONS

I. SHORT QUESTIONS.

1. How do you identify ripe worms ?
2. Define mounting.
3. Name the popular mountage in India.
4. What is the best time for mounting ?
5. Mention the reasons for bad cocoon formation.
6. What are the advantages or rotary mountage mounting ?
7. Define spinning .
8. Mention methods of mounting.
9. Define floss.
10. What is palade layer ?
11. What are the temperature and humidity levels required for spinning?
12. Define cocoons harvesting.
13. Define sorting of cocoons.
14. How do you transport cocoons?
15. What are the factors that influence price fixation ?

II. ESSAY QUESTIONS

1. Detail about mounting process.
2. Explain about mounting methods.
3. Write about care during spinning.
4. Write about harvesting and sorting of cocoons.
5. Write short notes on
   a) Transport of cocoons b) Ripe worms
6. Write short notes on
   a) Cocoons sorting b) Spinning

6
SILKWORM DISEASES

6.1. INTRODUCTION

Silkworms are not exceptional to diseases and pets. It is therefore very essential to take certain precautions so as not to allow their out break. At the same time it is desirable to find out effective measures to cure the silkworms once they get affected. But under measures to cure the silkworms do not get diseases. The income in sericulture depends on the disease and pest control. In general emphasis should be made on improving the silkworm strain on the aspects of health, along with excellent characters of silk.

Usually polyvoltine strains are healthy but cocoon quality is often poor. It can be considered by attempting efforts to increase the cocoon weight and yield. Presently bivoltine and multivoltine strains are better employed in sericulture. The outbreak of silkworm disease is mot closely related to the state of health of the silkworm. However, depending on the strain, the resistance varies to certain diseases. Only a few strains exhibit a strong relationship between disease and health but not others. Thus it is desirable to have overall healthy silkworm.

The resistance and susceptibility of the silkworm also vary according to the type of disease. These two aspects depend on nutritional status, environmental conditions. Pathogenic organisms from the infected silkworms disseminate to the rearing rooms, equipment, eggs etc. when disinfection is not properly carried out, the infection breaks out on a large scale. The diseases spreads widely if the diseased silkworms, dead bodies, excreta are not completely removed and the premises cleared. Thus good sanitation and healthy atmosphere favour the good health of silkworms.

The microorganisms like protozoans, bacteria, virus, fungi cause diseases to silkworms. All these diseases, their pathogenic effects, preventive and control measures are dealt in detail for the benefit of the learner.

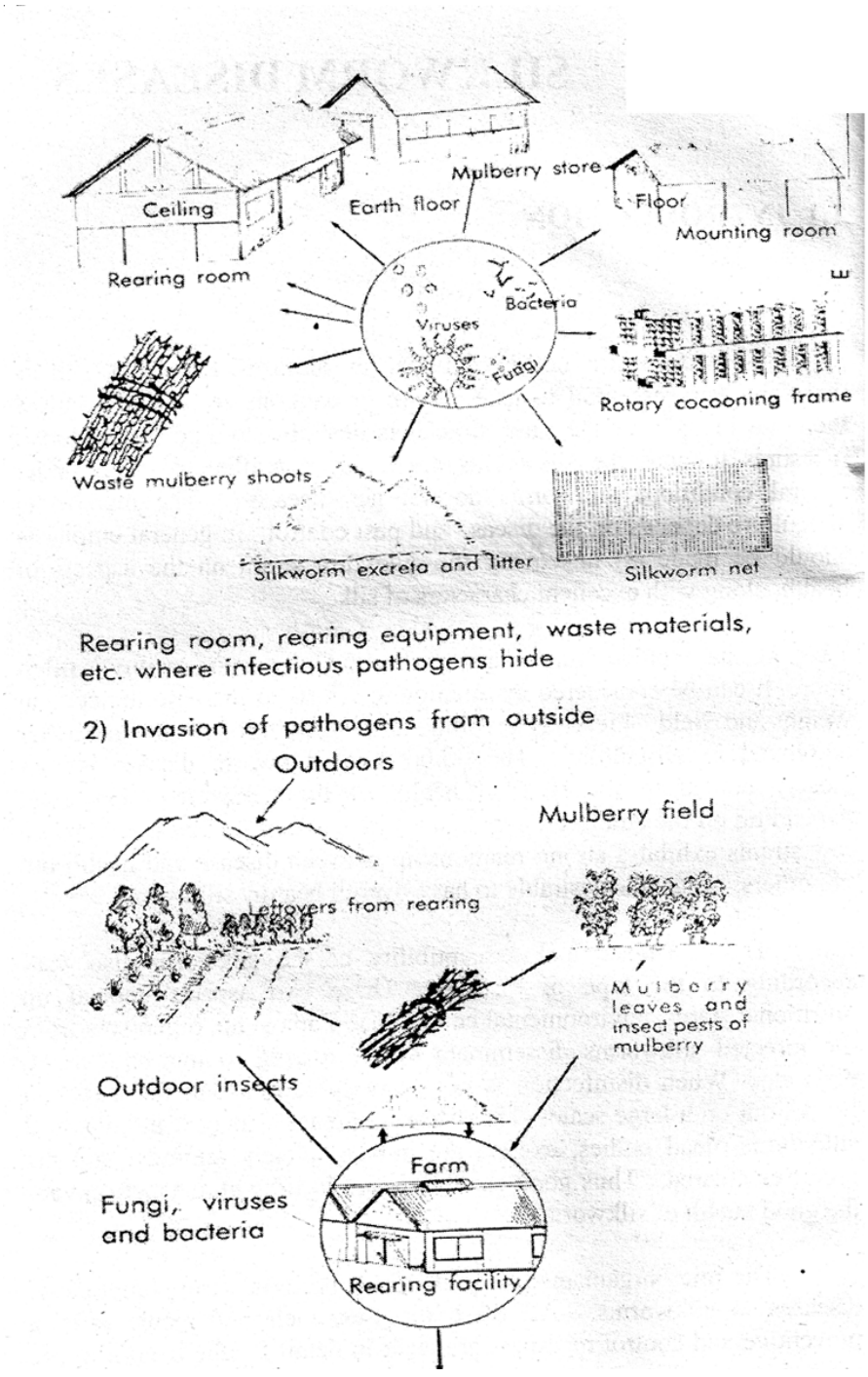


Fig. 6.1. Sources of infections

6.2. PROTOZOAN DISEASES

The major protozoan diseases of the silkworm is the pebrine. It is a chronic and disastrous of silkworm *Bombyx mori L*. It was this disease which was responsible for the sudden collapse of the silkworm industry of both France and Italy in1965. The name pebrine was given to the disease in 1860 by De Quatrefages because the black spots that appear on the diseased worm look like pepper grains.

6.2.1. Casual Agent and Infection

Pebrine is caused by *Nosema Bombycis* belonging to the family Nosematidae of order Microsporidia. Pasteur observed that the disease may be transmitted through the egg, by contact with diseased silkworms and though ingestion of contaminated food. Infection also results from diseased and dead larvae, faeces of larvae, moths, diseased egg shells, larval and pupal exuviae etc. in the rearing bed major source of infection is the faeces of diseased, contaminated tray, seat paper and dust from infected rearing and leaf storage rooms.

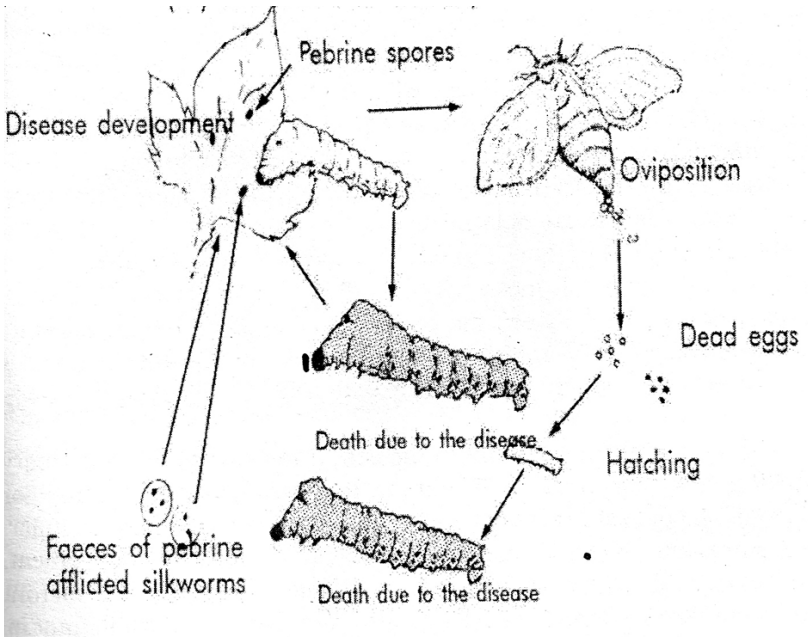


Fig. 6.2. Pebrine Infection

6.2.2. Life Cycle

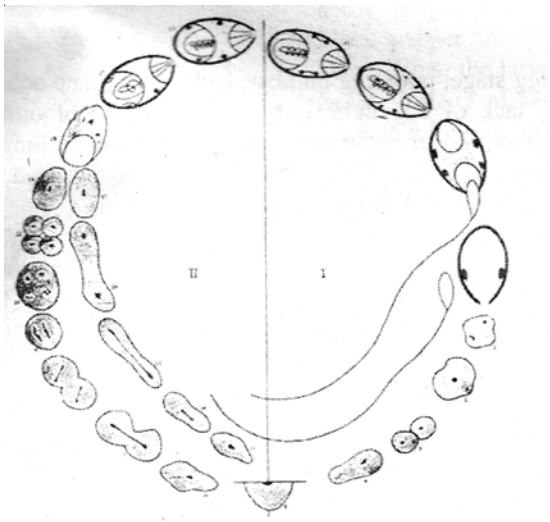
The life cycle of Nosema bombycis Nageli includes three stages namely, spore, planont and meront (Fig. 6.3.c).

The mature spore is oval or ovocylindrical measuring 3-4 X 1.5-2.5m with three layers membrane. They are inner, middle and outer layers. The sarcoplasm is stretched in the form of girdle across the width of the spore with a pair of nuclei. The spore has a polar capsule and polar filament. Polar capsule is a sac like structure that bulges out into the spore cavity from the anterior end. It is surrounded by the sarcoplasm and connected at one end to the outer membrane of the spore and communicates with the outside through small opening. The polar filament is more than 30 times the length of the spore (Fig. 6.3. a,b). The infection of the pathogen can retain after three years in the dried body of the female moth, but the spores are susceptible to desiccation and cannot survive for more than 6-7 hours.

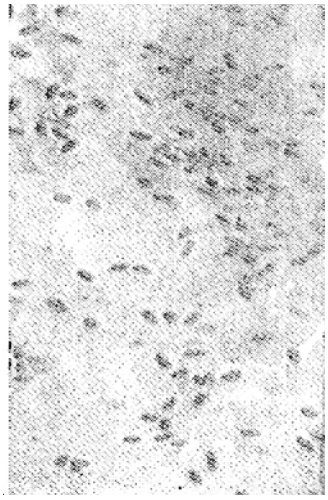
The spores stick to the mulberry leaves and enter into the silkworm body. The high alkalinity and potassium ions favour spores for germination. Thus the two nuclei in the spores divide into four nuclei, then digestive juices act on the spores. As a result the polar filament is extruded and soon becomes detached from the spore. The sarcoplasm along with two nuclei creeps out as an amoebula and the other two nuclei left behind degenerate in the spore. After then it enters into midgut tissue. Subsequently the polar filament gets digested in the alimentary track. The two nuclei of the sarcoplasm fuse to form a uninucleate planont. It is globular with a strong refractive nucleus without shell, shows amoeboid movement. It measures 0.5-1.5m and is formed in 1-2 days. These planonts pass between the epithelial cells of the insect intestine into the haemocoel and multiply by binary fission. Further it invades various susceptible tissues of the insect, which is called “auto-infection”.

Once the planont penetrates the cell, it transforms into secondary form after being covered by a membrane. It is now called as “meront” or “schizont” lanonts are extra cellular where as meronts are intra cellular. The meronts are larger in size than planonts, incapable of movements, spherical or oval with a definite cell wall and a nucleus. The meront absorbs nutrients from host cell and grows in size. At a certain point in its

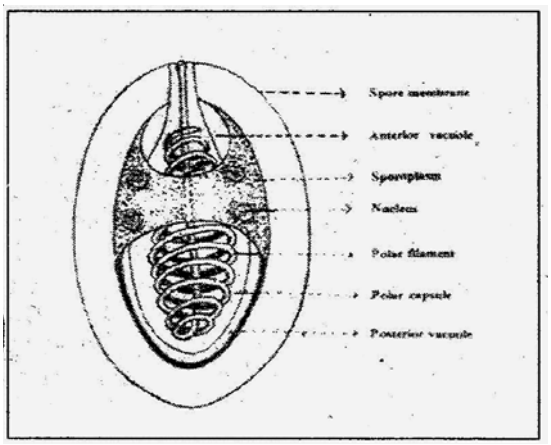
Growth the meront reproduces by binary fission, multiple fission or by budding. When cytoplasm of the host cell is exhausted, meronts are arranged in parallel rows. The meront after massive proliferation fills up the host cells and when nutrients are depleted, sporulation takes place.



