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# Sericulture Science: Biology, Rearing, and Management of Silkworms

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Silkworms are among the most economically valuable beneficial insects in the world, producing natural silk of unparalleled quality. The art and science of rearing silkworms, known as *sericulture*, has evolved over centuries and now represents a sustainable agro-based industry providing employment and income to millions. This chapter explores in detail the types and classification of silkworms, the biological and physiological basis of their life cycle, and the practical techniques for rearing, mounting, and harvesting cocoons. Emphasis is given to environmental conditions, hygiene, and modern management practices necessary for successful sericulture.

## Introduction

Silkworms are domesticated insects belonging to the order **Lepidoptera** and family **Bombycidae**. They are reared for their ability to produce silk—a fine, lustrous natural fibre secreted by the larval stage for cocoon formation. The most widely used commercial species is the **mulberry silkworm (*Bombyx mori*)**, which has been reared for more than 5,000 years, particularly in China, Japan, and India. Sericulture plays an important socio-economic role, especially in rural India. It integrates agriculture (mulberry cultivation), animal science (silkworm rearing), and industry (silk reeling and weaving). India is the only country that produces all five major types of silk — mulberry, tasar, eri, muga, and oak-tasar — thus holding a unique position in global sericulture.

## Importance of Silkworms as Beneficial Insects

Silkworms contribute significantly to the **agro-based economy** by converting plant biomass (mulberry leaves) into high-value silk fibre. In addition to silk production, they hold importance in:

- **Employment generation** – sericulture provides livelihood to rural and tribal populations.
- **Scientific research** – *B. mori* serves as a model organism for genetics, physiology, and molecular biology studies.
- **By-products** – pupae and litter can be used as feed, fertilizer, and raw materials in pharmaceuticals.

Hence, silkworms represent a bridge between entomology and rural development.

## Types of Silkworms

More than 400 insect species can produce silk, but only a few are **commercially important**. Based on the host plant, silk produced, and region of occurrence, the major silkworm species are:

➢ **Mulberry Silkworm (*Bombyx mori*)**

- Feeds exclusively on mulberry leaves.
- Produces **mulberry silk**, the finest and most lustrous type.
- Fully domesticated; cannot survive in the wild.

- Contributes nearly **95%** of world silk production.

➢ **Tasar Silkworms (*Antheraea* spp.)**

- Feed on forest trees like *Terminalia* and *Shorea*.
- Produce **tasar silk**, known for its coppery colour and strength.
- Common species:
  - *Antheraea mylitta* (tropical tasar)
  - *A. proylei* (temperate tasar)
  - *A. pernyi* (Chinese tasar)
  - *A. yamamai* (Japanese tasar)

➢ **Eri Silkworm (*Samia ricini*)**

- Feeds on castor and *Kesseru* plants.
- Produces **eri silk**, also called "peace silk," as moths are allowed to emerge.
- Spun silk with wool-like texture; used in warm clothing.

➢ **Muga Silkworm (*Antheraea assamensis*)**

- Native to Assam and Meghalaya (India).
- Feeds on *Som* (*Machilus bombycina*) and *Sualu* (*Litsaea polyantha*).
- Produces **golden-yellow silk** of exceptional durability and sheen.

## Classification of Silkworm Races

Silkworm races can be classified according to several biological and geographical criteria:

➢ **Based on Voltinism**

**Voltinism** refers to the number of generations produced per year.

1. **Univoltine:** One generation per year.
- Eggs undergo diapause in winter.
- Found in temperate climates (e.g., Europe, Japan).
2. **Bivoltine:** Two generations per year.
- First generation eggs are non-diapausing; second generation eggs enter diapause.
- Found in Japan, China, and temperate India.
- Produce silk of **superior quality** and longer filament.
3. **Multivoltine:** More than two generations per year.
- Eggs are non-diapausing and hatch continuously.
- Found in tropical climates like India.
- Cocoons are smaller but larvae are hardy and resistant.

