### Structure

1.1 Introduction

1.2 Classification of Silk worms

1.3 Types of Silk worms

1.4 Summary

### Learning Objectives

- Classification of silkworm characteristics.
- Systematic position of Bombyx mori.
- Types of mulberry and non-mulberry silkworms.

### 1.1 Introduction

In India man is being benefited by four types of silkworms. They are, Mulberry, Tasar, Eri and Muga silkworms. Except mulberry silkworm, all others are wild types. Mulberry silkworms is a domesticated variety which has been exploited for over 4000 years. Generally the term silk refers to Mulberry silk, because it contributes to 95% of world silk production. All the strains or races reared at present belong to the species BOMBYX MORI(L). It Produces
Cocoons with continuous filament and it can be industrially reeled to produce raw silk.

Silkworm, being a cold blooded animal, duration of each life stage, growth factors, feeding schedules are completely depend on environmental factors like temperature, humidity, rainfall, light and air. Further the insect’s racial characters also play vital role to overcome all these natural hazards. However life cycle may be delayed due to the above said factors and some may die without metamorphosis. The chromosomal studies revealed that Bombyx mori has evolved from Bombyx mandarina. The domestic silkworm has undergone a variety of genetic mutations like the ancestor silkworms.

### 1.2 Classification of Silkworm

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Arthropoda</th>
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<tbody>
<tr>
<td>Class</td>
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<td>Mori(L)</td>
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**The Characteristics Features of Phylum Arthropoda Appeared in Silkworm Bombyx Mori are as Follows**

Silkworms are classified on the basis of native regions, the number of hatchings in a year i.e. voltinism, moultng, rearing period, body markings body colour of freshly hatched larva, body colour of mature larva, colour of cocoon, colour of egg etc. But the taxonomic classification is based on the significant evolution of the organisms. It considers the body form, Organ system, Genetic traits etc.

Silkworm belong to the class Insecta, Phylum Arthropoda because the insects body is divided into Head, Thorax and Abdomen. The body has specific number of segments. A typical Insect has six segments in Head, three in Thorax and eleven in the Abdomen. The head segments are completely fused during embryo stage to form a head capsule.
The other two body divisions possess moveable segments. These insects may or may not have jointed appendages and may also possess one or two pairs of wings.

Insecta is divided into Apterygota and Pterygota. The silkworm comes under sub-class Pterygota. The sub-class Pterygota is divided into two divisions namely Exopterygota and Endopterygota. The silkworm comes under division Endopterygota. These two are further formed into different orders.

The mulberry silkworm is included in order Lepidoptera by possession of two membranous wings with few cross veins, flat scales on the body and appendages. The larval stage caterpillar with ervciform, peripneustic, three pairs of true legs, five pairs of pseudo legs.

The different kinds of silkworms are placed under super family Bombycoidae on the following characters:

- Maxillary palpi and Tympanal organs absent
- Fraenum (wing – locking apparatus) atrophied or vestigial.
- Proboscis absent.
- Chaetonema absent.
- Antenna pectinated especially in males.
- In the hind wings SC and R, diverge from cell and is connected to it by cross vein R1.
- In fore wing M1 is free.

The Bombycoidae consists of eight families of which Bombycidae and Saturnidae includes the economically important insects, which produce natural silk of commercial value. Mulberry silkworm comes under the family Bombycidae.

The wild silkworm name Bombyx mandarina is the ancestor of Mulberry silkworms. Artocarpus incisus is the ancestor of both Bombyx mori and Bombyx mandarina.

The Bombycidae includes domesticated silkworm along with ancestor stalks, while Saturnidae includes wild silkworms.

**Bombycidae**

a. Bombyx mori : The domesticated silkworm
b. Bombyx mandarina : Wild ancestor of commercially cultivated silkworms

Saturniidae

a. Antheraea pernyi - Chinese Tasar silkworm
b. Antheraea mylitta - Indian Tasar silkworm
c. Antheraea yamamai - Japanese Tasar silkworm
d. Antheraea Assama - Indian muga silkworm
e. Philosamia ricini - Eri silkworm
f. Philosamia Cynthia - Wild species of Eri silkworm
g. Eriogyna pyretorum - Fish – line silkworm of Hainan Island

1.3 Types of Silkworms

There are mulberry and non-mulberry silkworms. Besides this 400 to 500 varieties of non-mulberry silkworms are reared by tribal’s of Asia and Africa. India is the only country to produce all the four types of silk, i.e., Mulberry, Tasar, Eri and Muga. The following are the different types of silkworms.

1.3.1 Mulberry Silkworm

Bombyx mori is domesticated silkworm, feeds on mulberry leaves belonging to family Moraceae. These are classified and identified as uni-voltine, bi-voltine, and multi-voltine races and they are of pure and hybrid strains. These worms are have been reared in dwelling and separate rearing houses. The worms produce long, continuous silk filament which is white or light yellow in colour. The silk has good commercial value.

1.3.2 Tasar Silkworm

Tasar silkworms are of three types.

Antheraea mylitta - Feeds on Terminalia tomentosa and reared in India
Antheraea proylea - Feeds on Oak leaves and reared in India.
Antheraea yamamai - Feeds on Arjun, Sal, Oak, and Plum, reared in Japan.
These are Uni or Bi-voltine types. Cocoons are big in size and weigh about 7-14 grams with a peduncle and reeled to get 1000-1200 meters of fiber. Cocoons are yellow, light yellow, purple, brown, gray in color. These silkworms are found in Godavari river belt of Andhra Pradesh. The silk is highly valued for its quality.

1.3.3 Eri Silkworm

The scientific name of Eri Silkworm is Philosamia ricini and it is a domesticated silkworm, reared on Castor and Tapioca leaves. It produces a white or brick-red Silk. The cocoons are very weak and pediculate. The Eri silk filament is neither continuous nor uniform in thickness, thus cocoons cannot be reeled. Therefore the moth emerged from cocoons are used for to extract silk by process of spinning but not reeling. So the pupae are not killed, so called as 'ahimsa silk'. It is found in Assam, Bihar, West Bengal, Manipur, Odissa and Tripura.

1.3.4 Muga Silkworm

The scientific name of Muga Silkworm is Antheraea assamensis, feeds on Som and Soalu leaves to produce Golden – yellow silk thread which is very strong and attractive. It is the unique monopoly of India found in Brahmaputra Valley and adjoining hills in Assam. The rearing is done outdoors. The cocoons peduncle is weak and is of different in size and colour with continuous silk fiber. The moth emerged cocoons used to extract silk.

1.3.5 Anaphe Silkworm

Anaphe is a polyphagous Insect and feed on 22 varieties of food plants. It is a uni-voltine silkworm which is green in colour. A unique feature is that its silk nest and moths are never severely affected by the parasitism. The silkworm of genus Anaphe is found in southern and central Africa which produces the silk. Approximately 12-100 larvae form collective cocoons (spin in communes) enclosed by thin layer of silk. The cocoon is brown with 10-15 cm length, 5-12 cm thick and 10-21 cm width. Each Cocoon weighs 3.5 kg and it takes 3-4 months for spinning. This soft and fairly lustrous silk is more elastic and stronger than mulberry silk. The silk is used in velvet and plush (crafting, needlework) making.

1.3.6 Fagara Silkworm

Fagara silk is obtained from the giant silk moth Attacus atlas L. inhabiting the Indo-Australian bio-geographic region, China and Sudan. It belongs to the
family Saturniidae. It is the largest of the living insects reaching up to eleven inches in wing-span. The Fagara cocoons which are light-brown in colour measuring about 6 cm long with peduncles of varying lengths (2 – 10 cm) are less important since the silk is not commercially exploitable.

1.3.7 Coan Silkworm

Coan silk fibre is secreted by the larvae of Pachypasaotus D. These larvae are found in the Mediterranean bio geographic region (Southern Italy, Greece, Romania and Turkey etc.). This is a polyphagous insect feeding on pine, ash, cypress, juniper and oak. The cocoons are white in colour. The cocoon measures about 8.9 cm x 7.6 cm. In ancient times, this silk was used to make crimson dyed apparel worn by the dignitaries of Rome. The commercial production came to an end because of limited output and cost of production.

1.3.8 Cricula Silkworm

This Polyphagous insects feed on ten types of plants. It is found in Kishangunj area of Bihar on mango trees during August – December. The cocoons weigh 2.12 gr.

1.3.9 Mussel Silkworm

Mussel silk, a non-insect type of silk is obtained from a particular bivalve mollusk like Pinna squamosa. They are found in the shallow water along the Italian and Dalmatian shores of the Adriatic. The fibre is called byssus thread, which is brown in colour, strong in quality and keeps the animal to anchor itself to a rock or any surface of the habitat. The byssus is combed and then spun into a silk popularly known as fish-wool. Its production is largely confined to Toronto of Italy.

1.3.10 Spider Silkworm

The spider silk is a non-insect variety. The soft and fine spider silk is noted for its strength and elasticity. The commercial production is obtained from Madagascan species. The accumulated fibre formed by a dozen spiders is reeled out four or five times a month. Because of high cost of production this silk is not used in Textile Industry, but it is used as gill nets, dip nets, kite nets and various lures for the fishing activities and also for weaving bags, caps and head dresses.

**Practicals**

1. Study and observe different types of silkworm.
2. Collection of mulberry and non-mulberry cocoons, larvae and moths.
3. Collection of different types of non-mulberry food plants.
Terms Introduced

- \( CU_2 \) – Cubitus
- \( SC \) – Sub- Costa
- \( R \) – Radius
- \( M_1 \) – Media Byssus
- Fish – Wool

1.4 Summary

- The term silk refers to mulberry silk which contributes to 95% of world silk production.
- Bombyx mandarina is the ancestor of silkworms.
- Artocarpus incisus is the ancestor of both Bombyx mori and Bombyx mandarina.
- The classification is based on evolution of organisms in body form, organ systems, genetic traits etc.
- The silkworms belong to Phylum: Arthropoda, Class: Insecta, Order: Lepidoptera.
- The different kinds of silkworms are placed under super family Bombycidae and Saturniidae. These two cover commercially important silk producing insects.
- Mulberry silkworm is widely cultivated in 29 countries.
- Tasar cocoon are big weighing 7-14 gms with a peduncle and possess 1000-1200 mts. of silk fibre.
- Eri produces white or brick red colour silk while Muga gives unusual golden yellow silk which is very strong and attractive.
- Anaphe silk is produced by 12-100 larvae collectively.
- Fagara, Coan, Cricula contribute very less silk production.
- Mussel (a mollusk) and spider silk are non-insect silk.
- Mussel silk is called as fish-wool.
- A dozen of spiders collectively form cocoons.
I. Short Answer Type Questions

1. Write the classification of Bombyx mori.
2. Name some of the non-mulberry silkworm.
3. Mention the non-insect silk producers.
4. Write the scientific names of any four silkworms.
5. What do you mean by spinning in communes?
7. Mention the ancestor of Bombyx mori and Bombyx mandarina.
8. What does the term silk refers to?
9. Name some of the Chief food plants of silkworms.
10. Name the cocoons that can be reeled and spunned.

II. Long Answer Type Questions

1. Write a brief note on classification of Bombyx mori
2. Write in detail about the importance of non-mulberry silkworms.
3. Explain the different types of silkworm.
Learning Objectives

After studying this unit the student will be able to understand

- Life cycle of silkworms
- Morphological characteristic features of silkworm, Egg, Larva, Pupa and adult
- Definition of metamorphosis

2.1 Introduction

Morphology is the study of external characters of an animal. It helps us to identify the animal and also to know the different functional significance of the organs (or) structures found. The domestic silkworm undergoes complete metamorphosis (Holometabola) and passes through four morphological stages i.e. egg, larva, pupa and adult. The fundamental knowledge of rearing silkworms
for reeling cocoons is to learn the morphology and physiology of silkworm life stages and their importance.

## 2.2 Morphology of life stages

Out of these four stages larval period continues for several days at the silkworm larvae spin cocoon first prior to pupation. The morphological features of these stages are as follows.

### 2.2.1 Egg Stage

The silkworm eggs are tiny and weigh around 2000 eggs to a gram. It measures 1-1.3 mm in length and 0.9 – 1.2 mm in width. The size, weight, shape, colour of the egg, number of eggs per laying vary among the different races and according to the season. The eggs of European races are comparatively larger and heavier. An average Indian cross breed multi-voltine races lays about 400 eggs per laying.

![Fig. 2.1 Structure of Silkworm Egg](image)

The Eggs are ovoid, ellipsoid or oval and flat on one side. This is called egg dimple. The egg our also depends upon a racial character. Races producing white cocoons lay pale yellow eggs while yellow cocoons lay deep yellow eggs. The Japanese races lay slightly darker eggs than Chinese races. In diapausing eggs, the egg colour changes after 24 hrs of egg laying and becomes dark brown or purple with deepening of the colour of the seasonal pigment, but in non –
hibernating eggs the colour does not change. The protective covering of the egg is called Chorion, which has an opening called micropyle at the anterior end.

There is a thin membrane called Vitelline membrane inside the chorion. The vitelline membrane covers the protoplasm and the yolk. The yolk is not present throughout the egg but present just below the vitelline membrane. A thin layer of cytoplasm does not contain the yolk and this portion is called the Periplasm which is particularly thick around the micropyle. This area is called an anterior polarplasm and contains the egg nucleus.

2.2.2 Larval Stage

The newly hatched larva is black or dark brown in colour measuring about 3 mm in length. It is commonly called as ANT or KEGO. The head is large and the body is densely covered with bristles. There are four pairs of tubercles i.e., sub dorsal, supra spiracular, intra spiracular and basal tubercle each carrying 3-6 setae. As the larva grows by passing moults to enter into later instars the body becomes smooth and light in colour due to rapid stretching of cuticular skin. The body has 3 divisions i.e., head, thorax, abdomen. The thin elastic chitinous cuticle permits rapid growth of the larvae during any instar. (fig 2.2)
2.2.2.1 Head

The head consists of six body segments fused together with a cranium. The 2nd, 4th, 5th and 6th segments carry appendages which are modified into antennae, mandibles, maxillae and labium respectively. Median epicranial stature is well developed and prominent. Similarly on the outside, the clypeus and the labrum are also prominent. There are six pairs of Ocelli or larval eyes which are located behind and a little above the base of the antennae. There is a pair of antennae formed of five jointed segments and they are used as sensory organs (feelers). The mandibles are well developed, powerful and are adapted for mastication (fig 2.3).

The maxilla on the ventral side of the mouth consists of cardo, stipes, maxillary lobe and maxillary palpi. Maxillary lobe and Maxillary palpi discriminate the taste of food. The labium is located ventrally carrying a big-sized lightly chitinized mentum.

![Fig. 2.3 Mouth parts of Silkworm Larva](image)

The prementum is chitinized and black. Distally the prementum carries a median process or spinneret through which silk is expelled from the silk gland to form the silk bave or thread to form cocoon. The sensory labial palpi are found on both sides of the spinneret.