A. Nosema Life Cycle



B. Spores



C. Single Spore

Fig. 6.3.

The life cycle of Nosema bombycis is completed in a week after infection in a cold climate and in about four days in hot weather.

6.2.3. Symptoms

The symptoms of this disease can be observed in all the life stages of silkworm and from important criteria for identifying the disease.

In egg stage, poor egg number, lack adequate adherence to the substratum, lack of egg uniformly, more number of unfertilized and dead eggs, poor and irregular hatching, eggs are laid in lumps instead of closely side by side are observed. Some times infected eggs cannot hatch out and hatched larvae may also die. (Fig. 6.4.)

Larvae suffering from pebrine do not show any external symptoms until the disease is for advanced. The disease takes a more acute form in young larvae than in adult larvae. In advanced stage of the disease, the larvae become sluggish and dull.

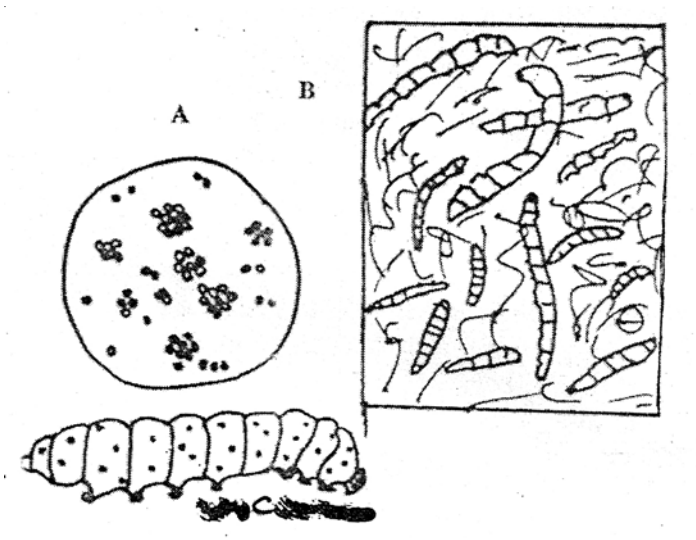


Fig. 6.4. Pebrine Symptoms (A-Eggs; B&C-larvae)

Larvae show poor appetite, retarded growth and development leading to unequal in size. Larvae moult irregularly and show sluggishness. Transovarially infected larvae die before third moult but those which are

heavily infected die during first instar itself. Larvae move slowly and appear paler and more translucent than healthy larvae. The larval body shows wirnkled skin with rustiv brown colour and in the moribund stage they do not rot but remain rubbery. The affect gut becomes opaque and the silk gland shows white pustules in different places along its length (Fig. 6.5).

Fig. 6.5. Pebrine infected silk gland

In acute cases larvae show irregular dark brown or black pepper like spots on the skin. When the larvae rest, their heads, instead of being held up hand down. The appearance of black spots is due to the presence of parasite in the hypodermal cells of the skin and as a result the hypodermal cells die, exhibiting melonosis as dark pepper. A severly affected larva may die before spinning or may spin poor, flimsy cocoon. But after then larvae spits silk and wastes it. Such larval body parts show numerous oval shining pebrine spores, which is a sure sign of the disease.

The infected pupae are flabby and swollen with lusterless. Black spots are noticed near the rudiments of the wing and abdominal area. Highly infected pupae fail to metamorphose into adults.

The moth emergence is delayed and improper. The moths show clubbed wings. Discolouration of scales may be seen on the abdominal area and rarely black round spots are seen on the abdomen and wings. The scales from wings and abdominal area easily come off. The wings do not stretch fully with distored antennae. The egg laying capacity is poor. if the

accessory glands are infected the moth may lay eggs with less gluey substance resulting in detachment from the egg cards (Fig. 6.6.).

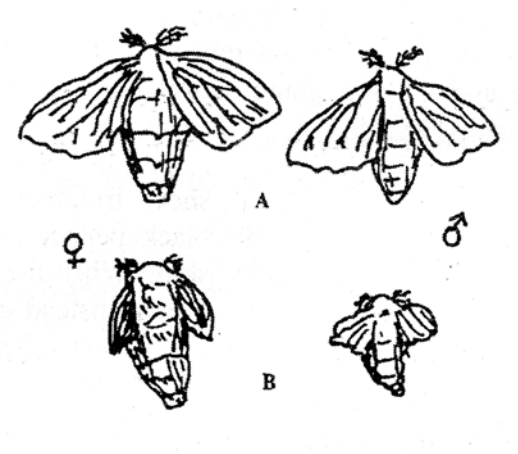


Fig. 6.6. Pebrine infected moths

Pebrine spores can be identified in mother moth after oviposition by crushing the female moth and examined under microscope with a magnification of 600. Pebrine spores appear as shining oval bodies.

6.2.4. Prevention and Control

Production of healthy eggs, is a must so as to avoid embryonic infection. This can be achieved by conducting mother moth examination. It is essential to surface disinfect the laying in 2 percent formalin for 10 minutes before incubation. This process though be carried in grainages, must be repeated after release of eggs from cold storage as also by farmers. If the eggs are in advanced stage of embryonic development surface disinfection is carried with 1 percent formalin for 5 minutes. The room and equipment must be washed and disinfected before incubation. The other preventive measures are maintenance of good sanitation, hygienic rearing, frequent and careful inspection of stocks foe signs of infection, destruction of diseased material and disinfection of rearing rooms and appliances. Dead eggs, dead larvae, dead pupae in the cocoon, dead moths, litter of larvae from infected trays, exuviae of infected larvae should be removed and destroyed.

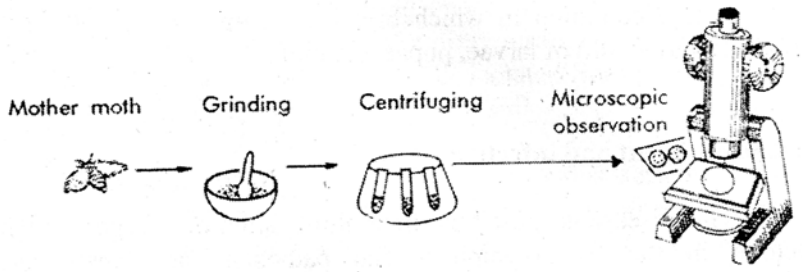


Fig. 6.7. Pebrine Detection

Young silkworms should be reared under hygienic conditions. As a precaution test examination of unhatched blue eggs, dead eggs, hatched larvae (Fig. 6.7) and egg shells can be carried out and if pebrine is detected such lot must be destroyed. Infected silkworms, faeces and mulberry field pests are important sources of infection and should be properly disposed of to prevent cross infection and spread of the disease. Besides all the above detailed preventive measures the rearer must also concentrate on resistant area.

6.3. Bacterial Diseases

Bacterial diseases affecting silkworm are collectively known as flacherie due to the flaccid nature of the diseased larvae. Pasteur separated flacherie from other silkworm diseases and attributed the diseases to microbial or infectious causes. This diseases is due to rapid multiplication of a large number of certain kinds of bacteria in the intestine, the digestive functions of the gut are affected giving rise the disease. The other reasons are high temperature, high humidity and bad ventilation, bad leaves, wet and fermented leaves, over feeding, decreased alkalinity of the gut, over crowding, poor disinfection, accumulation of faeces in the rearing trays, improper handling etc. Bacterial diseases of silkworms are divided into three major types i.e.. bacterial septicemia, bacteria diseases of the digestive tract and bacterial toxicosis.

6.3.1. Septicemia

It is condition in which bacteria multiply enormously in the blood (heamolymph) of larvae, pupae and moths.

A. Causal Agent and infection

This disease is caused by the multiplication of a large number of bacteria in the haemolymph. The pathogens are small bacilli, *Streptococci* and *Staphylcocci*. The infection is through injury or wounds in the skin. Pupae and moths which do not feed are also affected with septicemia. The black thorax septicemia is caused by ***Bacillus sp.*** Belonging to the family Bacillaceae. The other red septicemia or serratia septicemia is caused by the bacillus ***Serraia marcescens*.** The former is more resistant to disinfectants than the latter except for lime emulsion.

B. Symptoms

The worms show some common symptoms like sluggish movement, decreased appetite, straightened body, swollen thorax, shrinkage of abdominal segment, vomiting and bead like faeces and loss of clasping power of legs. Then the body becomes soft and discolored and the body wall ruptures easily emitting foul smelling fluid. When a silkworm is infected with more than one kind of bacteria, the symptoms are determined by the predominantly propagated one. There is no much difference between healthy and diseased larval body until it dies. When the larvae vomit fluid, the body shrinks. Further soft and liquid like excrements irregular inshape may be found. The colour of dead larvae varies depending upon the kind of bacteria. However many larvae become black or grayish black in colour. In general the infected dead larvae shows swollen fore-intestine shrunken posterior part. In case of black thorax septicemia, the blackening starts form the thorax and extends to the dorsal vessel till the whole body softens with a slightly reddish tinge. In any case, the septicemia are generally acute diseases, spreads quickly. The time between infection and death at 28^0 C is round 10 hours. But in higher temperature the disease spreads quickly.

C. Prevention and Control

High temperature and humidity are most favourable to the propagation of bacteria. Thus rearing under these conditions should be avoided. The disease is transmitted mainly though a injury or wound. The infected of diseased worms should be isolated from healthy ones and destroyed by burning or burying deep in the soil.

Effective maintenance of hygienic conditions during rearing are considered as best method to control the disease. Disinfection of rearing room and appliances with 2% formalin must be carried out after rearing is completed. Care should be taken to avoid injury to the worms, overcrowding and accumulation of faeces in the bed.

Fig. 6.8. Septicemia affected larva (early, late age)

6.3.1. Bacterial Disease of Digestive Tract

This disease is also know as transparent disease due to the multiplication of bacteria in the digestive tract leading to swelling and transparency of the dead.

A. Causal Agent and Infection

The Causal agent of the disease is non-specific. The common bacterium associated with this disease is Streptococcus sp. Belonging to the family streptococeae. It is round 0.7-0.9 m in size and are found joined by group of two or more togive a beaded appearance. Under poor nourishment and adverse environmental and rearing conditions, the physiological function of the digestive tract is disturbed. It is because the sterilizig power of the digestive fluid weakens. As a result the bacteria devoured along with mulberry leaves, multiply in large number in the digestive tract. The bacteria takes nutrition from the body of the silkworm, destroying the membranous tissue of the intestine. Besides Stretococcus some short and large bacilli were also found to cause disease.

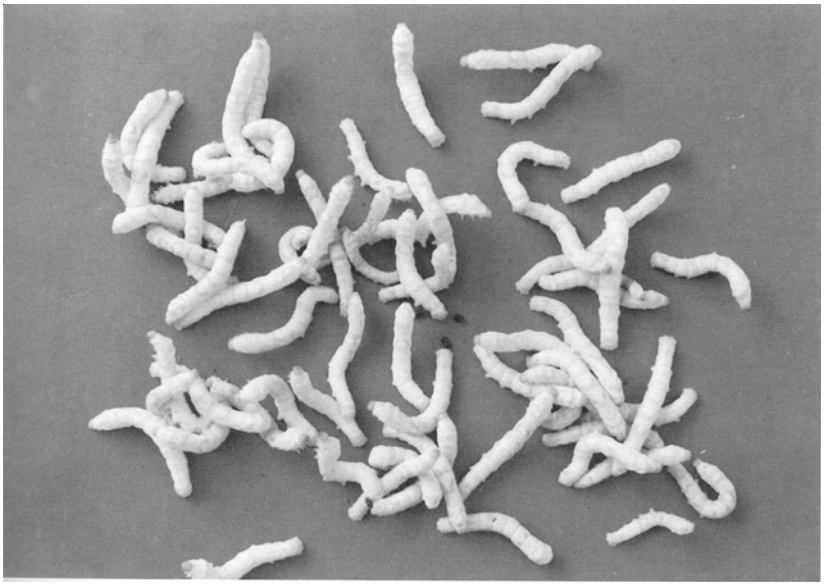


Fig. 6.9. Transparent head disease

B. Symptoms

The symptoms differ depending on the time of occurrence, kind of bacteria found indigestive tract, the silkworm race. The general symptoms are poor appetite, sluggish movement, transparent head, stuned body size, slow/retarded growth, inelasticity of skin, softening of body and some times with oral and anal discharges (Fig. 6.9). these are the symptoms of all flacherie affected worms but the time of infection and the progress of the disease also show certain features which are characteristic of each type of the disease.

1. Shrinking after moulting: the larva does not feed after moulting and body shrinks.
2. Shrinking: The larva body shrinks since it does not feed.
3. Diarrhoea : The fourth and fifth instar larvae pass soft exrements of irregular shape. In later stage the faeces contain intestinal membrane.
4. Vomiting : Larvae vomit and pass loose faecal matter (diarrhea). Then body softens, putrifies and shrinks as the time passes.

The sick worms often hide under the mulberry leaves. In late stage of disease attack the worms remain in the spinning stage without spinning till they die.

