1.1 Introduction

Sericulture refers to mass scale rearing of silk producing organisms in order to obtain silk from them. There are five major types of silk of commercial importance, obtained from different species of silkworms which in turn feed on a number of food plants. India is unique in its biodiversity and bounty of nature in having varieties of silk. Except mulberry, other varieties of silks are generally termed as non-mulberry silks, namely: Tasar, Muga, Eri etc where these silkworms thrive on nature grown host plants. These groups have been now given a new identity and are collectively known as “Vanya silks”.

In recent times, Vanya silks have assumed more importance in view of the scope for the transformation of this age-old tradition into industry with
immense potential. The country has rich natural resources and manpower and the challenge is to utilize these to bring about a balanced development without much disturbance to the forest ecology, traditional culture and the way of the way of life of the primary producers. Vanya silk culture is neither detrimental to the food plants available in forests, nor disturbing the forest ecology. When Vanya silkworms are reared on the food plants, they feed on the leaves and the litters spread in and around the plant, resulting in effective nutrient recycling.

1.2 Distribution

**Tasar**: China is the largest producer of tasar followed by India. Tasar producing states in India are Jharkand, Chattisgarh contributing 70% of the production, Andhra Pradesh, Orissa, West Bengal in appreciable quantities, while U.P, Maharastra, Bihar and Madhya Pradesh are minor producing states.

In Andhra Pradesh tasar growing districts are Adilabad, Karim Nagar, Warangal, Khammam and East Godavari.

**Muga**: Muga production is confined mainly to the state of Assam to 95%, as it is an integral part of traditional culture of that state. To a small extent it is seen in Meghalaya.

**Eri**: The states of Assam, Nagaland, Meghalaya and Manipur contribute to 98% of countries production. Other states practicing in small scale are Arunachal Pradesh, Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh and Tamil Nadu. (Fig. 1.1)

![Fig. 1.1 Distribution](image-url)
1.3. Saitent features of Non-mulberry silkworms

**Tasar:** The word tasar, apparently derives from the Sanskrit word Trasara {shuttle}. Tasar silk is mentioned in literature dating back to 1590 BC. The Indian tasar silkworm, Antheraea myleTta is a natural fauna of tropical India. Wide distribution and Polyphagous of this insect species had resulted in extensive variation in the population. As high as 19 ecoraces have been reported in this species which feed Terminalia species and Shorea robusta and also on number of secondary food plants.

The ecoraces are uni, bi or trivoltene depending upon the geo-ecological conditions and differ from each other in qualitative and quantitative traits. Tasar cocoons are reported to be largest among the silk producing in the world. Tasar silk fiber has its own distinctive color, is coarse to feel but has higher tensile strength, elongation than mulberry silk fiber. These properties have made tasar silk a competent and desirable as mulberry silk.

**Muga:** Muga silkworm is one of the economically important wild silk moths whose genome is among the least understood, is unique among saturnidae moths. Native of Assam and named after Assamese word “muga” which indicates the amber (brown) color of cocoon .It belongs to same family as Tasar. It is popular for its natural golden color, glossy fine textures and durability. *A. assama* is an endemic species prevalent in the Brahmaputra valley and adjoining hills. It is a polyphagous insect, which feeds on leaves of Som, Soalu and other plants. By virtue of the narrow ecological distribution of host food plant, *A. assama* is confined to only Assam state of India. Empirical observations show that the population is declining due to depletion in genetic variability. The silk proteins of this species have not been studied so far despite their unique properties of providing golden luster to the silk thread. The popular items made from this silk are ‘dhothi’, ‘chaddar’, ‘chapkan’, ‘pugree’ and mekhala.

**Eri:** The name eri derives from the Assamese word ‘era’, which means castor-oil plant, the main food plant of this silkworm. *Samia cynthia ricini* a multivoltine silkworm commonly called as ‘eri silkworm’ is known for its white or brick-red eri silk.

The primary food plant of this polyphagous insect is castor (*Ricinus communis L*), but it also feeds on a wide range of food plants such as Heteropanax fragrans, Manihot utilissima, Evodia flaxinifolia, Ailanthus gradulosa etc. The wild *S. C. ricini* silkworm completes one to three generations per year depending on geographical position and climatic conditions of the region, however, up to six generations occur in the domesticated cultures. Populations of *S.C.ricini*, that have been commercially exploited and are present in different regions of north-east India show wide morphological and quantitative variations.
in characters such as silk content, larval weight, cocoon weight, cocoon shell weight and silk ratio. Eri silkworms were successfully acclimatized in America and Europe, but could not take firm hold.

1.3.1 B. Life cycle of Tasar

**Scientific name:** Antheraea mylitta.

**Food plants**

- **Primary:** Terminalia tomentosa, Terminalia arjuna.
- **Secondary:** Terminalia catappa, Zizyphus jujube.

**Egg:** The egg is oval, dorsoventrally symmetrical along the anterio-posterior axis, about 3mm in length and 2.5 mm in diameter. It weighs approximately 10mg at Ovi-position and it is dark brown in color. Two brownish parallel lines along the equatorial plane of the egg divide the surface into three zones, disc, streak and edge. Eggs undergo incubation for 3-5 days.

**Larva:** The larva is typically cruciform and has a hypognathous head with biting and chewing mouth parts. On hatching it is dull brownish yellow with black head. The body normally turns green and the head brown after 48 hours, but also yellow, blue and almond colored larvae are seen occasionally. The size and weight at maturity are about $13 \times 2.1$ cm and 50gms. The larva passes 5 instars within a period of 26-28 days for I crop, 42-45 days II crop, 55-60 days III crop.

The prothoracic hood of the first instar larvae dorsally bears an oval black spot, which early in the second instar becomes M-shaped and then, later on V-shaped with two dots. These marks are absent in the third instar, but reappear in the fourth and fifth instars as two semi lunar red markings.

The anal flap bears a triangular black mark early in the first instar, which becomes V-shaped and brownish from the second instar onwards. The triangular mark on each of the claspers is black in the first two instars and brown in the succeeding instars.

Early in the first instar the larvae have a black mid-dorsal line extending from the first to the seventh abdominal segment and a dumb-bell shaped black mark on the eighth segment. Laterally, the first seven abdominal segments have a pair of black vertical lines, and on the eighth abdominal segment there is a single oblique line. The vertical lines are replaced by V-shaped marks late in the first instar. Each of the abdominal feet bears a horizontal black mark. All these markings disappear in the later stages of development. First to fifth instar larvae have a red mid-ventral line extending the length of the abdomen.
Third-instar larvae have a yellow lateral line extending from the second to the tenth abdominal segment. This line is bordered by a brown upper line in fourth and fifth-instar larvae.

**Tubercles**: The body of silkworm larvae has prominent protrusions or outgrowths on thoracic and abdominal segments. These outgrowths are called tubercles. They work as sensors for changes in environment related to temperature and humidity. Based on the position five types of tubercles are recognized. Dorsal (DT), upper lateral (LT), lower lateral (LLT) and caudal (CT). They are black in the first instar, orange red in the second and violet in the third to the fifth instar.

**Hairs and Setae**: The larval body is covered by hairs and setae. The hairs are white, minute and irregularly distributed over the body. The number and arrangement of setae vary according to the type of tubercle, body segment and age of the larvae. Generally, the total number of tubercular setae remains constant until the third instar and diminishes thereafter.

**Shinning Spots**: Silvery white lateral shining spots, either oval or triangular, appear during the third instar at the foot of upper lateral tubercles of the second to the seventh abdominal segment. Six regular and thirty-eight irregular patterns have recorded. Plain larvae are also common. Other shining spots are present at the base of the dorsal tubercles. These are brick red in green and yellow larvae and white in blue and almond-colored larvae.

**Sex markings**: The sex markings appear late in the fifth instar as milky white spots on the ventral surface of the eight and ninth abdominal segments.

**Pupa**: The pupa is obtect, having a well-defined and segmental body. It is dark brown in color and weighs 10 to 12gms.

**Cocoon**: The cocoon is single shelled, pendent, oval, closed and reelable, having a hard non-flossy shell with fine grains. At the anterior end, there is a well-formed dark brown peduncle with a ring at the distal end. The cocoons are generally yellow or grey. The females spin larger cocoons than the males.

**Moth**: The moths exhibit distinct sexual dimorphism. The females are bigger (4.5 cm), with a distended abdomen and narrow bipectinate antennae (1.5 cm long). The males are smaller (4.0 cm), with a narrow abdomen and broad antennae. The females are polymorphic in color, being grey and yellow, whereas the males are brown.

There are two pairs of wings attached to the middle and hind thoracic segments which differ in size. Each wing carries a vividly colored eye like patterned referred as ocellus. The colored core of the ocellus is called the hyaline area.
Life cycle of Tasar

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

Abdomen Segments
(a) Female; (b) male
Key: bw = brain window, An = antenna
TL = thoracic leg, Ga - genital aperture
Ao = anal opening

A.mylitta (C) Pupa (D) Cocoon

Male
Female
(E) A.mylitta Moth
Rearing

Tasar silkworm being wild semi domesticated, polyphagous, their rearing is much different from the rearing of Bombyx mori. While mulberry silkworm is reared indoor, tasar silkworms are reared outdoors. Outdoor rearing causes 50-55% [during early instars] loss due to diseases and pests, predator. Since the larva are exposed to natural conditions, the fate of the crop largely depends on choice of rearing site and food plants, brushing supervision and maintenance of larval population and other rearing operations. Tasar silk worms are mostly bi voltine or trivoltine. Bivoltine crops have the advantage of producing better quality cocoons per dfl due to the mild climatic conditions prevailing during that period. The cocoons are collected from the branches of food plants and marketed. The produce is measured in "Kahans" [1 Kahan = 1280 cocoons] and sold in numerical lots, which are as follows.

Ganda [4 cocoons], Pan [80 cocoons]

Kahan (1280 in Bihar, 1600 in Orissa, 1000 in M.P), Khandi (4000 in Maharashtra).

![Fig. 1.3. (A) Outdoor Rearing (B) Grainage](image)

Life cycle of Muga

Scientific name: Antherea assamensis.

Food plants

Primary: Machilus bombycina (som), Litsea polyantha (soalu).

Secondary: Litsea salicifolia, Celastrus monosperma.

Egg: The eggs are streakless, brownish and weigh 9 mg. The duration of the egg stage last for 7 days in summer and 16 days in winter.
**Larva**: The larva undergoes four moults and passes through five instars within a duration period of 26-28 days in summer, 50-65 days in winter.

The newly hatched larva is characterized by prominent black intersegmental markings over the yellowish body with brown head. After the first moult the body turns green, while head remains brown. At maturity

**The body weighs 15gms.**

In the third instar, the prothoracic hood marking consists of two prominent rectangular black marks which in the subsequent instars; these are replaced by a pair of semi lunar deep brown markings.

The anal flap carries posteriorly, a rectangular black mark in the third instar. In the fourth instar, it becomes U-shaped, with the two arms joining the lateral line, and in the fifth instar, it changes to V-shape with a black inner and a deep brown outer border.

The dorsal, upper lateral and lateral tubercles (DT, ULT and LT) are bluish and lower lateral tubercles are brown in the third instar. However, the first three change to brick red subsequently. The larval duration period in summer is 28-35 days whereas in winter 50-65 days.

**Pupa**: The pupa is copper brown in color and weighs about 5.7gms.

**Cocoon**: The cocoon is single shelled, light brown, oblong, closed reelable and slightly flossy with a weak peduncle and weighs about 6.3 gms with a soft shell about 0.5 gms. The cocoon is golden brown or glossy white in color.

**Fig. 1.4. Life Cycle of Muga**

**Moth**: The moths exhibit distinct sexual dimorphism. The female moths are larger than males. The fore and hind wings are brown, rarely with a pinkish tinge. The females have larger wings than the males and the ocellus of the female moth has a strikingly reduced hyaline area, which in fore wing is almost dot like
and the hind wing a horizontal slit. The area of the ocellus is greater in the hind wings.

Fig. 1.5. Female Moths Wings

**Rearing** : Muga silkworm is a multi voltine species with 5-6 generation in a year reared in out doors. Based on the assamese calendar the different generations are termed as follows jarua, chotua, jethua, Aherua, Bhodia and Katia. Of these six generations only autumn (kotia) and spring (jethua) are more favorable for commercial rearing. The other seasons are generally useful for seed stock maintenance and multiplication.

Hatched larvae along with khorika (the moths in copulation position are tied on a straw bundle or tender twigs called khorika) are tied to tender twigs of the food plant. When the leaves are fully consumed by the larvae they are transferred to another tree by means of triangular bamboo trays called “chalooni”. The ripe worms are placed on mountages for spinning. The mountage is called ‘Jali’ which is a bundle of dry twigs and leaves.

