Review Article

Predisposing factors determining the rearing performance of Muga silkworm (*Antheraea assamensis* Helfer): A review

Abstract

Muga silkworm (*Antheraea assamensis* Helfer) is endemic to North-Eastern India, and colour designates it as golden silk. From time immemorial, many ethnic and tribal groups have produced muga silk. Muga silk has a special status due to its natural golden-yellow colour. Semi-domesticated muga silkworm (*Antheraea assamensis* Helfer) is multivoltine in nature and commercial rearing is conducted during the spring (Jethua) and autumn (Kotia) seasons. The muga silkworm is a mono race with little genetic variation among populations, rearing is completely in an open environment and is subject to various diseases, pests and predators. Due to unpredictable weather conditions, natural calamities along with disease outbreakand natural enemies, the muga silk production has been affected dramatically. To improve the productivity of this silkworm it is important to have a better knowledge of the factors that affect the most to this silkworm. So, the present study is mainly discussed about factors responsible for the rearing of muga silkworm.

Keywords: Muga silkworm, seed, factor affecting, rearing seasons.

Introduction

Muga silkworm *Antheraea assamensis* Helfer is a Lepidopteran insect of *Saturniidae* family and, is geographically isolated only to NE region of India. The geographical endemicity of this silkworm is indicative of its special requirements for geo-climatic conditions that prevail in this region i.e. high humid temperate climate and forest vegetation of primary and secondary host plants (Singh *et al*., 2022). Thus, this species is phylogenetically less adaptive reaching its ecological isolation that is indicative of being on the verse of extinction. Although Muga silkworm has been reared for production of silk but outdoor practice on host plant under natural conditions poses a big challenge. Being exposed to the natural environment Muga culture faced lots of problems right from brushing of worms to spinning of cocoons. Outdoor silkworm larvae are invariably exposed to nature's vagaries such as seasonal climate change, rainfall, strong wind, and soaring temperature, besides pests, predators and pathogens inflecting heavy loss particularly in early three instars reported that In an average in all seasons more than 50% larval loss was due to abiotic factors and 80% of the total loss of muga silkworm occurred in second/third instars only (Sengupta *et al.*, 1992). Rearing being outdoor, the success of crops is always bestowed on the mercy of environmental conditions as Muga rearers practice traditional cultural methods. Out of the 5-6 broods of rearing in a year, the commercial crops fall in favorable period while all seed crops rearing coincide with the period of extremities of temperature, humidity, rainfall etc. The Aghenua crop which is pre-seed crop for Chatua seed crop falls during December-January. Low temperature prevailing during this season emanated to the lengthening of larval duration and outbreak of fungal diseases mainly muscardine leading to heavy larval mortality. The resultant in turn is low rate of seed multiplication affecting the availability of seed to Chatua Seed and subsequent multiplicati on for Jethua Commercial crops. Similarly, seed supply for Kotia commercial crop has also become inadequate as the seed multiplication rate of its preceding pre-seed and seed crops i.e. Aherua and Bhadia are very low. These two crops fall during unfavorable climatic conditions characterized by high temperature, high humidity and high rainfall (Neog *et al.*, 2015). According to (Choudhury, 1992) relative contribution of several factors responsible for a successful crop harvest has been estimated as: Host plant (38.2%), climate (37.0%), rearing technique (9.3%), silkworm race (4.2%), silkworm egg (3.1%) and other factors (8.2%). Since, the quality of host plants plays a major role in successful cocoon production, Several workers tried indoor rearing of muga silkworm to avoid early instar loss, unfavorable seasons of extremities of temperature, humidity and rainfall. Several works have been carried out on different factors affecting muga silk which are discussed in the present study.

Rearing Season

Muga silkworm is multivoltine and there are 5-6 crops in a year with two commercial crops. To raise either of the two commercial crops *Jethua* (Spring) and *Katia* (Autumn), the four seed crops have to be raised in two separate rearing cycles (Khanikor *et al.*, 2006). The seed crops such as *Saonia* (July-August), *Ahinia* (September-October), *Aghonia* (November-December) and *Chotua* (February-March) are to be raised for *Jethua* crop and *Jarua* (December-February), *Bohogua* (March-April), *Aherua* (June-July), *Bhodia* (August-September) seed crops are to be raised for *Kotia* (Sept.-Oct./Oct.-Nov.) crop (Saikia *et al.*, 2016). Multivoltinism is one of the major problem for which the maintenance of different seed broods of muga silkworm is difficult, time consuming, laborious and hazardous making the unavailability of good quality seed cocoons in specific seasons. (Dutta *et al.*, 2013) reported that Muga silkworm has the potential to lay a good number of eggs (250-280) but realized fecundity (120-150) is comparatively poor even during the favorable seasons of *Jethua* and *Katia* compared to eri (440-470) and mulberry (450-550).