C. Prevention and Control

The weakness of silkworm is the main source of infection thus healthy and strong silkworms are selected for rearing. Incubation of eggs and rearing should be carried at required temperature and humidity conditions. Feeding of proper type of nutritious leaf, maintenance of hygienic condition in rearing beds and culling out of diseased worms may prevent and reduce the disease. Chloramphenical along with diet found to be effective for improvement.

6.3.3. Sotto

It is called as bacterial toxicosis.

A. Causal Agent and Infection

The disease is caused by different strains of Bacillus thuringiensis belonging to family Bacillaceae of the order Eubacteriales. The pathogen has a vegetative, cytocyst and spore form. The spore produce delta endotoxin. Generally infection is preoral and can also take place through wounds or injury. After entering into the silkworm body the toxic crystals are dissolved in the alkaline digestive fluid. Then the toxic substance is absorbed through the gastric wall. It affects the nervous system, causing spasm and paralysis.

B. Symptoms

The diseased larvae suddenly loose appetite and exhibit the symptoms of convulsions, sluggishness, lack of skin tension followed by shrinkage of the body, lifting of head, spasm, tremors, paralysis, distress, constipation, shrinkage and diarrhea, loss of clasping power of proleg, sudden collapse and death. The corpse is out stretched, hard to touch and the head appears hook shaped (fig. 6.10). The larval body becomes dark brown and the internal organs are liquefied. The rot larvae exudes foul smelling, dark brown colour, substance.

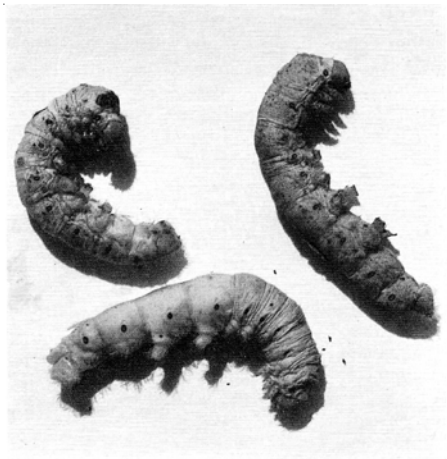


Fig. 6.10. Sotto disease affected larvae

C. Prevention and Control

The bacterial is found in the dead diseased larvae, diseased larvae found in mulberry leaves. The pathogen is found in air and water also. Prenvention of swallowing of toxic substance by the larvae would be a better method, to control the disease. Infected, symptomatic, diseased, ill-healthy larvae must be removed from the bed and destroyed. Maintenance of healthy and hygienic conditions prevents the incidence of the disease. Disinfection of rearing room and equipment must be carried out before starting the next rearing.

6.4. VIRAL DISEASES

These micro-organisms cause 70 percent damage to sericulture industry. Virus disease of silkworms comprise inclusion and non-inclusion types. The former includes Nuclea Polyhedrosis and Cytoplasmic Polyhedrosis while the later has infectious flacherie.

6.4.1. Nuclear Polyhedrosis

This disease is also known as Grasserie, Jaundice, Milky disease, Fatty degeneration and Hanging disease. This serious disease occurs throughout the year.

A. Causal Agent and Infection

The disease is caused by *Borrelina bomycis* virus belonging to the family Baculoviridae (Fig. 1.11). The virus multiplies and forms polyhedra in the nucleus of the tracheal epithelial cells, adipose tissue cells, dermal cells and blood cells. The pathogen may affect the nucleus of the middle and posterior portion of the silkgland cells. The viral particles are rod shaped and the size is round 330 X 80 n.m. Polyhedra vary from 3-6m. their shape also varies, they usally have five or eight facets, although polyhedra of six facets are the more common. The virus constitutes only 3-5 per cent of the polyhedron.

Infection takes place through reeding of polyhedra contaminated mulberry leaf, rarely through wounds. The disease occurs with the digestion of polyhedra in the alimentary canal of the silkworm larva.

The alkaline reaction of the silkworm gut and certain enzymes dissolve the polyhedra, releasing the virus. The free virus passes through the intestinal wall into the body cavity and invades the susceptible tissues. The disease is influenced by high temperature and humidity, and their sudden fluctutions, bad ventilation in the rearing room, ineffective disinfection of rearing room and equipment, feeding of tender leaves during late instars, inadequate spacing, starvation. Heat, cold and chemical treatments have also been known to induce the disease. Surface contamination of the silkworm eggs is possible and can be a source of infection. It is known that the grasserie virus reproduces very actively when the silkworm has vitamin deficiency.

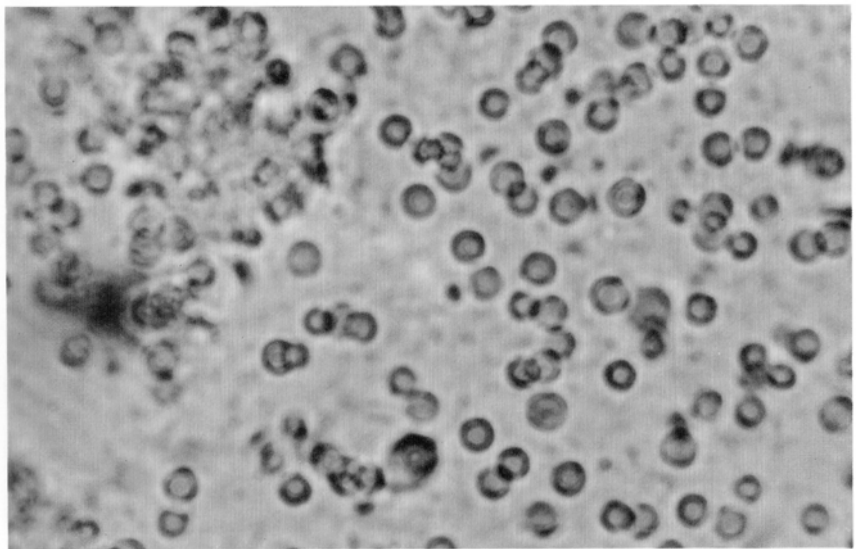


Fig. 6.11. Nuclear polyhydra

B. Symptoms

The disease cannot be identified during early stage of infection, except sluggish nature. Initially the skin shows oily and shinning appearance. In advanced stage larvae loose appetite, skin becomes thin and fragile. The body becomes milky white with inter segmental swelling. The skin is prone to rupture easily, liertaing the liquefied body contents containing number of polyhedra which become the source of secondary contamination.

The larvae become restless and crawl aimlessly along the rim of rearing trays, later fall on the ground and die. Generally larvae do not moult at all. In young age larva death occurs in 4-5 days after infection. While late age larvae die in 5-7 days. Diseased larvae hang with the head downwards. Since abdominal legs loose clasping power (Fig. 6.12). Early infected larvae die before spinning while late age infected worms spin the cocoons but die, producing melted cocoons. The period from the swelling of the inter segmental membranes to death is relatively short, from several hours to less than a day. No external changes are found in pupa during incubation of virus. But towards the end the skin ruptures easily on handling since the pupal body is completely homogenized.

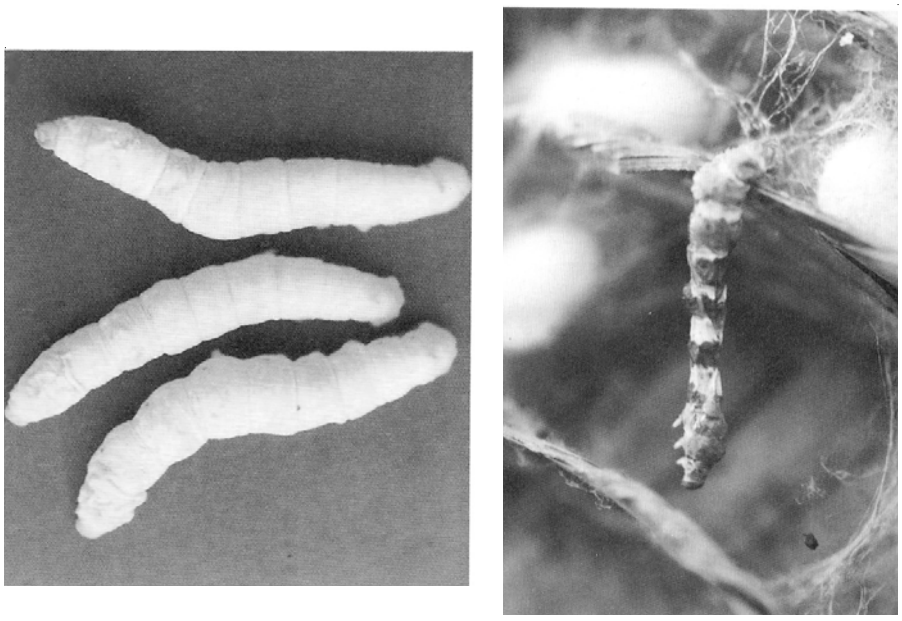


Fig. 6.12. Grasserie affected larva

C. Prevention and Control

Silkworm rearing under hygienic conditions, disinfecting the rearing room, appliances, mulberry storage rooms, mounting rooms, rearing premises are to be followed. Further avoiding feeding unsuitable leaves, proper ventilation and spacing, timely picking out and destroying the diseased worms are some of the precautionary measures. Silkworms

Are handled carefully not to cause any wounds. The diseased worms contain number of fresh polyhedra, thus worms are removed carefully without breaking the skin. The diseased worms, dead larvae are disposed carefully by putting in lime pots or by burning. Extremely low and high temperature and humidity during rearing should be avoided. Accumulation of moisture in the rearing bed should be avoided.

Under any condition polyhedra bodies retain their infectively for longer time. The infectivity is lost in 30 minutes at 70^0 C and inthree minutes at 100^0 C. tghus it is necessary to sterilize appliances with steam or hot water. Polyhedraal bodies present in the rearing room are inactivated by disinfecting with formalin or high power bleaching powder. Silkworm eggs are dipped in one per cent caustic soda solution or 2% formalin for two minutes for surface sterilization. Then eggs are rinsed in running water for few minutes.

Reshamkeet Oushadh disinfectant formulation containing. 1 per cent captan, 1 per cent Benzoic acid and 96 per cent slaked lime powder gives dual protection from grasserie and muscardine. This has to be dusted at the rate of 2-3 grms/0.1 sq.m. area during early instars and 4-5 grams/0.1 sq.m. during IV and V instars, once after each moult.

Fig. 6.13. Dusting of Reshamkeet Oushadh

6.4.2. Cytoplasmic polyhedrosis

This disease is found in summer season.

A. Causal Agent and Infection

The disease is caused by *Smithia* virus belonging to the sub group type I of the family Reoviridae. The virus is spherical, 60-7 mm in size. The polyhedra are formed in the cytoplasm of the cylindrical cells of silkworm larval mid gut. The polyhedra are also formed in goblet and regenerative cells. The infection in the midgut starts from posterior portion and extends towards anterior end. The polyhedra re 1-10 m in size, usually tetragonal or hexagonal but rarely trigon in shape.

Infection takes place through polyhedra contaminated mulberry leaf. Infection in the rearing trays is more common since polyhedra are released in the excreta of silkworms. The disease outbreaks by feeding inferior quality of leaf, high temperature and fluctuation in temperature and humidity.

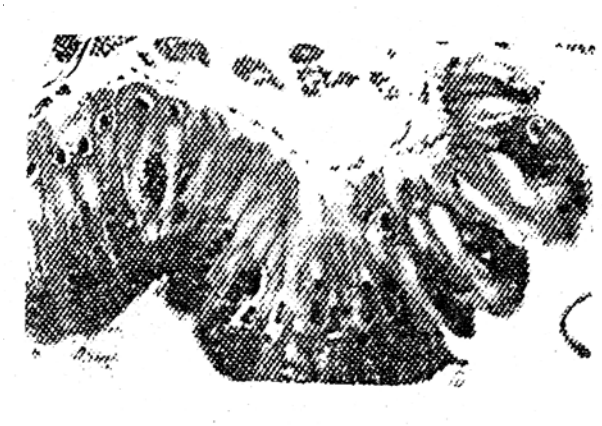


Fig. 6.14. CPV Affected midgut of larva

B. Symptoms

Infected larvae show slow growth, stunted body, reduced mulberry consumption and look dull white in colour (Fig. 6.13)., unequal size worms are common and the worms show delayed moulting. Larvae loose appetite and lag behind normal larvae in their development. In infected grown-up larvae, the thorax becomes transparent and the body atrophies. The head is sometimes disproportionately large. when

the disease advances the milky white portion advances and finally entire gut becomes chalky white. At this stage the worm looks milky white in colour. This larvae excrete soft whitish fecal matter containing numerous polyhedra. Some times rectal protrusion also occurs.

C. Prevention and Control

The virus occluded in polyhedra can persist for more than one year inside the rearing room, appliances and surroundings. It is resistant to formalin. Thus disinfection of rearing room, appliances and surroundings should be carried using 2 per cent formalin solution and 0.5 per cent fresh slaked lime. The dead larvae, infected worms, excreta, unused and refused leaf should be destroyed by burning. Rearing is conducted under proper environmental conditions. Feeding of poor quality leaves should be avoided. Mulberry leaf sprayed with 1 per cent calcium hydroxide are fed to larvae to reduce the occurrence of CPV.