Fig. 1.6. Muga Rearing
Life cycle of Eri

Scientific name: Cynthia ricini.

Food plants

Primary: Ricinus communis, Heteropanax fragrans.

Secondary: Jatropha curas, Carica papaya, Plumera rubra.

Egg: The eggs are ovoid, candid white and weigh about 6 mgs.

Larva: The larva on hatching is greenish yellow. The body color changes gradually to pure yellow by the end of third instar. From the third instar onward the body color segregates into yellow, cream, green, blue or white. The fully matured larva weighs about 8gms, is translucent and covered with a white powdery substance. Both spotted and unspotted larvae are found. The spots are of various types single, double, zebra and semi-zebra.

The prothoracic hood of the first instar larva has a black dorsal band which splits into a pair of crescent shaped markings in the second and third instar. These markings disappear during the fourth instar. The area around the antennae acquires a black dumb-bell shaped mark in the fourth instar, which in the fifth instar, splits into two oval dots.

The planta, anal flap and claspers are light yellow throughout the larval span. The planta has a horizontal blue band at the top. Early in the first instar, the markings on the anal flap and claspers are black and appear as a continuous band. In the second and third instars, the black marks are triangular on the anal flap and rectangular on the claspers. These marks disappear in the subsequent instars. The lateral line is creamy white and extends throughout the body length.

The tubercles are very conspicuous and tubular in shape. They are bluish at the base and cream at the tip. The setae are pointed and blackish, number 180 at third instar.

Pupa: The obtect aedectious pupa does not depart from the basic saturnidae pattern. It weighs about 2.6gms.

Cocoon: It is elongated, soft, woolly, peduncleless, open mouth and non- reelable. It weighs about 3gms and exhibits color polymorphism, being brick red and creamy white. The cocoon shell weighs around 0.4gms.

Moth: The moths exhibit distinct sexual dimorphism. The females are larger than males. The wing span of male is lesser than female. The fore wings and both sexes are more or less similar in structure and color pattern. The color is brownish, blackish or chocolate. The shape of ocellus is crescent shape. A
conspicuous black spot, the pterostigma with a whitish tinge is present at the wing apex. In addition, the wing has a few white oblique lines.

**Fig. 1.7. Life Cycle of Eri**

**Rearing**: Eri silkworm is polyphagous in nature and multivoltine which is reared indoor. Rearing these silkworms is entirely different from other wild silkworms. It requires ideal rearing house and a rearing rack. Worms are mounted on split bamboo tape (chandrika pool). Rearing of 100-125 layings from hatching to ripening requires about one metric ton of foliage.

The lifecycle of this silk moth runs for 49-53 days, depending upon climatic conditions. The duration shortens to around 49 days during the monsoon and the summer and lengths during the winter. Thus six generations are possible in a year.

**Fig. 1.8. Eri rearing stand**
Summary

- The silk obtained from other than mulberry silkworms are termed as non-mulberry silk.
- India is unique in producing all commercial varieties of silk i.e., mulberry, tasar, eri, muga.
- The wild silkworms which thrive on nature grown host plants are “Vanya silks.”
- Sexual dimorphism - differentiation of two sexes by observing the external characters.
- Non-mulberry silks are practiced by the tribal people inhabiting mostly central, eastern and north-eastern regions.
- In recent years, tasar which used to be an item for domestic consumption has attracted the foreign markets, and exports.
- Muga silkworm is indigenous to the north-eastern region and found nowhere else in the world.
- Eri as an attracting modern silk fiber can be blended with other yarns imparting a special texture and feel to the fabric.

Short Answer Type Questions

1. Define Vanya silks or non-mulberry silks.
2. What is polyphagous?
3. Name the places which are producing tasar silk in India.
4. Which place is monopolized for muga silks?
5. Name the scientific names of Tasar, Eri and Muga silkworms.
6. Mention the food plants of all the non-mulberry silkworms.
7. What are the items made of Muga silk?
8. What is chalooni?
9. Write the characters of Tasar, Eri, and Muga cocoons.
10. What is ocellus?

Long Answer Type Questions

1. Discuss the distribution of the non-mulberry silkworms.
2. Describe the salient features of non-mulberry silkworms.

3. Explain the life cycle of Tasar silkworm.

4. Write about the life cycle of Muga silkworm.

5. Explain briefly the life cycle of Eri silkworm.
UNIT 2

Rearing House

Structure

2.1 Introduction
2.2 Selection of building site
2.3 C.S.B. Model rearing house
2.4 Types of rearing houses

Learning Objectives

• To know importance of rearing house.
• To study the facilities of rearing i.e., rearing site, orientation and rearing house.
• To know different model rearing houses in India.

2.1 Introduction

The mulberry silkworm Bombyx mori is delicate, domesticated animal which cannot tolerate diurnal and seasonal fluctuations in the environmental conditions which occur in nature. Hence they are reared in special rearing houses.

Most of the commercial rearers in India are small holding farmers who previously were using own houses for rearing silk worms. Presently adapting new technologies they started to construct separate rearing houses for better results. Natural fluctuations in the environmental conditions outside are reduced to the minimum, in that the silkworms receive more uniform conditions. Enough space must be available to carry out leaf preservation, young age rearing.
late age rearing and mounting. It should also be convenient enough to conduct effective cleaning and disinfection.

### 2.2 Selection of building site

The site for rearing house must not be waterlogged. For a high rainfall area, a dry, sunny, well ventilated and well drained land should be selected or there should be a basement high enough to secure a dry floor. For a region where rainfall is scarce, wind velocity is high, climate is dry and temperature fluctuation is more, cool sunny and rather moist place should be selected. For the regions of high temperature and high humidity, rearing house should be built where good aeration and shade are available. Too stagnant air due to thick vegetation all around the rearing house or too much open area with strong wind should be avoided. Generally it must supply plenty full of fresh air, without being exposed to violent draughts or direct heat of sun.

#### 2.2 (A) Orientation of rearing house

The orientation of the rearing house is very important as it affects the temperature and humidity of the room. The orientation of the building should be such that the interior is protected from direct sunlight. In tropical regions, the best orientation of the building will be north-south. The doors and windows are on north-south walls and width side of the buildings in the east-west direction, avoiding direct sunlight into the rooms.

If this ideal orientation cannot be secured, the next best should be north-west face and south-east back. A room which faces east is quite alright in the morning, as the rays of the early morning sun would help warm up the cold night air to a desirable level. But the afternoon sun will make the room get hotter and hotter leading to drying up of leaves. A room facing west should be least convenient for the rearing of silkworms. In all these cases open verandah and shade trees have beneficial influence in moderating heat. When rooms face east or west, broad verandah should be provided or shade trees should be planted on the exposed side. In temperate and sub-tropical region, rearing house should be constructed in north-south direction with doors and windows facing east-west. By this method, maximum sunlight is available to warm up the rearing rooms adequately.

#### 2.2 (B) Size of the rearing house

The size of the rearing house depends largely upon the quantum and type of rearing. Space requirement is minimized in shelf or stand rearing and maximum in floor rearing. In general, a floor area 2sq. ft/dfl is required for tray method and 4sq. ft/dfl in the case of shoot feeding method.
2.2 (C) Points to remember in construction of rearing house

1. The width of a room must be small in proportion to its length to regulate the inequalities of temperature.

2. Windows should be provided so as to admit free passage of air. It would be especially good if ventilators are also provided on the upper part of the wall opposite one another.

3. Verandahs of 4ft-6ft should be provided at least on that side which is most exposed.

4. The roof of the building should be non-conducting material, the roof structure can be simple and made up of thatch, country tile etc depending on the need and the availability. A high roof is better than a low one and a false ceiling is desirable.

5. To prevent uzi entry into the rearing house, uzi nets should be meshed for doors, windows and ventilators. Anti- uzi proof chamber can be provided in front of rearing room to avoid uzi entry.

2.3 C.S.B. Model rearing house

It is a rat proof building provided with a projecting ledge all round at plinth level. The projection should be at least 0.35 to 0.40m to effectively prevent the rats from gaining access to the rearing house. The stairs should also be movable so that the same could be pushed away during night time and the building rendered completely rat proof.
The building should be provided with a verandah of 2.45m all round and also with doors and windows to ensure good ventilation and light. The rearing house should have a ceiling of wood or it should be provided with a false ceiling if the roof is of cement concrete or tiles. Height of the ceiling should be at least 3.65m. Ventilators should always be provided to ensure free circulation of air.

The rearing house is partitioned into four convenient rooms, in one of which, by maintaining high temperature and humidity, the young age silkworms could be conveniently reared.

2.3 (A) Rearing room for young age larvae

The young silkworm larvae require relatively high temperature and high humidity. The rearing rooms should be constructed in such a way to regulate the same besides better ventilation and provision for disinfection. The chawki rearing room should not be too big to facilitate effective control of temperature and
humidity. Hence it is advisable to select a smaller rearing room with proper windows and doors to close for maintaining the temperature and humidity.

Fig. 2.3 (A) Chawkic rearing house for 200-300 dfls.

Fig. 2.4 (B) Chawkic rearing house for 500-600 dfls.

2.3 (B) Rearing room for late age silkworm larva

Rearing house for late age rearing should have larger area with good ventilation for manipulation of humidity and temperature apart from provision for preventing uzi flies. If the building is too large, it is difficult to regulate the indoor temperature and humidity, windows and doors should be provided for ventilation suiting to various climatic conditions.
2.4 Types of rearing houses

i. Mud wall and mangalore tiled roof.

ii. Mud wall and country tiled roof.

iii. Mud wall and thatched roof.

iv. Plank wall and thatched roof.

v. Raised platform type floor, bamboo mat wall and thatched roof.

vi. Double brick wall and mangalore tiled roof.
vii. R. c. c building

Front Elevation

Ground Plan

Fig. 2.6 Double Wall and Mangalore Tile Roof Model
Fig. 2.7 Mud Wall and Country Tile Roof Model
Front Elevation

Ground Plan

Fig. 2.8 Mud Wall and Mangalore Tile Roof Model
Fig. 2.9 Mud Wall Thatched Roof Model
Fig. 2.10 Bamboo Wall and Thatched Roof Model
Fig. 2.11 Plank wall with thatched roof
Summary

• Silkworm rearing needs specified environmental conditions. Hence, rearing houses are planed to provide the conditions required, for better results.

• Rearing site supply a plenty full of fresh pure air, without being exposed to violent draughts or direct heat of sun.

• The best orientation of rearing house is north and south following northwest and southeast, lastly east.

• Commercial farmers have to maintain a separate rearing house for young age and late age to regulate the necessary environmental conditions.

• Rearing houses constructed with mud walls and thatched roof are good for tropical conditions.

**Short Answer Type Questions**

1. Which is the best orientation for rearing house.
2. Mention different types of rearing houses.
3. Which type of rearing house is ideal for tropical conditions.
4. How uzi entry is restricted in designing of rearing house.
5. How the chawki rearing room should be designed.

**Long Answer Type Questions**

1. Selection of rearing site is important-justify it.
2. Discuss the orientation of rearing house.
3. Describe and draw ground plan of the C.S.B model rearing house.
4. Mention few points to remember in construction of rearing house.
UNIT 3

Rearing Equipments

Structure

3.1 Introduction.
3.2 Equipment and uses
3.3 Chemicals used in rearing house.

Learning Objectives

• To study about the rearing equipments.
• To know about the chemicals used in rearing house

3.1 Introduction

Sericulture is a rural based industry and accordingly the appliances used are made from cheap and locally available materials. Hence, the appliances differ from place to place and also according to the system of rearing and leaf harvest method.

Anyhow in silkworm rearing the equipments should be properly arranged without wasting the space and should be clean and convenient for practicing disinfection.

The most common method of rearing in India is shelf rearing where within a limited space the worms are reared. The size of the silkworm rearing and number of equipment required depends on the availability of mulberry leaf.
3.2 Equipments and uses

(a) Rearing stands

The stands are frames made of wood or bamboo, which are arranged in vertical rows in the rearing room. It measures 2.5m height, 1.5m length and a width of 0.65m. It has 10-12 shelves with a space of 0.15m to accommodate ten rearing trays. Six stands are required for each rearing room. Fig. 3.1 a.

(b) Rearing trays

Rearing trays are portable receptacles for keeping worms during rearing. There are many kinds of trays differing from one another in material, shape and size.