2.2.2.2 Throax

Thorax consists of three body segments called the pro-meso and metathorax. Each of the three thoracic segments carries ventrally a pair of legs each comprising in turn three jointed segments. These are the true legs which are conical in shape and carry sharp distal claws. These claws are not used for
crawling, but are used for holding mulberry leaves while feeding. Silkworms contain eye spot (spiracle) on the dorsal side of the meso-thorax.

2.2.2.3 Abdomen

The abdomen is comprised of eleven body segments although only nine can be distinguished and the last three are fused together to form the apparent ninth segment, the anal plate and the caudal legs. The third to sixth and the last abdominal segments bear a pair of abdominal legs in each segment which are fleshy, unjointed muscular protuberances. At the extremity they form a sort of disc with a series of hooks inwardly curved and arranged in a semi-circular fashion. On the dorsal side of the eighth abdominal segment, the larva carries the caudal horn.

Sexual Markings

The abdominal segments carry the sexual markings which develop distinctly in the fourth and fifth instars, in the eighth and ninth segments on the ventral side. (fig 2.4)

In the female the sexual markings appear as a pair of milky white spots in each of the eighth and ninth segments. The pair of spots on the eighth segment is known as Ishiwata’s fore glands and a pair on the ninth segment is referred as Ishiwata’s hind gland. In the male a small milky white spot named Herald’s gland appears at the centre of the ventral side between the eighth and ninth segments.

Fig. 2.4 Larval sex markings
Spircles (Respiratory pores)

On either sides of the silkworm body there are nine pairs of spiracles placed laterally. They are found on the first thoracic segment and the first to eighth abdominal segments. These are the breathing or respiration pores.

Larval skin

The larval skin or integument consists of the cuticle and the hypodermis. The cuticle is made of chitin as well as protein and is covered with a thin layer of wax. Nodules are found all over the body surface of the silkworm larva. The distribution of the nodules differs according to the variety of silkworms. The larval markings in silkworms are caused by skin pigment.

Pupa or chrysalis

The pupal stage is generally called the resting, inactive stage of the silkworm when it is incapable of feeding and appears motionless. This is a misnomer. The pupal stage is a transitional phase during which definite changes take place. During this period of biological activity the larval body and its internal organs undergo a complete change (Metamorphosis) and assume the new form of the adult moth. The mature silkworm larva passes through a short transitory stage from pre-pupa to a pupa stage. During the pre-pupa stage the dissolution of the larval organs takes place and this is followed by the formation of the adult organs during the pupa stage. Soon after pupation the pupa is white in colour and soft, but gradually turns brown to dark brown and the pupa skin harden. (fig 2.5) The prominent morphological parts visible are a pair of large compound eyes, a pair of large antennae, fore and hind wings and the legs. Ten of the abdominal segments are seen on the ventral side when nine are seen from dorsal side. Seven pairs of spiracles are found in first seven segments and last pair is non-functional.

Sexual Markings

These are prominent and very easy to identify the sex of pupa. The female pupas with broader abdomen while the male pupa with narrow abdomen. The female has a fine longitudinal line (X mark) on the ventral side of eighth abdominal segment. In the male there is a small round spot on ventral side of ninth segment.
2.2.4 Adult Stage

The adult moth emerging from the pupa is incapable to fly. It does not feed during its short adult life. The body of the moth is composed of three distinct segments i.e., Head, Thorax and Abdomen. The adult body surface is covered with scales. (fig 2.6)

Head

The compound eyes are situated on the either side of the head. The ocelli are absent. The antennae are conspicuous, large and bi-pectinate.
Thorax

The thorax consists of three segments namely pro, meso and meta thorax. The meso thorax is the largest and is pentagonal. There are three pairs of thoracic legs, one pair on each of the three thoracic segments. Each of the thoracic leg consists of five segments. The meso and meta thorax bear two pairs of wings, the front pair overlapping with the hind pair when the moth is in the resting position.

Abdomen

In the male adult eight abdominal segments are visible, in the female seven segments. There are six pairs of spiracles present laterally on either side of the body.

Sexual Markings

Morphologically the female and the male can be distinguished in the adult stage. The female has comparatively smaller antennae, its body and the abdomen are fatter, larger and it is generally less active than the male moth.

Fig 2.7 Sexual Markings of Moth Stage
At the caudal end, the male moth has a pair of hooks known as harpes, whereas the female moth has a knob like projection with sensory hairs.

These differences help to a large extent in separating the sexes for preparation of hybrid eggs (Fig 2.7).

2.2.5 Life History of Bombyx Mori

2.2.5 Stages of Life Cycle

The silkworm passes through four important stages (Egg, Larva, Pupa, and Adult) during its life cycle (fig 2.8). The life cycle is completed in six to eight weeks depending on climatic and racial characters. In nature uni-voltine, bi-voltine, multi-voltine races are confined to different bio-geographical parts. Among them multivoltines of tropical areas have the shortest life cycle. The uni-voltine races produce only one generation in summer and the second generation Eggs undergoes hibernation till next spring. In Bi-voltine races the third generation eggs undergoes hibernation thus producing thus only two crops in a year. In the case of multi-voltine are non- hibernating thus yields as many as seven to eight generations in a year in tropical sericulture areas. The multi-voltine races have the shortest life cycle because of warmer ecological conditions and the rearing activity continues throughout the year. However, the rearing is stopped in summer because of high temperature which affects growth and disease attack besides non- availability of mulberry leaves. But these races are also grown in acclimatized environmental conditions, artificial diet in the lab, Which is not yet commercialized.

### Table 2.1

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<th>Multi-voltine</th>
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<td>Larva</td>
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<td>24-26 days</td>
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<td>Pupa</td>
<td>12-15 days</td>
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<td>Adult</td>
<td>6-10 days</td>
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<td>3-6 days</td>
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</table>

2.2.5.1 Egg Stage

The duration of egg stage in the life cycle depends on diapausing or non-diapausing eggs. The diapausung eggs remain dormant under natural conditions for months together till spring of next year. This diapause can be
broken artificially by acid treatment, after which eggs are incubated at a constant temperature for 11-14 days for hatching. The temperature (24-25 c) provided during incubation favours the embryonic development of the egg to larva. While the non-diapausing eggs normally hatch in 9-12 days period. These eggs can also be preserved for next year by postponing the embryonic development by various cold preservation sheds.

2.2.5.2 Larval Stage

This stage is important to the rearer since the complete crop yield depends on the various physiological process of the larva. The larval life may last from 20-24 days in multi-voltine species in tropical areas or 24-28 days in uni and bi-voltine races in temperate areas. The larval life of the worm is divided into five respective stages known as 5 Instars and 4 moults, so as to accommodate the growth that takes place in each instar, the feeding period. Thus the larva casts off its skin and develops a new one to enter into succeeding instar. Most of the silkworm races are tetra moulters. Silkworm larva start feeding on mulberry leaves soon after hatching. After reaching the certain growth first moult and second instar, second moult and third instar, third moult and fourth instar, fourth moult and fifth instar occur.

During this long period of feeding the larvae grows to 8,000 to 10,000 times compared to newly hatched worm. However the weight gain varies with the silkworm variety, besides nutritional condition. The first three instars are referred as “young age” or “Chawki worms” and fourth and fifth instars as “late age” worms.

2.2.5.3 Moulting

Moulting refers to shedding of old skin and forming a new skin. Each larval instars has feeding phase and moulting phase. Since the larval period is the active and feeding stage it enables to build up the energy reserves for the next life stages. After feeding voraciously and having attained full growth for the particular instar the worm looses its appetite and the larva prepares to moult and cast off its old skin. The each moulting period lasts for 15 to 30 hrs. The first moult is the shortest than remaining. The moulting is a physiological process under the control of ecdysone hormone while the active feeding period is administered by juvenile hormone.

Mature Worms

After passing four moults the larvae reaches fifth or final instar, which continues for 6-8 days and larvae are fully matured and ready for mounting. At this stage the larvae loses appetite, stops feeding and excretes soft faeces and
urine with high moisture content and turns to golden yellow colour ripen worm starts spinning the cocoon.

**Fig. 2.8 Life cycle of Silk worm (Bombyx mori)**

**2.2.5.5 Cocoon - Pupa**

The mature and ripen worms spin the cocoon immediately after mounting and completes the spinning process in 48-72 hrs. In another day or two the worm transforms into pupa within the cocoon.
Pupa is an inactive stage where the larval structures degenerate and adult structures differentiate. The pupal period may last for 8-10 hrs. The differentiated adult emerges slitting through the pupal skin, and piercing the final fibrous cocoon shell by releasing a mild protease.

### 2.2.5.6 Adult Moth

Adult moth exhibits sexual dimorphism like larvae and pupa. These moths are ready to copulate immediately after emergence. Adults’ life span is very short and last for 3-10 days depending on the season and races. Adults do not feed and incapable of flight. The females are with broad abdomen and males have narrow abdomen. The female lays about 400 eggs after copulation with male.

### 2.3 Metamorphosis

The silkworm completes metamorphosis by passing through four developmental stages which were explained earlier in this chapter. Such development through different stages which are morphologically different to each other is called holometabolous development. The mature larva spin the cocoon, sheds its skin and metamorphoses into pupa. During pupation, the pro-thoracic gland plays a vital role. In the pupae the brain secretes a hormone which activates the pro-thoracic gland which in turn secretes a hormone inducing the metamorphosis into the moth. The pro-thoracic gland hormone is called moulting hormone or ecdysone.

### Pрактические

1. Observe and examine the morphological characteristics and sex separation of silkworm, Egg, Larva, Pupa and adult.

2. Observation of life history of silkworm i.e., duration of each instar, moulting, metamorphosis.

### Terms

- Holometabola
- Egg dimple
- Kego
- Chrysalis
- Moultng
- Mounting
Summary

- The silkworm undergoes complete metamorphosis.
- There are four stages in the life cycle of silkworm. They are egg, larva, pupa and adult.
- The eggs are tiny, ovoid, elliptical flat on one side. The flat part is called dimple. The non-hibernating eggs do not change their colour.
- Freshly hatched larvae are called “ants”. The head is large, body covered with bristles.
- The head plates are epi cranium, parietals, clypeus and labrum. The 2nd, 4th, 5th and 6th segments carry appendages which are modified into antenna, mandibles, maxillae and labium.
- Head bears sense organs and mouth parts.
- The laval thorax has a pair of legs in each segment which are use to hold the leaf while feeding.
- Abdomen has eleven segments. The third-sixth and the last segment has a pair of legs for crawling.
- A caudal horn is present on eighth segment.
- Female larva has ishiwata glands on eighth and ninth segment by these two features sexes are identified.
- Pupa is soft and white soon after spinnig but becomes hard and brown while tanning of pupal cuticle.
- Compound eyes, antennae, mouth parts are present at the anterior end. Wing pads and limb buds are present.
- Female abdomen is broad and has a longitudinal line on the ventral side of the eighth abdominal segment. In male only a round small spot is on ninth segment.
- Adult moth body is covered by scales. Thorax has two pairs of wings and three pairs of legs.
- The caudal end of female moth has a knob like projection. Male moth has large antennae with narrow abdomen and are very active, the caudal end has harps.
• The silkworm undergoes complete metamorphosis in its life cycle by passing through four different stages i.e., Egg, Larva, Pupa, Adult.

• Life cycle is completed in 6-8 weeks depending upon racial characters and climatic conditions.

• Multi-voltine races of tropical areas have shortest life span because of warmer ecological conditions.

• Duration of egg stage depends on diapausing or non-diapausing eggs.

• Non-diapausing eggs normally hatch in 9-12 days.

• Larval period is active feeding stage and important for the rearer as the crop yield depends on various physiological processes of the larva.

• The larval period is 24-28 days consisting of five instars and four moults and grows normally.

• The larvae after reaching the peak growth level they become mature larva.

• The larvae grows to 8,000 to 10,000 times compared to newly hatched worm.

• The first three instars are referred as “young age” or “chawki worms” and fourth and fifth instars as “late age”

• Moulting is shedding of old skin and forming a new one time and duration varies for each moult.

• Moulting is controlled by ecdysone and development of embryo from egg is controlled by juvenile hormone.

• Spinning of cocoon is completed in 48-72 hrs.

• Pupal period lasts for 8-10 days.

• Adult moths copulate immediately after emergence.

• Life span of adult is only 3-10 days.

• Moths do not feed, incapable of flight.

• Female lays about 400 eggs.

• Metamorphosis is holometabolus type.
Short Answer Type Questions

1. How do you identify hibernating and non-hibernating eggs on the basis of egg colour?
2. What do you mean by ant in sericulture?
3. What are the mouth parts of silkworm larva?
4. How do you identify male, female larvae?
5. How do you identify male, female pupae?
6. How do you identify male, female moths?
7. Draw a neat diagram of male and female pupa.
8. Write the characters of silk moth.
9. What do you mean by egg dimple?
10. Mention some of the head plates.
11. What are the life stages of silkworms?
12. What is the difference between the hibernating and non-hibernating eggs?
13. What do you mean by moulting?
14. What is young age and late age?
15. What are the hormones to carry on moulting and instar?
17. Define metamorphosis

Long Answer Type Questions

1. Write about the morphology of silkworm larvae.
2. Write about the morphology of egg and pupa.
3. Write about the morphological features of pupa and adult.
4. Narrate the morphology of silkworm egg and add a note on sexual markings of larva, pupa and adult.

5. Discuss about the life stages of silkworm (or) Bombyx mori.

6. Write short notes on
   
   (a) Larva           (b) Pupa
There are plenty of silkworm races and strains. Being a domesticated and commercially exploited animal each country is actively engaged in evolving new varieties of Bombyx mori by crossbreeding of native and exotic races. A race is formed by combination of all characters heritable to offspring’s. The morphological and ecological characters are heritable. The morphological
characters are size of egg, colour of egg, colour of newly hatched larvae, form of larvae, size of larvae, colour of larvae, larval markings, shape of cocoons, size of cocoons, colour of cocoons, shape of pupae, size of pupae, colour of pupae, size of moths, markings on wings of moths, colour of moths. The ecological characters are length of larval stage, diapause, moulting, eating behavior, quality of cocoons and filaments, etc. The races are based on native region, voltinism, moulting and cocoon colour. Among these some of the good characters are considered to evolve a hybrid variety. It is necessary to understand about the different parental races from which the present hybrids are evolved for commercial production of cocoons.

The advantages of rearing hybrid silkworms are shorter larval period, low leaf cocoon ratio, mortality is reduced, cocoon weight and the shell weight are high, filament length of fibre is longer, silk filament is thicker, cocoons are more uniform in size and shape.

3.2 Global Distribution

On the basis of native regions these silkworms are four types. They are Japanese, Chinese, European and Tropical races. European races are native of Europe and Central Asia. Tropical or Indian races are native of India and south East Asia. The uni-voltine, bi-voltine and multi-voltine races are found in Japan, China, Europe and India. But some of these varieties like multi-voltine is popular in warmer region and reared in India. However, these parental races confined to a particular Geographic region are involved in certain combination to evolve new hybrid varieties. Some of them are maintained (stock) in basic seed forms for future purposes. In Japan alone, more than 2000 genetically identified races are maintained (JOCV, 1981). In India there are about 200 races maintained at different breeding centres (FAO, 1981). At present there are separate breeding stations in India for evolving commercial races of multi-voltine and bi-voltine varieties.

