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Rearing techniques of mulberry silkworm

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Introduction

Sericulture is an agro-based industry dedicated to rearing silkworms for the production of raw silk, a fiber derived from the cocoons spun by certain insect species. Silk is known as the "queen of textiles" and is often called "BIOSTEEL" because of its exceptional strength. India is the world's second-largest producer of silk, with China leading the way. The four types of commercially produced silk are Mulberry, Eri, Tasar, and Muga. India is the only country in the world that produces all four varieties.

Mulberry silkworm *(Bombyx mori)*

This silkworm species contributes significantly to global silk production and belongs to the Bombycidae family. These silkworms feed mainly on mulberry leaves and exhibit all three types of voltinism: univoltine, bivoltine, and multivoltine. In India, the leading mulberry silk-producing states are Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu, and Jammu & Kashmir, which together account for 92% of the country's total mulberry raw silk output.

Identification of *Bombyx mori*

This type of silkworm experiences complete metamorphosis.

Eggs: The eggs are minuscule. They measure around 1-1.3 mm in length and 0.9-1.2 mm in width.

Larvae: Body of larvae is segmented into three parts: the Head, Thorax, and Abdomen. When newly hatched, the larva appears predominantly black or dark brown, gradually transitioning into a smoother and lighter. Fifth instar larval head movement is so quick (while spinning cocoon: 65 movements per minute). It consists of pair of silk gland.

Pupa: Inactive or the resting stage. After entering the pupation phase, the pupa initially displays a white and soft appearance, gradually darkening to shades of brown.

Adult: It possesses compound eyes but lacks ocelli, and it has three pairs of thoracic legs—one pair on each of its three thoracic segments.

Life cycle of Mulberry Silkworm

Chowki Rearing: This involves providing young silkworms (in the 1st and 2nd stages)

with tender, finely cut leaves, ensuring their freshness by preserving moisture, and maintaining the necessary environment for feeding, molting, and sanitation.

Rearing techniques

Procurement of Seeds

Obtain good quality and disease free eggs (Dfls) from various Government or private agencies.

Black Boxing: The process involves enveloping the silkworm eggs with black paper or fabric for synchronized hatching of the eggs.

Brushing

Recently hatched larvae are carefully removed from their egg shells and then relocated to the designated rearing bed. Appropriate time for brushing is 10 am.

Brushing from Loose eggs: Cloth/Net Method- Finely chopped mulberry leaves are gently scattered onto a net or muslin cloth, which is then positioned above the eggs. The newly hatched larvae make their way upwards by crawling through the mesh towards the leaves.

Brushing from Egg cards: Feather Method- In this approach, egg cards are positioned in a vertical orientation on the rearing bed. Using gentle strokes of a feather, the larvae are delicately separated, causing the hatched ones to descend onto the rearing bed along with the leaves.

Husk Method: Spread the husk evenly across the egg sheet, and then sprinkle the chopped leaves onto the husk. Once this is done, allow the hatched larvae to crawl over the husk. Finally, gently transfer the hatched larvae onto a rearing tray using a brush.

Net/Cloth/Paper Method: Chopped mulberry leaves are gently scattered over a net or muslin cloth, which is then positioned above the eggs. As the larvae hatch, they instinctively crawl upwards through the mesh, interacting with the leaves. The net or muslin cloth is subsequently lifted, carrying the larvae along, and they can be carefully relocated onto a rearing bed.

Maintenance of Optimum Temperature and Humidity

The larvae's optimal growth and development depend on specific temperature conditions. Charcoal stoves and wet gunny bags are used to regulate both humidity and temperature.

Larval instar	Temperature (°C)	Relative Humidity (%)
First instar	26-28	85
Second instar	26-28	85
Third instar	24-26	80.5
Fourth instar	24-25	75
Fifth instar	23-24	70

Table 1: Temperature and Relative Humidity for various instars

Feeding of Larvae

Quantity of Leaves: Among the entire feed provided, approximately 85% is consumed by larvae in their 4th and 5th instar stages. ***Moulting:*** Prior to moulting, larvae exhibit reduced eating habits, and during the moulting process, they cease feeding altogether.

Following moulting, their feeding activity increases significantly.

Quality of leaves: Offer tender, moist leaves to young larvae, ensuring a higher moisture content. For mature worms, provide mature leaves with reduced moisture and increased nutrient content.

Frequency: In India, generally four feeding per day- 7 a.m., 11 a.m., 5 p.m.and 8 p.m. In case of Shoot and Floor rearing three feedings are given per day. Provided chopped leaves to 1st, 2nd and 3rd instar larvae and entire shoot to 4th and 5th instar larvae. In humid condition, leaves are chopped into rectangular shape and in Dry condition square shape and if large amount of feed is needed chopped into triangular.