(c) Bamboo trays

The bamboo trays are most popular as they are light and easy to handle. These trays are locally available at marginal cost. It measures 138cm diameter with a depth of 6.5cm and round in shape. Fig. 3.1 b.

(d) Rectangular trays

Rectangular trays are made of light wood with dimensions of 0.9cmx1.2cm are used for young age silkworm rearing in the box rearing method. The trays are placed one above the other directly on a stand. About four such trays are required to rear 100dfls up to second instar. 8 to 10 trays are required for rearing up to third moult. Fig. 3.1 C.

(e) Ant wells

Ants are serious menace to silkworms. Hence ant wells are used to avoid there crawling. The legs of rearing stands are rested on the ant well and are filled with water. Enamel or aluminum trays of convenient size are sufficient for this purpose. Cement ant wells of 21x21x8cmsize with a groove of 4cm can also be used. On the other hand a piece of cloth dipped in kerosene can be placed around the legs of rearing stand. Dusting of BHC also prevents entry of ants. Fig. 3.2.
Fig. 3.1 Rearing Equipments

Fig. 3.2 Rearing Equipments
(f) **Paraffin Paper**

This is a thick craft paper coated with paraffin wax \([m,p55^*c]\) is used to prevent evaporation of moisture and to maintain high humidity in the rearing bed of the young silkworms there by prevents withering of chopped leaves.

(g) **Foam rubber strips**

Long foam strips of 2.5cm wide and 2.5cm thick, soaked in water are placed all around the bed of young worms. Thick folding of newspaper soaked in water may be used instead of foam strips. This is used to maintain high humidity in bed of young worms.

(h) **Chopsticks**

The bamboo stick is 17.5 to 22cm long, thin girth and tapering. At the thick end the two sticks are connected by a small thread. These sticks are used like a forceps for picking worms for hygienic reasons and to prevent damage of young worms. (Fig. 3.3)

(i) **Feather**

Birds feather, preferably white ones are used for brushing newly hatched larvae from the egg card to the rearing trays and to spread the young worms during spacing operations. (Fig. 3.3)

(j) **Chopping board**

This is a rectangular board made of soft wood used for cutting mulberry leaf in the desired size for feeding the worms in different instars. The size of the chopping board may be 0'9x0'9m and 5cm thick or any other convenient size.

(k) **Chopping knives**

Chopping knives are used for cutting the mulberry leaves. They are usually 0.3-0.5m long with a broad knife blade and wooden handle. (Fig. 3.3)
(l) Mats

These are placed below the chopping board prior to chopping and used to collect cut leaves. Clean newspaper may be used instead. They prevent the dust and dirt on the floor getting mixed in with the leaves.

(m) Feeding stand

A folding stand of 0.9mts height, made of wood are used to place the removed trays from the stand for feeding and bed cleaning. A lot of different height, adjustable heights and revolving types have been introduced in the field

(n) Bed cleaning nets

Nets of different mesh size (2mm, 10 mm and 20mm) made of cotton or nylon thread is used for different stages of the silkworm. They are used for cleaning the rearing beds and at least two nets are required for each rearing tray.

Using of bed cleaning nets is advantageous to avoid direct handling of larvae, which facilitates proper maintenance of hygiene resulting in their healthy growth. (Fig. 3.4)

(o) Leaf chamber

A rectangular chamber made of wooden reapers with a size 1.5mt long, 0.9mts wide and 0.8 m of depth is used to store harvested mulberry leaf. Wet gunny cloth is covered on all sides of the leaf chamber. Water is sprinkled periodically on the gunny cloth to keep the leaves inside the chamber fresh.

![Fig. 3.4. Rearing Equipments](image-url)
(p) Mountages

The equipments used for supporting the larvae when they spin their cocoon are called mountage. There are different types of mountages basing on the availability of local material, cost, convenience of storage, drying etc. But presently there are newly modern devices used for better results.

Chandrika; which is made up of bamboo is most popular in south India. This consists of a bamboo mat of size 1.8x1.2mt supported by a split bamboo reapers on all sides. On the bamboo mat, a bamboo tape of 4-5cm width is wounded in a spiral manner. It accommodates about 1,000—1200 worms for cocoon spinnig.

There are various other types of mountages, plastic collapsable mountage, straw mountage, bottlebrush and rotary mountages. The advanced mountage is rotary mountage which gives best results. (Fig. 3.5)

![Chandrika and Rotary mountage](image)

Fig. 3.5 Chandrika       Rotary mountage

(q) Hygrometer and Thermometer

These equipments are used to record the temperature and humidity of the rearing rooms and helps to maintain ideal conditions for the growth of silkworms.

(r) Shoot rearing stand

Shoot rearing stand having 4 tiers of 5to 5 ft width is convenient, the length of the stand is optional basing on building size and convenient. The first rack should be at least 1ft above the floor. There should be a gap of 2ft between rack to rack. A moving space of 2ft gap between stands; and at least 4-6 ft working space has to be maintained. A gap of 3-4ft between the roof of the building and upper most rack is must. (Fig. 3.6)
(s) Sprayer

Normally formalin solution of 2% is used for disinfection of rearing house and rearing equipment, a sprayer to spray any disinfection solution either hand or power operated is needed.

**Other equipments**: like humidifier to raise the humidity, an oven or stove to warm up the rearing room, a floor mat soaked in formalin kept at the door to prevent germs entering the room and a washbasin to wash hands those who operate the rearing activities.
For successful rearing of silkworm, maintenance of hygienic conditions is necessary. To prevent and control the micro organisms disinfectants like formaldehyde, Para formaldehyde, bleaching powder, sodium hypo chloride, slacked lime powder are necessary. Silk worms are not so exceptional for diseases and pest, hence some chemicals are used as precautionary resham keet oushad (R.K.O), uzi cide, china clay dimiline and dithaneM-45 or capton are used.

**Summary**

- Rearing equipments must be simple, easy to handle, available at a low cost and also should be convenient for disinfection.
- Bamboo is used for preparation of stands, trays, chandrika, are popular and available easily at local places.
- Paraffin paper, foam rubber strips are important in regulating temperature and humidity during chawki rearing.
- Leaf chamber or earthen pots or cloth is used to preserve harvested leaves as it is done twice in a day.
- As a part in maintenance of hygienic conditions chopsticks, bed cleaning nets, formalin mat, wash basin stands are used.
- Rotary mountage is advanced and best for getting good quality cocoons.

**Short Answer Type Questions**

1. What is the importance of ant well?
2. What are the advantages of bamboo trays?
3. Name any four equipments used in chawki rearing.
4. What is the purpose of paraffin paper in rearing?
5. Write the use of foam rubber strip in chawki rearing.
6. Mention any four mountages used in rearing.
7. Write different sizes of bed cleaning nets used in rearing.
8. What are the chemicals used in disinfection?

**Long Answer Type Questions**

1. List out the rearing equipments and explain six important equipments used in rearing.
2. Describe few rearing equipments with neat sketches?
3. Write about disinfectants and chemicals used in rearing.
4. Draw neat diagrams of the following equipment and mention their uses.
   (a) Antwel    (b) Chop stics   (c) Leaf chamber
UNIT 4

Preparation for Rearing

Structure

4.1 Introduction
4.2 Cleaning
4.3 Disinfection methods
4.4 Preparation of disinfectants
4.5 Maintenance of hygienic conditions.

Learning Objectives

• To know about the process of various disinfection methods used in silkworm rearing.

• To know preparation of disinfectants for disinfection of equipments and rearing house.

• To know the importance of maintenance of hygienic conditions for ideal rearing

4.1 Introduction

The first fore most operation in rearing is preparation for disinfection. Disinfection forms an integral part of healthy and successful silkworm rearing, which aims at destruction of disease causing microorganisms present in the rearing room and surroundings. The disease caused by bacteria, viruses, fungi and protozoa affect the silkworm. These pathogens released by diseased silkworms easily accumulate and spread in the rearing environment through different routes.
They are not easily destroyed and can persist for longer period under congenial condition. The spores of pathogens especially those of fungi are light and can easily away by air current there by easy in spreading of disease. There are no curative methods for any of silkworm diseases. Hence it is better to follow the “Prevention is better than cure’. This can be achieved by adoption of proper and effective methods of disinfection.

4.2 Cleaning

This process has to be done prior to disinfection. The rearing room and surroundings has to be thoroughly swiped with out any dust and dirt .All the accumulated junk, debris diseased and dead larvae should be collected and burnt out .If there is stagnation of water , it has to be drained to avoid the development of microorganisms. All the crevices and holes in the rearing room should be closed. The ceiling and walls of the rearing has to be cleaned. The rearing room and appliances are washed thoroughly with water and dried under sun. In case of chandrika the waste sticke to mountage is burnt with match stick.

Fig. 4.1. Cleaning of Rearing House
4.3. Disinfection methods

The destruction and extermination of disease causing germs is called disinfection.

Methods of disinfection

Disinfection may be carried out by physical or chemical method. The most effective and simple method of disinfection is by using chemicals i.e. disinfectants since sericulture is a rural activity feasibility, availability, simplicity in adopting, cheaper in cost and does not damage the building and equipments are taken into consideration.

(A) Physical method

Sun drying: In this method the rearing appliances are exposed to direct sunlight for disinfection. This is effective and cheap method but it cannot be used for disinfecting the rearing room and useful for tropics.

Steaming: Steam is a good sterilizing agent. It can be successfully used for disinfecting the rearing room and its appliances. But due to initial cost of installation and hot steam is harmful to some appliances.

Hot air: This too is a good sterilizing method in which hot air is utilized to disinfect the rearing room and appliances. But due to cost in practice it is not used.
(B) Chemical method

The effectiveness of disinfectant chemicals depends on three factors namely concentration, duration of treatment and ambient temperature at the time of disinfection. The most commonly used disinfectants in sericulture are Formalin, bleaching powder, slaked lime and chlorine dioxide.

(a) Formalin: Formalin is a colorless, transparent and neutral liquid formed by dissolving formaldehyde gas in water. Commercial formalin contains 30 to 40% formaldehyde and has a specific gravity of 1.081 to 1.087. Its effectiveness is due to the reducing property of formaldehyde. Formaldehyde reduces by accepting an oxygen atom from the germ cells and get converted to formic acid, thereby the germ cells become inactive.

\[ \text{HCHO} + \text{O (from active cells)} \rightarrow \text{HCOOH} + \text{in activated germ} \]

The disinfecting action of formalin is stronger at higher temperatures (above 25ºC) and more than 70% humidity.

Formalin has pungent and irritating odour requiring protection against inhaling a gas mask and gloves must be worn. After spraying, the room is kept closed by shutting all the doors and windows for at least 15 hours. All the rearing equipment must be sprayed on all sides thoroughly and kept within the sprayed room for same time. After disinfection, the rearing room is washed with water to remove the smell of formaldehyde and tools are dried under sun.

(b) Bleaching powder: It is a white amorphous powder with a pungent odour of chlorine. Commercial grade bleaching powder contains about 25-30% chlorine. The action of bleaching powder is optimal under wet and contact conditions and therefore, the surface of equipment and walls should be drenched with this solution.

Bleaching powder is a strong oxidizing agent where HCl is bactericidal and ‘O’ is powerful oxidant.

\[ \text{CaOCl}_2 \cdot \text{H}_2 \text{O} + \text{CO}_2 \text{ in air} \rightarrow \text{HCl} + \text{HOCl} \rightarrow \text{HCl} + \text{O} \]

Hypo chlorous acid unstable

Bleaching powder when comes in contact with weak acid (CO\text{2} in air) and moisture, it releases HCl and hypo chloric acid (HOCl). HOCl being unstable, resolves into HCl and nascent oxygen has a strong oxidizing power against pathogens, Cl\text{2} has bactericidal action. More over, Ca++ ions are effective on viruses and alkalinity of bleaching powder solution acts as germicidal agent.

(c) Slacked lime (calcium hydroxide): Slacked lime is a very useful disinfectant in sericulture, especially against viruses. Absorbs moisture and can be
used to regulate bed humidity and maintain hygiene. Application of lime dust in combination with bleaching powder in around rearing houses and premises improves hygiene in the environment.

(d) Chlorine dioxide: Chlorinedioxide (ClO$_2$) marketed in different trade names such as sanitech, serichlor etc is an ideal disinfectant in sericulture. The disinfectant available at 20,000 ppm concentration is a strong oxidizing agent. Chlorine dioxide 2.5% concentration in combination with 0.5% slacked lime is effective in all silkworm pathogens. It possesses tolerable odour and least corrosive at the suggested concentration.