3.3 Seed Organization

The silkworm seed organization is a vital programme for any successful sericulture programme. To produce good quality seeds there must be a sound seed organization. The silkworm eggs required for commercial rearing should be of high quality and free from disease.

The production and supply of disease free laying’s (DFL’S) is highly specialized work at the seed organization. It will be the responsibility of those who are engaged in silkworm seed organization with technical and scientific skills to maintain the basic stock of the races, its multiplication and supply them to the main streams of commercial seed production.
National Silkworm Seed Organization is a separate entity under Central Silk Board, established in the year 1975 to supplement the efforts of State Governments in supplying high quality Bi voltine and Multi voltine and its cross breed silkworm seeds to the farmers.

It has a mandate to maintain, multiply and supply authorized silkworm stocks, production and supply of quality industrial silkworm seeds and transfer of technologies in the field to improve the productivity and quality of silk.

The seeds maintained at the seed organization can be of Reproductive seeds and Industrial seeds.

**Reproductive Seed**

It is intended for producing the pure seed cocoons which are required in large numbers for producing commercial hybrid eggs.

**Industrial Seed**

These are generally specific hybrids between two or more pure races of silkworms and are reared by the sericulturists for producing cocoons on a commercial scale for reeling purposes.

### 3.4 Races

As detailed earlier in this chapter there are different races in silkworms. Their classification is based on native regions, the number of hatchings in a year, rearing period, body markings, cocoon colour, egg colour etc.

#### 3.4.1 Based on Place of Origin

There are four types of races. They are as follows.

(a) Japanese race.

(b) Chinese race.

(c) European race and.

(d) Tropical or Indian race.

Above said races can be distinguished from one another on the basis of morphological characters of Egg, Larva, Pupa and Adult. Biological characters like duration of lifecycle, diapause, moults, environmental factors, commercial characters like filament length, denier, reelability, mortality, shell ratio etc.
(a) **Japanese Race**

It has uni-voltine and bi-voltine silkworms. The eggs are in many colours and are non-hibernating. Many white, rotten eggs are produced in which many eggs die after pigment stage. The larvae are healthy and strong but grow slowly. The markings on the skin of the larvae are normal but sometimes show quail markings. The body is black in colour.

The larvae are yellowish during moult and red in ripe stage. The larvae are slow in eating thus the duration continues for a long period. Worms do not identify leaf quality. Nf (Neurofibromatosis) type virus disease is observed. Cocoons are dumbbell shape or peanut shape or spindle shaped with white or straw colour. Many of these are double cocoons. Cocoons are inferior with less fibre length and reeling is generally poor.

(b) **Chinese Race**

Chinese eggs are light yellowish in colour. The larvae are white with round body form. They are white during moult and blue in spinning stage. The larva are robust against high temperature and weak against high humidity. They grow rapidly by feeding actively on mulberry leaves. These are trimoulters, cannot identify the differences in temperature, humidity and air. These larva are not resistant to Muscardine disease. Cocoon are round or oval or spindle shaped and are white, golden yellow, green, flesh colour, red or even pink in colour. Cocoon filament is long with good reelability. This cocoons are uni, bi, multi-voltine types.

![Fig. 3.1 Types of Races](image)

(c) **European Race**

Eggs are big, heavy and dark brown in colour. The hatching is irregular. The larvae are long, big with pale normal markings. The larvae are yellowish
during moult and red in ripe stage. The larval period is longer and larvae grow fat by feeding actively on mulberry leaves. These are weak against the high temperature and humidity. Pebrine, Muscardine, C-virus diseases are common. Cocoons are long oval, white or flesh or yellow in colour. Shell weight is more; fibre is long with good reelability. Double cocoons are less. The sericin counter is more, making easy reelability. These are uni-voltine. (fig. 3.1)

(c) Indian Race

Eggs are small and are light weight with lustrous shell. The larva are small, long and are robust against high temperature and humidity. The larval duration is quick except Pure Mysore race. Muscardine disease is common. Cocoons are spindle shaped with green, yellow or white and flossy. Shell weight is less. Cocoon filament is fine but thin. These are poly-voltines.

3.5. Voltinism

Voltinism is the ability of silkworm to produce one to several generations in a year. Based on voltinism the silkworms are broadly classified into three types.

(a) Uni-Voltine
(b) Bi-Voltine
(c) Multi or poly-Voltine

(a) Uni-Voltine

Silkworms producing one generation in a year are called uni-voltine. Uni-voltine lays diapause eggs due to absence of juvenile hormone. They have a long life cycle. Larvae and Cocoons are large. They are very sensitive to environmental conditions. They are unsuitable for summer and autumn. The diapause eggs are reared by artificial breaking. The cocoon filament is of good quality. The shape of cocoon is round and oval which is white and pale yellow in colour.

(b) Bi-Voltine

They produce two generations in a year. The first generation adult lays non-diapausing egg. The second generation adult developing from non-diapausing egg laid during first generation lays diapause eggs due to absence of juvenile hormone, which is dormant till next spring. The larval duration is short. Larvae are robust and tolerate environmental conditions. The leaf cocoon ratio is less. The quality of the cocoons is inferior to that of Uni voltine races. Cocoon weight, shell weight, silk percentage and filament length are lesser than uni-voltines.
Cocoons are dumbbell or oval in shape, white or pale yellow in colour. Example: NB4D2, NB18, KA, NB7 etc.

(c) **Multi-Voltine**

They produce more than 5-6 generations in a year. The larval duration is short. The leaf cocoon ratio is high. Cocoons are small in size. The cocoons produce inferior quality silk than uni and bi-voltine races. The shell ratio is less. The filament length is short. The filament is fine and clean with little lousiness, but with more lustrous. The larvae are robust and can tolerate fluctuating environmental conditions and hence best suited for tropical climates. They lay only non-diapausing eggs due to presence of juvenile hormone. Example: Pure Mysore, C.nichi, Hosa Mysore.

### 3.5.1 Moultinism

Silkworm larvae cast off its old skin and develop new skin and this process is known as **Moultinism**. Each moulting period lasts for 15-30 hrs. It is a hereditary character. The moulting is a physiological process under the control of ecdysone hormone. Based on number of moults the Bombyx mori can be of tri-moulter, tetra-moulter and penta-moulters. In tri-moulters the length of the larval stage is short. The larval body and cocoons are small and the cocoon filament is fine. The tetra-moulters larval duration is medium and produces thin fibre. Most of the commercially reared worms are tetra-moulters with five instars.

These worms are reared most widely. In Penta-moulters larval length is long, the body, cocoon and the filament length is large in size.

### Practicals

1. Observe and examine the different races of silkworm.
2. Analyse hibernated and non-hibernated eggs.

### Terms Introduced

- Hibernated and non-hibernated.
- Nf virus (Neurofibromatosis).
- Reproductive & Industrial seed.

### Summary

- There are plenty of silkworm races.
- Hybrids are evolved from different parental races.
• These parental races are distributed in different geographical parts. There are Japanese, Chinese, European and Indian races.

• Races are classified on the basis of native origin, moultinism, voltinism, cocoon colour, larval marking etc.

• The race can be differentiated from one another on the basis of morphological, biological and commercial characters.

• Japanese race lay non-hibernating eggs, larvae grow slowly, black in colour, slow eaters, inferior cocoons.

• Chinese races are robust to high temperature, rapid growth, tri moulters, good reelability, filament is long.

• European race eggs are big, heavy, and irregular in hatching, larvae are long, long life, fast growth, and weak against high temperature. Cocoons are long with more shell weight with long fibre and good reelability.

• Indian race eggs and larvae are small, robust against temperature and humidity. Cocoons are flossy with less shell weight, filament is fine.

• Silkworms are of three types on the basis of the number of generations produced per year. They are uni-voltine, bi-voltine and multi-voltine.

• Moultinism is a racial character based on which the silkworms are classified into three groups. They are Tri-moulters, tetra-moulters and penta-moulters.

**Short Answer Type Questions**

1. Mention the parental races of silkworm.

2. What are the types of Moultinism?

3. Mention the type of races based on Voltinism.

4. Define Voltinism.

5. Define Moultinism.

6. How many generations does uni, bi and multi-voltines produce in a year?
Long Answer Type Questions

1. Write about parental races based on place of origin.

2. Add a note Voltinism and moultinism.
Grainage Equipments

Structure

4.1 Introduction

4.2 Prerequisites for Grainage Operations

4.3 Grainage Building

4.4 Grainage Equipments and their uses

4.5 Summary

Learning Objectives

• Study the plan of model Grainage building.

• Different types of Grainage equipments.

• Types of disinfectant solutions.

4.1 Introduction

Grainages are the centres for production of large scale quantities of disease free layings of silkworm. Grainages produce pure and hybrid seed. These centres are more popular as commercial egg production centres because they have a direct link with seed rearers. These centres encourage progressive farmers and seed rearers to produce seeds commercially. Farmers always intense to produce good quality cocoons, hence the farmer look forward to the Grainage
for the supply of high vigor disease free commercial seeds. These seeds produce cocoons with rich silk content and high yield.

The Grainage should have proper facilities, good environmental conditions, and well spacious rooms, without water stagnation around the Grainage building and should be away from factories and pesticide industries. A Grainage must be established where sericulture is popular among the villages. It can also help the farmers technically. These Grainage centres conduct training program for the unemployed youth to create awareness on commercial rearing

4.2 Prerequisites for Grainage Operations

There are important prerequisites for running a Grainage operation. They are (1) Building location (2) Structure of Grainage building (3) Grainage equipments (4) Technical staff.

4.2.1 Building Location

The location of the Grainage should be in commercial cocoon producing area to fulfill the needs of commercial rearers. If the Grainages are located away from the seed areas, transport of seed cocoons and eggs is unsafe especially in summer, the high temperature leads to pupal death, melting of cocoons, irregular hatching, more number of dead eggs and poor moth emergence which effect the complete rearing activity. Hence Grainages should be located in commercial cocoon producing areas for easy transport of seed cocoons and also to transport layings to the rearing centres. The surrounding of the Grainage must be free from polluted air since it is unsuitable for egg production.

4.2.2 Labour

Processing of egg production highly requires large number of laborers. Since the span of seed cocoons is very short and the large numbers of cocoons are utilized for egg production, more than the technical staff requirement the unskilled labour is almost essential.

4.2.3 Seed Rearers

The Grainage should have a proper number of rearing centres for easy transport and for getting technical support and supervision.

4.3 Grainage Building

The egg production and processing should be carried out with lot of care and necessary techniques. It requires specific environment to carry out the Grainage activity. Hence separate convenient building is required. Each stage of Grainage activities is confined to a particular room with suitable environment.
Light, temperature and humidity plays a major role in various activities. Some rooms require good ventilation and some rooms require darkness. For preservation of seed cocoons long and spacious room is required (fig 4.1)

4.3.1 Well Planned Grainage Building

Well planned Grainage building must posses the following components.

1. Seed cocoon reception and processing rooms.
2. Seed cocoon / Pupae preservation rooms.
3. Coupling and decoupling room.
4. Egg laying chambers.
5. Moth examination lab.
6. Egg processing room.
7. Incubation chambers.
8. Cold storage room.
10. General and pierced cocoon stores.
The size of the Grainage building varies with the target of egg production. A model Grainage for industrial seed production for a capacity of 25 lakh dfls per annum is shown in the above diagram.

The industrial Grainage should not be located in seed areas. In temperate and sub-tropical regions they should be constructed in a north-south direction to get maximum sunlight to warm up the rooms. In tropical regions they should be oriented in an east-west direction to avoid the effects of direct sunlight and to achieve cooler temperature. The Grainage building must be in such a way that the rooms for step by step processing are located adjacent to each other to avoid movement of laborers and staff and confusion in preparation of layings. Moth examination room should be away to avoid contamination. Ovi position room should be nearer to cocoon preservation rooms. The cocoon preservation rooms, Pairing rooms, Ovi position rooms must be provided with facilities to maintain temperature, humidity, to provide darkness and light when needed.

Moth examination rooms are provided with wider windows and artificial light for examination. Washing and facilities for acid treatment are compulsory in egg washing room. Cold storage room must be near egg laying room for easy maintenance of optimum temperature in ovi position rooms.

4.3.2 Technical Staff

The Grainage activity has three components i.e., supply of parent seed cocoons; processing of cocoons; moth examination and disposal of seed. All these activities are carried out by group of technical staff. The Grainage of 15 lakh capacity should have 16 technical staff to carry on all the process of egg production.

4.4 Grainage Equipments and Their Uses

The Grainage equipments are designed for a specific function. These equipments are made in such a way to transport and handle easily. Equipment is used to control disease incidence, to sterilize, to check the attack of ants, to check light, to keep moths undisturbed. The Grainage equipment and their uses are as follows.

4.4.1 Cocoon Preservation Stand

Cocoon preservation stand are made of wood or bamboo or iron. It is easy to move them from place to place. This rack measures 228.6 cm height, 144.8 cm length and 61 cm breadth and should have 10-12 shelves with a space of 20 cm between each self. The seed cocoon preservation trays are arranged on the shelves and each stand can accommodate 10 trays. It is used for preservation of seed cocoons on the shelves (fig 4.2).
4.4.2 Cocoon Preservation Trays

Grainage trays are portable receptacles for keeping seed cocoons, paired moths and egg laying moths.

Trays are of two types:

(a) Round tray  (b) Rectangular tray

**a. Round tray**

It is made of bamboo and easy to handle. It is used for preservation of seed cocoons. Each tray is of 137.2 diameter in size, depth 6.5 cm (fig 4.3A).

**b. Rectangular trays or Wooden trays**

It is made of wood, ply wood or wire mesh bottom. It is used in Grainage for pairing and ovi-position of moths. It measures 91.5 cm length and 61 cm breadth (fig 4.3B).

4.4.3 Ant Well

It is made of concrete or stone blocks, 21 cm square and 8 cm high with a deep groove of 4 cm running all round the top. The leg of Grainage stand rest on the centre of the block and water is poured into the groove to stop
crawling of ants on to cocoon preservation trays. Each stand leg must rest in a well. Antwell are used to control the attack of ants. Ants cause lot of damage to cocoons and moths (fig 4.4).

Fig. 4.4 Ant Well

4.4.4 Cellule

It is made of plastic which is black in colour measuring 3.2 cm in height and 5.1 cm in diameter. The copulate females are kept on an egg sheet and are covered with a cellule. It provides semi-dark condition around the paired moths and ovi-positing female moths. It increases the fertility and egg laying capacity (fig 4.5).

Fig. 4.5 Cellule (Plastic)

4.4.5 Moth Crushing Set

It is made of porcelain, having 10 mortars and 10 pestles. It is used for crushing the larva, pupa and moths to prepare smears. The supernant liquid after centrifuge is examined under the microscope for identification of pebrine spores. Diseased moth eggs are discarded before processing. The same work can also be done by moth crushing machine and pebrine separator (fig 4.6).
4.4.6 Microscope

Compound microscope is used for conducting mother moth examination after ovi-position and pupal examination to detect pebrine spores. This microscope is having 600 magnifications (fig4.7).
4.4.7 Wet and Dry bulb Thermometer

It is used to measure the room temperature and relative humidity in the Grainage (fig 4.8).