Bed Cleaning and Hygiene

This technique involves regularly removing leaves that haven't been consumed and dried, as well as the larvae's waste. This practice is essential to prevent the proliferation of microorganisms and to prevent staining of cocoons.

Conventional Method: Using a feather or manual selection, the larvae are gathered and then moved to a fresh rearing bed. To distribute them, a chopstick can be employed.

Husk Method: The rearing bed is lightly covered with husk. During the initial feeding, chopped leaves are positioned over the husk. The larvae climb onto these leaves, and for the subsequent feeding, they are transferred to a different rearing bed.

Net Method: A layer of cotton or nylon net is set over the rearing bed, and fresh leaves are laid upon it. The larvae ascend through the mesh of the leaves, after which the net is lifted, carrying the worms and fresh leaves along, and then these are moved to a new tray.

Combination of Husk and Net method: Spread paddy husk across the rearing tray, then position an appropriately sized mesh over the tray. Offer two consecutive feeds on this mesh, allowing the larvae to crawl over. Later, carefully transfer both the larvae and the mesh to a different tray.

Instars	Frequency	Time
First	Once	Pre moulting stage
Second	Twice	Pre and post moulting stage
Third	Thrice	Pre and post moulting and in between
Fourth	Once	For shelf rearing
Fifth	Once	For shoot rearing

Table 2: Bed cleaning frequency

Spacing of Larvae

Adequate spacing is essential for optimal growth. It's important to offer expanding worms more room. Fifth instar larvae, in particular, require 80-100 times the initial space they occupied upon hatching.

Care while Moulting

The process by which larvae shed their old skin and emerge with fresh, loose skin is known as moulting. These larvae are classified as tetra moulters, and the moulting process usually lasts between 15 to 30 hours. It consists of three stages: Pre-moulting (which involves thorough bed cleaning, providing more space, and reducing feed quantity), Moulting, and Post-moulting. To maintain dryness and serve as a disinfectant, lime powder is sprinkled on the

bed. To prevent diseases like grasserie and muscardine and to ensure consistent moulting, disinfectants such as "Resham Keed Oushad (RKO)" and "Labex" are used.

Mounting of Mature Worms

Mounting involves relocating mature worms to designated mountages, providing optimal conditions for cocoon spinning. Fifth instar larvae, fully developed and translucent, are prepared for cocooning. During this process, it's crucial to uphold a temperature of 24°C and humidity levels between 60% and 70%. Thoroughly washing and disinfecting the mountages before use is essential.

Few methods for mounting, Net method, Branch method, Hand picking and Simultaneous mounting.

Harvesting of Cocoons

The process of collecting fully developed cocoons from the mountages is referred to as Cocoon harvesting. This should be done before the adult moth emerges. For tropical species, the recommended day is the 5th day, and for temperate species, it's the 8th or 9th day.

Harvest Processing of Cocoons

The cocoon of *Bombyx mori* is constructed from a solitary silk fiber held together by sericin, or silk glue. After harvesting, it is essential to carry out post-harvest processing on the cocoon before beginning the reeling process.

Stifling: This refers to the procedure of terminating the pupal stage within the cocoon and subsequently drying the cocoons for preservation.

Various methods for stifling:

a. Sun drying (Cocoons spread in direct sunlight for a long time)

b. Steam stifling (Over harvested cocoons, hot and wet steam is passed)

c. Hot air conditioning (Stifling and drying of cocoons done simultaneously by using hot air).

Cocoon sorting: Sorting involves laying out the stifled cocoons. Imperfect cocoons (such as double cocoons, deformed cocoons, stained cocoons, multilayered cocoons, and fragile cocoons) are identified and eliminated.

Cocoon deflossing: The outer side of the cocoon is enveloped by an intricate tangle of silk that cannot be unraveled, known as floss. The process of removing this floss is termed

Deflossing. It is done before reeling.

Cocoon cooking: For extracting silk thread for the cocoon we need cocoon cooking. Done by two methods, for top reeling- Open pan system, three pan system and for sunken system- Traditional system, Circular system and Conveyer Type.

Cocoon cooking for Top Reeling:

Top Reeling- Only outer layer of cocoons get wet and they float in the reeling water basins (40-45oC). Cocoon Cooking by the method of *Open Pan System*: Boiling in open vessel directly over fire. Cocoons are boiled in water till they become dull, and soapy to touch. Easy & cheap method but less no. of cocoons are boiled at a time.

Common diseases of silkworm

Protozoan disease

Pebrine (*Nosema bombycis nageli)*

Symptoms: Infected larvae exhibit black pepper-like spots. Instead of being held upright, they hang their heads down. Pupae appear weighty and weak.