(c) Disinfection of rearing house and appliances: The required quantity of disinfectant (1.5/sq.m or 0.140 l/sq. ft. floor area of the rearing house +10% floor area of the rearing house +10% for outside the rearing house +25% of disinfectant solution for tray rearing) sprayed using powerful jet sprayer uniformly to drench all parts of rearing house inside, outside and appliances.

The rearing equipment such as rearing trays, feeding stands, basins, antwells, etc, which are smaller in size and easier to handle are best disinfected by dipping them for 10 minutes in a tank containing 5% bleaching powder solution. The bigger equipments i.e. stands, chandrike, leaf chamber etc. are disinfected by spraying 2.5% of ClO$_2$ in 0.5% slacked lime or with 2% formalin in 0.5% detergent solution. In India it is a common practice among the reares to smear the bamboo trays with cow dung to increase durability. While smearing cow dung is made slurry with 5% bleaching or 2% formalin and smeared.

Disinfection in the gaseous form is called fumigation. Formalin is used for this process. The quantity of original formalin solution required for disinfection is calculated according to the room size. The solution is allowed to evaporate in a pan, by heating using electric or charcoal stove. Slowly the formalin gas comes out.

Fig. 4.3. Disinfection of Rearing House & Equipments
Precautions

1. The process of spraying and fumigation has to be done at raising temperature (25°C) around 11a.m for better disinfection.

2. Disinfection rearing house has to be done in air tight condition along with equipments

3. In fumigation process care should be taken that chemical does not catch fire, nullifying the disinfecting effect.

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

4.4 Preparation of disinfectants

For preparing required strength Formalin the following methods are used.

First method

\[
\text{Required strength of formalin} = \frac{\text{Strength of original formalin} - \text{Strength of formalin required}}{\text{Strength of formalin required}}
\]

Second method

\[
\text{Quantity of Formalin required} = \frac{\text{Required concentration} \times \text{required quantity of solution}}{\text{Available concentration of commercial formaldehyde}}
\]

Model problem

Calculate the required 2% formalin solution and also the required amount of commercial Formalin for disinfection of rearing house of 6 x 9m with 4mts height and terraced roof

Solution

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

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

To disinfect 6x9m with height of 4mts size room, the required 2% formalin is calculated.

Floor area = 6x9mts = 54mts² or (20’x30’) = 600sqft.
Area of 2 walls = 6x4x2mts = 48mts² or (20’x10.3’x2’) = 412sqft
Area of 2 walls = 9x4x2mts = 72mts² or (30’x10.3x2’) = 618sqft.

Total area = \( \frac{\text{Area of roof} = 6x0 = 54mts² \text{ or } (20’x30’) = 600sqft.}{\text{228sqmts or 2230sqft}} \)

Requirement of 2% solution = \( \frac{228 \times 5.73}{100} = 13.06 \text{ liters} \)

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

Total requirement of 2% formalin is 26 liters.

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

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

To get 26 liters of formalin.

\[ \frac{26}{20} = \frac{13}{10} = 1.3 \]

About 1.3 liters of commercial formaldehyde is required to disinfect rearing equipment and rearing house (6x9x4mts) which can accommodate 250-300 dfls.

**Second method**

\[ \frac{2 \times 100}{40} = \frac{2000}{40} = 50 \text{ cc of commercial formalin} \]
To calculate quantity of formalin requires is \[
\frac{2 \times 26}{40} = \frac{52}{40} = 1.3
\]

1.3 liters of commercial formalin is required

### 4.5 Maintenance of Hygienic conditions

The prime aim of maintaining hygiene in the rearing place and premises is to prevent the entry of pathogens from a wide range of external sources during period of rearing after disinfection.

1. Disinfection of rearing house and equipments is must before starting rearing and daily disinfect the foot and hand before entry.

2. Restrict the entry of persons in the rearing house especially during chawki rearing.

3. Periodically check if any unequal or diseased worms seen separate it immediately and dispose off into 5% bleaching powder in slaked lime in a basin.

4. Cleaning of rearing bed has to be done regularly as per recommendation with the help of disinfected net , immediately after cleaning the room should be swept and has to be wiped with 2% bleaching powder solution.

5. The compost pit should be away from the rearing house.

6. Avoid borrowing the rearing appliances. Do not use appliances without disinfection.
Summary

- Preparation of rearing house is must before starting rearing.
- Cleaning of dust and dirt in and around the rearing room is ensured. All the crevices and holes should be concealed before disinfection.
- Disinfection process is done with chemicals like formalin, bleaching powder, slaked lime, chlorine dioxide so on.
- Equipments are dried under Sun after dusting and before disinfection.
- 2% Formalin is used for spraying, 5% bleaching powder, 0.5% of slaked lime is used for disinfection.
- Required and strength quantity is calculated according to the room area.
- Fumigation process is effective and total disinfection is achieved simultaneously.
- Slaked lime is very useful disinfectant in sericulture, especially against viruses.
- Maintenance of hygienic conditions checks the spread of diseases.

Short Answer Type Questions

1. Define disinfection.
2. What is involved in cleaning?
3. Define fumigation.
4. Name any four disinfectants used in sericulture.
5. What is Sun drying?
6. Write the principle to calculate required strength of Formalin.
8. What is the ideal temperature and time for disinfection?
9. Mention the precautions to be taken during disinfection.
10. What is the purpose of hygienic conditions inside the rearing room?

Long Answer Type Questions

1. What is disinfection and detail the process of disinfection?
2. How the process of disinfection of rearing house and equipments is done?

3. Write in detail about the process of fumigation.

4. Maintenance of hygienic condition in rearing is important, justify the statement.
UNIT 5

Environmental Conditions

Structure

5.1 Introduction
5.2 Temperature
5.3 Humidity
5.4 Air
5.5 Light.
5.6 Regulation of environmental conditions.

Learning Objectives

• To study the effect of environmental conditions on silkworms
• To know about regulation of environmental conditions for ideal growth of silkworm

5.1 Introduction

The silkworms are by nature quite delicate and very sensitive to environmental conditions. Environmental factors such as temperature, humidity, light and air current during rearing have a remarkable influence on the growth of the larvae and ultimately on cocoon crop quality. However their influence is not the same throughout the rearing period, but vary in different stages of growth. Hence
it is necessary to provide the most favorable climatic conditions suiting to the silk worms at different stages.

The importance of various environmental conditions and their effects on various aspects of rearing and silkworm development in particular are detailed in this chapter.

5.2 Temperature

Silkworms are Poikilotherms, thus they change their body temperature according to the environmental temperature. Temperature has direct impact on the various physiological activities of silkworm i.e. metabolic rate, activity of enzymes, nutrients conversion, digestion and assimilation, excretion, nervous stimulations, hormonal actions so on.

The silkworms are capable of growing in temperature between 15ºC to 40ºC. But in view of its effect on the physiology of silkworms it is divided into three groups.

A 20º-28ºC; This temperature range which is harmless to the growth of silkworms. But higher or lower than this range is harmful to the physiology of silkworms which deteriorates larval health.

B 25ºC; The temperature which is favorable for the healthy growth of late age silkworm.

C 26º—28ºC; The temperature which is favorable for making good quality cocoons which the larval resistance or sturdyness is achieved resulting the productivity.

If the temperature is raised above the optimum, the metabolic activities of the worm are increased resulting in the reduction of larval duration on the other hand growth becomes slow at low temperature leading to prolong of larval duration. Hence to keep the temperature range within the limit is absolutely necessary for silkworm rearing. Incase of early age of larvae decrease in temperature will retard physiological activities and worms do not feed on mulberry leaves leading to starvation and the worms become weak, there by susceptible to diseases resulting poor quality.

The temperature in the early instars should be relatively higher than in later instars Incase sufficient amount of nutritive mulberry leaves are not given to silkworms, high temperature effects on physiology there by injuring the health leading to poor quality cocoons.
The ideal temperatures of rearing silkworms in different instars are as

<table>
<thead>
<tr>
<th>Age</th>
<th>Optimum temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26 - 28°C</td>
</tr>
<tr>
<td>2</td>
<td>26 - 28°C</td>
</tr>
<tr>
<td>3</td>
<td>24 - 26°C</td>
</tr>
<tr>
<td>4</td>
<td>24 - 25°C</td>
</tr>
<tr>
<td>5</td>
<td>23 - 24°C</td>
</tr>
</tbody>
</table>

The rearing room temperature can be recorded using thermometer.

5.3 Humidity

The effect of rearing humidity upon the growth and health of silkworm is similar to that of rearing temperature. High humidity causes reduction in the growing period of silkworms by accelerating the physiological activities, where as low humidity leads to prolongation of the growing period. The pH value of the blood is remarkably lower at high humidity (80 - 85%) than at low humidity (60%) condition. Expiration of CO$_2$ increases with rise in humidity. On the contrary, low humidity makes to prolong the length of growing period of larva. The combined effect of both temperature and humidity largely determines the satisfactory growth of silkworms and produce of quality cocoons.

The role of humidity is both direct and indirect influencing physiology, rate of withering respectively. Therefore suitable rearing must be determined by considering by following points.

(A) The optimum humidity for the growth of silkworm is about 75% relative humidity. The early instars are resistant to high humidity with relatively little or no effect change in the moisture. On the contrary the late age instars are weak against high humidity.

(B) In an extremely desiccated rearing room, silkworms cannot eat mulberry leaves owing to the withering of leaves. Then they become mal nutritious especially this is seen chawki worms.

(C) If the air of rearing room is to moist, it becomes favorable to grow the pathogenic microbes thus silkworms are apt to suffer from diseases.
Considering the above, the following different humidity conditions have to be maintained.

<table>
<thead>
<tr>
<th>Age of worms</th>
<th>humidity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
</tr>
</tbody>
</table>

The humidity in the rearing room is recorded using hygrometer or wet & dry bulb thermometer and conversion chart is used.

5.4 Air

Silkworms breathe through spiracles (9 pairs i.e., 18 in number) on both sides of the body, supplying oxygen to blood through tracheae. These tracheae oxygen to the body and at the same time unnecessary substances i.e. CO$_2$, or water produced in the body are exhaled through tracheae. Therefore fresh air is required for silkworms.

In the rearing room, the air gets polluted due to accumulation of CO$_2$ released from the respiratory activities of workers and mulberry leaves, formaldehyde gas from disinfectants and ammonia from litter. The safe limit for these gases in silkworm rearing is CO$_2$ 1-2%, formaldehyde gas 1%, SO$_2$ 0.02%, and ammonia 0.1%. The young silkworms are less resistant to toxic gases. As the production of these gases is comparatively less during younger stages than during later instars, it is less important to ventilate these gases during younger stages than later instars. The effect of SO$_2$ cause prothetely in the cocoons and makes cocoon quality worsening the reelability of cocoon filaments. Ammonia gas in the room makes the sericin insoluble while reeling.

5.5 Light

Silkworms are fond of dim light (15-30 lux) and avoid strong light and darkness. Light has little influences on the health and survivability of silkworms, but influences the distribution of the larvae in the rearing bed. The appetite of silk worm is more in a light place than in a dark place. The larvae come up more quickly under light condition than in dark condition. Longer photoperiod during early instars greatly affects the hibernating character in the next generation as 18 hrs photoperiod per day is found optimum for silkworms. When the silkworms
are reared under such conditions the weight of cocoons and cocoon shell become heavier than those reared under dark condition.

5.6 Regulation of environmental conditions

(A) Temperature: The temperature varies from season to season and place to place. In case of lower temperature condition, temperature is raised with the help of electric heater or oven or charcoal stove. Care should be taken while using charcoal stove, as it should not emit smoke. It is better that live cylinders are covered with a layer of ash for better, regulated and uniform dissemination of heat. Besides this the doors and windows are kept closed during nights to keep out the cold and later in the day, as outside temperature goes up, they should be opened to allow the warm air to get in.

Whereas in the case where temperature has to be reduced i.e. tropical conditions proper designing of rearing house can mitigate the higher temperatures to some extent and by ensuring adequate ventilators for free circulation of air inside the rearing house. The temperature is quite opposite in summer when compared to winter and rainy seasons.

During this period the windows should be kept open at night. Further all the doors and windows are opened early in the morning so that cool air from outside flows into the rearing room and brings down the temperature. When the day temperature increases all the opened doors and windows have to be closed. The hanging of wet gunny cloth to doors and windows also brings down the temperature. Use of air coolers or air conditioners regulates temperature but it is not feasible for marginal Indian farmers.