4.4.8 Dial Hygrometer

It is used to measure room humidity directly (fig 4.9)

*Fig 4.9 Dial Hygrometer*

4.4.9 Wash Basin or Basin Stand

It is a tripod stand with a height of 86.5 cm to hold a basin (30.5 cm dia). The basin is filled with 2 % formalin. This liquid is to wash and sterilize
hands while entering into the room. It is kept nearer to cocoon, moth preservation room and egg laying room (fig 4.10).

Fig. 4.8 Wet and Dry Bulb Thermometer

Fig. 4.9 Dial Hygrometer

Fig. 4.10 Wash Basin
4.4.10 Acid Treatment Bath

This equipment is used for treating the uni-voltine and bi-voltine layings to break hibernation and enables them to hatch as usual (fig 4.11).

4.4.11 Crates

Crates are used for preserving the male moths after emergence.

4.4.12 Refrigerator

Refrigerator is used for synchronization of moths and also to preserve male moths which can be used for second pairing.

4.4.13 Incubator

Incubator are used to incubate the silkworm eggs at 23-25°C temperature and 80-85% relative humidity for uniform development of the embryo (fig 4.12)
4.4.14 Sprayer

It is used for disinfecting the Grainage building and equipments.

![Sprayer](image1)

Fig. 4.13 Sprayer

4.4.15 Mouth Mask

The silkworms have plenty of scales on body and wings. These scales are spread in the moth emergence room during their emergence. Thus mask is used to prevent inhaling of scales, dust and formalin fumes by workers.

4.4.16 Deflossing Machine

Deflossing machine is used to defloss the cocoon before moth emergence. It is operated by pressing the pedal. The deflossed cocoons are collected and preserved (fig 4.14).

![Deflossing Machine](image2)

Fig. 4.14 Deflossing Machine
4.4.17 Cocoon Cutting Machine (CCM)

It is used to cut the cocoon and separate the pupae which is one of the important grainage activity. It is mechanized equipment. (Fig. 4.15)

![Cocoon Cutting Machine](image)

Fig. 4.15 Cocoon Cutting Machine

4.4.18 Formalin Mat (Foot Cleaning Tray)

A gunny bag or cloth piece is spread in a iron sheet tray having 2% formalin or any other disinfectant and kept in front of the door. While entering into the room one should keep the foot in the tray for disinfection (fig 4.3.c).

4.4.19 Moth Testing Table and Stool

These are used to keep microscope during moth examination. The table is to keep moth crushing set, slide box, cover glass packet, water or KOH and observation note book. The stool is used for sitting during moth examination (fig 4.16).

![Moth Testing Table and Stool](image)

Fig. 4.16 Moth Testing Table and Stool
4.4.20 Other Equipments
Other equipments like air cooler, slide box, cover glasses, electric heater, egg sheets, loose egg boxes, hydrometer, clock are also required for Grainage.

4.5 Disinfection
Destruction of diseased germs in Grainage building and equipments is called disinfection.

4.5.1 Types of Disinfectants
The basic chemicals used for disinfection are

1. Chlorine compounds like chloramines.
2. Iodine as iodophors.
3. Phenol derivatives like cresol, hexachlorophene.
4. Cetylpyridinium chloride and benzyl alkonium chloride.
5. Formaldehyde.
7. Sodium hypo chloride.
8. Lime powder

Among all chlorine dioxide, formaldehyde, bleaching powder are most popular disinfectants used by silkworm rearers. These are used as spray, dusting and for fumigation.

Practicals

1. Observe and examine the different plans of model Grainage buildings.
2. Prepare a model of Grainage building using thermocoal.
3. Observe and perform the functions of different Grainage equipments in the nearest Grainage centre/lab.
4. Prepare some grainage equipments using wood or thermocoal.

Terms Introduced

- Incubation.
- Pebrine spore.
• Disinfection.
• Deflossing.

Summary

• Grainages are the centers for production of large scale quantities of disease free layings.

• Location of Grainage must be near to commercial cocoon producing areas for easy transport of eggs as well as seed cocoons.

• Grainage location must be free from polluted air.

• Procurement of laborer is an important pre requisite.

• Identification of seed rearers is carried by technical persons.

• Egg production and processing is carried out with lot of care and technique.

• A separate, convenient building to carry on all activities pertaining to egg production is required.

• The components of a Grainage building are to be kept in mind while construction.

• In temperature and sub-tropical regions buildings should be constructed in a north-south direction.

• A Grainage of 15 lakh egg production capacity should have 16 technical staff to carry on all the process.

• Grainage equipments are designed for a specific function.

• Cocoon preservation rack is used to keep trays containing cocoons, pupae and moths.

• Ant wells, enamel plate, kerosene dipped cloth, are used to prevent ants attack.

• Washbasin, foot cleaning tray are used for disinfection of hands and foot before entering into Grainage room.

• Moth crushing set is used to crush the moth and then to observe under microscope to examine for pebrine infection.

• Pebrine diseased eggs are discarded.
• Hygrometer, thermometer used to find out temperature and relative humidity.

• Cellule is to cover coupling, egg laying moths.

• Other equipments like deflossing machine, cocoon cutting machine, sprayer, crates, refrigerator, incubator, mask, air cooler, egg sheets, and loose egg boxes are required.

• Acid treatment bath is to treat the bi-voltine and uni-voltine eggs to stop diapausing.

• The common disinfectants used in sericulture are formalin solution, lime powder, bleaching powder applied as spray, dust and for fumigation.

**Short Answer Type Questions**

1. Define Grainage.

2. What is the best location for establishing a Grainage?

3. What are the components of the well planned Grainage building?

4. What is the best orientation for Grainage?

5. How many technical staff is required in 15 lakh Grainage?

6. Mention some Grainage equipments.

7. Draw a neat diagram of ant well and wooden tray.

8. What is the use of Ant well?

9. Draw a neat diagram of cellule and bamboo tray.

10. What is the use of microscope?

11. Draw a neat diagram of moth crushing set.

12. How do you measure room humidity?

13. What is the use of acid treatment bath?

14. What is the use of face mask?

15. What is the importance of formalin mat?
16. What are the uses of washbasin?
17. What are the uses of cellule?
18. What is the use of incubator in Grainage?
19. Mention some disinfectants used in Grainage.
20. What are the disinfectants used in Grainage?

Long Answer Type Questions

1. What are the prerequisites for Grainage operations?
2. Discuss about the components of Grainage building.
3. List out the Grainage equipments and its uses.
4. Write about the equipment used for pebrine detection.
5. Write short notes on
   a. Trays    b. Moth crushing set    c. Ant well
6. Write short notes on
7. Write short notes on
   a. Grainage staff   b. Incubator   c. Formalin mat
UNIT 5

Grainage Operations

Structure

5.1 Introduction
5.2 Selection of Seed Races
5.3 Procurement of Seed
5.4 Sex Separation
5.5 Synchronisation of Moths
5.6 Moth Emergence
5.7 Coupling
5.8 Depairing
5.9 Ovi - Position
5.10 Grainage Registers
5.11 Summary

Learning Objectives

- Study the stock maintenance and types of silkworm seeds.
- Study the procurement of seeds.
- Find out the price fixation of the seed cocoons.
• Study the selection, transportation and preservation of cocoons.
• Study the sex separation, Moth emergence, synchronization, Coupling and decoupling, Ovi-position of moths.
• Study the Grainage register and its uses.

5.1 Introduction

The climatic conditions of our country vary in different parts of the region, so they grow different varieties of silkworms, which produce cocoons yielding poor silk. Whereas the foreign varieties like Chinese, Japanese produce superior quality of cocoons but unable to rear in India because of climatic conditions. These foreign varieties (uni-voltine, bi-voltine) crossed with local varieties (multi-voltine) to produce hybrid varieties. Apart from that disease free laying is must to get best quality of silk. Thus egg production is a technical job carried out systematically under trained technicians and laborers to achieve good results.

Grainage is one of the important aspects of sericulture. Therefore the grainage operations directly reflect on survival rate, life span, growth, and quality of cocoon, etc. Hence it is necessary to conduct these grainage processes with utmost care and technique. All these processes must be recorded for future use to improve the skills, to identify the faults, to minimize the expenditure, to increase the production of dfls, to know the pebrine disease and to confirm improved varieties etc.

5.2 Selection Of Seed Races or Stock Maintenance

The silkworm eggs required for commercial rearing should be of high quality and free from diseases. To produce good quality seed there must be a good seed organization. Considering the importance of quality seed, the Sericulture countries have established a network of institutions for egg production and also to impart training to the staff working in Grainages.

Silkworm seed is divided into two types i.e., a. Reproductive seed b. Industrial seed.

5.2. a. Reproductive Seeds

These are used for producing the seed cocoons (parents of seed cocoons) which are required in large numbers for producing commercial seed. The purpose of these is for maintaining the racial purity which is difficult to rear, So special care must be taken by technical staff. The selling price of these is 30-50% more than reeling cocoons. Reproductive seeds are often multiplied in number in a series of breeding centres called breeding stations (P4 or P3, P2,
and P1). In three or four stages in order to ensure that the racial characters are not diluted during the multiplication stages.

### 5.2.2 Industrial or Commercial Seed

There are specific hybrids between two or more pure lines of silkworm races and are reared by the sericulturists for producing cocoons on a commercial scale for reeling purpose. These are hybrid seeds, produced in special organizations called Grainages.

There are three aspects in seed production. They are

1. Breeder’s stock.
2. Basic seed multiplication.
3. Industrial seed production.

The race breeding stations are maintained by the government. These centres multiply great great grand parents or the grandparents (P4 or P3) of commercial Grainage seeds. These centres contain all pure races, and are aimed to maintain purity of the races. These centres supply the basic or initial material for multiplication, to the breeding centres.

Normally the seeds of multi-voltine races (pure or CB) are multiplied in three-tier system (P3) while exotic pure breed races of bi-voltine, rare multi-voltine have four-tier system (P4). The above said stations (P3 or P4) supply parental seed cocoons for rearing at foundation stock seeds (P2 Station). A multiplication of pure breed races are done by seed cocoon rearers who in turn produce seed cocoons. These seed cocoons are brought to the industrial seed producing Grainages (P1) to produce the hybrid seeds which are also called foundation hybrids.

Generally Grainages where the layings of the parental races are produced and managed by government agencies whereas the industrial seed Grainages may be private or government owned. These Grainages are aimed to produce reproductive and industrial seed.

### 5.2.3 Selection of Seed Rearer

The rearing of seed cocoons requires technical skill. Seed Cocoons must be healthy, hygienic and preserve the racial characters. The seed rearer is to be selected on the following criteria.

The rearer should have a scientific knowledge of the Grainage operation and silkworm rearing. He should have an interest in sericulture and co-operate with Grainage personnel.
Mulberry garden should be cultivated by adapting new package of practices.

The rearing house should be located in an area suitable for pure breed rearing with optimum rearing conditions. It should be free from germs of silkworm diseases.

### 5.3 Procurement of Seed

Seed cocoons are those which are produced under ideal climatic condition, free from diseases, exclusively for the purpose of reproduction, seed cocoons should confirm to the racial characteristics. In practice these seed cocoons are raised in seed areas.

As the quality of seed cocoons determines the quality and productivity of seeds, it is very important that the cocoons procured for seed preparation should be of high standard. Keeping this in view, Standards are fixed in respective of different races and seasons. The important norms for producing the seed cocoons are as follows.

1. Purchase cocoons which have been closely watched by the extensive staff and health certificate affixed on inspection card.
2. Gut examination of the pupae must be conducted before purchase.
3. The seed crop should be free from diseases especially pebrine.
4. Cocoons showing even a slight incidence of pebrine must be rejected.
5. The seed crop should have been reared under ideal conditions and fed with nutritious mulberry leaves.
6. The seed crop should have a good survival rate.
7. The seed crop should have a high pupation rate, but do not purchase cocoons which are with very heavy pupal weight that might lead to melting.
8. The cocoons should have good cocoon weight.
9. Cocoons which are not confirming to the characters of the race should not be purchased.
10. Crops showing an average yield of cocoons and above as fixed by the norms should only be purchased.
11. Rates are fixed as per the standards.
12. Purchase officer must certify for the quality of the cocoons and its disease freeness.

13. Details of rearer, quality and quantity of cocoons, race, spinning date, cost, total amount paid, name of the market are recorded and sent to the Grainage along with cocoons.

### 5.3.1 Price Fixation

There are certain norms for fixing the price of the cocoons which are periodically revised by the government in favor of the seed cocoon growers. On the day of marketing to the Grainage the yield of cocoons must not be less than 30 kg per 100 dfls for bi-voltines and 20 kg per 100 dfls for multi-voltine. Number of cocoons per kg in bi-voltine must not be less than 550 to 700 and in multi-voltine must not be less than 850 to 1100.

### 5.3.2 Process of price fixation

- **a. Standard Cocoons**: Bi-voltine- 650/kg, multi-voltine- 1000/kg.

- **b. Standard Rate**: It is fixed by the government from time to time.

- **c. Rate fixed per kg of cocoons brought by the farmer**

  \[
  \text{Cost of the cocoons} = \frac{\text{Standard Rate} \times \text{No. of standard cocoons/kg}}{\text{No. of cocoons/kg of the farmer}}.
  \]

**Model Problem I**

Raja has brought 40 kg of bi-voltine cocoons which are 620 in number per kg. The standard rate is Rs. 125/kg. Calculate the cost of cocoons per kg and calculate total amount to be paid to the farmer.

```
Standard cocoons = 650 per kg.
Standard Rate per kg = Rs. 125
Number of cocoons per kg of the farmer = 620

Cost of the cocoons = \frac{\text{Standard Rate} \times \text{No. of standard cocoons/kg}}{\text{No. of cocoons/kg of the farmer}}.
```
Cost of one kg = Rs 131.00

Total no. of cocoons of the farmer = 40 kg

**Total amount to be paid to the farmer = 131 x 40 kg = Rs. 5240.**

**Model Problem – II**

Dilip a seed rearer procured 55 kg of multi-voltine cocoons are 900 in number per kg. The standard rate is Rs. 100/kg. Calculate the cost of cocoons per kg and calculate total amount to be paid to the farmer.

\[
\text{Standard cocoons} = 1000 \text{ per kg.} \\
\text{Standard Rate per kg} = \text{Rs. 100} \\
\text{Number of cocoons per kg of the farmer} = 900
\]

\[
\text{Cost of the cocoons} = \frac{\text{Standard Rate} \times \text{No. of standard cocoons/kg}}{\text{No. of cocoons/kg of the farmer.}}
\]

\[
= \frac{100 \times 1000}{900} = \frac{100000}{900} = \text{Rs. 111.11}
\]

The total to be paid to farmer is =111 x 55 = Rs. 6105.