6.4.3. Infectious flacherie

It is the most dangerous and highly contagious disease.

A. Causal Agent and Infection

The disease is caused by non-occluded *Morator* virus belonging to the family Picornaviridae. The virus is globular and measurers 24-28nm. Infection takes place perorally. The pathogen preferably infects the goblet cells. In advanced stage of infection the virus is dispersed in the lumen of the digestive tract and excreted along with the faeces. The disease never exhibits the chalky white appearance.

B. Symptoms

The disease shows symptoms like loss of appetite, transparent, cephalothorax, shrinkage of the body, retarded growth and empty foregut. These symptoms are followed by vomiting of gastric juice and diarrhoea. The midgut contains little amount of mulberry lead and full of yellowish brown fluid. The disease cannot be identified by external features. The histochemical changes of mid-gut tissue can be observed under microscope (Fig. 6.14).

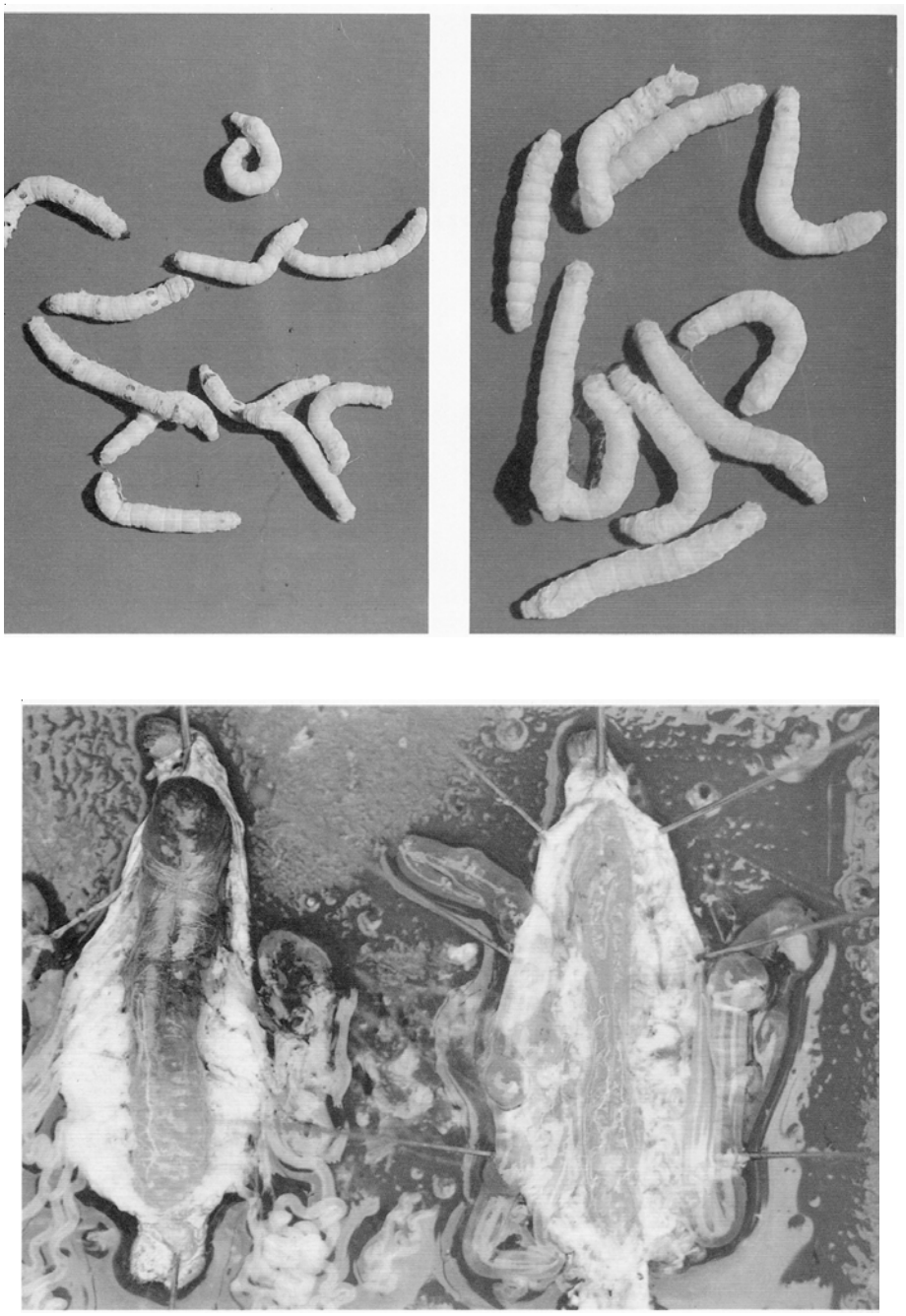


Fig. 6.14. infections flacherie affected larva
(a) early, (b) late (c,d) midgut of normal and infected

C. Prevention and Control

The virus may retain its pahtogenicity in the body of the dead worms for 2-3 years. Thus the rearing room, appliances and surrounding must be disinfected using 2% formalin and 0.5% CaOH or bleaching powder. The other measurers are the same as in grasserie.

6.4.4. Gattine

This disease is also called as the disease of the clear heads.

A. Causal Agent and Infection

The diseased caused by a submicroscopic virus to which *Streptochocus bombycia* is a secondary invader. At the beginning of the disease no micro organism is found in the intestine. Later the pathogen multiplies and causes disease symptoms. The virus alone produces certain histopathological lesions in the intestinal epithelium. The *Streptococcus* is not the principal cause but plays a vital role in the development of gattine.

The infection occurs perorally and through the eggs.

B. Symptoms

The symptoms are clear and prominent when both virus and bacterium occurs in the larva. The larval anterior or cephalic part becomes swollen and translucent. The head is clear. Other symptoms are loss of appetite, ejection of clear ropy liquid from the mouth, diarrhoea.

C. Prevention and Control

Maintenance of good sanitary conditions in the rearing room are necessary. Affected larvae are picked and destroyed.

6.5. FUNGAL DISEASES

These diseases are also called as mycosis, caused by parasitic fungi. There are two kinds i.e. Muscardine (calcino) and Asopergillosis. The muscardine disease appears in various forms depending upon the colour of spores which cover the larval body. They are white, green, yellow, black, red in colour.

6.5.1. White Muscardine

This disease occurs during rainy or winter season under low temperature and high humidity.

A. Causal Agent and Infection

The causal organisma is *Beauveria Bassiana* (Bal Vuill) belonging to the family Monliacea. The infection occurs by body contact and rarely though wounds. The main source of infection are the mummified larvae, infected seat paper, tray and dead wild lepidopterous larvae. The disease is highly ontagious.

The fungi shows three stages namely conidium, vegetative mycelium and aerial mycelium (Fig 6.15) in the life cycle. The conidia are globular or oval in shape, colourless and collectively appear chalky white. The conidia germinates within 8-10 hours after infection under favourable environmental conditions. The conidia spread throughout the body fluid. The blood becomes scanty, blood cells are destroyed and acidity reaches to neutrality. In advanced stage of infection blood circulation slows down and blood becomes pasty and finally larva dies. The conidia germinate in the blood and penetrate into the adipose tissue, muscles, nervous system, silk gland, malphigian tubules etc. the conidia on germination gives out germ tube and secretes chitinase enzyme. This enzyme favours the germ tube to penetrate into the body wall for further multiplication. The germ tube develops into vegetative hyphae after invading the blood tissue. After the death of the silk worms propagation in various tissues is more rapid. The vegetative hyphae develop round or oval shaped short hyphae at their tips. These detach on their own and elongate to develop into vegetative hyphae. The vegetative hyphae bores out of the skin to form aerial hyphae innumerable

conidiophores. The conidiophores produce one or two conidia on their small branches. Thus the surface of the dead larvae shows white mealy appearance after the formation of the conidia. The conidia are the fresh source to cause secondary infection.

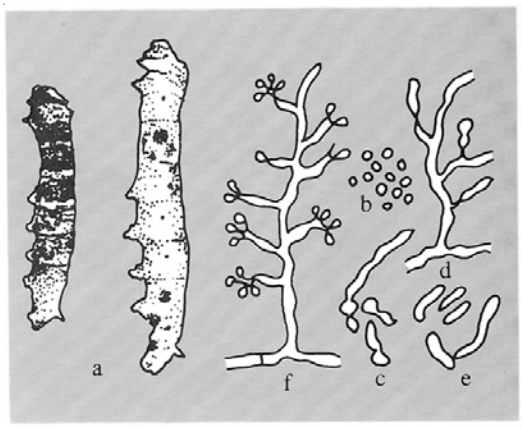


Fig. 6.15 Development cycle Beauveria bassiana
a) Affected larva
b) Conidia
c) Germination of conidia
d) Formation of cylindrical spores
e) Cylindrical spores
f) A Condiophore with conidia

B. Symptoms

No symptoms are seen during the early stage of infection. As the disease advances moist specks appear on the skin (Fig. 6.16). the larva loses appetite and becomes inactive. The body becomes limp, loses elasticity, ceases to move and dies within 3-5 days of infection. The larvae show diarrhea and vomiting. The dead larval body generally hardens and becomes stiff. At this stage the body is pink in colour. The colour is due to multiplication of secondary bacterium *Serratia marcescens*. After 2-3 days of death the body is covered with white wooly aerial hyphae between intersegemental membrane. Further the whole body is covered with white powdery conidia except the chitinous parts of the head. The body remains hard as the fungus secrets of double oxalate crystals of ammonium and magnesium. The whole body of the dead larva is chalky white and mummified (Fig. 6.17).

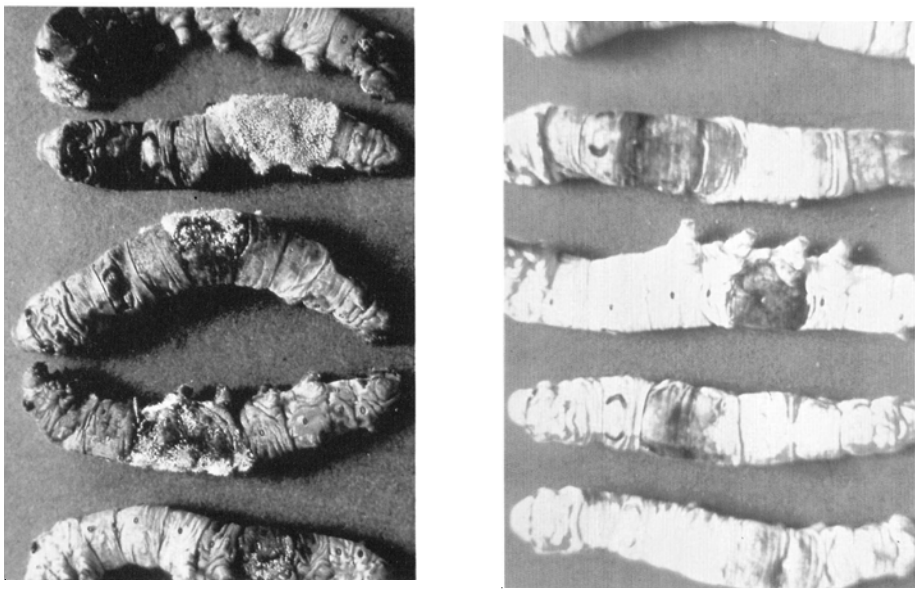


Fig. 6.16. Muscardine affected larva

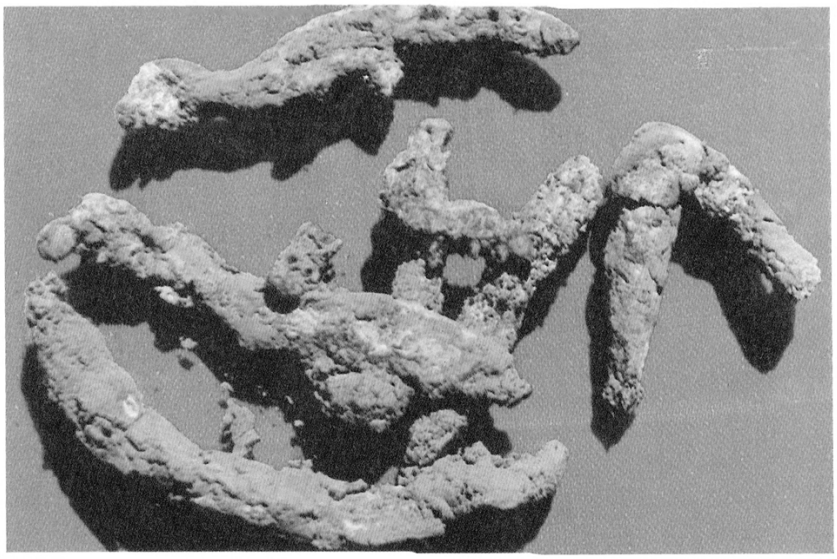


Fig. 6.17. Mummified Larvae

When the worms are infected before spinning, the larvae spin cocoons but moths will not emerge. In pupal infection the pupae will not emerge. In pupal infection the pupae slow down their reaction to outside stimuli. The thorax shrinks and abdomen is wrinkled. The pupa hardens, covered with white conidia and dries to one third of its ordinary weight. These cocoons sound like dried cocoons when shaken. In moths also body hardens and wings fall of easily.