(B) Humidity

The effect of humidity is very wide and changes from season to season and also within the day itself during any season. Regulation of humidity for young age rearing is achieved by adopting box rearing or by paraffin papers and wet foam pads surrounding the rearing bed. Care should be taken while using wet foampads not to wet faecal matter by using plastic sheet below the bed. The humidity requirement during feeding and moulting in each instar is different. It is necessary to lower humidity to 65% during moulting in each instar for uniform moulting. Otherwise the worms remain under the net, it results in unequal which easily gets susceptible to diseases. On the contrary high humidity is maintained during feeding which prevents leaf withering.

If temperature is high as normally seen in tropical conditions, humidity has to be increased to lower the body temperature as both these parameters are highly detrimental to late age worms.
If leaf withering is due to high temperature and low humidity it is better to give more water to the leaves by sprinkling while they are in storage. It is not advisable to raise the humidity of room by sprinkling water inside the rearing house, where the temperature is already high.

(c) Air

It is more important from the point of physiology of silkworm. Fresh air is comparatively heavier than polluted air and sufficient number of windows and ventilators should be provided in the rearing houses for better results. This also regulates temperature and humidity. Chawki worms are more susceptible to toxic effect. However, care should be taken by removing paraffin paper cover before half an hour of each feeding which facilitates entry of fresh air into the rearing bed.

Air current of 1.0 m/sec during V age rearing reduce the larval mortality and improves ingestion, digestibility, larval weight, cocoon weight and pupation rate compared to those recorded under poor ventilation condition.

(d) Light

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

Summary

- The ecological factors chiefly temperature, humidity, light and air during rearing have a significance influence on the growth of larva and ultimately on crop yield and quality.
- The influence of these factors on rearing varies in different stages of larval growth.
- Temperature directly influences the growth of the worms. The ideal temperature ranges from 24-28 oC.
- The effects of humidity are direct and indirect, optimum humidity ranges from 70-85% for better growth of silkworms.
- Chawki worms need high humidity, this is possible when paraffin paper, wet foam pads and box rearing is adopted.
- High humidity generally helps to prevent leaf withering.
- Silk worms are delicate and sensitive. Fresh air is needed for healthy growth.
- Silkworms are fond of dim light of 15 to 20 lux and avoid strong light and darkness.
Short Answer Type Questions

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

Long Answer Type Questions

1. Discuss in detail about the influence of temperature and humidity on silkworm growth.
2. How the air influences the growth of silkworm.
3. Write on the role of light on the growth.
4. Explain the regulation of temperature and humidity during silkworm rearing.
6.1 Introduction

After selection of rearing house, the equipment required for accommodation of silkworm rearing has to be known. The rearer has to utilize all the resources available in the field for procurement/preparation of equipment. Usually the equipments are procured as per the method of rearing, local availability, cost of equipment, convenience for disinfection so on. Presently with adoption of new technologies all the rearing requirements were improved resulting better crop quality and yield. New improved bivoltine hybrids need more space and leaf, hence all the requirements varies accordingly. For rearing 100dfls 400 square feet bed area is required.

Following are the appliances required for rearing silkworms for 1 acre of mulberry garden (300dfls).
### 6.2 Equipment required for chawki and shoot rearing (300 Dfls)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipments</th>
<th>Required Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chawki rearing trays</td>
<td>24</td>
</tr>
<tr>
<td>2.</td>
<td>Chawki rearing bottom stand</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Rearing stands (to accommodate 12 trays in a row for chawki rearing)</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Feeding stand</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Ant wells</td>
<td>72</td>
</tr>
<tr>
<td>6.</td>
<td>Leaf chopping board</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>Leaf chopping knife</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>Leaf mat (4’x 6’)</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Leaf chamber</td>
<td>1</td>
</tr>
<tr>
<td>10.</td>
<td>Bed cleaning nets</td>
<td>48</td>
</tr>
<tr>
<td>11.</td>
<td>Earthen pot</td>
<td>1</td>
</tr>
<tr>
<td>12.</td>
<td>Litter basket</td>
<td>2</td>
</tr>
<tr>
<td>13.</td>
<td>Late age rearing trays (Bamboo) (for leaf feeding method)</td>
<td>120 for CB, 300 for BV</td>
</tr>
<tr>
<td>14.</td>
<td>Rearing stands (leaf feeding method)</td>
<td>12 for CB, 14 for BV</td>
</tr>
<tr>
<td>15.</td>
<td>Feeding stands (leaf feeding method)</td>
<td>3</td>
</tr>
<tr>
<td>16.</td>
<td>Shoot rearing rack 5’x35’x 4’ tiers (for shoot feeding method)</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>Mountages (Bamboo chandrike) or Rotary mountages</td>
<td>120, 100</td>
</tr>
<tr>
<td>18.</td>
<td>Plastic basin -18”dia and 9” dia.</td>
<td>2</td>
</tr>
<tr>
<td>19.</td>
<td>Plastic bucket with lid 20lts cap.</td>
<td>2</td>
</tr>
<tr>
<td>20.</td>
<td>Plastic mug</td>
<td>2</td>
</tr>
<tr>
<td>21.</td>
<td>Foam pads</td>
<td>50</td>
</tr>
</tbody>
</table>
Summary

- Rearers should procure good, suitable equipments.
- Usually the equipments are procured as per rearing method.
- New improved bivoltine hybrids need more space and leaf, hence rearing requirements varies.
- For rearing 100 df1s 400 square feet area is required.

Short Answer Type Questions

1. Mention some feeding equipments.
2. Mention leaf storing equipment used in silkworm rearing.
3. What are the equipments used for regulation of environmental conditions?
4. Mention disinfecting equipments.

Long Answer Type Questions

1. What are the equipments required for rearing 300 df1s?
UNIT 7

Anatomy of Bombyx mori (L)

Structure

7.1 Introduction

7.2 Digestive system of larva and moth

7.3 Silk gland

7.4 Reproductive system of larva and moth.

Learning Objectives

After studying this unit, the student will be able

- To study the anatomical structure and functions of silkworm larva, moth digestive system and reproductive system.

- To know the structure and function of silk gland.

7.1 Introduction

The anatomy of larva is different from that of pupa. The anatomical changes required for the formation of adult anatomy are brought in the pupal stages. The following account pertains to anatomy of fifth instar larva and the moth.

When the larva or adult is cut open mid dorsally or laterally, the organs which are exposed in the body cavity is called viscera. The visceral organs revealed in larva are dorsal blood vessel, alimentary canal, malphigian tubules, tracheal bushes, silk gland, ventral nerve cord and fat body. Moth visceral organs are partially hidden by the fat body in the abdomen and muscles in the thorax which
are extensively developed. The organs that can be identified are heart, alimentary canal, malphigian tubules, tracheal bushes, nerve cord, reproductive organs, fat bodies.

7.2 Digestive system of larva and Moth

(A) Larva

The digestive system in silkworm larvae is a straight tube extending from mouth to anus. The alimentary canal can be divided into three regions Stomodeum or fore gut, Mesenteron or mid gut, and Proctodeum or hind gut. The alimentary canal is made of three layers Tunica intima which protects the alimentary canal from abrasive action of food. The Epithelial layer, Which will have gland cells helps in absorption and digestion. The Muscle layer comprised of circular and longitudinal muscle layer. The digestion of food in larva is peristaltic in nature.

Fore gut (Stomodeum): The anterior part of alimentary canal i.e. fore gut comprises buccal cavity, pharynx leads into oesophagus. The oesophagus connects the fore gut with mid gut. A valve is observed between the oesophagus and mid gut called cardiac valve, this will help to prevent the flow of food back from mid gut to fore gut. The colorless saliva is secreted by a pair of salivary glands, which are present in buccal cavity. The saliva contains an enzyme called amylase, it helps in digestion of leaves. The pharynx is a small tube and has three pair of muscles which help the larvae to swallow the leaves due to contraction and expansion.

The oesophagus is narrow at the anterior end and gradually widens to posterior end. The mulberry leaves chewed in the fore gut remains for a short, and then it enters into mid gut.

Ingestion: In the fore gut the mandibles crush the leaves ingestion of food starts in newly hatched larvae after about 20 -60 minutes of hatching. The time varies from race to race and the process of ingestion and egestion are influenced by environmental conditions.

Mid gut (Mesenteron): The mid gut ranges from 2nd to 9th segment. Digestion and assimilation takes place in mid gut only. The walls of mid gut consists of muscular layer basal membrane, epithelium and peritrophic membrane which is chitinuous structure. The epithelium is formed of goblet cells and cylindrical cells. The goblet cells secretes digestive juices and cylindrical cells are absorptive in nature, the cytoplasm of cylindrical and goblet cells has mitochondria and golgi apparatus. The mitochondria involve in secretary activity. Digestive juices can be divided into saliva and gastric juices Saliva is a weak alkaline contains enzyme called amylase. Gastric juices are strong alkalines having PH from 9.2 to 10.3 this is due to presence of sodium in the blood.
**Hind gut (Proctodeum)**: The hind gut comprises small intestine colon and rectum. It forms from invagination of outer ectoderm. There is a pyloric valve at the junction of hind gut and mid gut, which will regulate the passage of food from mid-gut to hind-gut and restricts the reverse flow. The malphigian tubules arise at the junction between small intestine and colon and opens into rectum. The main function of malphigian tubules is metabolism. The nitrogenous compounds are metabolized and excreted as uric acid and also excretes calcium oxalate. The colon extends into rectum to anus. The rectum narrows towards anus. The rectum has six muscles which help to eliminate the excreta by pressing the muscles. The faecal matter is released out through anus. The time taken for food to travel through the entire alimentary canal varies from 2 – 4 hrs to 4 - 5hrs.

![Digestive system of larva](image)

**Fig. 7.1** Digestive system of larva.

(B) Adult

The moths do not feed and hence the alimentary canal is very much reduced. The adult fore gut has a tubular oesophagus followed by the stomach and the sucking stomach which are in the mid-gut posterior then hind-gut. The rectal sacarise from rectum ends in the anus.

The alimentary canal has no digestive function. The alimentary canal of the newly formed moth is presumed to secrete the alkaline eclosion fluid which digests the cocoon for the emergence of the moth. The secretion contains a protease which attacks and desolves the sericin of the cocoon, which facilitates for breaking the cocoon. The other function is the storage of air swallowed by the newly emerged moth for distending its body and wings.
7.3 Silk gland

The silk thread of the cocoon is secreted by a pair of silk glands which are actually modified labial glands. These dermal glands are well differentiated in the fourth and fifth instar larvae. They lie below the alimentary canal and are so large in the fully grown final instar larva that it occupies most of the body cavity ventral to alimentary canal and accounts for about 50% of the weight of the larva.

The silk glands are tubular in nature and the width of the tube varies in different regions of the gland. The entire gland is formed of three layers. The outer tunica propria is of uniform thickness, the middle glandular layer and the tunica intima is of varying thickness.

There are three distinct regions in the silk gland differing in structure and function. They are the posterior region, the middle region and the anterior region.

The posterior most region is folded and the folds are in the midst of the dermo-visceral muscles. They secrete the major protein of silk namely ‘Fibroin.’

The middle region is the most prominent region of gland and is also the widest. It is folded into a w-shaped structure and hence has three limbs, the posterior, the middle and the anterior limb. The middle region acts as a reservoir of the fibroin secreted by the posterior region and fibroin matures in this region during storage period. The layer of sericin secreted by the posterior limb of the middle region is called Sericin I, that added around Sericin I by the middle limb is Sericin II and added around SericinII by the anterior limb is Sericin III.

![Fig. 7.2 Silk gland](image)

The anterior region is of uniform thickness and is very thin; it does not secrete any material and serves only to conduct the silk fiber assembled in the middle region to the spinneret. The anterior region of the two sides open at the
base of the median projection in the labium called spinneret which draws out silk in the form of a fine filament.

A pair of Fillip’s gland open into the silk gland at the junction right and left anterior parts of gland and it is assumed that this gland secretes some waxy material which covers the silk filament.

### 7.4 Reproductive system of larva and moth

(A) Larva

The reproductive system of the adult is represented as the genital imaginal disc in the larva. It is clearly visible in the fifth instar larvae. It consists of the gonad (ovary in the female and testis in the male) and the band or duct in a rudimentary condition. In addition, the female has a pair of ishiwata’s gland in the eight and ninth segments and the male have a pair of herold’s gland in the ninth segment.

(B) Moth

**Female:** The female reproductive consists of a pair of ovaries with four ovarioles occupying the entire abdominal cavity. The ovarioles are covered by a sheath, which has muscle fibers. The ovarioles are polytrophic. In each ovariole there is a succession of nutritive cells surrounding an egg cell which they nourish. The ovarioles of aside unite to form an oviduct. The two oviducts join to form the common oviduct which opens to exterior by the female genital pore. Arising from the junction of the two oviducts is a sac-like structure called bursa copulatrix. This opens to the exterior by the opening called ostium bursae. The male transfers the spermatophores through the ostium bursae to the bursa copulatrix from where they are transferred to the common oviduct serve to store the sperms received during copulation.