**5.3.3 Transportation of Seed Cocoons**

It means carrying seed cocoon safely from producing centres to egg processing centres. Safe transportation is necessary not to affect pupae and cocoons which hamper the moth emergence. The seed cocoons are harvested on the 5th or 6th day after spinning. This stage is suitable for transportation. If the pupa has turned dark brown in colour and if it is hard to touch then the seed cocoons are fit for transportation. Transportation at the late pupal stage causes damage. The best time for transportation of seed cocoons is the cooler hours of the day i.e., early morning or late evening. Hot days damage the pupae due to the heat. such cocoons emerge weak moths which either die or lay poor eggs. Laying and hatching of such eggs will be irregular.

Seed cocoons should be loosely packed in the containers (cloth bags, Bamboo conical basket, and plastic perforated bins) So as to allow sufficient space for aeration. Each container is perforated and the containers are placed horizontally one upon the other in rows.
5.3.4 Selection Of Seed Cocoons

As soon as the cocoons arrive at the grainage, they are checked for their quality and quantity as per the details received from the cocoon market. Thus a preliminary examination is conducted to make sure that the seed cocoons are free from pebrine. From each batch of cocoons from the rearer, about 20 pupae are collected and gut examination is conducted for pebrine disease.

5.3.5 Preliminary Examination

Preliminary examination is of two types. Pupal gut examination and forced eclosion. As the pebrine spores tend to concentrate in the gut region, the pupal gut is extracted and examined. When the infection is at initial stage, identification becomes difficult. To overcome these, the cocoons are subjected to high temperature (30-32°C) for early eclosion. The emerged moths (after 2-3 days) examined for pebrine spores. The identification of pebrine is crucial, thus the cocoons are subjected to both type of examination.

In each test examine 2-3 smears and 8-10 fields carefully. The pebrine spores, if present appears as a oval shining body under 600 magnifications of the microscope. If pebrine is noticed, further processing of cocoons is stopped and they are immediately disposed by burning.

5.3.6 Processing of Seed Cocoons

It is also called as cocoon sorting where good and bad cocoons are separated from the cocoons lots. The seed cocoons declared as free from pebrine disease are preserved for egg production. The cocoons, which are deformed, flimsy, stained, double, flossy, thin, pointed, malformed, dead are rejected. Batches of cocoons showing higher percentage of melting are sent to reeling centres. Only good cocoons of quality conforming to the breeds are selected and preserved. Deflossing of cocoons is done to facilitate easy eclosion of moth. Bad cocoons are either stifled or sent to cocoon market. It is unhealthy to keep such cocoons in the grainage.

5.3.7 Preservation of Seed Cocoons/Pupae

Good cocoons are arranged in a single layer in bamboo trays. Each tray can hold 1000-1200 multi-voltine cocoons or 800-900 bi-voltine cocoons. Overcrowding should be avoided, which leads to pupal mortality. The cocoon trays are arranged on stands.

Temperature and humidity play vital role in cocoon and pupa preservation. The proper temperature range of 23-26°C and 70-80 % humidity are maintained during preservation. The uniform eclosion of moths depends on
the intensity and duration of light. Cocoons should be exposed to diffused light during the day and darkness during the night. The higher the temperature the lower will be the eclosion rate. At a temperature 30°C and above, the eclosion rate get reduced to the minimum and infertility sets in the male moth. The moths become weak, not able to copulate and the eggs laid by them do not hatch. At lower temperature (20°C), the eclosion is delayed and the egg laying period is extended and becomes irregular, lushness is affected, the size of the egg is reduced and laying percentage decreases while unfertilized eggs increases. Similar phenomenon is also noticed with the humidity.

Cocoons are cut on one side or both sides to increase the percentage of moth emergence and they are stored in the round bamboo tray. In some Grainages pupae are taken out from the cocoon and male, female pupae are stored separately in wooden rectangular trays containing a corrugated paper or saw dust or powdered paddy husk. Over the thin layer of cocoons or pupae perforated paper is placed through which emerged moths make their way out. This facilitates easy picking of moths for coupling.

5.4 Sex Separation

For preparation of hybrid eggs, the male and female moths of two different races are crossed (bi-voltine, multi-voltine races). When the moths emerge, the male and female moths of the same race copulate, this produces eggs of a pure race. To prevent this, it is necessary to separate the sexes before emergence so males and females are kept in separate trays. The sex separation can be done at larval stage, pupal stage and moth stage.

Larval Stage

In larval stage the abdominal segments carry the sexual markings, which develop in the 4th and 5th instars, in the 8th and 9th segments on the ventral side of the larva.

In Female larva a pair of milky white spots present in 8th and 9th abdominal segments (Ishiwata’s glands). In the male a small milky white spot (Herold’s gland) appear at the centre of the ventral side between the 8th and 9th abdominal segments.

Pupal Stage

When compared to larval stage it is easy to determine the sex in the pupal stage. Female pupae are larger in size with a broad abdomen and an ‘x’ mark can be seen on the ventral side of the 8th abdominal segment.
Whereas the males are smaller in size having a narrow pointed abdomen with a small dot-like mark on the ventral side near the top demarcation line of the 9th abdominal segment.

**Moth Stage**

Female moths are inactive, larger in size and possess narrow antennae without bristles. The abdomen is bloated due to the presence of eggs. At the posterior end of the abdomen, there is a protractile knob-like ovi–positor.

Male moths are distinct by their smaller size, narrow abdomen and broader antennae with bristles known as **Pectinate Antenna**. Male moths are very active and are seen fluttering their wings in search of females. At the posterior end of the abdomen, there is a pair of hooks-like structures called **Harps or Claspers**.

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**5.5 Synchronization of Moths**

Moths of different races are made to emerge simultaneously on the same day and at the same time, so that the male and female moths are readily available for Hybridization. This phenomenon is referred to as **“Synchronization”**. The synchronization process is to be planned from the brushing time of the parent races or cold preserved based on emergence time.

To prepare hybrid eggs, some adjustments are made so that the moths of different races emerge at the same time. This is done by selecting cocoons which spin on different dates, depending on the number of days required for emergence. If it cannot be adjusted for any reasons, the cocoons of the early emerging races have to be refrigerated at 5–10°C for 2–4 days. The refrigeration should be done preferably on the 7th or 8th day after spinning. The cocoons which are about to emerge should not be refrigerated. If refrigeration is not done in the cocoon stage, synchronization can be achieved by refrigeration of moths which emerge earlier.

Male moths can be refrigerated at 5°C for 7 days. Female moths can be refrigerated at 5°C for 2-3 days. However, refrigeration of female moths is not advisable as it increases the percentage of unfertilized eggs and poor layings.

**Precautions**

1. Refrigeration should be restricted to any one stage.

2. Significant humidity should be maintained during cold storage.

3. In General, cold storage of either sex of multi-voltine is discouraged as it affects egg yield.
5.6 Moth Emergence

The silkworm after spinning the cocoon, lodges inside the cocoon and transforms into a pupa. The pupa later transforms into a moth and comes out of the cocoon. The process of moth coming out of the cocoon is called “Moth Emergence” (fig 5.1).

Fig. 5.1 Emergence of Moths

Generally moths emerge out of the cocoon after 9-14 days of spinning. But the pupal age varies according to races and seasons. Multi-voltine races emerge earlier than other races. The expected time of moth emergence can be predicted by observing the pupal and cocoon characters. A day before becoming moths, the pupae appear soft, dark in colour, with loose pupal skin, prominent eye formation, wing parts, appendages appear. A day before emergence a distinct sound is heard in the seed cocoon room, due to transformation of pupae into moths, which are trying to rupture the pupal skin to come out.

It requires a specific environmental condition for cocoon or pupae before emergence of moths. These are two be kept in total darkness. On the expected day of emergence, bright lights are illuminated in the early hours of morning at 4-6 a.m. At the time of emergence temperature of about 25°C with humidity 70-80 % should be maintained. Moths start emerging from 6-8 a.m. which are picked and kept in a tray for urination. Then healthy moths are are taken for coupling or for preservation. The emergence of moths decreases as the day light intensity increases. Moths do not emerge after 8.30 a.m. Light is provided only in the subsequent days of emergence. Thus room is once again made dark and
light is provided only in the subsequent days of emergence. The emergence of moths lasts for 3-4 days only. Some times due to mistakes in sex separation moths of other sex mix and emerged moths mate. Such pairs are rejected.

While emergence the moth ruptures the pupal skin and secretes an alkaline juice on one end of the cocoon and makes it wet. Then moth using its legs and head, wriggles out of the cocoon. After emergence, moths stretch its wings for about 5 min. After passing urine especially male moths are seen moving actively in the tray.

5.7 Coupling / Mating / Pairing

After emergence of moths, the males and females are picked and allowed to mate as per the desired combinations. This is known as Pairing (Fig 5.2).

The female moths are collected in the tray into which the desired male moths are left over the female gently. The moths pair within 5-10 minutes. The left over male moths are collected into another tray. If the males available in excess, they should be preserved at 5°C for later use.

Each paired moths are kept in cellules arranged in a tray. All the trays are kept in dark room for about 3-4 hrs with a temperature of 25°C and 75-80 % humidity.

Fig. 5.2 Pairing of Moths
5.8 Depairing

Depairing is the process of separating the moths after 3 hours of mating. The moths are separated by holding the female lightly and moving the male side ways using the fingers. This facilitates easy separation without injury to the female reproductive organs. The trays in which the female moths are kept gently tapped to induce the moths to urinate.

Second Pairing

Properly preserved male moths pair 8 times. But with increase frequency of mating fertilization decreases rate of egg fertilization. Thus male moths can be used in pairing for 3 times. The male moths are preserved at 5°C temperature for about 4 – 5 days. Prior to second pairing the male moths preserved are released at room temperature for 5- 10 minutes. Second pairing duration for about 4 hours with a temperature of 25°C and 80 percent humidity.

5.9 Ovi-Position

After de-coupling the females are first placed on a paper and tapped to induce them to pass urine. Later female moths are placed on egg cards, covered individually with a cellule. This provides darkness and keeps not disturbed. The moths normally lay eggs from the afternoon onwards and reach peak stage by early night hours. This egg laying process is known as ovi-position (Fig 5.3 a)
The ovi-position room is kept dark by closing the doors and windows. At the time of ovi-position a temperature of 23 – 25°C and humidity 80% should be maintained for egg laying. If the humidity is less than 80% the gummy substance secreted by the female dries up on the ovi-posit or and obstructs egg laying. This results in less number of egg laying, because most of the eggs remain in the body.

5.10 Grainage Registers/Records

It is essential that accurate data of seed production are maintained in the Grainage. This will help in efficient management, control of quality. The following are the types of records to be maintained in Grainage.

A. Seed Cocoon Register

The register should contain information about the parental race, yield, silk and its quality details, bad cocoon percentage, seed reaper details, details of seed cocoon seller, cocoon purchase rate, weight of cocoons purchased and their cocoon quality details.

B. Moth Emergence Register

The register should contain details of moth emergence such as number of moths obtained each day, number of moths kept for pairing, percentage of emergence, number of moths left for egg laying under each combination are recorded. This will help in forecasting the production and planning for hibernation. These data are to be maintained separately for different batches.

C. Moth Examination Register

Maintenance of this record is important, as it provides information on the number of moths examined, type of examination conducted, presence of pebrine, if present, percentage of infection, whether the batch is to be rejected.

D. Egg Production Register

Information pertaining to the quality and quantity of eggs laid, unfertilized eggs rejected, quality fit for distribution, type of egg (hibernated and non- hibernated) are maintained.

E. Hibernation and Refrigeration Register

In this register contains details of refrigeration, hibernation, date of release, temperature in cold storage and number of moths kept in refrigerator.
Practicals

1. Observe the selection and preservation of Seed cocoons.

2. Observe the moth emergence, sex separation, synchronization, Coupling and De-coupling, Oviposition of moths in the nearest Grainage centre/Lab.

Terms Introduced

- Synchronization.
- Coupling.
- Ovi-position.
- Moth emergence.
- Pectinate Antenna.
- Harps.
- Breeding-Station.
- Eclosion.
- Alkaline juice.

5.11 Summary

- The Bi-voltine and multi-voltine pure races are reared systematically to cross-breed.

- Grainage operations are conducted under supervision of trained technical staff.

- The silkworm eggs required for commercial rearing should be of high quality and free form disease.

- Reproductive seeds are used for producing the seed cocoons which are required in large numbers for producing commercial seeds.

- Reproductive seeds are often multiplied in number in a series of breeding centres called Breeding-Station.

- Industrial seed are specific hybrids between 2 or more pure lines of races. These are produced in Grainages.

- There are three components in seed production. They are breeder’s stock, basic seed multiplication, Industrial seed production.
• Seed organization is at 3 – tier or 4 – tier level.

• P4 or P3 supply parental seed to P2 station. The seed cocoons produced at P2 Station are brought to P1 station to produce hybrid seeds.

• Selection of seed rearer is to be carried on according to the norms.

• Seed cocoons are those which are produced and ideal climatic conditions, free from diseases exclusively for the purpose of reproduction.

• Seed cocoons are procured on the basis of norms laid down.

• After confirming the commercial characters of cocoons the price is fixed as per the standards.

• The standard number of cocoons and standard size is fixed by government.

• Number of cocoons per kg in bi-voltine must not be less than 550-700, in multi-voltine 850-1100.

• Seed cocoons are transported safely from production centres to egg producing centres on the 5th or 6th day after spinning.

• The best time for transporting is cooler early hours of the day i.e., early morning or late evening.

• Cocoons are loosely packed in the containers during transport.

• Cocoons are once again examined for pebrine disease.

• The examination is of two types i.e., pupal gut examination and Forced eclosion. The identification of pebrine is crucial, Thus cocoons are subjected to both type of tests.

• Pebrine spores if present appear as an oval shining body under 600 magnifications of the microscope.

• The cocoons are sorted to separate good and bad cocoons.

• Good cocoons are arranged in a single layer on bamboo tray.

• Proper temperature range 23–26°C and 70–80 % humidity are required.

• Uniform eclosion of moths depends on the intensity and duration of light.
• Cocoon are exposed to diffused light during the day and darkness during the night.

• The seed cocoons are stored in round bamboo trays while pupae are kept in wooden rectangular tray containing corrugated paper/saw dust/paddy husk.

• Sex separation facilitates mating of desired variety.

• Sexing helps in true hybrid preparation.

• The best period of sex separation is when the pupae are 2 – 3 days old. Sex markings are clear in pupae/moths.

• Moths of different races are made to emerge simultaneously on the same day, so that both sexes are readily available for hybridization and called as synchronization.

• The emergence can be adjusted by refrigerating the cocoons or pupae and are freezed for 7 days.

• The process of moth coming out of cocoon is called “Moth Emergence”.

• Generally moths emerge after 9 – 14 days after spinning.

• The expected time of moth emergence can be predicted by observing the pupal and cocoon characters.

• A day before emergence a distinct sound can be heard in the seed cocoon room.

• It requires specific environmental conditions for cocoon or pupae before emergence of moths.

• On the day of emergence the room is illuminated at 4-6 a.m. Moths starts emerging from 6-8 a.m.

• Emergence of moths lasts for 3-4 days.

• Moth ruptures the pupal skin and secretes alkaline juice on inner layers of cocoon, which pierce the cocoon and emerge out.

• The males and females mates which is called as Pairing.

• Only healthy moths are used for pairing and kept for 3-4 hours.