C. Prevention of Control

Disinfection of rearing room, appliances and surrounding must be carried using 2 per cent formalin or 5 per cent bleaching powder solution. During rearing low temperature and high humidity are avoided. The rearing bed must be kept dry to avoid germination of conidia. Infected/diseased worms are identified and removed before they get mummified. The diseased larvae are put in lime jars or burned along with bed refuse.

Application of formalin chaff at 0.4 per cent during I and II instars 0.5 per cent in III instar, 0.6 per cent in IV instar and 0.8 per cent in V instar should be followed to control the outbreak and spread of the disease. Further Dithane M45 or captan or Reshamkeet Oushadh are used at required dose (Fig. 6.18).

Fig. 6.18. Application of formalin chaff

6.5.2. Green Muscardine

This fungal disease occurs during autumn and winter season.

A. Causal Agent and Infection

The disease is caused by *Nomuraea riley* belonging to family Moniliaceae. Infection occurs through skin by conidia. The conidia germinate in 15-20 hours after infection under favourable condition. The dead mummified larva and infected wild lepidopterous insects are the major source of infection.

The development stages of this pathogen are similar to white muscardine (Fig. 6.19). The conidia are oval and slightly pointed at one end. It is light green, single celled, germinate at 22-24^{0}C in 20 hours. The vegetative mycelium has a germinating tube which elongates to give rise filamentous mycelia with septae. The mucelia produce colourless tubular or bean shaped hyphae. Further hyphae from conidiophores, which are wheel shaped and unbranched. Conidiophores bear a chain of conidia.

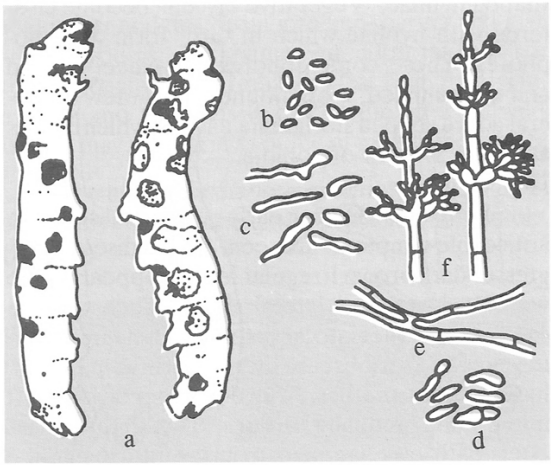


Fig. 6.19. Development cycle of Nomuraca riley
a) Attacked larva
b) Conidia
c) Budding of conidia
d) Hyphal bodies
e)Anastomosis of mycelia
f) Condiophore bearing conidia

B. Symptoms

No symptoms are seen during early period of disease. But at the later stages dark brown irregular lesions appear on all sides of the body. Some times the lesions gather to form large spots with clear circumstance. The laevae show vomiting, diarrhea and finally dies. Then the body slowly hardens and after two or three days, mycelin appear from spiracles and intersegmental regions. After 10-15 days the mucelia are covered with fresh green conidia (Fig. 6.17)

C. Prevention and Control

These are similar to white muscardine.

6.5.3. Aspergillosis

Young silkworms are affected by this pathogram when the humidity is high.

A. Causal Agent and Infection

The disease is caused by different species of Aspergillus and Sterigmatocytis belonging to the family Moniliaceae. The important species are as follows :-

1. ***Aspergillus flavus*** **(link)**
2. ***Aspergillus oryzae*** **(Whemer)**
3. ***Aspergillus ochraceus*** **(Wilm)**
4. ***Sterigmatocystis fulva*** **(Saccl)**
5. ***Sterigmatocystis japonica*** **(Aoka)**
6. ***Sterigmatocystis*** **Sp.**

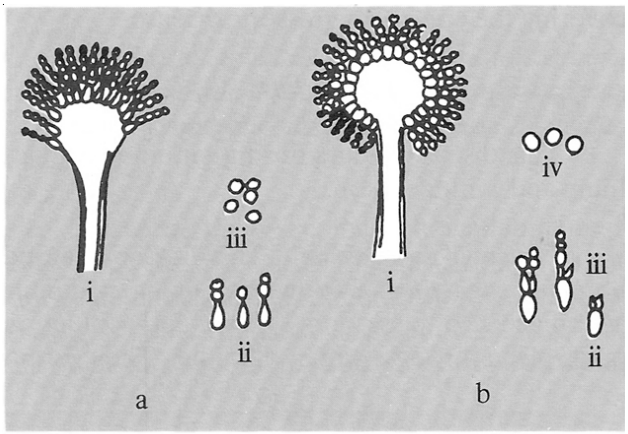


Fig. 6.20. Morphology of Aspergillus Sp.

a) Aspergillus flavus	***b) Aspergillus oryzae***
i) Conidiophore	***i) Conidiophore***
ii) Sterigma	***ii) Phialidae***
iii) Conidia	***iii) Sterigma***
	iv) Conidia

The developmental stages had conidium, vegetite hyphae and aerial hyphae (Fig. 6.20). The conidia are spherical, 3-7 m in size which re resistant to environmental conditions and formalin treatment. The conidia germinate at 30-35^0 C to invade the larval body and develop into vegetative hyphae. The vegetative hyphae grow at the site of invasion. The conidiophores are thick with an expansion at distal end to form globular or oval structure. It bears one to two rows of radiating sterigmata, on which conidia are formed.

B. Symptoms

Diseased larvae cease eating become lethargic, show body tension, lustrousness and finally die. Just before death the head and thorax is extended outwards and vomiting occurs. The aerial hyphae appear one day after death and late conidia cover the larval body. Depending on the pathogen the colour appears. Depending on the site of fungal penetration, dead body hardens while other parts turn black and rotten (fig. 6.21)

C. Prevention and Control

These are similar to white muscardine. Instead of formalin 4 per cent pentachlorophenol is used for disinfection.

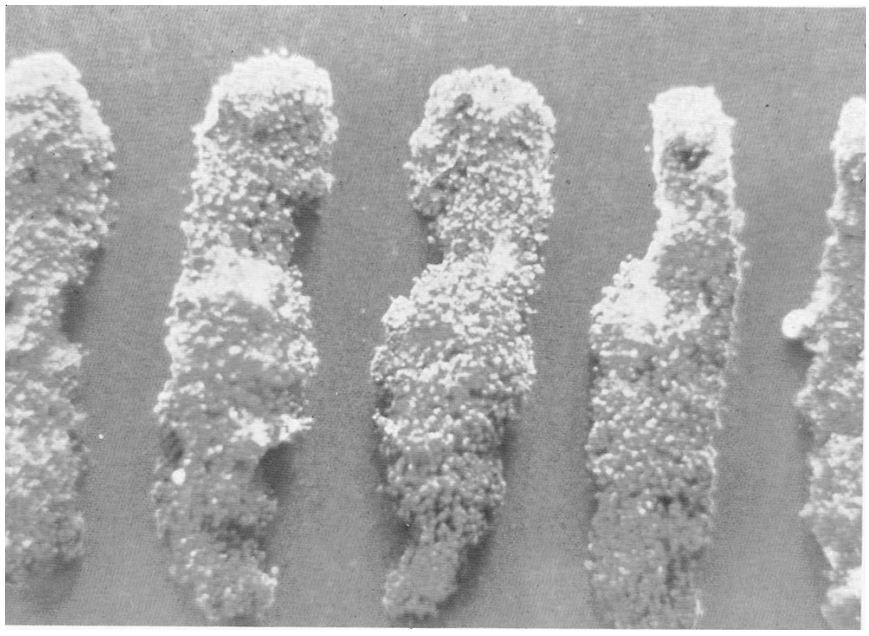


Fig. 6.21. Aspergillus (a) early (b) late stage

SUMMARY

- The silkworm diseases are caused by protozoans, bacteria, virus and fungal pathogens. Among protozoan diseases pebrine is a chronic and dangerious disease caused by *Nosema bombycis*. The disease is transmitted through egg from one generation to the other. Dead worms, infected worms and bed form major source of infection.
- The disease shows symptoms in all life stages of silkworm. Eggs are laid in lumps with less adhesive.
- Larvae become sluggish, show retarded growth, loose appetite, moult irregularly, show pepper like spots on the skin.
- The infected pupae are flabby and swollen with lusterless. Moths show clubbed wings, discolouration of scales, falling of scales, delay in emergence.
- The pebrine spores are identified by mother moth examination under microscope with 600 magnification.
- Perfect surface sterilization, production of healthy eggs prevents the disease.
- Bacterial diseases (Flacherie) are septicemia, bacterial diseases of digestive tract and sotto.
- In septicemia the bacteria multiply in the haemolymph of larva, pupa, adult.
- The Body wall oozes fluid when punctured.
- The transparent disease is caused by *Streptococcus sp.* Poor nourishment and adverse environmental conditions favours the diseases. Generally the symptoms resemble septicemia.
- Sotto is caused by *Bacillus thuringinesis* which has three stages. The pathogen spore produces delta endotoxin. Infection is through wounds or preoral.

- The infected larvae lose appetite, show convulsions sluggishness, lack of skin tension, shrinkage of the body, tremors etc.
- Viral diseases of silkworms cause 70 per cent damage to sericulture industry.
- The nuclear polyhedrosis is caused by Borrelina bombycis. The virus multiplies and forms polyhedra in the nucleus of tracheal epithelial cells, blood cells. Infection is by feeding polyhedra along with mulberry leaf.
- The larval body becomes milky white with intersegmental swelling. the skin ruptures easily liberating the liquefied body contents.
- Cytoplasmic polyhedrosis is caused by *Smithia* virus. The polyhedra are formed in goblet and regenerative cells. Infection is though polyhedra contaminated mulberry leaf.
- Infections flacherie is caused by *Morator* virus which infects by entering preorally.
- Gattine is caused by submicroscopic virus which produces certain histopathological lesions in the intestinal epithelium.
- Muscardine is caused by a fungal pathogen. It appears in various forms depending upon the colour of spores which cover the larval body. The white muscardine is caused by *Beauveria bassiana* while green muscardine is caused by *Nomuraea rileyi.*
- Infected seat paper, dead wild larvae, mummified larvae are main source of infection.
- The larva loses appetite and becomes inactive, body becomes limp, loses elasticity, ceases to move and die.
- The dead larvae hardens and becomes stiff. The dead larvae develops white, wooly aerial hyphae between intersegmental membrane.
- The complete body is covered with white or green powdery conidia. Disinfection of rearing room, appliances must be carried using formalin.
- Aspergillosis is caused by different species of Aspergillus and Sterigmatocytis.

QUESTIONS

I. Short Questions

1. How do you detect pebrine in silkworm ?
2. What symptoms are seen in pebrine affected larvae ?
3. What are the features of Sotto disease ?
4. How do you identify muscardine ?
5. What are the symptoms of flacherie ?
6. What is the causative organism of pebrine ?
7. Mention silkworm diseases ?
8. Draw the diagram of Pebrine spore ?
9. What is the causal agent of Septicemia ?
10. Mention bacterial diseases ?
11. Mention viral diseases ?
12. What is causal agent of CPV, NPV ?
13. What is the other name of gattine disease ?
14. Mention fungal diseases ?

II. Essay Questions.

1. Explain the disease caused by Nosema ?
2. Detail about muscardine (white) disease ?
3. Explain about septicemia disease ?
4. Detail about Sotto disease ?
5. Explain NPV disease. Add a note on its control ?
6. How do you identify pebrine disease ?
7. Write about gattine disease ?
8. What are the symptoms of fungal disease ?
9. Add a note on symptoms of pebrine disease ?
10. Write short notes :
    a) CPV b) Aspergillosis
11. Write short notes on
    a) Gattine b) Septicemia

7

SILKWORM PESTS

7.1. INTRODUCTION

There are different microorganisms, which cause diseases beside serious pests like uzy and dermisted beetle attack silkworms and stored pests affecting the crop yield and quality. The symptoms of different diseases vary. Some have specific symptoms and others have common symptoms, such as fast or slow larval growth, late mouling nonmoulting, irregular growth, poor appetite, unusal behaviour abnormal spots ont the skin, changes in body colour, defects in intersegmental membranes, abnormal saliva or excreta, unusually soft or hard skin and which can be observed with the naked eye. These feature facilitate the rearer to identify the disease.

Pests of silkworm can be seen with naked eye. The larval stage are affected by uzy fly while dermisted beetle is fond of eating pupae. Thus it requires proper preventive measures rather than its control.

Keeping in view of all the above facts, healthy silkworm strains are selected and properly reared by adopting modern methods to keep away the incidence of diseases. It is also necessary to disinfect the rearing chamber, equipment etc., to kill pathogenic organisms.

7.2. Major Pests

7.2.1. Uzy fly

The parasitoid insect belongs to order Diptera and family Tachinidae. This pest incidence is very high in tropical contries like Bangladesh, China, India, Thailand and Vietnam. *Tricholyga bombycis* is a major pest of silkworms.