A pair of accessory gland lies dorsal to the common oviduct and they secrete the adhesive glue by which the eggs are attached to the substratum.

**Male**

A pair of testes are present on the fifth abdominal segment on either side of the ventral nerve cord. Each testis is formed by a number of seminiferous tubules. The vasa efferentia of each side unite to form the vas deferens. The two vasa deferentia have each an enlarged seminal vesicle situated in the middle. From the seminal vesicle arises the ejaculatory duct opening into the male genitalia the aedagus.

A pair of accessory gland opens by a common duct into the seminal vesicle. The secretion of the accessory glands serve to pack the sperms in a membranous sac to form the spermatophores.
Summary

- Study of an organism by dissecting the body and opening the body cavity is called anatomy.

- The visceral organs of larva are dorsal blood vessel, alimentary canal, ventral nerve cord, fat body, except silk gland all are seen in moth.
Sericulture

- Alimentary canal is a straight tube extending from the mouth to anus.
- Digestive system is divided into three regions fore gut, mid gut and hind gut which are called stomodeum, mesenteron and proctodaeum.
- Fore gut region function is reception and storage of food, the mid gut is the region of water reabsorption.
- A pair of silk gland is modified labial glands.
- There are three distinct regions in the silk gland differing in structure and function i.e., posterior, middle and anterior regions.
- The posterior region which secretes the core protein fibroin, the middle region secretes sericin in three layers I, II, III. and anterior region acts as a passage to reach spinneret.
- The female has a pair of Ishiwata’s gland in the eight and ninth segments and males has a pair of Herold’s gland in the ninth segment. It is clearly seen in the fifth instar larva.
- The female reproductive system consists of a pair of ovaries with four ovarioles.
- Pair of testes is present in male moths on the fifth abdominal segment.
- A pair of accessory glands in females secrete glue for adhesion of eggs, whereas in the males they serve to pack the sperms.

Short Answer Type Questions

1. Name the parts of digestive system of silkworm.
2. What is the function of cardiac valve?
3. Mention the function of foregut, midgut and hind gut.
4. Name the proteins secreted in the silk gland.
5. How male and female larva is differentiated.
6. What is the function of accessory glands in male and female moths?
7. What is the time taken for processing of the food?
8. What is the function of adult digestive system?
9. What are the digestive juices secreted in digestive system?
Long Answer Type Questions

1. Describe in detail about the digestive system of silkworm larva.

2. Write about the structure and function of silk gland.

3. Give an account on female reproductive system with a neat sketch.

4. Detail the male reproductive system of moth.
UNIT 8

Silkworm Diseases and Pests

Structure

8.1 Introduction
8.2 Protozoan disease
8.3 Bacterial disease
8.4 Viral diseases
8.5 Fungal diseases
8.6 Pests (Major and minor pests)
8.7 Integrated disease and pest management

Learning Objectives

After studying this unit, the student will be able

- To know and study the diseases which attack on silk worms.
- To identify and study about the pests of silk worms
- To understand the precautions and control measures taken for control of diseases and pests.

8.1 Introduction

Silkworms are not exceptional for attack of diseases and pests. As they are commercially exploited organism it is subjected more to diseases and pests. Due to centuries of domesticated life, the silkworms lose natural resistance and
don’t show any adaptation to escape from it. Man’s attempts to evolve a disease resistant variety of silkworm have been only partially successful. Generally, healthy and hygienic rearing reduces the incidence of diseases. However with adaptation of improved silkworm rearing technology and use of certain bed disinfectants and chemicals for the prevention of diseases and pests, the cocoon productivity has increased in recent years.

Apart from diseases, silkworm pests also cause considerable damage to cocoon crop. In this uzi fly is the major pest responsible for loss about 10% of the production. The common diseases and pests are dealt in this chapter.

**Fig. 8.1 Sources of infection**

**Diseases:** Silkworms are infected by the following microorganisms (pathogens) Protozoa, Bacteria, Virus and Fungi.
8.2 Protozoan disease

The protozoan disease of silkworm is called **Pebrine** because of characteristic pepper like spots appearing on the infected silkworm. The disease spreads very quickly and assumes epizootic importance, the entire silk industry of France and Italy would have been wiped out if Pasteur’s discover was not come into result for the cause and control for this disease. The name ‘Pebrine’ was coined by Dequatrifage. In India it was officially recorded in 1895, with introduction of mother moth examination and supply of disease free layings it is under reasonable control.

**Causal organism**: The disease is caused by Nosema bombycis Nageli belonging to family Nosematidae and order Microsporidia.

**Mode of transmission**

**Oral**: Feeding of contaminated mulberry leaf

**Contact**: The infected larva in the rearing bed liberated spores enter through skin wounds of healthy worms.

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**Fig. 8.2** Pebrine infection
**Transovarian**: By rearing infected silkworm eggs

**A Life cycle of pebrine**: The life cycle of the parasite is completed within a single host, the silkworm. There are two stages in the life cycle.

**Sporestage**: This is a resistant and infective stage.

**Vegetative stage**: It is a growing stage.

**Sporestage**: The mature spore is oval or ovocylindrical it measures approximately 3.4x1.5x5.4 microns and refracts light. The spore stage is also called sporont. The spore has a protective thick tunic called spore capsule. Two large vacuoles present at the two poles restrict the protoplasm to a girdle like structure in the middle. It is called sporoplasm and is binucleate. At one end of the spore capsule is a bag-like structure called polar capsule. The bag extends to the other end through the interior of the sporoplasm. A long polar filament (30 times as long as the body) is kept coiled inside the polar capsule. The polar filament opens to exterior by means of a small opening called micropyle. The spore can survive in ordinary conditions of aerating house for more than 1 year.

![Fig. 8.3 Structure of spore](image-url)

**Vegetative stage**: When live spores enter into the silkworm through mulberry leaf, they germinate in the gut due to high alkalinity and potassium ions. As a result the polar filament is extruded and the sporoplasm along with two nuclei creeps through it and injects into the mid gut tissues. Subsequently the
polar filament gets digested in the alimentary tract. The two nuclei of the sporoplasam unite to form a uninucleate ‘planont’. The planont measures 0.5-1.5 microns and is formed in 1-2 days and multiplies by binary fission and penetrates through the gut epithelium, enters the haemocoel and infects various organs like fat body, trachea, silk gland and reproductive organs. This is called “autoinfection”.

Planonts are extracellular, motile and uninucleate and divide by binary fission and produce vegetative planonts.

Once the planont penetrates the host cell, it transforms into a sedentary form and becomes localized. This stage is known as ‘Meront’. Meront is an intra cellular stage and has a definite cell wall immobile which absorbs nutrients from host cell and are larger than planonts. They grow and under go multiplefission. The products are the spores when cytoplasm of the host cell is exhausted; meronts are arranged in parallel rows. Ultimately, the cells die and liberate the spores.
**Symptoms:** The symptoms of this disease can be observed in all the stages of silkworm i.e. egg, larvae, pupa and adult.

**Egg stage:** The eggs are overlapped, more of unfertilized and dead eggs indicating pebrine infection. Poor and irregular hatching or immediately after hatching they may also die. The infected eggs have insufficient or irregularly deposited glue and hence get easily detached from the egg card. (Fig. 8.6A)

**Larval stage:** The larvae show poor appetite, retarded growth and development leading to unequals. Larvae moult irregularly and show sluggishness. Transovarially infected larvae die before third moult but those which are heavily infected die during first instar itself. (Fig. 8.6 B & C)

The larval body shows wrinkled skin with rustic brown colour and in moriband stage they do not rot remain ruberry. The affected gut becomes opaque and the silkglands shows white pustules in different places along its length. Sometimes black irregular pepper like spots is noticed on larval skin.
**Pupal stage**: The infected pupae are flabby and swollen with lusterless and softened abdomen. Sometimes irregular black spots are noticed near the rudiments of the wing and abdominal area. Highly infected pupae fail to metamorphose into adults.

**Moth stage**: The moth emergence is delayed and improper. They have clubbed wings with distorted antennae and do not mate properly. The scales from wings and abdominal area easily come off. In infected moths if the accessory glands are infected, the moth may lay eggs with less gluey substance resulting in the detachment from the egg cards. (Fig. 8.7 A & B)

**Infected Silk gland**
Prevention and control

1. Rearing disease free layings prepared in grainages.

2. Effective disinfection and maintenance of hygienic conditions during rearing helps in controlling the disease.

3. Collect and burn the diseased eggs, larvae, pupae and moth, bed refuges faecal pellets, etc.

4. Chemicals like fumagillin, benomyl, bengard, bavistin, methylthiophanate controls the occurrence of disease.

Fig. 8.7 Pebrine infection

Fig. 8.8 Protocol for Pebrine detection
8.3 Bacterial diseases

Bacterial diseases affecting silkworms are collectively known as flacherie due to the flaccid nature of diseased larvae.

The incidence of flacherie is high during hot and humid seasons. The outbreak of the disease is due to fluctuation of environmental conditions, under nourishment, accumulation of litter in rearing beds i.e. unhygienic conditions etc.

Bacterial diseases of silkworms are divided into three major types namely

(a) Bacterial septicemia (b) Bacterial disease of the digestive tract (c) Bacterial toxicosis.

(A) Septicaemia

Causal organism: Bacillus, Streptococci and Staphylococcus

Site of infection: Haemolymph

Source of infection: Injury or rarely orally.

Symptoms: They have common symptoms like sluggish movement, decreased appetite, straightened body, swollen thorax, shrinkage of abdominal segments. Vomiting and bead like faces and loss of clasping power of legs. Further, the body becomes soft and discoloured. Body wall easily ruptures and emits foul smelling fluid.

Fig. 8.9 Septicemia affected larva (Early, late age)
(B) **Bacterial disease of the digestive tract**

This disease is otherwise known as transparent head disease due to the bacterial multiplication in the digestive tract leading to the swelling and transparency of the head.

**Causal organism:** Streptococci, Coli aerogenous bacilli and Proteus group bacillus.

**Site of infection:** Digestive tract

**Source of infection:** Oral and induction by bad rearing conditions.

**Symptoms:** General symptoms are poor appetite, sluggish, transparent head, stunted body size and retarded growth. Sometimes with oral and anal discharges. The diseased worms often hide under the mulberry leaves. Incase of a late stage attack the disease worms remain in the spinning tray for a long period without spinning cocoons till they die.

![Transparent head disease.](image)

(c) **Sotto**

This disease other wise known as bacterial toxicosis this happens when the silkworms come in contact with the toxin produced by bacilli.

**Causal organism:** Bacillus thuringiensis.

**Site of infection:** Gut and nervous system.
**Source of infection**: Usually per oral and wounds/injury.

**Symptoms**: Infected larvae lose of appetite. Suddenly show the symptoms of convulsions, lifting of head, spasm, tremors, paralysis, distress, sudden collapse of body and turns to black after death.

![Fig. 8.11 Sotto disease affected larvae.](image)

**Prevention and control measures**

1. Disinfection of rearing room and appliances.
2. Disinfection of worms, trays and discarding of sick worm.
4. Feeding the larvae with nutritious leaves.
5. Avoid injury to the worms, over crowding of trays and accumulation of faeces in the rearing bed.
6. Apply antibiotics like streptomycin/tetracycline/ampicillin on leaves.

### 8.4 Viral disease

A virus is a biological entity which lacks metabolism but undergoes multiplication at the expense of the host cell.

Viral diseases of silk worm are a major problem to sericulture as they account for almost 70% of the total loss due to disease. Viral disease of silkworms is of two types.

(A) **Inclusion type**: Possess inclusion bodies which can be detected through ordinary microscope. Nuclear polyhedrosis and cytoplasmic polyhedrosis come under this type.
(B) **Non-inclusion type**: They do not possess inclusion bodies and can be detected only through electron/fluorescent microscopy. Infectious flacherie and Gattine comes under this type.

**Nuclear polyhedrosis**: It is a major viral disease commonly known as Grasserie, Jaundice, Milky disease, Fatty degeneration and hanging disease.

**Causal agent**: Borrelina bombycis belonging to the sub group A of the family Baculoviridae.

**Site of infection**: Nuclei of tracheae, fatbodies, epidermis and haemolymph of silkworm body. Occasionally seen in middle and posterior portion of silk gland.