• After mating time moths are depaired.
• Male moths can be used for second pairing by preserving at 5°C temperature for about 4-5 days.

• The silkworm rearing depends on the eggs produced in a Grainage. Thus it is important to conduct the grainage activities with technique and care.

• A systematic recording of all the activities of Grainage will be helpful for future development.

• There are 5 important records that are maintained in the Grainage.

• Seed cocoon register, Moth Emergence Register, Moth Examination Register, Egg Production Register, Hibernation and Refrigeration Register are the essential registers for Grainage.

• These registers speak about the economics of the Grainage.

## Short Answer Type Questions

1. What are reproductive seeds?
2. What are Industrial seeds/Commercial Seeds?
3. What are breeding Stations?
4. Define Grainage.
5. What are the aspects in seed production?
6. What do you mean by seed cocoons?
7. What is meant by foundation Hybrids?
8. What is meant by seed rearers?
9. What are the chief points in procurement of seed cocoons?
10. What are the stages of price fixation?
11. Write the principle to calculate cost of 1 kg cocoons.
12. What is the safe period for transport of seed cocoons?
13. What is the best time for transportation?
14. Why preliminary examination of seed cocoons is required?
15. Mention the methods of preliminary examination of seed cocoons.
16. How is forced eclosion test conducted?
17. How is pupal examination conducted?
18. What is Cocoon sorting?
19. Mention some Bad cocoons.
20. Mention temperature and humidity required for preservation of seed cocoons.
21. How sex separation is helpful in hybrid egg production?
22. Draw neat diagram of male and female pupae.
23. Define synchronization.
24. Define moth emergence.
25. When does moth emerge?
26. How do you identify moth emergence?
27. How does emerging of moth occur?
28. What is the moth emergence time?
29. Define Pairing and depairing.
30. Mention mating time of moths.
31. Mention temperature and humidity required during pairing.
32. What is second pairing?
33. What is the importance of synchronized emergence?
34. What are stages suitable for refrigeration of pupae?
35. How do you synchronize moth emergence?
36. Define Ovi-position.
37. What happens if the humidity is less during ovi-position?
38. What are the environmental conditions required for ovi-position?
39. What are the uses of Grainage registers?
40. Mention some of the Grainage registers?
Long Answer Type Questions

1. Write about three tier/four tier system of egg production.

2. Mention the norms for procurement of seed cocoons.

3. Write short notes on
   (a) Industrial/Commercial seed   (b) Seed rearer

4. Calculate the cost of 75 kg bi-voltine numbering 700 per kg and standard rate being RS. 125. Calculate the total amount.

5. Calculate the cost of 55 kg multi-voltine numbering 800 per kg and Standard rate being RS. 110. Calculate the total amount.

6. Calculate the cost of 30 kg of bi-voltine and 40 kg multi-voltine cocoons weighing 540 (bi-voltine), 1000 (multi-voltine). Standard cost being Rs. 125 and Rs. 110 respectively. Find out the total amount.

7. How is preliminary examination conducted on seed cocoons?

8. Write short notes
   (a) Reproductive Seed   (b) Transport of Seed Cocoon.

9. Write about the preservation of seed cocoons.

10. Write short notes on
    a. Sex separation   b. Synchronization.

11. Describe moth emergence.

12. Detail about Pairing and Depairing.

13. Write about the Grainage registers and their uses.
Seed Production

Structure

6.1 Introduction
6.2 Preparation of Layings
6.3 Mother Moth Examination
6.4 Surface Sterilization
6.5 Assessment of Layings
6.6 Incubation of Silkworm eggs
6.7 Summary

Learning Objectives

- Study the Ovi-position of moths.
- Study and observe the preparation of eggs in different types.
- Study and observe the different types of mother moth examination.
- Study and observe the surface sterilization of silkworm eggs.
- Evaluate the difference between the good and poor layings.

6.1 Introduction

Seed Production is one of the critical important processes of Grainage. The production of good, disease-free layings improves sericulture. But diseased
egg production would be a great threat to sericulture. As it has evidence from the history. This activity is to be carried on with lot of care and technique. Pebrine is a dangerous disease, through eggs. Thus examination of pupae before moth emergence and moth examination after ovi-position is compulsory so as to confirm disease-free eggs. All the Grainage operations are carried on after perfect sterilization of rooms, equipments and even hands and foot of technical persons who are involved to carry on the operations. This kind of check at every stage is to reduce the incidence of the disease and also to improve the quality of silkworm eggs. Thus it is necessary to know about the various stages in egg production.

### 6.1.1 Ovi-Position / Egg laying

After de-coupling the females are first placed on a paper and tapped to induce them to pass urine. Later female moths are placed on a egg cards, covered individually with a cellule. This provides darkness and not disturbed. The moths normally lay eggs from the afternoon onwards and reach peak stage by early night hours. This egg laying process is known as Ovi-position (fig 6.1). This has been explained in detail in the previous chapter.

![Fig. 6.1 Ovi-Position of Moths](image)

### 6.2 Preparation of Layings

There are two types in preparation of layings.

1. Segregated egg laying has two methods.
   a. Pasteur’s method (followed in China, Japan)
b. Cellular bag method (followed in European countries)

II. Mixed egg laying also has two methods.
   a. Flat card method
   b. Loose Egg method

II a. Flat card method

It is used for industrial egg production on a very large scale. Egg sheets contain 20-42 squares, arranged in 60 x 90 cm tray. Each female moth is kept in a square and covered with cellule. Such trays are arranged in one tier in a wooden rack kept in ovi-position room. The room is maintained dark and optimum temperature of 23 – 25°C and humidity 80 % should be maintained for better egg laying. The egg sheets along with the moths are taken for moth examination hall after 24 hrs of egg laying. The moth samples are taken for crushing and examined for pebrine disease. If a certain percentage of the sample is found to have pebrine, the entire lot is discarded and burned.

Advantages

1. Pebrine inspection is perfect.
2. Egg laid by pebrine infected moths are eliminated.

II b. Loose Egg Preparation

It is similar to the flat card method except that the eggs are laid on smooth side of a starched paper. Preparation of loose eggs has specific advantage. A large number of moths are allowed to lay eggs and only sample moths are drawn for examination. As the commercial seeds are required in large quantity and the preparation of eggs in loose form is similar. Thus loose egg method is adopted for preparation of commercial seed (Fig 6.2).
About 100 – 120 gr. of arrow root or maranta starch is added to one liter of water and boiled to prepare a paste. After cooling, smear paste uniformly on craft sheet (90 x 60 cm) or cloth in thin layer. These sheets are spread in a wooden tray. Female moths (30–200) after urination are transferred in the oviposition room and moths are allowed to lay eggs for 1-2 days on the sheets. On the next day moths are removed for examination. After examination the egg sheets/cloth are soaked in water for 15 minutes. It is gently brushed to remove the eggs from the cards. Then eggs are collected by removing the sheet and filtering through a muslin cloth. These eggs are soaked in 0.5% bleaching powder for 5-10 minutes to remove the gum and ovoid’s formation of clumps of eggs. Eggs are washed in water and transferred to salt solution with a specific gravity of 1.06 – 1.09 at room temperature. The fertilized eggs having higher specific gravity sink in the solution. The floating dead eggs with low specific gravity are separated and rejected. The good eggs are washed again in water then with 2% formalin solution for 20 minutes. Again wash the eggs in water and dried in shade. These eggs are packed in loose egg box, each box consists of 20,000 eggs. If one gram eggs weigh 1600 eggs, then one box will have

\[
\frac{20,000}{1,600} = 12.5 \text{ grams.}
\]

The boxes are sealed and labeled. The label has the details of race, date of egg laying, quantity of eggs, name of the grainage, technician signature. In multi-voltine a gram of eggs has about 2000 eggs while 1800 in bi-voltine.

**Advantage of Loose Eggs**

1. Egg Processing and handling is easy.
2. Dead and unfertilized eggs are removed.
3. A unit number of viable (possible) eggs can be supplied.
4. It saves space in storage.
5. Transportation is easy.

**6.3 Mother Moth Examination**

Pebrine is a transovarial transmitted disease. The infected mother moth transmits this disease through the eggs to next generation. The elimination of eggs laid by a diseased moth is important. Hence it is necessary to examine the
mother moth. The moths after egg laying are examined for pebrine disease. If there is lack of time, moths are dried, preserved and examined later.

6.3.1 Methods of Moth Examination

There are two methods.

1. Fresh moth or green moth examination

In this the moths are examined soon after egg laying when the seeds are required for immediate use.

2. Dry Moth Examination

When the eggs are to be hibernated, the moths can be dried and tested in leisure time. The samples of 30 moths are oven dried at 65°C to 75°C for 6 hrs. There should not be any fluctuation in temperature, leading to unidentification of pebrine spores. The spores are seen very clearly.

6.3.2 Kinds of Examination

There are two types of moth examination depending upon the purpose for which the seed is used viz., reproduction purposes or commercial purposes.

6.3.2.1 Individual Moth Examination

It is conducted for producing reproductive seeds. Thus all moths are examined individually to make sure that they are completely free from pebrine disease. After ovi-position the moths are transferred to the mortar and crushed with the help of pestle by adding 2-3 drops of 2% KOH solution. A smear is taken on to a glass slide and fine smears are arranged on each slide. The smear are covered with cover slip and observed under the microscope with 600 magnifications. Infected moths are marked to scrap the egg laid(fig 6.3)

![Fig.6.3 Photomicrograph of Pebrine Spores.](image)

![Fig. 6.3a Single Pebrine spore](image)
Advantage

1. Perfect method
2. Easy identification of particular pebrine moth.

Disadvantage

1. This method is laborious.
2. Time Consuming.

6.3.2.2 Mass Moth Examination

It is followed in commercial/industrial seed production where only samples of moths are examined in groups of 10 – 30. After ovi-position, moths are taken in groups to the crusher by adding 90 – 100 ml of 0.5 % potassium carbonate solution. Moths are crushed at 10,000 rpm to separate pebrine spores from the tissues. After that, crushed material is filtered through a coarse filter paper. And filtrate is centrifuged at 2000 rpm for 3 minutes and to dissolve the sediment in 2-3 drops of 2% KOH. The smears are taken from the solution on to glass slides and observed under the microscope for pebrine spores.

6.3.2.3 Identification of Pebrine Spores

Pebrine spores are identified at 600 magnifications. These spores appear as shining oval bodies under the microscope. Though the spores are colourless with a luster, decreased intensity of light gives a satisfactory contrast and shade, making the observation clear (fig 6.4).

Fig. 6.4 Structure of Single Pebrine spore
6.4 Surface Sterilization

The eggs are processed after moth examination. While egg laying, the surface of egg may be stained with moth urine and scales and disease causing germs. Thus the egg surface has to be washed and surface is dis-infected to remove the stains and surface contaminations. It is called egg processing. Only sheets with standard layings after removing the poor layings and dead layings soaked in 2 % formalin for 5 – 10 minutes. Then eggs are washed in water and allowed to dry. These egg sheets marked by the name of the Grainage, Hybrid combination, date of egg laying, signature of moth examiner, number of good layings. Such eggs are now ready for sale. While sterilizing loose eggs 0.5 % bleaching powder is used.

6.5 Assessment of Layings

The egg sheets sometimes contain deformed eggs, poor eggs, unfertilized eggs, diseased eggs which are identified and marked during moth examination. These eggs are removed from the egg card/loose eggs. The egg processing refers to sorting of good eggs, rejection of defective eggs and removal of surface stains and infections by following suitable procedures.

6.5.1 Characters of good laying

The total number of eggs laid by a single female moth is called laying. Only good layings are to be supplied to the farmers.

a) Each laying should have minimum 300 eggs.

b) Layings with less fertilized eggs are not considered.

c) There should not be any piling of eggs.

d) The eggs are laid in a single layer, side by side.

e) Good laying has maximum number of eggs.

f) The disease free laying is called good layings.

6.6 Incubation

Incubation of silkworm eggs aims at uniform development of the embryo thereby securing uniform hatching through proper maintenance of environmental conditions. Incubation greatly influences the voltinism character of the egg in the succeeding generation and also the larval growth and the success of the cocoon crop and cocoon quality.
The egg incubation room or chamber should be absolutely clean and steps to disinfect the incubation room and appliances used in the room must be taken in time. Heating or cooling arrangements must be perfect so as to maintain uniform temperature throughout the incubation period. The egg cards and egg cases should be so arranged inside the rearing room that all the eggs are exposed to the temperature and humidity maintained in the room.

Before 48 hours of hatching a black spot appears on the egg. This condition is referred as ‘Head Pigmentation’ stage. One day before hatching, the eggs turn black or blue in colour. This is referred as body pigmentation stage or “blue eggs”. These eggs are placed in black boxes and covered with black cloth or paper and kept in dark place. So the hatching can be made more uniform on the next day morning (Fig 6.5).

If hatching has to be delayed after incubation has started this can be done by storing the eggs in cold storage room at 5°C on the 2nd and 3rd day of incubation for a week.

If hatching has to be delayed at the blue egg stage this can be done by storing the eggs at 5°C for a week.

If brushing has to be delayed after hatching, the newly hatched larvae can be stored for 3 days at 7.5 – 10°C.

6.6.1 Methods of Incubation

There are two methods i.e., constant temperature incubation and raised temperature incubation.
Constant Temperature Incubation

In the incubation room optimum humidity should be 80 – 85%. Optimum temperature for the incubation of non-hibernating eggs and eggs after acid treatment for immediate hatching should be 24 – 25°C right from the beginning.

Raised Temperature Incubation

It is used mostly for incubating hibernating eggs. The eggs after release from cold storage, are preserved at 10-15°C for three days, at 18-20°C for two days, at 23-24°C for four days and then at 25-26°C till hatching.

Practicals

1. Preparation of eggs in egg cards and loose egg method in Grainage centre.
2. Find out the pebrine spore by conducting the individual mother moth examination.
3. Practice the surface sterilization of silkworm eggs.
4. Identify the good and poor layings.

Terms Introduced

• Pebrine Spore.
• Surface sterilization.
• Incubation.
• Good layings.
• Head pigmentation stage.
• Body Pigmentation Stage/Blue eggs.
• Black boxing.
• Egg Processing.

Summary

• Seed production is one of the critical and important processes of Grainage.
• After decoupling, female moths are placed on a paper(egg card), covered with a cellule and kept in darkness for 24 hrs.
• In case of loose egg preparation, moths (50-100) are released in a tray and kept in darkness for 24 hrs.

• Multi-voltines lay 300 – 400 eggs, Uni and Bi-voltines lays 400 – 500 eggs in 24 hrs.

• The temperature of 24°C and 80 % humidity are maintained for good egg laying.

• There are two types in preparation of layings i.e., segregated and mixed egg laying methods.

• Mixed egg laying has two methods i.e., Flat card and Loose egg method.

• In flat card method eggs are prepared on egg sheets by individual moths and moth examination is conducted individually for pebrine spore.

• In loose egg preparation arrow or Maranta starch is pasted to craft paper on which a batch of (30–200) moths are allowed for egg laying. Next day moths are crushed for examination. In this method only fertilized eggs are obtained after egg processing.

• Moth examination is aimed to assess the pebrine free egg preparation.