➢ **Based on Moultinism (Number of Larval Moults)**

Silkworms are also classified according to the number of moults during larval growth:

- **Trimoulters:** Three moults (four larval instars)
- **Tetramoulters:** Four moults (five larval instars) – most common
- **Pentamoulters:** Five moults (six larval instars)

➢ **Based on Geographical Origin**

- **Chinese races:** White cocoons, high silk yield, delicate to heat.
- **Japanese races:** Hardy, uniform silk quality.
- **Indian races:** Adapted to tropical conditions.
- **European races:** Large cocoons, slow-growing larvae.

➢ **Based on Genetic Nature**

- **Pure races:** Maintained by inbreeding; used as parents for hybridization.
- **Hybrids:** Result from crossing of distinct races; superior in vigour and productivity.

## Biology of the Silkworm

Silkworms are **holometabolous insects**, exhibiting complete metamorphosis through four stages: *egg, larva, pupa, and adult.*

**Egg**

- Minute, oval, and flattened on one side ("egg dimple").
- Each female lays **400–600 eggs**.

- The incubation period lasts about **8–10 days** at 25°C and 80–85% RH.
- The eggs are either **diapausing** or **non-diapausing** depending on the race.

**Larva**

- Also called the **caterpillar**; soft-bodied and voracious feeder.
- Passes through **five instars** with four moults.
- First instar larvae are black; later instars become creamy white.
- Feeds exclusively on mulberry leaves.
- Grows from 3 mm to about 8–10 cm in length.

**Sex differentiation in larvae**

Visible during 4th or 5th instar—females show two round spots (gonadal rudiments) on 8th and 9th segments.

**Pupa**

- Formed inside the cocoon after last larval stage.
- It is of **obtect type**, with appendages glued to the body.
- Transformation into adult takes **8–10 days** depending on temperature.
- The pupal stage is non-feeding and motionless.

**Adult Moth**

- Non-feeding, weak flier, creamy white moth with scaly wings.
- Males are smaller with bushy antennae; females are larger and heavier.
- Life span: 3–6 days.
- Females lay eggs within a day of emergence.

## Rearing of Silkworms

Rearing involves maintaining larvae under controlled environmental conditions and feeding them with fresh mulberry leaves to obtain high-quality cocoons.

**Rearing House**

A well-designed rearing house ensures optimum temperature, humidity, and hygiene.

**Specifications (for 200–250 disease-free layings – DFLs):**

- Size: **50 ft × 20 ft × 10 ft**
- Built on elevated, shaded ground with a 3-ft verandah.
- Proper ventilation, windows covered with nylon net to prevent pests like *Exorista bombycis* (Uzi fly).
- Cemented floor for easy cleaning.

**Rearing Appliances**

Include:

Power sprayer, rearing trays, stands, foam pads, nylon nets, paraffin papers, baskets for leaves, disinfectants (bleaching powder, Sanitech solution), and **mountages** (rotary, bamboo, plastic collapsible types).

**Disinfection Schedule**

- **First disinfection:** 5% bleaching powder immediately after previous crop.
- **Second disinfection:** 2.5% chlorine dioxide solution two days before next rearing.
- Dry thoroughly before introducing eggs.

**Incubation and Brushing**

**Incubation of Eggs**

- Maintain at **25–26°C** and **80–85% RH.**
- Eggs are spread on paraffin-coated paper and covered with tissue or black cloth.
- Exposure to diffused sunlight triggers hatching synchrony.

**Brushing**

- Gently transfer newly hatched larvae (black head stage) with a soft brush to rearing trays.
- Provide tender, chopped mulberry leaves (0.5–1 cm pieces).

**Chawki Rearing (Young Age Rearing)**

Covers the **1st and 2nd instars.**

These stages require high humidity, tender leaves, and hygienic handling.

- **Temperature:** 27–28°C

- **Humidity:** 80–90%
- **Feeding:** 3–4 times daily with soft leaves
- **Leaf quantity:**
  - 1st instar: 5 kg/100 DFLs
  - 2nd instar: 18 kg/100 DFLs
- **Bed spacing:** Increase gradually to ensure ventilation.

**Late Age Rearing (3rd to 5th Instar)**

- Conducted on **shoot rearing racks** made of bamboo or wood.
- Each rack has 3 tiers with 2-ft spacing between.
- **Temperature:** 25–26°C
- **Humidity:** 70–80%
- **Feeding:** 2–3 times daily with mature leaves or entire shoots.
- **Bed cleaning:** Once during 5th instar.
- **Leaf requirement:** 2500 kg shoots/100 DFLs.