**Shape of the polyhedra**: The virus is rod shaped and varies in size from 280-300 milli microns. The polyhedra is usually hexagonal rarely tetragonal

**Source of infection**: Contaminated leaves, bad environment and through orally or wound infections.

**Symptoms**: Incubation period of this virus varies from 5-7 days. During early part of the disease no external symptoms are noticed. But the larvae becomes thin and fragile and body becomes milky white with inter segmental swellings. The fragile skin gets easily ruptured liberating the liquefied body contents containing innumerable number of polyhedra. This becomes the source of secondary contamination. The larva become restless and crawl aimlessly along the rims of rearing trays and falls down on the ground and die. Another important symptom is that the diseased larva looses the holding power of legs except the last pair of legs with which they hang their heads downwards. If the infection is early larva fails to spin cocoon and die, whereas if the infection is late they are able to spin cocoons but die inside resulting melted cocoons.

(A) **Nuclear polyhedra**
Cytoplasmic polyhedrosis

**Causal agent:** Smithia virus belonging to subgroup type 1 of the family Reoviridae.

**Site of infection:** Cytoplasm of cylindrical cells of midgut.

**Shape of the polyhedral:** The virus forms polyhedral in goblet and regenerative cells also showing the characteristic chalky white appearance of the whole midgut. The virus is spherical and varies in size from 60-70 Millimicrons. The polyhedra are either hexagonal or tetragonal in shape.

**Source of infection:** Contaminated leaves and environment, peros or wound infection. Faeces enters peros is main source.

**Symptoms:** Infected larvae lag behind in their growth and development with stunted body and dull white in colour. More unequals are seen resulting irregular Moulting and if infected larva is dissected, the midgut is seen as whitish and opaque, compared to greenish midgut of the healthy larva. The whitish and opaque nature of midgut start from Posterior to anterior with the advance of disease finally entire gut becomes chalky white.
Prevention and control: The virus can persist in the form of polyhedra for more than one year inside the rearing house, hence disinfection with 2.5% Formalin and 0.5% slacked lime can control the disease. Ensure proper environmental conditions. The infected larvae, faecal matter and bed refuge are destroyed by burning or decomposing in a pit. Feeding quality leaves and mulberry leaf sprayed with 1% calcium hydroxide are fed to larvae to reduce the occurrence of c.p.v.

Prevention and control

1. Disinfection of rearing house and equipments with 3% bleaching powder.
2. Ensure proper ventilation and air circulation.
3. Collect and burn infected larvae, faecal matter and refuges.
4. Feed the larva with nutritious mulberry leaves and during later age feeding of tender leaves should be avoided.
5. Proper bed drying is necessary before each feed to avoid accumulation of moisture in the bed.
6. Dust bed disinfectant, vijetha or reshamkeetoushad on the larvae, 1/2 hr after each moult before resumption of feeding (3kg/100dfl).
Infectious flacherie

**Causal agent:** Morator virus belonging to the family Picornviridae.

**Site of infection:** Infects the goblet cells of the mid gut epithelium with advance of disease the virus is dispersed in the lumen of digestive tract and excreted with faeces.

**Shape of polyhedra:** The virus is gobular and measures 24-28 nm in diameter and no polyhedra are formed.

**Source of infection:** Infected larvae and contaminated faeces enter per os.

**Symptoms:** The symptoms are similar to Bacterial flacherie, such as loss of appetite, transparent cephalothorax, body shrinkage, retarded growth and development followed by vomiting of gastric juice and diarrhoea. The midgut contains little amount of mulberry leaf and full of yellowish brown fluid. The disease cannot be identified by external features only histochemical changes of midgut can be observed under microscope.
Prevention and control.

Disinfection of rearing house and appliances with 2% formalin and 0.5% CaOH or 5% bleaching powder solution and chlorine dioxide is effective in exterminating pathogen. Silkworm rearing under hygienic conditions and good quality mulberry leaf help in checking the disease.

Gattine: Causal agent: Denso virus is primary agent and streptococcus bombycis is secondary invader.

Site of infection: Nuclei of cylindrical cells of midgut.

Shape of polyhedra: No polyhedra formed.

Source of infection: Faeces enter perorally.

Symptoms: The symptoms are clear and prominent when both virus and bacterium occurs in the larvae. It includes lack of appetite, vomiting of an alkaline clear ropy liquid from the mouth and diarrhoea. The anterior part of the alimentary canal is free of mulberry leaves and contains only the digestive fluid these areas appear transparent and give the name of ‘Clear head’ to the disease.

Prevention and control: Maintenance of good sanitary conditions, disinfection between rearing prevents the disease. Picking affected larvae and destroying controls spread of this disease.
8.5 Fungal diseases

Fungal diseases of silkworms are called Muscardine. The study of fungal diseases is called Mycosis. The fungal disease attacked on chawki worms is called Aspergillums.

Different infecting fungi produce different colored spores and accordingly they have been named as.

White Muscardine caused by **Beauvoria bassiana**.

Green Muscardine caused by **Spicaria prasina**.

Yellow Muscardine caused by **Isaria farinosus**.

Black Muscardine by **Metarrhizium anisopliae**

**White muscardine:** The characteristic feature of Muscardine is the mummification of larvae after death by deposition of calcium oxalate salts. Hence, this disease is also called Calcino disease.

It is the most common fungal disease occurs during rainy and winter seasons under moderate to low temperature and high humidity conditions.

**Causal agent:** This disease is caused by Beauveria bassiana (Balsamo), belonging to the family Moniliaceae, class: Fungi imperfecti.

**Mode of transmission:** Muscardine infection 90% occurs by penetration through the cuticle, 10% Through the spiracles or mouth.

Development cycle Beauveria bassiana

(a) Affected larva  
(b) Conidia  
(c) Germination of conidia  
(d) Formation of cylindrical spores  
(e) Cylindrical spores  
(f) A Conidiophore with conidia
Life cycle of muscardine

The developmental cycle of white muscardine consists of three distinct stages namely conidium, vegetative mycelium and aerial mycelium. The conidium is colourless, globular or rarely oval in shape and porcelain white when gathered in a mass. Under favourable conditions of temperature and humidity the conidium germinates within 8-10hrs of contact with the body of silkworm. On germination the conidium not only sends out its germ tube but also secretes chitinase which facilitates the germ tube to penetrate the body wall for further multiplication. The germinating tube of conidium after invading the blood of the larvae develops into vegetative hyphae. At the tip of hyphae round or oval shaped short hyphae develops. These often detach themselves and elongate to form vegetative hyphae.

The vegetative hyphae come out of the skin to form aerial hyphae bearing innumerable conidiophores. These conidiophores give rise to small branches which bear one or two conidia.

Symptoms

Loss of appetite, inactiveness and lag in growth results ‘unequal ‘in the rearing bed are the early symptoms. Moist / oily specks appear on the body mostly around the spiracles or the legs. The body of the larvae shrinks and skin becomes inelastic. Larvae do not respond to external stimuli and lose spontaneous movement and finally they die. Before death, symptoms of diarrhoea and vomiting appear . After death, larva becomes soft, within 6-8hrs it becomes stiff and hard. Subsequently whole body is covered with conidia except the chitinised parts of the head. Due to deposition of calcium oxalate by the fungus the dead larva becomes mummified into a chalky white structure.

Incase of infected pupa , they do not respond to external stimuli. The thorax shrinks and abdomen is wrinkled. The conidia grow up to one third of its
ordinary weight inside the cocoons, such cocoons sound like dried cocoons when shaken.

During moth stage the body is hardened and wings falloff easily.

Fig. 8.17 Mummified larvae

Prevention and control

If muscardine attack is noticed, control measures have to be taken both during rearing and in between rearing. The first and foremost is disinfection of rearing room and appliances and surroundings thoroughly with 2% formalin or 5% bleaching powder solution. During rearing this disease favours with low temperature and high humidity, it has to be regulated. The rearing bed should as much as possible be kept thin and dry in order to avoid the germination of conidia and spread of infection.

Fig. 8.18 Application of formalin chaff
Diseased worms should be destroyed by burning or burying with a disinfectant spray. The bed refuse of the infected source should be disposed of properly, if the disease is found during rearing, the trays, seat papers, cleaning nets, foam pads etc must be disinfected and replaced. Preservation of leaf inside rearing house during late age adds to humidity and should be avoided.

Keeping anhydrated lime in the corners during rainy seasons absorbs excess moisture and reduces the humidity. During moulting the bed should be kept thin and bed disinfectants should be used.

They are formalized chaft (burnt husk), chlorinated lime, dithane M₄₅, Resham Keet Oushad (R.K.O).

**Aspergillus**: Aspergillus attacks on young age larvae particularly when high humidity is prevalent.

**Causal agent**: This is caused by different species of Aspergillus and Stemigmtocyctis belonging to the family Monilaceae of class Fungi Imperfeci. Silkworms are infected about dozen species of which Aspergillus flavus Aspergillus oryzae are common.

**Life cycle of Aspergillus**

The growth stages of the pathogen consist of the conidium, vegetative hyphae and aerial hyphae.

The conidium is spherical, 3-4 microns in size. They are resistant to environmental factors and formalin treatment. The favourable temperature for germination of conidia is 30-35 C. Conidia after germination invades the body of the silkworm and develops into vegetative hyphae without the formation of short hyphae and they grow only at the site of invasion. The conidiophore is thick and at distal end expands into a globular or oval structure bearing one to two rows of radiating sterigmata on which conidia are formed.

![Fig. 8.19. Morphology of Aspergillus Sp.](image)
(a) *Aspergillus flavus*  
(b) *Aspergillus oryzae*

(i) Conidiophore  
(ii) Sterigma  
(iii) Conidia  
(iv) Conidia

**Symptoms**

The disease pathogen attacks only on chawki worms as it is not strong enough to attack on late age larva. Infected larvae stops eating mulberry leaf, becomes lazy, show body tension, restlessness and then die. Just before death the head and thorax is extended outwards and vomiting occurs. One day after death aerial hyphae appear and later conidia cover the body. The color depends on the type of pathogen. The hardening of corpse in dead larvae is limited to the site of fungus penetration and other parts become black and rotten.

**Prevention and control**

They are basically similar to white muscardine, but main source is through appliances, special care should be taken to bake or sun dry. For disinfection purpose 4% Pentachlorophenol may be used instead of formalin.

### 8.6 Pests (Major and minor pests)

Besides being susceptible to different diseases, the silkworm is also attacked by a number of pests. One important and serious pest is uzi fly which causes major damage to crop loss.

Upto 10-20%. Some minor pests like beetles, straw mite, ants, nematodes, lizards, rats, squirrels and birds also damage to the silkworms and cocoons.

**Major Pests :**

**Uzy fly :**

The parasitoid insect belongs to order Diptera and family Tachinidae.

This pest incidence is very high in tropical countries like Bangladesh, China, India, Thailand and Vietnam. *Tricholyga bombycis* is a major pest of silkworms.
Life Cycle of uzifly

(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 to 18 days. And females live 2-3 days longer than males. Survival period is long during summer. Sexual dimorphism is very clear in uzifly. 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 denser 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 genital 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 oviposition.

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.

(A) 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.

(B) 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 creamy 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 eleven 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.

**Damages and Symptoms**

Uzy infested silkworm larvae upto early fifth instar die before spinning, the larvae attacked in fifth instar the Uzy 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. 8.21 a, b, c. Uzy maggot coming out from larva and cocoon. d. Uzy pupa
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 lavigated china clay on the body of silkworm during mounting prevents oviposition by uzi.

In chemical control, uzicide 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% diflourobenzuron.

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, Dirhinus himalayanus, Brachymeria lugubris, Spilomucrus Karnatakensis, Splangia cameroni and Pachycrepoideus vindimmae.

Dermestid Beetle (*Dermestes Cadverinus*)

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.

**Life Cycle**

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 beetle moves around in dark places in the cocoon storage room and deposits eggs in the crevices. Each adult lays 50-400 eggs. The eggs hatch in a week. The grubs are spindle 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 afteremergence mates and lays eggs which develop to become the adults of second generation. 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 dermestid beetles that are important from sericulture point of view are as follows.

**Fig. 8.23 Dermestid life stages**

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)

**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 derrmisted 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 C) and maintenance of low humidity (30%) also help to kill the beetles. Fumigation with Methyl bromide 0.5 gr. Per 3 m2 for three days kills all the stages of beetle.

**Minor Pests**

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

**Mites (*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. In 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 mating 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.

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 change 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.

**Ants**

Ants attack silkworms in the rearing trays, can be prevented by placing the legs of the rearing stands in ant wells. Pouring of little kerosene or keeping kerosene dipped cloth around the legs of rearing stand and chandrika prevents ant crawling.
Nematodes

The Nematode Hexamermis microamphidis is found in silkworms. 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.