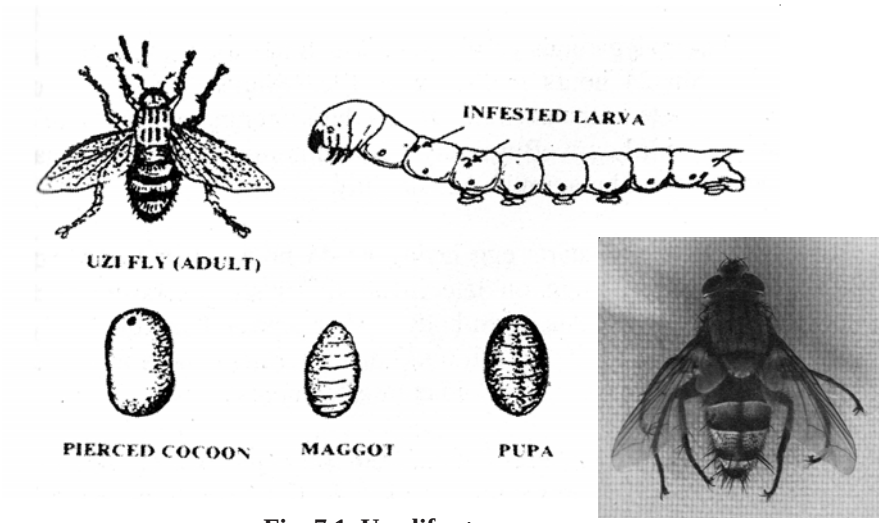


Fig. 7.1. Uzy life stages

7.1.1.1. Life Cycle

The life cycle has four stages i.e., adult, egg, maggot and pupa (Fig. 7.1.).

A. Adult

It is blackish gray in colour and distinguishable into head, thorax and abdomen. The head is triangular in shape with conical abdomen. Thorax has four longitudinal black bands on the dorsal side, while the first abdominal segment is black and rest grayish yellow. The life span of adults varies with sex and season. Males survive for about 10-18 days. And females live 2-3 days longer than males. Survival period is long during summer.

Sexual dimorphism is very clear in uzy fly. Males are longer (12 mm) than females (10mm). Male has external genitalia covered with brownish orange hairs on the ventral side of the abdominal tip. The bristles on the lateral region of abdomen are more dense in male, while they are restricted to last two segments in females. The width of the frons of the male fly is narrower than that of female.

Generally males strike the resting and walking females. Mating strike is followed by agitated state of the female before successful genetal contact. This premating period prolongs for about 4-6 hours.

The polygamous adults mate 1-2 times after emergence and 3-7 times within 24 hours in the entire life. Mating occurs during early morning or late in the evening, with a duration ranging from half an hour to two and half hours. But it requires a minimum of one hour mating for full fecundity and maximum hatchability.

Female fly starts egg laying 44-45 hours after emergence. The fly prefers to lay egg on late instar (3rd instar onwards) because of relative area of the silkworm body. After repeated survey the fly settles down on the host for ovipostion. Under normal condition 1-2 eggs are laid per larva. The eggs are laid at intersegmental area.

A single female lays about 300-1000 eggs over a period of above 9-25 days. Initially few eggs are laid which gradually increases to reach the peak between fourth and seventh day after emergence. But egg laying decreases with advancing age. Female fly lays eggs throughout its life.

B. EGG

The eggs are creamy white measuring 0.45-0.56 mm in length and 0.25-0.30 mm in width with along shape. Depending on the environmental conditions the eggs hatch in about 2-5 days after laying. The newly hatched maggot penetrates into the silkworm body.

C. MAGGOT

The maggot hatches out through operculum of egg shell which generally faces the silkworm body. The maggot penetrates into the silkworm which is surrounded by a sheath formed by granulocytes and proliferating tissue at the site of the wound. With the growth of maggot the size of the sheath increase and becomes thick and black which finally seen as a black lesion or scar on the silkworm body. This is a good identification of uzy infestation.

The first and second instar maggots are yellowish white in colour measuring 0.7-1.5 mm and 2.75 mm width and length respectively. The third instar maggots are creramy white measuring 1.3-1.6 cm in length. Maggots have eleven body segments and pass through three instars. The first two instars develop just below the skin but final instar maggots move into the body cavity and grows in size. After a lapse of 5-8 days the mature maggot escapes by piercing the host integument by its prothoracic hooks.

The maggot feeds on the body tissues of silkworm and the host dies by the time maggot escapes.

C. PUPA

Maggots pupate in about 10-20 hours in the darker area in and around the silkworm rearing house like rearing beds, crevices, corners, below ant wells and rearing stands or in the superficial soil. The body becomes motionless and shrinks before pupation. Pupae are oblong in shape, reddish brown to dark reddish brown in colour, with elevean segments and measures 0.9-1.2 cm in length and 0.4-0.6 cm in width. It takes 10-12 days to metamorphose into adult which emerges out.

7.2.1.2. Damages and Symptoms

Infested larvae upto early fifth instar die before spinning. Of the larvae are attacked in fifth instar the maggot comes out by piercing the cocoon.

Uzy infected worms are identified by black scar at intersegmental region where the maggot penetrates into the silkworm body. Minute creamy white eggs are observed on the larvae at the initial stage of infestation. Maggot pierced cocoons are unfit for reeling (Fig. 7.2).

7.2.1.3. Prevention and Control

Good sanitary and hygienic conditions in and around rearing room are important. The holes and crevices in the rearing room are to be closed before rearing activity. Early spinning cocoons which are generally uzy infested, and are to be carefully separated from normal cocoons. These cocoons are stifled to kill the inside maggot (Uzi).

A physical barrier is created in the rearing room to prevent uzi entry. Fine wire mesh barrier in the doors and windows or mosquito net curtain around the rearing stand will solve the problem. Dusting of levigated china clay on the body of silkworm during mounting prevents oviposition by uzi.

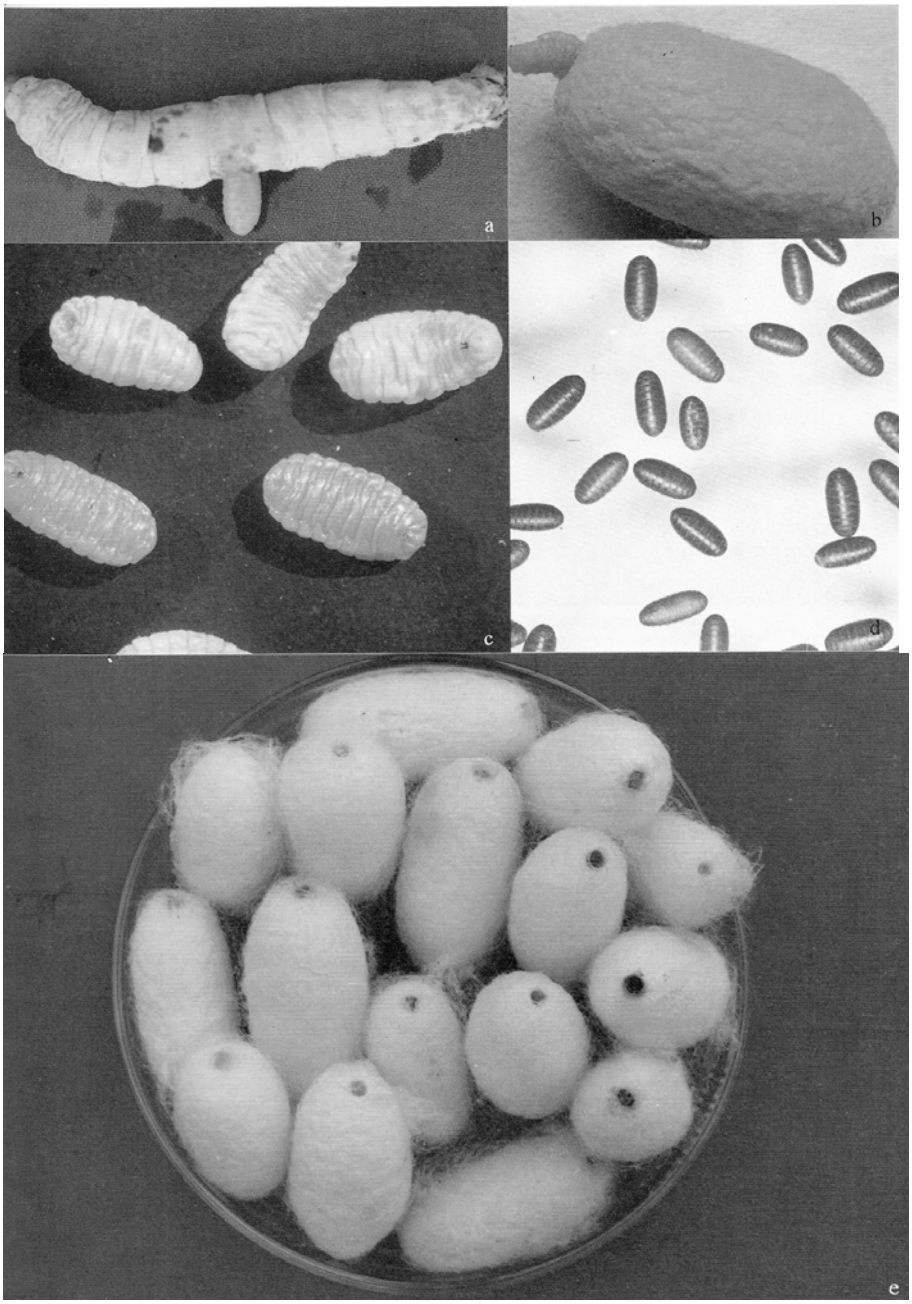


Fig. 7.2. Uzy Infection

In chemical control, uzicied containing one per cent of Benozoic acid is recommended at the dose of 7.8 m.sq.ft. It is effective when applied within 48 hours of egg laying. Control of uzi fly is effective against use of 2.5% difulubenzuron.

Control of uzi fly through biological means (hyperprasitoids) is better. A number of parsitoids of uzi fly pest of silkworm have been identified which are as follows. They are ***Trichopria sp., Nesolynx thymus, Exoristobeia philippinensis, Dirhimus himalayanus, Brachymeria lugubris, Spilomucrus Karnatakensis, Splangia cameroni*** and ***Pachycrepoideus vindimmae.***

7.2.2. Dermestid Beetle

Among pests coleopteran insects cause much damage to stored cocoons. These insects are harmful to silkworm directly sometimes indirectly. Most of the damage is done by the larvae when cocoons are stifled and stored for a long time. The pest larvae bores the holes to the cocoons and the pupae are eaten. Besides this, they also damage animal and plant products including leather, furs, dried fish, carpet, woolen and silk materials. These beetles belong to family Dermestidae.

7.2.2.1. Life Cycle (Dermested Cadverinus)

The adult insect is oval-elongate and dark brown in colour. It measures about 1 cm in body length. The adult lives on animal matter for one year after oviposition. Generally the pest passes the winter in the adult stage, and begins mating and starts egg laying in May. After mating the female beetel moves around in dark places in the cocoon storage room and deposits eggs in the crevises. Each adult lays 50-400 eggs. The eggs hatch in a week. The grubs are spinkle shaped, reddish brown in colour. The insect prefers to be in dark places. Grub moult 5-7 times in about 1-2 months and attains a length of about 1.5 cm. the body of the grub is covered with hair. Then grub becomes pupa. The adult after emergence mates and lays eggs which develop to become the adults of second generation (Fig. 7.3).

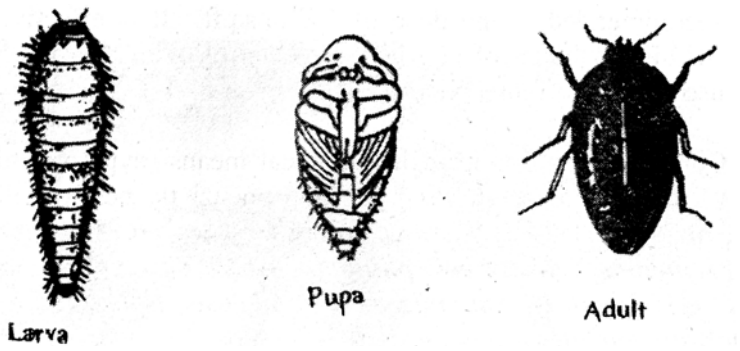


Fig. 7.3. Dermisted life stages

Although the insect generally passes the winter in the adult stage, since the time of metamorphosis is not fixed both the larval and pupal stages may be encountered in winter. The other dermisted beetles that are important from sericulture point of view are as follows:

1. ***Dermestes valpinus (Fab)***
2. ***Dermestes vorax (Motschulsky)***
3. ***Dermestes frishehi***
4. ***Dermestes tessolatocollis***
5. ***Dermestes coarctatus***
6. ***Trogoderma versicolor***
7. ***Anthrenus verbasi L.***
8. ***Anthrenus pipinellae Fab.***
9. ***Attagenus piceus (Oliver)***
10. ***Attagenus japonious (Reitter)***

7.2.2.2. Damage, Symptoms, Prevention, Control

The larva and adults are attracted by the smell of stifled cocoons and the dried pupa inside. They bore into the cocoons and eat the dried. Pupae and sometimes eggs. Damaged cocoons are unfit for reeling. Rarely the young larvae attack living silkworms. The pests occur throughout the year causing damage to stored and stifled cocoons. They also damage pierced and melted cocoons which are stored in the grainage building. Presence of cocoon pierced at several places and the egg laying silkworm adults in the grainages damaged mostly on the abdominal parts are indications of attacks by dermisted beetles.