Control: Use of disease free eggs and moths. Sterilization of rearing house and equipments with 2% formalin.

Bacterial Diseases

Flacherie

Symptoms: Body of larvae becomes soft & loose. Affected larvae fail to undergo moulting, and those that have died display a blackened body with a noxious odor.

Control: Avoid the predisposing factor, burning of diseased larvae, provide good quality of leaves, avoid unhygienic condition apply recommended bed disinfectant as per schedule and quantity.

Septicemia

(*Bacillus sp.)*(Infection through wounds or injury in skin)

Symptoms: The thorax becomes swollen, accompanied by vomiting, weakened gripping by abdominal legs, and a soft, discolored body. In warmer conditions, the body takes on a blackish hue, and the body wall may rupture, leading to rapid decomposition and the emission of an unpleasant odor.

Control: Avoid injury, affected silkworms should be separated from healthy, avoid high temperature and humidity, as a disinfectant 2% formalin used after rearing is over.

Fungal diseases

Muscardine

White Muscardine: *Beauveria bassiana*, **Green muscardine:** *Spicaria prasina*, **Yellow muscardine:** *Paecilomyces farinosa*

Symptoms: During the initial infection stage, the body surface, spiracles, and legs of the larvae develop black spots resembling oily specks. Appetite diminishes, and the larvae become sluggish and limp. Upon death, their bodies progressively harden.

Aspergillosis

Caused by genus *Aspergillus*

Symptoms: A severe ailment affecting chawki worms results in infected worms acquiring a glossy appearance and eventually perishing. In the later stages of the disease, the parts of the worm's body not covered by mycelia tend to decompose readily.

Control: Disinfection of rearing house and equipments with 2% formalin, dry bed.

Viral diseases

Grasserie (Nuclear polyhedrosis)

Borrelina bombycis

Symptoms: During the initial stages of infection, the larvae's skin becomes glossy and

delicate, causing them to experience difficulties in moulting. Swelling occurs in the inter-segmental regions. The skin is prone to rupturing, leading to the release of body fluids containing viral polyhedra.

Control: Thoroughly disinfect using appropriate disinfectants. Apply a dusting of slaked lime when larvae are preparing to moult.

Pests of silkworm

Uzi fly

Exorista bombycis is a significant parasitoid of *Bombyx mori*, causing approximately 10-15% damage to the silkworm cocoons. The female uzi fly infiltrates the rearing facility, selecting the silkworm's body for egg deposition. Each female lays one or two eggs on the intersegmental regions of a silkworm larva. After 2-3 days, the eggs hatch, giving rise to maggots. These maggots penetrate the larva by creating small openings and subsequently consume its internal contents. Upon maturation, the maggot ruptures the silkworm's integument to emerge. In cases of early instar infection, the worms succumb to the infestation before the cocoon-spinning stage.

Control: Provide wire mesh/nylon net on all windows/doors. Cracks and crevices should be sealed. Place uzi traps inside the rearing house to trap uzi flies emerging inside. Release *Nesolynx thymus* (a pupal parasitoid of the uzi fly) inside rearing house on 2nd day of V instar.

Conclusion

In conclusion, the rearing of silkworms is a fascinating and intricate process that plays a pivotal role in sericulture and silk production. The successful cultivation of these delicate creatures demands a comprehensive understanding of their life cycle and the implementation of meticulous techniques. Throughout this paper, we have explored the critical aspects of silkworm rearing, starting from the careful selection of mulberry leaves to the systematic management of environmental conditions within the rearing chamber. The availability of high-quality mulberry leaves is the lifeblood of silkworm development, ensuring their healthy growth and robust cocoon spinning. Maintaining optimal environmental parameters, such as temperature, humidity, and ventilation, is essential for promoting efficient metabolism and preventing stress-related issues among the larvae. Silkworm rearing is not only an ancient tradition but also a significant contributor to the global economy. The sericulture industry has been a major source of employment and income for numerous communities, particularly in rural areas where it is a traditional practice. Moreover, silk production supports various allied industries, including textiles, fashion, and luxury

goods, driving economic growth and trade worldwide. As technology continues to advance, silkworm rearing is also subject to innovation and modernization. Researchers and sericulturists are continually exploring ways to improve the efficiency of rearing techniques, develop disease-resistant silkworm strains, and implement sustainable practices that benefit both the environment and the industry. The rearing of silkworms remains a valuable and time-honored craft, exemplifying the harmonious integration of nature, tradition, and human ingenuity. Its continued success depends on the preservation of traditional knowledge and the embrace of innovative solutions, ensuring a vibrant future for sericulture and silk production worldwide.

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