• Pebrinised eggs are completely rejected.

• Method of moth examination are of two types i.e., fresh moth or green moth examination and dry moth examination. Kinds of examinations are of two types i.e., Individual moth examination, Mass moth examination.

• Moths are crushed to paste by adding 2-3 drops of 2 % KOH and smears are observed under microscope at 600 magnifications.

• Pebrine spores appear as shining oval body, colourless with a luster, decreased intensity of light gives a contrast.

• Sterilization is to eliminate harmful microorganisms, gum, and scales on the egg surface and also to disinfect the egg surface.

• Surface sterilization is carried with 2 % formalin for 5- 10 minutes.

• The sorting of eggs into good and bad is called assessment of eggs. It is aimed to identify all bad eggs and elimination.
• Incubation aims at uniform development ensuring uniform hatching through proper maintenance of environmental conditions.

• There is constant and raised temperature in incubation.

• In Constant temperature incubation the temperature is constant till hatching. It is used for acid treated eggs, non- hibernating eggs.

• Raised temperature incubation is for hibernating eggs, the temperature is raised from 10-15°C to 25- 26°C till hatching.

• Before 48 hours of hatching a black spot appears on the egg. This condition is referred as ‘Head Pigmentation’ stage. One day before hatching, the eggs turn black or blue in colour. This is referred as body pigmentation stage or “blue egg “.

**Short Answer Type Questions**

1. Define ovi-position.
2. How much time is required for egg laying?
3. What is the difference between flat egg card and loose egg preparation?
4. What are the types in preparation of egg?
5. What are the best methods of commercial and reproductive egg preparation?
6. Why starch is applied to craft paper in loose egg preparation?
7. What are the chemicals used in egg preparation?
8. What are the advantages of loose eggs?
9. What are the contents of egg label?
10. Define moth examination.
11. Mention methods of moth examination.
12. When is fresh moth examination conducted?
13. What are the kinds of examination?
15. How is pebrine spore identified?

17. What is the need for surface sterilization?

18. What is the assessment of layings?

19. Write the characters of good laying.

20. What is the best time for disposal of eggs?

21. How much time is required for egg laying?

22. Define incubation of eggs.

23. Mention methods of incubation.

24. What is the optimum temperature, humidity to be maintained for incubation?

25. Define Blue Eggs.

**Long Answer Type Questions**

1. Write the preparation of flat card egg method.

2. Describe loose egg preparation.

3. How does moth examination is helpful for good laying production?

4. Define the process of mother moth examination.

5. Write short notes on

6. Write short notes on
   a. Mass moth examination. b. Flat card method.

7. Write short notes on
   a. Methods of moth examination. b. Disposal of dfls

8. Write short notes on
   a. Surface sterilization. b. Good Layings.

9. Detail about incubation of silkworm eggs.
UNIT 7

酸液处理和冷冻储藏

Structure

7.1 Introduction
7.2 Types of Eggs
7.3 Physical and Chemical Stimulants
7.4 Acid Treatment
7.5 Cold Storage of Eggs
7.6 Transportation of Eggs
7.7 Summary

Learning Objectives

• Study the types and different methods of handling the silkworm eggs in Grainage.
• Tabulate the physical and chemical stimulants in Grainage.
• Study the storage of eggs in Grainage.
• Study the preparation of HCL, HCHO solution.
• Study the types of acid treatments and storage of Eggs.
7.1 Introduction

In silkworm rearing it is important not only to produce silkworm eggs of high quality, but also to carefully protect and preserve them to ensure good and uniform hatching. If uni-voltine eggs are left after ovi-position without any treatment will undergo diapause, hence no hatching occurs. But the bi-voltine eggs if incubated at high temperature become hibernating or black eggs and do not hatch for the second time during the year. However in order to meet the need for multiple rearings in a year it is necessary to hatch the eggs collected in spring. When the eggs of bi-voltine are incubated in the dark at low temperature, they become non-hibernating eggs which have several drawbacks. The most important point to be considered in the prolongation of the storage period is by utilizing the diapause. The continuation of diapause for an adequate length of time through proper temperature control until the beginning of incubation, so as to ensure uniform hatching of eggs.

7.2 Types of Eggs

The silkworm eggs are of two types i.e., diapausing and non-diapausing eggs. After ovi-position further processing of the eggs depend upon their diapausing or non-diapausing nature. Generally uni-voltines are diapausing eggs and multi-voltine eggs are non-diapausing type.

7.2.1 Handling of Eggs

In the diapausing eggs a hormone responsible for inhibition of embryo development, whose effect is neutralized by the effect of cold temperature. Thus the eggs are activated. The duration of aestivation period, i.e., the duration of higher temperature at which the egg is kept and the related duration of cold temperature treatment required to break the diapause. Thus the eggs laid in any season can be properly preserved and hatched as required during the following spring.

The Important Factors in Egg Handling as Follows

1. Eggs are handled depending on the nature of the eggs.
2. Hatching of eggs has to be obtained in desired time.
3. Conditions that are required should be maintained for various purposes.
4. Disinfection of eggs is essential factors in egg handling.
Eggs are processed according to whether they are produced by multi-voltine or bi-voltine breeds.

### 7.2.1.1 Methods of Handling Eggs

#### A. Handling of Multi-voltine Eggs

These breeds produce non-hibernating eggs. They hatch in 10 – 11 days after laying. If hatching has to be delayed, the eggs on the second day of laying should be placed for preservation at 5°C with 75-80% humidity for 20 days. During this period eggs can be released for incubation on any day.

#### B. Handling of Bi-voltine Eggs.

These breeds lay hibernating eggs, which do not hatch in 10 – 11 days after laying because these eggs undergo diapause. However they can be made to hatch by following artificial treatments. Depending on the requirement of their hatching, they are processed by different methods.

### 7.3 Physical and Chemical Stimulants

These are stimulants which are very useful for artificial hatching of eggs. The acid treated hibernating eggs can be utilized after 10 days up to one year at any given time.

The following physical and chemical stimulants are used in artificial hatching process.

<table>
<thead>
<tr>
<th>PHYSICAL STIMULANTS</th>
<th>CHEMICAL STIMULANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lowest Temperature</td>
<td>1. Hydrochloric acid (HCL)</td>
</tr>
<tr>
<td>2. Dipping in hot water</td>
<td>2. Nitric Acid (HNO₃)</td>
</tr>
<tr>
<td>3. High Electric stimulation</td>
<td>3. Sulphuric Acid (H₂SO₄)</td>
</tr>
<tr>
<td>4. Rubbing with brush or feather</td>
<td>4. Aqua regia</td>
</tr>
<tr>
<td>5. High atmospheric pressure</td>
<td>5. Acetic acid</td>
</tr>
<tr>
<td>6. Ultra hi-frequency vibration</td>
<td>6. Sodium Chloride</td>
</tr>
<tr>
<td>7. Exposing to sunlight</td>
<td>7. Hydrogen peroxide</td>
</tr>
</tbody>
</table>
7.4 Acid Treatment

The hibernating eggs laid are usually diapause eggs. They do not hatch till 10 – 12 days. These eggs are treated with HCL to break the diapause. This Process is known as acid treatment. Acid Treatment is to be conducted before first stage. It is not advisable to carry on acid treatment before 1- 10 hrs of laying, which leads to death, irregular hatching. Treatment can be done after 15 hours. However, treatment between 20 -24 hours is better for good results. Acid treatment after 48 hours leads to irregular hatching.

7.4.1. Selection and preparation of Acid (HCL)

In acid treatment, strong and inorganic acids give good results than organic acids. The Nitric acid and Sulphuric acid are very strong acids and should be handled carefully. Now a days, Hydrochloric acid (HCL) is used for acid treatment of eggs. The HCL is mixed with required quantity of water to get required specific gravity needed for acid treatment. The Specific gravity is tested by hydrometer and corrected accordingly (Table 7.1).

<table>
<thead>
<tr>
<th>Available Specific Gravity of HCL</th>
<th>1.075 HCL</th>
<th>1.100 HCL</th>
<th>1.110 HCL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>Acid</td>
<td>Water</td>
</tr>
<tr>
<td>1.150</td>
<td>500</td>
<td>500</td>
<td>333</td>
</tr>
<tr>
<td>1.155</td>
<td>516</td>
<td>484</td>
<td>355</td>
</tr>
<tr>
<td>1.160</td>
<td>531</td>
<td>469</td>
<td>375</td>
</tr>
<tr>
<td>1.165</td>
<td>545</td>
<td>455</td>
<td>394</td>
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<tr>
<td>1.170</td>
<td>559</td>
<td>441</td>
<td>412</td>
</tr>
<tr>
<td>1.175</td>
<td>571</td>
<td>429</td>
<td>429</td>
</tr>
<tr>
<td>1.180</td>
<td>583</td>
<td>417</td>
<td>444</td>
</tr>
</tbody>
</table>

Table 7.1 Details to prepare 1 liter acid (in ml)

\[
\text{Required Concentration HCL} = \frac{(\text{Required specific gravity} - 1.00) \times (\text{Required HCL in ml})}{(\text{Available specific gravity} - 1.00)}
\]

1.00 = Specific gravity of water.
The above value gives the amount of water to be mixed to get required specific gravity of acid.

**Model Problem**

Prepare 15 ltrs of 1.075 Specific gravity HCL with commercially available HCL (1.160 Specific Gravity).

**Solution**

Substitute the values in the principle

\[
\frac{(1.075 - 1.00) \times (15,000)}{0.075 \times 15,000} = \frac{0.075 \times 15,000}{0.160} = 7031 \text{ ml of Acid}
\]

To get 15 ltrs acid, add 7969 ml of water to 7031 ml of acid.

This acid contains 1.075 Specific gravity.

**7.4.2 Formalin Treatment**

The eggs are surface sterilized in 2% formaldehyde solution for 15 min. This method helps to fix the eggs to the card otherwise the eggs are released into the acid during acid treatment. After the time lapse, the eggs are removed and washed in water to remove the traces of formalin. Thus it is necessary to know about the calculation of formalin solution for sterilization.

**Preparation of Formalin Solution**

Commercial formaldehyde available in the market is 38-40%.

The below formula is used to prepare 2% formalin solution.

\[
\text{Formalin solution required} = \frac{\text{Commercially available} - \text{required Strength of formalin}}{\text{Required Strength}}
\]

**Model Problem 1**

Prepare 2% formalin solution with the available commercial solution (36%)

\[
\frac{36 - 2}{2} = \frac{34}{2} = 17
\]

For every liter Formalin 17 lts of water is added to get solution of 2%.
One Liter = \frac{1000}{17 + 1} = 55.55 \text{ ml of formalin}

An amount of 944.45 ml of water is added to 55.55 ml of formalin to get one liter of 2\% solution.

**7.4.3 Methods of Acid treatment**

There are two methods. They are

1. Hot Acid Treatment.
2. Cold Acid Treatment.

**Hot Acid Treatment**

In hot acid treatment eggs are dipped in HCL having specific gravity of 1.075 at 46°C for 5-6 minutes. It is always necessary to maintain proper specific gravity of HCL. Before heating the specific gravity of the acid is first adjusted to room temperature. HCL is not heated directly. Hot acid treatment bath is used for treatment, which favors to heat HCL indirectly. Acid is taken into a glass tube and placed in treatment bath. When the temperature reaches to 46°C the eggs are dipped. The dipping time is different for different types of eggs.

After treatment eggs are washed in water. Hot acid is treated eggs after 24 hours, otherwise eggs cannot withstand. (fig 7.1)

**Cold Acid Treatment**

It is also called as room temperature acid treatment. There is no heating of acid; treatment is carried at 23 – 30°C temperature to eggs after 24 hours of ovi-position. The treatment is conducted on first embryo stage. Further the eggs are likely to get separated from the egg card and the unfertilized eggs crumble,
which help in their removal. In this method HCL 1.110 specific gravity at 15°C at room temperature is used to treat the eggs. Eggs are first treated with 2 % formalin before acid treatment for egg agglutinization and washed in water to remove acid traces.

7.4.4 Acid Treatment of Loose Eggs

The loose eggs after sterilization are kept in porous plastic container for acid treatment. The process of treatment is similar as explained earlier. After washing in water eggs are dried on a smooth cloth.

7.4.5 Stopping of Acid Treatment

Generally it is not advisable, if inevitable eggs are kept at 5°C for 5 days, up to 7 days at 2.5°C. This process is to be carried out later they are processed as detailed earlier. The eggs are kept at 15-25°C for 2 hrs and slowly brought to 2.5°C. This method saves spoiling of eggs. During egg preservation 70-80% humidity is to be maintained.

The hibernated eggs are acid treated to prevent diapause. This eggs are cold stored at 5°C not beyond 3 days.

7.5 Cold Storage of Eggs

There are two types i.e., Short term and Long term chilling.

7.5.1 Short Term Chilling

Temperature of 25°C and 70 – 80 % humidity is maintained during ovi-position. These eggs are left for 30 – 35 hrs, at 25°C to reach spoon head stage and then preserved at 5°C with 75 – 80 % humidity for 45 – 50 days. If chilling has to be prolonged beyond 60 days, it is first carried out at 5°C for about 40 days and then at the lower temperature of 2.5°C. The eggs can be released after 35 days and up to 50 days. While releasing, the eggs are kept at 15°C for 6- 12 hrs and then at 25°C for 3 – 4 hrs. The eggs are treated with HCL of 1.100 Specific gravity at 47.8°C for 5- 6 minutes. Then eggs are washed in water to remove all traces of acid. Thus eggs could be made to hatch in 45 – 60 days after laying.

7.5.2 Long Term Chilling

The eggs are kept at 25°C for 40 – 50 hrs and then preserved at 5°C with 75 – 80 % humidity for 50 – 70 days. Eggs turn to brown colour and reach to spoon head stage. The eggs can release on any day during this period. While releasing they are preserved at 15°C for 6- 12 hrs and then at 25°C for 3- 4 hrs. Later eggs are treated with HCL having a specific gravity of 1.100 at 47.8°C
for 5 min. After treatment eggs are washed in water to remove all traces of acid. Thus eggs treated can be made to hatch in 60 – 80 days after they are laid.

7.6 Transportation of Eggs

It means carrying the silkworm eggs from the Grainage to the rearing centres. During the period of transportation, friction, air, light conditions, saltiness and high temperature should be avoided. The safe transportation of eggs is highly essential in order to protect the embryo and to ensure good hatching results, which affect the yields and quality of cocoon crop.

The silkworm eggs should be transported during the cooler hours (morning/evening). Eggs should not be transported during the hot hours or in rainy weather.

The egg cards are loosely placed in a wooden egg carrier/perforated paper cover. For loose eggs also same method is adopted. It is preferable to carry the eggs in specially made egg boxes, with perforations for aeration and provision for maintaining humidity.

Practical

3. Preparation of HCL, HCHO solution in lab.
4. Observation of acid treatment process in Grainage.

Terms Introduced

• Stimulants.
• Specific Gravity.
• Acid Treatment.