The rearing house and cocoon storage rooms should be cleaned periodically. Storage of rejected cocoons for long period should be avoided, wooden equipment are to be dipped in 0.2% malathion for 2-3 minutes. After 10 days the trays should be washed in water and sun dried for 2-3 days before re-use. Passing of hot air (50-60^{0}C) and maintenance of low humidity (30%) also help to kill the beetles. Fumigation with methyl bromide 0.5 gr. Per 3m^2 for three days kills all the stages of beetle.

7.3. Minot Pests

Besides major pests there are many minor pests than cause damage to silkworms as well as to cocoons and increase cost of production and crop loses.

7.3.1. Mite (Pediculoides ventricosus)

This non insect pest belongs to the order Acarina and class Arachind. This mite is encountered at the time of re-thaching of the roof of the silkworm rearing house or brought into the rearing room along with building material such as straw, wood or bamboo. The female mite attacks all the stages of silkworm except eggs, causing death.

Both the sexes are in different shape. The adult fully grown female has a swollen around abdomen 30 times the normal ordinary size to attain spindle shape. Males are oval shaped. Head is triangular and thorax-abdomen carry four pairs of legs each having small claws. This pest is ovoviviparous. I female the young acarids hatch out from the eggs and pass out in the form of adult like small acarid. Each adult produces about 100-150 young ones. The newly born mite is about 0.2 mm in length with light yellow colour body. Males are produced first than females. Each male after matching with some females dies in about a day. Female mite with large number of eggs attains spherical shape as posterior half of the body becomes enlarged. Fertilized female gets attached to the suitable host with its claws and suckers. Young larvae and pupae of silkworm are preferred hosts. The mite passes through 17 generations in a year. Each generation time ranges between 7-18 days (Fig. 7.4).

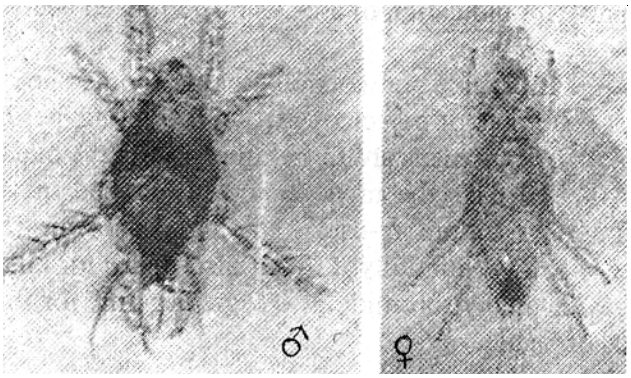


Fig. 7.4. Pediculoides

The larvae, pupa and adult silkworm are attacked by this pest. The body surface of a silkworm stuck with this mite, develops a few black specks. The purpose of attachment between the host and pest is to obtain nutrition. Further, the pest animal saliva contains toxin which ultimately kills the host. The infested silkworms loses appetite, becomes inactive and has difficulty in excreting. It takes time to pass the excreta and frequently the excreta are attached bead like to the anus. In severe infestation, silkworms vomit yellowish green fluid and excretes black fluid from the anus. Irregular and decreased pulsation of the dorsal vessel occurs. The skin surface of the attached host bears several rough and uneven black sports. Worms attacked during moult fail to pass the moult and die in a day or two. Infested pupae develop lesions, the body is blacken and they fail to moult into adult. In acute attack, silkworms die in as few hours and starts putrifying. Young silkworms do not putrify rapidly.

On identifying acarid attack the rearing room and trays should be replaced. All the appliances should be disinfected with steam. Straw (Cotton, Rice) should be kept away from rearing room and appliances.

7.3.2. Ants

Ants attack silkworms in the rearing trays, can be prevented by placing the legs of the rearing stands in ant wells. Dusting of gamzxine of pouring of little kerosene around the legs of rearing stand and chandrika prevents ant crawling.

7.3.2. Nematodes

The nematode Hexamermis Microamphidis is found in silkworms of late autumn rearing. This worm attacks the young silkworms and penetrates into the body. The head of the affected silkworm becomes transparent and the body turns milk white.

7.3.3. Lizards

These reptiles re seen frequently on the rearing houses. These pests cause serious damage to the rearing by swallowing young silkworms.

7.3.4. Rats and Squirrels

These pests eat silkworms avoiding on silk gland and the pupa after opening the cocoons. Thus entry of these animals is to be prevented by arranging suitable wire mesh for doors, windows and ventilators.

7.3.5. Birds

Crows, sparrows pick up the silkworms when the mountages are kept our doors at the time of spinning. The damage caused by these birds can be avoided by indoor rearing.

SUMMARY

- The parasitoid pest (uzifly) has four life stages i.e. adult, egg, maggot and pupa. The adult shows sexual dimorphism.
- The fly is blackish gray with head, thorax and abdomen. It lives for about 20 days.
- Female fly lays about 300-1000 eggs at the intersegmental region of late age worms.

- The site uzy maggot entry becomes black. Maggot passes three instars and escapes out side by killing the larvae. Pupae are formed in dark areas which metamorphos into adult in 10-12 days. Infected larvae die before spinning.
- The pierced cocoons, melted cocoons are unit for reeling.
- The uzi fly can be controlled by a physical barrier, uzicide and through biological control.
- Dermested beetle (Coleopptera insect) causes much damage to stored stifled cocoons. Its life stages are egg, grub, pupa and adult.
- The adult and grub causes damage to sericulture industry.
- Grub moults 5-7 times in 1-2 months then undergoes pupation and metamorphose into adult.
- The grubs and adults are attacked by the smell of stifled cocoons and make them unfit for reeling.
- Maintenance of good and bygienic conditions helps to reduce the attack.
- There are some minor pests such as mites, ants, nematodes, lizards, birds, rats and squirrels which contribute to damage worms and cocoons.
- Among all mites cause mush damage.
- All these can be controlled by adopting simple preventive precautionary measure during rearing activity.

SUMMARY

I. Short Questions

1. Mention pests of silkworms.
2. How do you identify uzy fly ?
3. What are the symptoms of uzy infection ?
4. Mention minor pests of silkworms.
5. How do you control uzy fly ?
6. How do you prevent minor pests ?

II. Essay Questions

1. Detail about the damage caused by uzy fly.
2. Explain the life cycle of dermisted beetle.
3. Write about minor pests and add a note on control.
4. Write short notes

   a) Symptoms of uzy attack b) Minor pests

8
ECONOMICS

8.1. 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 very good commercial value. Silkworm rearing is to be conducted systematically. All the aspect directly or indirectly influence the rearing and reflect on cocoons production. On the other 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 a rearer should know the economics of silkworm rearing and the factos that hamper the cocoons production.

The by products 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 pharmaceuties, chemical industries, fertilizers. In this chapter economics and by products of silkworm rearing are discussed.

Sericulture is an agro-based industry which requires a proper planning to ensure successful crop results. The rearer should have an idea about the crop which he is going to start. Like other crops, sericulture has different aspects i.e. mulberry cultivation, grainages, silkworm rearing and reeling. And it is necessary for a beginner to know about the economics of sericulture industry. There4 by he proceeds further with care and confidence. Further he must have an idea regarding various operations involved in a particular branch of sericulture. All the information regarding various operations and aspects are noted in different specific records from time to time for getting good results. Silkworm rearing also requires certain records to be maintained by the rearer as a guidance.

8.2. ECONOMICS OF REARING 300 DFLS OR ONE ACRE

From economics point of view the improved techniques of rearing are more important, for achieving good crop results. The profits are nearly 50 per cent more than normal rearing processes. The new techniques of rearing are to be followed right from the selection and cultivation of mulberry. Hybrid variety of mulberry i.e. M5 yields more quantity and quality 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 crop and low quality of cocoons. For this purpose hybrid multivoltine and hybrid bivoltine races are selected for rearing purpose. The third and final important part of sericulture is rearing. The rearing of worms should be conducted in a methodical way. Thereby the no. of cocoons per crop 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, quality of leaf to feed the worms and leaf preservation methods. Depending on the growth of the worms they are to be properly spaced. Further the worms are given quality lead depending on the age of worms. Care should be taken during moulting, feeding, bed cleaning, mounting, harvesting. During the process of rearing disinfection of rearing room 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 rearing. It is also advised to rear chawki worm in co-operative rearing centers. This enables to reduce the expenditure and also to ensure proper growth of the 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.

Table. 8.1 Investment on equipment for rearing 325 DFL's in one acre of mulberry under Irrigated conditions (approximately).

Sl. No	Equipments	Required No.	Cost per item Rs.	Total cost Rs.	Utility (Yrs)	Value Per Yr. Rs.
1	Rearing stands	4	500/-	2,000/-	10	200/-
2	Rearing trays	30	80/-	2,400/-	10	240/-
3	Round bamboo trays	100	25/-	2,500/-	3	840/-
4	Leaf chopping boards	2	150/-	300/-	10	30/-
5	Chopping knives	2	40/-	80/-	3	27/-
6	Feeding stands	4	75/-	300/-	10	30/-
7	Leaf chamber	1	300/-	300/-	10	30/-
8	Sprayer	1	750/-	750/-	10	75/-
9	Hygrometer	1	250/-	250/-	10	25/-
10	Foam pads	1kg	150/-	150/-	4	38/-
11	Chandrikas (bamboo)	60	50/-	3,000/-	3	1,000/-
12	Cleaning nets	300	5/-	1,500/-	3	500/-
	TOTAL			**13,530/-**		**3,035/-**
13	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 dfls under irrigated condition.

from second year onwards the leaf yield increases to 14,000 kg per acre with a rearing capacity of around 1625 dfls (five crops in a year). From second year onwards the net profit per acre is about Rs. 25,660.50 per five crops.

Table. 8.2 Expenditure on rearing 325 dfls (approximate)

Sl.No	Item	Total Cost Rs. Ps.
1.	Cost of dfls @ 250/- per 100 dfls so 1625 dfls cost	4,062=50
2.	Cost of labour wages Young age 14 days, 3 men/day= 42 days Late age 14 days, 5 men/day=70 days Spinning and harvesting 2 days, 8 men/day = 16 days Total = 128 days Labour charges @ 20/- = 128 X 20	2,560=00
3.	Misc ie. paraffin paper, formalin, news paper, transport etc.,	1,000=00
4.	Non-recurring expenditure on rearing equipments and moriculture equipments	4,316=00
5.	Building value	2,633=00
6.	Leaf production (14,000 kg per year) @ 0.78ps. per kg.	10,956=00
	GRAND TOTAL	**25,527=50**

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

Table. 8.3 Net Profits from one acre of mulberry/year.

Sl.No	Item	Profits Rs.	Ps.
1.	Returns through sale of cocoons of 568.75 kg. @Rs. 90/- per kg. @ 35 kg cocoons for 100 dfls.	51,187	50
2.	Expenditure per one acre per year	(-) 25,527	50
	GRAND TOTAL	**25,660**	**50**

NOTE : Above data may change from time to time according to cocoon market, grainage etc.

8.3. BY PRODUCTS

Sericulture is an agro based industry which includes various aspects such as mulberry cultivation, grainages, 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 with an integrated approach where sericulture can be combined with pisciculture, 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, and these can be utilized 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 they are involved in collecting the by-products and transporting to the particular person/industry.

The sources of by-products are mulberry garden, grainage silkworm rearing and reeling.

The mulberry crop has to be well manured. The manuring includes cattle manure, manure of sheep/goat and silkworm faeces. It may be suggested that an effective, modified recycling procedure would be to dump silkworm faeces into fish ponds, where it can become the source of nutrition as a fish food.

Silkworm litter can be used a fertilizer as it contains more amounts of nitrogen. It is also used in bio-gas production. Excess of harvested leaves (accounting for 10-20% of harves), unfed leaves (20-30% of leaves furnished at each feed), larval litter (60% of ingested food), and exuvia of the moulted larvae are the major wastes generated in this activity. They are collected daily during bed cleaning. A part from these, rejects, or worms rejected because they are weak, diseased or unhealthy, and dead larvae also constitute wastes. The following uses have been found for them.

8.3.1. Uses of leaf and litter as compost

The amount of nitrogen, phosphorus and potassium present in the left-over mulberry leaf is 3.1, 0.5 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 if 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 1.5 X $1m^3$). Each day's collection of silkworm litter, mulberry left-over leaves, weeds (grasses etc) are spread in a thin layer. A mixture of fresh cowdung solution (4-5 kg cowdung in 100 liters of water) or biogas slurry, ashes (140-170g) and water (18-22 liters) 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 super phosphate of lime is added to enrich the nutrient value of the compost. When the pit is filled, it is plastered with a 25 cm layer of a mixture of mug and cowdung. This prevents flies from collecting on the garbage and creating nuisance. A shed of asbestcs or thatched roof prevents the pit from being soaked with rainwater. Compost can be dug 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 from 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 human pathogens that may grow on the garbage and also helps to prevent environmental pollution.