**Care During Moulting**

Silkworms stop feeding before moulting; 90% larvae in moult = stop feeding.

- Spread bed to dry leaves.
- Apply lime powder to absorb excess moisture.
- Avoid disturbances.

**Mounting and Spinning**

**Mounting**

Transferring mature larvae to *mountages* for cocoon formation.

- Usually done 8 days after entering 5th instar.
- Select **healthy, ripe worms** (shiny, translucent, reduced movement).
- Density: **40–45 worms/sq.ft** of mounting surface.
- Maintain **27–28°C**, RH 60–70%, and gentle air circulation.

**Spinning and Cocoon Formation**

- The larva secretes silk from **two silk glands** that open through the mouth.
- The silk thread solidifies on contact with air to form **fibroin** (core) and **sericin** (gum).
- Spinning lasts 2–3 days; the filament length may reach **700–1100 metres.**

**Harvesting of Cocoons**

- Collect cocoons on the **5th or 6th day** after mounting.
- Remove flimsy, diseased, or irregular cocoons.
- Dry or stifle cocoons by hot air or sunlight to prevent moth emergence.

**Rearing and Personal Hygiene**

- Wash hands before entering rearing house.
- Restrict entry of outsiders.
- Sprinkle **5% bleaching powder** around rearing area weekly.
- Collect diseased larvae and destroy them by burning or deep burial.
- Use **bed disinfectants** (e.g., Vijetha, Serichlor) after each moult.

## Hygiene and Disease Management in Silkworm Rearing

Maintaining **strict hygiene and sanitation** is the backbone of successful sericulture. Diseases of silkworms can spread rapidly under crowded, humid, or unhygienic conditions, leading to heavy cocoon crop losses. Therefore, each stage of rearing—from egg incubation to cocoon harvest—must follow scientific hygiene protocols.

Importance of Hygiene

Silkworms are delicate insects highly sensitive to changes in temperature, humidity, microbial contamination, and even human handling. Pathogens such as *Nosema bombycis*, *Bacillus thuringiensis*, and various viruses can devastate crops if preventive measures are not adopted. A clean environment ensures healthy larval growth, uniform spinning, and maximum cocoon yield.

Sources of Infection

1. **Contaminated Equipment:** Old rearing trays, racks, and mountages often harbor fungal spores and bacterial residues.
2. **Infected Silkworm Seed:** Disease can enter through infected eggs or larvae (DFLs).
3. **Poor Ventilation and High Humidity:** Favors bacterial and fungal growth on mulberry leaves and beds.
4. **Unclean Mulberry Leaves:** Leaves contaminated by dust, pesticides, or pathogens can introduce infection.
5. **Human Contact:** Unwashed hands or rearing clothes may transmit pathogens.
6. **Uzi Flies (*Exorista bombycis*):** Parasitize larvae and are a major threat in tropical regions

## Common Silkworm Diseases

a) Pebrine (Protozoan Disease)

- **Causative agent:** *Nosema bombycis* (a microsporidian).
- **Symptoms:** Irregular black spots on body, sluggish movement, poor appetite, unequal larval size, black pupae.
- **Transmission:** Transovarial (from mother to offspring through eggs) and through contaminated rearing materials.
- **Management:**

✓ Use disease-free layings (DFLs) certified through "mother moth examination."
✓ Destroy infected lots immediately.
✓ Disinfect with 5% bleaching powder or 2% formalin.
✓ Maintain 25–28°C temperature and 80% relative humidity.

b)Flacherie (Bacterial and Viral Complex)

- **Causative agents:** *Serratia marcescens*, *Bacillus thuringiensis*, and viral pathogens.
- **Symptoms:** Larvae become flaccid, soft, and emit foul odor; vomiting may occur.
- **Management:**

✓ Maintain proper ventilation.
✓ Avoid feeding wet or over-mature leaves.
✓ Dust lime to reduce bed humidity.
✓ Apply commercial bed disinfectants such as **Labex**, **Serichlor**, or **Resham Keet Oushad**.