Summary

• There are two types of eggs i.e., Diapausin and non-diapausin eggs.
• A hormone in diapausin eggs is responsible for inhibition of embryo development whose activity is neutralized by cold temperature.
• Handling of eggs refers to processing of eggs under optimum conditions to obtain hatching whenever desired.
• There are two methods of handling eggs which is different for multi and bi-voltine eggs.

• Storage of spring eggs, autumn eggs are different.

• Physical and chemical stimulants are useful for artificial hatching of eggs.

• The acid treated hibernating eggs can be utilized after 10 days up to one year at any given time.

• Acid Treatment is for breaking the diapause eggs.

• Inorganic acids are better for treatment especially HCL is commonly used.

• The HCL is mixed in water to get required specific gravity needed for acid treatment of eggs.

• The required quantity of HCL is calculated.

• Prior to acid treatment formalin treatment is necessary to sterilize the eggs, and to fix the eggs to egg card.

• The required percentage and quantity of HCL and HCHO are calculated for use.

• Acid treatment is conducted before first stage (between 20-24 hrs after ovi-position).

• Acid treatment is of two types i.e., hot acid and cold Acid treatments.

• In hot acid treatment, eggs are dipped in HCL of 1.075 Specific gravity at 46°C for 5-6 minutes.

• Cold acid treatment is conducted at room temperature. Eggs are treated with HCL of 1.110 Specific gravity at 15°C at room temperature.

• Acid treatment can also be done after chilling. It is of two type i.e., Short term, Long term chilling.

• In Short term chilling, the eggs are preserved at 5°C with 75-80% humidity for 40-50 days. While releasing, the eggs are kept at 15°C for 6-12 hrs and then 25°C for 3-4 hrs. Then eggs are acid treated.
In long term chilling, eggs are kept at 25°C for 40 – 50 hrs and preserved at 5°C with 75 – 80% humidity for 50 – 70 days. While releasing eggs are preserved at 15°C for 6 – 12 hrs, then at 25°C for 3- 4 hrs and then the eggs are acid treated.

Eggs are transported during cooler hours of the day. Eggs are loosely placed in a wooden carrier/perforated paper cover.

Short Answer Type Questions

1. Mention the different types of eggs.
2. What are the factors in handling eggs?
3. Define handling of the eggs.
4. What are the methods of handling the eggs?
5. Why storage of eggs is necessary?
6. What is the use of stimulants?
7. Mention some physical and chemical stimulants.
9. What is the best acid for treatment of eggs?
10. Write the principle to calculate HCL to be taken.
11. What is the necessity of formalin treatment before acid treatment?
12. Write the principle to calculate required formalin.
13. What is the best age for acid treatment?
14. What is the specific gravity in hot and cold acid treatment?
15. Mention methods of acid treatment after chilling.
16. What is transportation of eggs?
17. When and how the eggs are transport?

Long Answer Type Questions

1. What is the aim of acid treatment? Prepare 20 liters of 1.075 specific gravity HCL using commercial HCL.
2. What is the importance of formalin in acid treatment? Calculate 3% of 25 liters of formalin with commercial available formalin.

3. Write about storage of eggs?

4. Detail the process of Hot and Cold acid treatment.

5. Write about acid treatment after chilling.

6. Write short notes on
   a) Methods of handling eggs  b) Stimulants.

7. Write about handling of eggs.

8. Write short notes on
   (a) age of eggs in acid treatment  (b) Short term chilling.

9. Write short notes on
   (a) Transport of eggs  (b) stopping of acid treatment.

10. Write short notes on
   (a) Long term Chilling  (b) Storage of Autumn eggs.
8.1 Introduction

Grainages are aimed to produce silkworm eggs commercially and are sold to the farmers for commercial cocoon production. The production of egg is influenced by various factors. The seed cocoons are produced in seed areas under scientific guidance and supervision, cost of seed cocoons is generally fixed by the state government from time to time and seed cocoons are offered about 20-25% higher rates than hybrid cocoons. The quality of seed cocoons has direct relation in producing more number of disease free layings. Since nearly 60 percent of the cost of production of seed goes to the cost of the cocoons, the egg producer must concentrate on procuring good quality seed cocoons.

Generally the following are considered for working out the economics of grainages.

1. Cost of seed cocoons.
2. Establishment charges.
3. Wages.
4. Depreciation cost on equipment.
5. Interest on revolving capital.
6. Cost of chemicals, rent, electricity and water charges.
7. Total Dfl’s produced. In any case one must be sure of producing disease-free layings at a lower cost utilizing all the latest easy techniques which improve the economics of the grainage. One should not be determined to reduce the cost of production, because quality of eggs determines the reputation, stability of a grainage.

Utilization of seed cocoons has direct relation to the cost of seed production. If the quality of seed cocoons is good, then recovery of Dfl’s is high.

8.2 The following is the example to estimate the economics of grainage.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Multivoltine</th>
<th>BiVoltine</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Seed Cocoon cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Seed cocoons purchased</td>
<td>33.20</td>
<td>16.60</td>
</tr>
<tr>
<td>2. Bad cocoons 20 %</td>
<td>6.64</td>
<td>3.32</td>
</tr>
<tr>
<td>3. Good cocoons to be used for dfl preparation</td>
<td>26.56</td>
<td>13.28</td>
</tr>
<tr>
<td>4. Percentage of dfls from total seed cocoons(item 3)</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>5. Total dfls produced</td>
<td>10 lakhs</td>
<td></td>
</tr>
<tr>
<td>6. Cost of multi-voltine seed cocoons @ Rs.60 per 1000 cocoons</td>
<td>Rs. 1.99</td>
<td></td>
</tr>
<tr>
<td>7. Cost of bi-voltine seed cocoons @ Rs.80 per 700 cocoons</td>
<td>Rs. 1.89</td>
<td></td>
</tr>
<tr>
<td>8. Total cost of seed cocoons(6+7)</td>
<td>Rs. 3.88</td>
<td></td>
</tr>
<tr>
<td>9. Recovery from pierced cocoons</td>
<td>Rs. 0.42</td>
<td></td>
</tr>
<tr>
<td>a. Bi-voltine cocoons 0.533 kg @ Rs.80</td>
<td>Rs. 0.42</td>
<td></td>
</tr>
<tr>
<td>b. Multi-voltine cocoons 0.55 kg @ Rs.80</td>
<td>Rs. 0.43</td>
<td></td>
</tr>
<tr>
<td>10. Total cost of seed cocoons(8-9)</td>
<td>Rs. 3.03</td>
<td></td>
</tr>
</tbody>
</table>

II. Expenditure
A. Recurring
a. Labour charges | Rs. 0.94 |
| b. Cost of egg sheets | Rs. 0.08 |
| c. Cost of chemicals | Rs. 0.08 |
| d. Rent etc | Rs. 0.14 |
| e. Transportation of seed cocoons | Rs. 0.12 |
| f. Miscellaneous | Rs. 0.04 |
Note
This is only a model calculation, not standard. Rates mentioned changes according to season and place.

8.3 Summary

• Grainage aim is to produce dfls at an offer able cost.
• 60% of the cost of production of seed goes to the cost of the cocoons.
• Items like investment, recurring, non-recurring are considered to calculate cost of production of eggs.
• One should not aim to reduce the cost of production, but to concentrate on the quality.

Short Answer Type Questions

1. What is the aim of a Grainage?
2. What are the items to be considered for calculating the cost of production of eggs?

Long Answer Type Questions

1. Estimate the cost of production of 10 lakh eggs.
**GLOSSARY**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaphae Silk</td>
<td>Anaphe a uni-voltine green silkworm (20-100) Collectively produce silk cocoons.</td>
</tr>
<tr>
<td>Ant</td>
<td>A Common name to freshly hatched silkworm larvae.</td>
</tr>
<tr>
<td>Antennae/Feelers</td>
<td>There are a pair of sensory receptive organs present on the dorsal side of the head.</td>
</tr>
<tr>
<td>Ant Well</td>
<td>An equipment used to prevent crawling of ants on to rearing trays.</td>
</tr>
<tr>
<td>Acid Treatment</td>
<td>A process to make the eggs to hatch especially bi-voltine eggs.</td>
</tr>
<tr>
<td>Breeding Stations</td>
<td>Place to multiply reproductive seed.</td>
</tr>
<tr>
<td>Bi-Volntine</td>
<td>The silkworms have two generation in a year.</td>
</tr>
<tr>
<td>Cellule</td>
<td>A plastic black conical cup used to cover paired moths and female moth during ovi position.</td>
</tr>
<tr>
<td>Chawki worms</td>
<td>Worms of I to III instar age.</td>
</tr>
<tr>
<td>Cocoon</td>
<td>A compact structure spun by silkworm larvae as a protective covering for undergoing population.</td>
</tr>
<tr>
<td>Commercial</td>
<td>Specific hybrids between two or more pure lines of Industrial seed races of silkworms.</td>
</tr>
<tr>
<td>Seed Crop</td>
<td>Cacoon production which is used to produce eggs in commercial egg production center</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Crumpled Wings</td>
<td>Wings which are having numerous folds but not uniform.</td>
</tr>
<tr>
<td>Defloss</td>
<td>Removing of floss from seed cacoons before moth emergence.</td>
</tr>
<tr>
<td>DFL</td>
<td>Disease Free Laying.</td>
</tr>
<tr>
<td>Disease</td>
<td>Any deviation from the regular physiological activities in the body of an organism</td>
</tr>
<tr>
<td>Disinfection</td>
<td>This is the process of cleaning the room and appliances for hygienic.</td>
</tr>
<tr>
<td>Domestication</td>
<td>Rearing any animal under laboratory conditions.</td>
</tr>
<tr>
<td>Eri silk</td>
<td>A domesticated silkworm Philosamia ricini feed Castor leaves to produce white or brick-red silk.</td>
</tr>
<tr>
<td>Fagra silk</td>
<td>A giant silk moth Attacus atlas produce light brown colour cocoons.</td>
</tr>
<tr>
<td>Fish Wool</td>
<td>It is a silk obtained from a bi-valve Pinna Squamosa.</td>
</tr>
<tr>
<td>Floss</td>
<td>An outermost loose, fragmented layer of cocoon. It is waste silk to be removed before reeling and moth emergence.</td>
</tr>
<tr>
<td>Grain</td>
<td>The term given to the eggs of silk moth.</td>
</tr>
<tr>
<td>Grainage</td>
<td>A centre aimed to produce disease free seeds.</td>
</tr>
<tr>
<td>Hibernating eggs</td>
<td>These breeds do not hatch normally in 10 – 11 days and enter diapause stage.</td>
</tr>
<tr>
<td>Hygrometer</td>
<td>It is an equipment to measure humidity.</td>
</tr>
<tr>
<td>Instar</td>
<td>It is the stage between two moults in larval development of an insect (feeding period).</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Incubation</td>
<td>A process aimed at uniform development of an egg, to ensure uniform hatching through proper maintenance of environmental conditions.</td>
</tr>
<tr>
<td>Insect</td>
<td>An animal having 3 pairs of legs present on the Ventral Side of the thorax.</td>
</tr>
<tr>
<td>Kego</td>
<td>A common name of freshly hatched larvae.</td>
</tr>
<tr>
<td>Labium</td>
<td>It is a part of mouth parts present on the ventral side of the head (lower lip).</td>
</tr>
<tr>
<td>Larva</td>
<td>A form in which some animal hatch from the egg. It is capable of feeding for itself and for the future Stages of life cycle.</td>
</tr>
<tr>
<td>Laying</td>
<td>A number of eggs laid by a single silkworm.</td>
</tr>
<tr>
<td>Lustrous</td>
<td>Glittering or shinning.</td>
</tr>
<tr>
<td>Mandible</td>
<td>Teeth like structure with cutting edge present as a Part of mouth parts of larva.</td>
</tr>
<tr>
<td>Micropyle on egg</td>
<td>A small microscopic opening present</td>
</tr>
<tr>
<td>Morphology</td>
<td>Study of External structure of an organism.</td>
</tr>
<tr>
<td>Moultinism</td>
<td>It is racial character which indicates the number of moults during larval stage of an insect.</td>
</tr>
<tr>
<td>Muga Silk</td>
<td>A silk worm Antheraea assamensis feeds on som and Soalu to produce golden yellow silk.</td>
</tr>
<tr>
<td>Multi-voltine</td>
<td>The silkworms have many generations in a year.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------------</td>
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</tr>
<tr>
<td>Moulting</td>
<td>Shedding of old skin and forming new skin.</td>
</tr>
<tr>
<td>Metamorphosis</td>
<td>Change of form or character by natural growth or development in the life of an insect starting from egg and evolving with adult.</td>
</tr>
<tr>
<td>Moth examination</td>
<td>It is examine of moths after oviposition to identify pebrine infection.</td>
</tr>
<tr>
<td>Moth emergence</td>
<td>The process of moth coming out of cocoon.</td>
</tr>
<tr>
<td>Mortality</td>
<td>It denotes the death rate of an organism.</td>
</tr>
<tr>
<td>Non- hibernating</td>
<td>These breeds hatch in 10-11 days after laying. Eggs</td>
</tr>
<tr>
<td>Ovi-Position</td>
<td>Process of laying of eggs.</td>
</tr>
<tr>
<td>Pupa</td>
<td>Stage between larva and adult of endopterygota insect, in which commotion and feeling cease but great development changes occur.</td>
</tr>
<tr>
<td>Pebrine</td>
<td>A transovarially transmitted disease.</td>
</tr>
<tr>
<td>Pectinate</td>
<td>Antenna possessing numerous hairs which look like a comb.</td>
</tr>
<tr>
<td>Pro legs</td>
<td>3 pairs of thoracic legs of larva which are singleclawed.</td>
</tr>
<tr>
<td>Pro thetel</td>
<td>An intermediate form between larva and pupa of an Insect.</td>
</tr>
<tr>
<td>Reproductive seed</td>
<td>Used to produce seed cocoons which are required in large number for producing commercial seeds.</td>
</tr>
<tr>
<td>Silk</td>
<td>A fibrous proteinous secretion secreted by certain Insects.</td>
</tr>
<tr>
<td>Spinneret</td>
<td>It is a special organ used to spin the cocoon in certain group of insects.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sexual Dimorphism</td>
<td>It is a phenomenon where male and female are identified by their external morphological features.</td>
</tr>
<tr>
<td>Spiracle</td>
<td>An opening meant for respiration in insects.</td>
</tr>
<tr>
<td>Synchronization</td>
<td>The moths of different races are made to hatch simultaneously on the same day, so are available for hybridization.</td>
</tr>
<tr>
<td>Sterilization</td>
<td>A process to eliminate harmful micro-organisms, and to make the room clean and hygienic.</td>
</tr>
<tr>
<td>Tasar Silk</td>
<td>A wild silk produced by Antheraea mylitta which feed on Terminalia tomentosa.</td>
</tr>
<tr>
<td>Uni-voltine</td>
<td>The sillworms have only one generation in a year.</td>
</tr>
<tr>
<td>Voltinism</td>
<td>It is a character which indicates the number of generations per year of an insect.</td>
</tr>
</tbody>
</table>


12. Bulletins on Sericuluture, CSB, Bangalore.


17. Pattu Parishrama Practical Manual(Telugu) by Maruthi Ram and P.Srinivas, Telugu Academy, Hyderabad.