Lizards

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

Rats and Squirrels

These pests eat silkworms 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.

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.

8.7 Integrated Disease and Pest Management

One of the major problem in silk cocoon production is the diseases and pests of silkworm. To overcome this problem during rearing, implementation of combined preventive and controle measures is termed as integrated disease and pest management (IDPM). Among silkworm diseases the nuclear polyhydrosis, flacherie caused by bacteria and viruses such as infectious flacherie and densonuleosis viruses and muscardine used by fungi. All these diseases are common during rainy and winter season cause annual crop loss of 20% , NPV and flacherie 22-33 of 43-55% respectively. At the same time the damage caused by major and minor pests of silkworm during rearing and spinning also should be considered to reduce the crop loss to minimum extent.

For combined control of above all diseases and pests integrated disease and pest management must be followed. Silkworm rearing house its utility rooms, corridor, mounting hall and the surrounding, rearing appliances etc., were disinfected once immediately after completion and before the commencement of the rearing. The disinfectant schedule employed is as follows.

- For first disinfection 2% bleaching powder (stock powder having 30% chlorine) in 0.3% slaked lime solution and the second disinfection 2% for malin or 500 ppm chlorine dioxide in 0.5% slaked lime solution. Additional disinfection before the second disinfection should be performed by using
0.3-0.5% slaked lime solution in extreme cases where NPV and Flacherie were noticed during previous crop. The disinfection solution prepared fresh and used @ 2 lt/sq. m floor area. The disinfection process should be done 5 days prior to brushing.

Silkworm are reared following hygiene practices to avoid secondary contaminations and spread of disease in the rearing house. It involved the surfaced disinfection of eggs with 2% Formalin, dusting of slaked lime containing 5% bleaching powder around the rearing house, at the entrance and on the passage to the rearing house, restricting the entry of unauthorised persons into the rearing house, washing hands and feet before entry into the rearing house, washing hands after picking diseased larvae and cleaning the rearing bed before feeding silkworms. To avoid the contamination of the floor of rearing house, spreading the venyl sheet of thick gauge over the floor while collecting and disposal of rearing bed waste, disinfecting the venyl sheet after disposal of waste and before reuse should be practiced. The rearing house is wiped everyday by 2% bleaching powder in 0.3% slaked lime solution.

During rearing, the silkworm body and rearing seat were disinfected with Vijetha@3-5g/sq.ft once, immediately after first moult and again on the fourth day of final instar. In extreme case of high incidence of muscardine, use of 1-2% Dithane M45 with kaolin dusting should be done during the mid larval period of each instar. Early instar larva reared on scientific lines in chawki rearing centre are The worms selected should be certified as free of all types of diseases.

Regarding pests, care should be taken to control all major and minor pests. For controlling Uzy fly all the windows and doors should fitted with wire mesh which also control the entry of other minor pests. Uzycide can also be sprayed especially on 4-5 age larvae. Lavigated china clay dusting prevents uzy infestation during spinning.

Rearing house should be rat proof, antwels are placed below all the legs of rearing stands. Dusting of bleaching powder around the rearing house also prevents the entry of ants and other pests. During silkworm rearing the maintenance of optimum temperature and humidity is more important, any fluctuations leads to outbreak of different disease causing pathogens. Along with optimum conditions regular sprayings and dustings of different disinfectants should be followed as a preventive measure. The schedule of applications is as follows.
Bed disinfection

Pathogens from different sources like leaf, appliances, air, water, infected larvae may settle on the rearing bed or silkworm body and they spread the infection to healthy silkworms. This type of contamination is called secondary contamination.

As periodical preventive measure of secondary contamination bed disinfection is practiced.

Different types of bed disinfectants used in sericulture are as follows. Formalin chaff, Resham keet oushad, Labex, slaked lime, Dithane M₄₅, Kaolin mixture, Ceresan-lime etc.

Formalin chaff

I & II age Worms: 0.45% (75:1 water & Formalin)

III age Worms: 0.5% (65:1)

IV age Worms: 0.6% (55:1)

V age Worms: 0.85% (40:1)

Mix 1 ml of the above solution with 10 grms of roasted paddy husk, sprinkle the chaff on the rearing bed and cover with news paper for 30 minutes, then feed the worms.

Resham keet oushad (R.K.O.): This is an anti-muscardene bed disinfectant evolved by CSR & TI, Mysore. The powder has to be dusted by using white fine muslin cloth on the worms after each moult approximately 30 minutes before they resume feeding. For every 100 layings 3-4 Kg. of the powder is to be applied.

Quantity of bed disinfectant required

<table>
<thead>
<tr>
<th>Stage of silk worm</th>
<th>S.R.M.</th>
<th>T.R.M</th>
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<tbody>
<tr>
<td>I</td>
<td>72 g.</td>
<td>72 g.</td>
</tr>
<tr>
<td>II</td>
<td>144 g.</td>
<td>144 g.</td>
</tr>
<tr>
<td>III</td>
<td>540 g.</td>
<td>288 g.</td>
</tr>
<tr>
<td>IV</td>
<td>1440 g.</td>
<td>768 g.</td>
</tr>
<tr>
<td>V</td>
<td>2160 g.</td>
<td>1348 g</td>
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Labex

This mixture has been evolved by CSR&TI, Berhampore. It is a mixture of lime and bleaching powder. It controls both muscardene grasserie and at the same time improves larval growth and commercial cocoon characters. The powder is to be taken in a muslin cloth and dusted directly on the worms.

It is to be applied once in each instar up to IV instar and once daily for V instar. The recommended dosage is 4g/0.1m². The mixture should be kept in ourthht containers.

Slaked lime: ie Ca(OH)²

When water is sprinkled on lime it releases heat and becomes powder. After cooling it is pulverized, sieved and the resulting slaked lime powder is packed and stored in air tight containers toll use.

It is a very effective disinfectant because it absorbs mixture and toxie gases on the rearing bed and makes the bed ry, also kills the pathogen and reduce contamination.

Dithane M₄₅ - Kaoline Mixture

For I to III instars one part of Dihare M₄₅ is mixed with 99 parts of Kaoline and for IV and V instars 2 parts are mixed with 98 parts of kaoline. The mixture can be applied on the silkworm after each bed cleaning and during moulting.

Cerasan - lime

This is a mixture of slaked lime with 5% cerasan. The mixture is to be spread evenly on the rearing trays of silkworms at the rate of 5 gms/0.1m²

Summary

- The silkworms are attacked and infected by various microorganisms. They are Protozoa, Bacteria, Virus and Fungi
- The protozoan Pebrine is important and with the timely intervention of Pastuer with the mother moth examination sericulture industry was survived.
- Pebrine disease shows symptoms in all stages of silkworm.
- Pebrinized eggs shows overlapped, few numbers of eggs with insufficient glue for adhesion.
• At larval stage they become sluggish with retarded growth and loose appetite resulting unequals. And irregular pepper like spots is seen on the skin.

• The maggots develop in three instars, first beneath, second and third inside the body, piercing out maggot comes out of the body for pupation.

• Pupation takes place in the darker areas like corners, crevices, trays or ant wells or in soil.

• The adult flies exhibit sexual dimorphism with distinguished features of male and female.

• Dermistid beetles cause much damage to stored stifled cocoons and undergo 4 stages egg, grub, pupa and adult.

• There are some minor pests such as mites, ants, nematodes, lizards which damage the crop

• All these can be controlled by adopting simple preventive precautionary measures during rearing activity.

• The bacterial diseases of silkworms are collectively called as Flacherie”. They are of three types Septicemia, Bacterial diseases of digestive organs and Bacterial toxicosis.

• In Septicemia the bacteria multiply in haemolymph of larva, shows beaded like faeces apart from the general symptoms.

• In case of Bacterial diseases of digestive organs swelling and transparency of head is seen. Hence the disease is also called as ‘ transparent head diseases’.

• In Sotto or toxicosis because of bacteria bacillus releases endotoxin, which causes convolutions and tremors in larva.

• Viral diseases are classified with the presence of inclusion bodies as Inclusion and Non-inclusion type which includes nuclear polyhedrosis and Cytoplasmic polyhedrosis. (NPV & CPV)

• C.P.V is caused by Smithia which shows sluggishness, transparent of thorax and dull white in appearance at this stage if larva is dissected the infected mid gut is seen as white instead of green.

• Infectious flacherie is caused by Morator virus. The diagnose of infection is concluded with flouroscent antibody technique.
• Gattine is primarily invaded by virus and secondarily by bacteria Streptococcus, which produces histopathological lesions in the intestinal epithelium.

• Muscardine appear in various forms and depending upon the colour of spores they are called white, green, black and yellow muscardine.

• White muscardine is caused by Beaveria bassiana which is common and prevalent. It shows inelasticity of skin, stops movement and finally die.

• The body is covered with white powdery Conidia with which it becomes stiff without rotting or decay. This is due to deposition of double oxalate-crystals of ammonium and magnesium.

• Aspergillus is caused by different species of aspergillus and sterigmatocytes which prefers young age larvae.

• The parasitoid pest undergoes complete metamorphosis with egg, maggot, pupa and adult stages.

• The egg is deposited on intersegment of silkworm larvae within 2-5 days they hatch into maggot which penetrates into larval body, resulting in black scarth.

**Short Answer Type Questions**

1. What is the causal organism of protozoan disease?
2. Write the symptoms of pebrinized eggs.
3. How pebrine is detected in silkworm.
4. What are the causal agents of N.P.V and C.P.V?
5. How sotto disease is identified.
6. Name the causative organism of sotto disease.
7. Draw a neat sketch of structure of pebrine spore.
8. Name the causal organism of muscardine and aspergillus.
9. What is the other name of Gattine and why is it so?
10. How non-inclusion virus is detected.
11. Mention the pests of silkworm.
12. What is parasitoid?
13. Write the scientific name of Uzy fly with classification.
14. What are the symptoms of uUzi yfly ?
15. What is the damage caused by Dermestid beetle ?
16. How biological control is done in Uzy fly.
17. Write the scientific name of bBeetles.
19. Mention minor pests of silkworms.
20. What is uzicide ?

**Long Answer Type Questions**

1. Explain symptoms of Pebrine in silkworm life stages.
2. Write briefly on symptoms of bacterial diseases.
3. Give an account on Grasserie disease of silkworm.
4. Detail the symptoms of Cytoplasmic polyhedrosis.
5. Write short notes on Pebrine spore structure.
6. Describe the symptoms of Muscardine on silkworm larva with preventive and control measures.
7. Explain the life cycle of Uzy fly.
8. Write about the integrated pest management in uzy fly.
9. Describe the life history of Beetles.
10. Brief an account on minor pests seen in rearing.
### Glossary

**Sericulture**: It refers to mass scale rearing of silk producing organism in order to obtain silk from them.

**Vanya Silks**: The silk obtained from wild silk worms which are thrive on nature grown plants.

**Tasar Silk**: A Wild type silk spun by Antheraea species feeding on Terminalia or Quercus leaves.

**Muga Silk**: The golden yellow silk spun by Antheraea assamenses feeds on som and soalu leaves.

**Polyphagous**: Habit of feeding on various types of food plants is called polyphagous.

**Primary food plants**: The food plants of first choice and give a commercial yield is called Primary food plants.

**Secondary food plants**: The food plants which are utilized for survivality, doesn’t give commercial yield is called secondary food plants.

**Tubercles**: The prominent protrusions (or) out growths on thorasic and abdominal segments. These out growth are called “Tubercles” which acts as sensors.

**Out door rearing**: Rearing of warms openly on trees naturally is called out door rearing.

**Cleaning**: It is a process of removing or eliminating dust and durt.

**Slacked lime**: It is a very effective disenfectant which dries the bed and kills the pathogens.

**Fumigation**: It is a gaseous form of desenfection.

**Disenfection**: The extermination or destruction of desease causing germs is called disenfection.

**Prothetely**: Intermediate form between larva and pupa of an insect.

**Spiracles**: It is an opening meant for respiration in insects.

**Anatomy**: Study of an organism by dissecting the body and opening the body cavity is called anatomy.

**Viscera**: When the larva or adult is cut open middorsally or laterally, the organs which are exposed in the body cavity is called viscera.
**Peristatic**: Rhythmic smooth muscular contractions of alimentary canal which pushes contents forwards.

**Spinnerette**: It is a part in mouth parts of silkworm larva, through which silk is expelled out.

**Polygamous**: A female having sexual relationship with several males.

**Grubs**: It is a stage of an insect metamorphoses where the larval stage is devoid of thoracic legs.
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