**c) Grasserie (Viral Disease)**

- **Causative agent:** Nuclear polyhedrosis virus (NPV).
- **Symptoms:** Larvae appear swollen, translucent, and exude milky fluid when pressed.
- **Management:**

✓ Maintain hygienic rearing.
✓ Avoid overcrowding and excessive humidity.
✓ Destroy infected larvae and sterilize trays immediately.

d) Muscardine (Fungal Disease)

- **Causative agent:** *Beauveria bassiana*.
- **Symptoms:** Dead larvae become stiff and are covered with white fungal growth (white muscardine).
- **Management:**

✓ Maintain dryness in rearing beds.
✓ Disinfect trays after each use.
✓ Apply **0.2% sodium hypochlorite** spray or commercial antifungal powder.

e) Uzi Fly Infestation

- **Causative agent:** *Exorista bombycis* (tachinid fly).
- **Symptoms:** Maggots feed inside silkworm body causing death before cocooning.
- **Management:**

✓ Cover windows with nylon nets.
✓ Spray 2% bleaching powder solution every 5–6 days.
✓ Use **UZICIDE** traps or **UZIFLY parasitoids** (e.g., *Nesolynx thymus*).
✓ Destroy infested larvae promptly.

**Disinfection Schedule**

| Stage | Disinfectant & Strength | Purpose | Frequency |
|---|---|---|---|
| Post-crop cleaning | 5% Bleaching powder | Surface sterilization | Immediately after previous crop |
| Pre-rearing (2 days before incubation) | 2.5% Sanitech (chlorine dioxide) | Final disinfection | Before introducing DFLs |
| During rearing | 2% Bleaching powder floor wash | Maintain hygiene | Weekly |
| After bed cleaning | Bed disinfectant spray (e.g., Resham Keet Oushad) | Control pathogens | After each moult |

## Summary

Sericulture is one of the most important agro-based industries in India and several other countries, contributing significantly to rural employment and the textile sector. It involves the scientific rearing of silkworms for the production of silk — a natural protein fiber primarily secreted by the mulberry silkworm, *Bombyx mori*. This fiber is valued worldwide for its luster, strength, elasticity, and smooth texture, making it a vital raw material in the luxury fabric industry. Silkworms are broadly classified into mulberry and non-mulberry types, including tasar, eri, and muga species, which differ in their host plants and the quality of silk they produce. The life cycle of the silkworm follows a complete metamorphosis—egg, larva, pupa, and adult moth—each stage demanding precise care and environmental control. The establishment of a well-designed rearing house, scientific rearing practices, and proper disease management are crucial for obtaining high-yield, good-quality cocoons. Sericulture, when practiced with scientific precision and hygienic standards, not only boosts cocoon productivity but also provides sustainable livelihoods to farming communities.

## Key Points

- Sericulture produces silk — a natural protein fiber secreted mainly by *Bombyx mori*, the mulberry silkworm.
- Silkworms are divided into **mulberry** and **non-mulberry types** such as tasar, eri, and muga.
- Based on **voltinism**, silkworms are classified as univoltine, bivoltine, or multivoltine depending on the number of broods per year.
- The **life cycle** includes four stages: egg, larva, pupa, and adult moth, representing holometabolous development.
- A **rearing house** must be clean, well-ventilated, and equipped with trays, racks, and other rearing appliances.
- **Chawki rearing** focuses on young larvae, using tender mulberry leaves and maintaining high humidity for uniform growth.
- **Late-age rearing** emphasizes shoot feeding, adequate spacing, and temperature control for healthy cocoon development.
- **Mounting** involves transferring mature larvae to mountages for cocoon spinning, typically completed in five to six days.
- **Hygiene and disease management**—including disinfection, sanitation, and pest control—are essential to prevent infections and ensure quality yield.
- Adopting **scientific and hygienic sericulture practices** enhances silk quality, filament length, reeling efficiency, and overall profitability for sericulturists.

## Conclusion

Sericulture plays a vital role in sustainable rural development by combining scientific insect rearing with agricultural enterprise. Through proper management and hygiene, silkworm rearing ensures high-quality silk production and economic stability for farming communities. Overall, it stands as a promising bio-based industry linking science, livelihood, and sustainability.

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