8.3.2. 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.

8.3.3. 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.

8.3.4.a. Uses of litter as Biogas

Silkworm litter can be effectively used as raw material in the biogas plant along with cowdung 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 maybe transferred to the next generation.

The quantity of cattle manure available with small and marginal farmers may not be sufficient to feed a small $2m^3$ biogas plant. Silkworm larval litter with a better biogas yield (96.20% more than cowdung) can be used as a supplement to cowdung 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 destroyed was also high in cowdung0silkworm litter incorporated treatment. The manorial value of the biodigested 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 microorganisms pathogenic to both mulberry and silkworm are alos possible in the bioidigester, since the environment in the digester is not conductive to the survival of these pathogens. This leads to a break in the perpetuation of pathogens and reduces the loss in cocoon crops due to diseases.

8.3.4.b. Pharmaceutical Industry

In China silkworm litter was used as manure, feed for fish during 1950. pharmaceutical and perfumery compounds are produced from silkworm litter in China. In 1970 paste chlorophyll, copper chlorophyllin sodium was produced from silkworm litter. In 1975 phytol, kerotine, triactinal, pectin were produced to utilize them in food, chemical, pharmaceutical, cosmetic 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 ($C_{55}H_{72}MgN_4O_5RCH_3$) is worth mentioning because it is in demand internationally for pharmaceutical and food processing industries. Food processing industries. Chlorophyll extracted from pine needless 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 as 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 chlophyll or 30 kg of sodium iron chlorophyll and that too with less expenditure than the conventional process of manufacturing it from dried alfalafa leaves. They have also developed a technique for producing fructose form silkworm litter.

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

Table 8.4. Other by products and their uses.

Sl.No	Product	Uses
1.	Paste chlorophyll	Chemical industry
2.	Copper chlorophillin sodium	Pharamceutical industry (fo Human stomach, liver, pancreas, cronic renal diseases); for wine, fruit concentrate preparation; Toothpaste, shampoo preparation.
3.	Phytol	To produce vitamin (K,A)
4.	Triactinol	As growth regulators in rice, wheat, maize, groundnut, vegetables
5.	Kerotine	To produce K vitamin, medicine for stomach, lung disease. To prevent cancer to these organs.
6.	Pectin	For preparing Jam, fruit juice concentrates, ice creams, medicines to control pressure and cholesterol

8.3.5. Pierced cocoons

Pierced cocoons produced in rearing are categorized as grade I waste. These cocoons and cut-open cocoons form 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.

8.3.6. Uses of Waste Moths

The moths unused for seed purposes, dead months, and the discarded eggs are generally dumped in pits and allowed to form compost without any commercial motive. But as some of these discarded moths and eggs are pebrinished, they may spread pebrine to the seed cocoons reared unless special care is taken to burn them.

The silkmoths, 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.

8.4. RECORDS AND USES

Maintenance of records helps the farmer to understand and act accordingly. It helps in money and man-power management.

8.4.1. Dairy

It is a useful record of rearing. It records the operations conducted, equipment used, labour-employed and money received and paid. Weather conditions and important events to be undertaken in future are also noted in the diary.

8.4.2. Cash Register

It is also maintained daily by recording the details of cash received and cash paid.

8.4.3. Egg Purchase Register

It is a record for entering the purchase of layings in a particular rearing, season and year. Nomenclature of the eggs such as race, voltinism, breed, etc., are noted for future record purpose. Further names and places of available4 grainages are also entered in the register.

8.4.4. Feed Register

Is is a record for entering all the feeds. The silkworm leaf eating capacity increase from fitst instar to last instar. So depending on their digestibility they are to be given adequate amount of mulberry Leaf. The records should contain day wise and feed wise record for every rearing. This also helps to know about the leaf utilised in a particular rearing.

8.4.5. Cocoon Production Register

It contains the record of cocoons produced in each rearing i.e. no of kg/crop or rearing/season/ it also contains the incidence of diseases in a particular crop, nature of damage caused by the pathogen and details of economics of rearing.

Further it contains rate of cocoons per kg of each rearing and name of the market where it is sold.

8.4.6. Wage Register

It is a register for the permanent labour force employed and the casual layout hired and their wages, attendance.

8.4.7. General Register

It is a record of miscellaneous items of expenditure such as land revenue, water rates, replacement of grainage implements and machines, tools, disinfactants etc.

8.4.8. Inventory

It is property record. It shows the number and value of each item such as land, building, water supply, livestock, equipment, machinery, cash in hand and in the bank and the amount to be paid or received.

SUMMARY

- ✦ Improved techniques of rearing are more important, for good crop results.
- ✦ All the aspects of silkworm rearing are carried with lot of care.
- ✦ Leaf yield increase from second year onwards with a rearing capacity of 1625 dfls (Five crops per year)
- ✦ 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 as animal feed. Silk glands of dead larvae are used for preparing suturing material.
- ✦ Silkworm litter can also be used in biogas production.
- ✦ In China silkworm litter is used in large scale for extracting paste chlorophyll, copper chlorophyllin sodium, pectin, kerotine, phytol, triactinol. All these are used in pharmaceutical, food, chemical and cosmotic industries.
- ✦ Pierced cocoons are used for hand spinning to get silk like ghicha, katia.
- ✦ Waste moths are used for compost, to treat impotence, abnormal menstruation and menopausal symptoms.
- ✦ Maintenance of records helps the rearer to carry on various activities in time.
- ✦ Diary is for recording daily operations performed in the rearing.
- ✦ Egg details are noted in egg purchase register.
- ✦ Feeding schedules are entered in fedd register.
- ✦ Crop produce are noted in cocoon production register.
- ✦ Further wage register, inventory, general registers are also maintained.

QUESTIONS

I. SHORT QUESTIONS

1. Mention the factors that influence economics of rearing
2. What are the reasons for poor cocoons 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 ?
9. What are the uses of diary ?
10. Mention any four records used in rearing house.
11. What do you entire in general registger ?

II ESSAY QUESTIONS

1. Detail about the economics of silkworm rearing
2. Explain the uses of silkworm litter
3. Brief about by products of rearing and their uses.
4. Write about rearing records.

REFERENCE BOOKS

1. Silk Worm Rearing, Volume-2-15/2, FAQ of United Nations, Rome, 1987.
2. Appropriate Sericulture Techniques,Manjeet S.Jolly, CSRTI, Mysore, 1987.
3. Hand Book of practical sericulture, Ullal & Narsimhanna, CSB, Bangalore, 1981.
4. Hand Book of Silkworm Rearing, Tazima, Agriculture Technical Manual-1, Fuji Publishing Co. Ltd., Japan, 1992
5. Techniques of Silkworm Rearing in the Tropic, ESCAP, United Nations, New York, 1993.
6. New Illustrated Sericulture Reader, CSB, Bangalore, 1997
7. New Technology of Silkworm Rearing, S. Krishnaswamy, CSRTI, Mysore.
8. An Introduction to Sericulture, Ganga & Sulochana Chetty, Oxford & IBH Publishing Co. (P) Ltd., New Delhi, 1995.
9. Principles of Sericulture, Hisao Aruga, Oxford & IBH Publishing Co. (P) Ltd., New Delhi, 1994.
10. Pattuparishrama (B.Sc.), P. Srinivas *etal*., Telugu Akademy, Hyderabad, 1996.
11. Pattuparishrama (Intermediate), P. Srinivas, Telugu Akademy, Hyderabad, 1996.
12. Text Book of Tropical Sericulture, Japan Overseas Co-operation Volunteers, Japan, 1975.
13. A Practical Guide to Mulberry Silk Cocoon Production, Krishnaswamy, Bangalore, 1994.
14. Sericulture Instructional Cum Practical Manual, Vol.II, NCERT, New Delhi,1990.
15. Bulletins on Sericulture, C.S.B., Bangalore.
16. Hand Book on Agriculture, ICAR, New Delhi, 1992.

17. Hand Book on Pest and Disease Control of Mulberry and Silkworm, ESCAP. United Nations, Thailand, 1990.

18. Silk in India, Statistical Biennial, C.S.B., Bangalore,1992.

19. Lecturers on Sericulture by Boraiah, SBS Publishers, Bangalore, 1994.

20. Global Silk Secnario-2001 by CSB, Oxford & IBH Publishers, Bangalore, 1996.

21. Annadata, Telugu Magazines, Vasundara Publications, Eenadu, Hyderabad.

22. Sericulture, Silk Worm Rearing Techniques, Department of Sericulture, Government of A.P., 1991.

GLOSSARY

APPETITE	Behaviour desirous for food
ASSIMILATION	Absorpotion and building up of simple food-stuffs, or products of digestion of food-stuffs, into complex constituents of the organism.
BIVOLTINE COCOONS	It produces white silk, the silkworms have two generations in a year.
BLEACHING	It is a chemical process involved in eliminating harmful micro-organisms.
BREED	Capability to propagate, give birth to.
BRUSHING	Process of transferring the newly hatched silk-worm larvae from egg shells into rearing trays.
CHAWKI REARING	Rearing of I,II,III instar silkworms.
COCOON	Protective covering of eggs, larvae etc.eg.eggs of some annelide are fertilized and developed in a cocoon. Larvae of many insects spin co-coons in which pupae develop.
LEAF CHOPPING	During early stages of rearing (Chawki) the worms are fed with finely cut leaves so as to enable to feed sufficiently.
DIGESTION	Breakdown of complex foodstuffs by enzymes to simpler compounds which can be incorpo-rated into metabolism.
DEBRIS	It is an unwanted, waste product.
SPINNERET	A Special organ used to spin the cocoon found in certain insects.
DENIER	A number which indicates the weight in grams of 9000 meters of silk filament/yarn etc.
DFL's	Disease Free Layings.
DISINFECT	The destruction and extermination of disease causing germs.

DIMILIN	It is a chemical used to sterilize an animal especially insects.
ECDYSIS	Moulting. In Arthropoda, periodic shedding inner part of old cuticle is absorbed the rest is split at line of weakness, and the insect draws itself out, clothed in a preformed soft new cuticle. By swallowing air the insect quickly increases its bulk and the new cuticle finally hardens a size larger than the old. The lining of all but the finest tracheae is shed with the old cuticle. Ecdysis in insects is initiated by a hormone (ecdysone), periodic ecdysis produce a succession of stages of growth and development called instars, the last of which is the adult.
EXCRETION	Getting rid products of metabolism either by storing them in insoluble form by removing them from body.
FERMENTATION	Decomposition of organic substances by organisms especially bacteria and yeasts. Eg. Decomposition of sugar forming ethyl alcohol and carbondioxide by yeast. Sometimes means anaerobic respiration.
FLIMSY COCOONS	Defective cocoon which possesses very thin shell consisting little amount of silk.
FLOSS	It is the outer most loose, fragmented layer of cocoon. It is to be removed while reeling. It is a waste silk.
FYM	Farm Yard Manure. It is a manure made by waste products such as a dung, urine and litter of farm animals.
GLOSSY LEAF	It is the largest leaf found on the top of the shoot among the first few leaves. It is smooth, glossy and light green.

GOSSAMER LAYER	After spinning the compact shell (cocoon) the shrinking larvae warps itself in gossamer layer (palade layer) and detaches itself from the shell to undergo pupation.
GROWTH	Increase in size of the body
HATCHING	Emergence of developed embryo from egg.
HYGROMETER	It is instrument used to measure humidity of the environment.
HYGIENE	It is a state where total healthy conditions are available.
INSTAR	Stage indevelopment of an insect, between two ecdyses or the final adult stage.
INCUBATION	Preparation of eggs for hatching or providing suitable conditions favourable for uniform development of embryo.
LARVA	The pre-adult form in which some animals hatch from the egg; capable of feeding for itself though usually in a way different from adult; but usually incapable of sexual reproduction and distinctly different from sexually mature adult in form. Changes into adult, usually be a rather rapid metamorphosis.
LATE AGE REARING	Rearing of IV and V instar worms.
LAYING	The total number of eggs laid by a single silkmoth
METAMORPHOSIS	Period of rapid transformation from larval to adult form. Often involves considerable destruction of larval tissues.
MORALITY	It denotes the death rate of an organism.
PENTAMOULTERS	The larval life stage of an insect moults for five times.
PHYSIOLOGY	Study of the processes which go on in living organisms.

PROTEIN	Very complex organic compound, composed of many amino acids.
PUPA (CHRYSALIS)	Stage between larva and adult of endopterygote insect, in which locomotion and feeding cease but great developmental changes occur.
SUCCULENT	Having a fleshly appearance.
PROTHETELY	Intermediate form between larva and pupa of an insect.
SILK	A fibrous protenous secretion secreted by certain insects.
SILK GLAND	It is a modified salivary gland found in silkworms for synthesis of silk, which will be used to spun the cocoon for undergoing pupation.
GHICHA	Yarn drawn by hand out of tasar cocoons without any twist. Waste mulberry cocoons are also used for this kind.
KATIA	Yarn spun out of tasar and mulberry waste after opening and cleaning.