Influence of Climate and Season

The performance of muga silkworm rearing has been impacted in recent years by climate change and pollution i.e., prolonged summer and short winter. Rescheduling the crop cycle in coordination to changing climate is a prerequisite. The ideal conditions for rearing of muga silkworm are 20–31°C temperature and 65 to 95% relative humidity (Tikeder *et al.*, 2013). Change of climatic factors, especially temperature and relative humidity affects almost every aspect of the life cycle of silkworms including their development and survival (Saikia *et al.*, 2013). Even, the change of season can influence the consumption and utilization of food in muga worms (Das *et al*., 2002). Muga silkworm is semi-domesticated and rearing is conducted in outdoor condition; they may not be able to adjust to the new changing environment (Singh *et al*., 2003) and thus the differential seasonal conditions greatly influence the growth and development of muga silkworm (Chiang *et al.*, 2002). Because of unpredicted climatic conditions as well as other biotic factors, the seed crops are low productive (14-40% crop loss) and sometimes highly uncertain leading to uneconomic crops (Chakravorty *et al*., 2007). However, these seed crops are mandatory to maintain the linkage for production of commercial seed for *Kotia* and *Jethua* crops. There is no clear cut demarcation of seed and commercial zone for muga silk worm rearing. As a result, the main constraint remains the availability of high-quality muga silkworm seed, which is critical to the muga industry's productivity, sustainability, and profitability. During the last few decades, atmospheric pollution and the resultant variability in temperature and relative humidity due to global warming along with abnormal rainfall patterns, drought, and floods have caused the continuous failure of the crop or low crop yield despite all efforts and utilization of resources. Besides an abnormal increase in temperature, the other reasons enlisted for the heavy loss of muga silkworm were air pollution caused by rampant use of pesticides in neighboring tea gardens, pollution from the brick kilns and burning of natural gases emitting from oil wells and a seismic survey by ONGC for oil exploration (Bhattacharyya *et al*., 1994). It is also reported that large-scale of muga culture was destroyed in Upper Assam by pesticides sprayed in nearby tea gardens (Bhattacharyya *et al*., 2012).

Effect of Food Plant

The muga silkworm, *Antheraea assamensis* Helfer feeds on a wide range of host plants among which Som, *Persea bombycina* and Soalu, *Litsea monopetala* are the primary food plants of this silkworm (Kumar *et al*., 2022). *Persea bombycina* plantation is evergreen in nature, easy to maintain and propagate, and overall, its rearing performance is better than that of other food plants. Although *L. monopetala* is a primary food plant, Muga silkworm farmers rarely raise nursery or plantation of this plant because it defoliates and has poor leaf quality during winter (Yadav & Goswami, 1987). The silkworms were mostly attracted to semi-mature leaves of *P. bombycina* rather than other primary and secondary food plants. Som leaves are said to be suitable in rearing muga silk for higher yield. Chawki rearing can be done in Soalu plants and then switched to Som plants for late age rearing if there is a paucity of Som leaves during commercial rearing (Borpuzari *et al*., 2022). However, the pupal weight and oviposition rate was higher when the silkworms fed on *L. monopetala* leaves compared to *P. bombycina*, *L. salicifolia,* and *Cinnamomum glaucescens* (Nees.) Hand.-Mazz. (Barah & Sengupta, 1991). Larval duration did not vary when Muga silkworms fed on *P. bombycina* and *L. monopetala* leaves in different seasons (Kakati, 2012). There were no significant differences in shell weight, shell ratio, filament denier and length, or silk recovery, and there was no significant variation in fecundity, hatching percentage, effective rate of rearing (ERR), and cocoon:dfl (disease-free layings) ratio between the two food plants, as reported by Kakati (2012). The primary food plant

Soalu (*Litsea monopetela*) is mostly utilized for production of seed cocoon purpose. The plant is distributed in plains as well as hills, and the propagation occurs by falling seeds. Proteins and amino acids are important for silkworm larvae as they are utilized for synthesis of silk protein (Bose & Bindroo, 2001).

Effect of nutritional status of the leaf

Feeding is one of the major factors in silkworm rearing. Healthy host plant leaves that are rich in essential nutrients are essential for optimal feeding. Muga silkworm obtain their all essential nutrients from the leaves which they take as food. The nutritional status of the leaves can be improved by enriching them with vitamins and other nutrients (Kanafi *et al*., 2007). The feeding of nutritionally enriched leaves showed better growth and development of silkworm larvae, as well as directly influencing the quality and quantity of silk production (Neto *et al*., 1995). The host leaves mainly constitute proteins, carbohydrates, vitamins, sterols, stimulants, and minerals. Such nutritional requirements in food consumption have a direct impact on all genetic traits such as larval and cocoon weight, the quantity of silk production, pupation and reproductive traits (Khurram, 1998). Yadav & Goswami (1992) reported 16.2% crude protein in the tender leaves of *P. bombycina*, and 15.5% in medium and mature leaves, whereas leaves of *L. monopetala* contained 20.7% (tender), 18.2% (medium), and 15.5% (mature) crude protein.

Incidence of Disease

Disease and pest infestation poseserious threats to seed crop rearing. Muga silkworm is subjected to viral, bacterial, fungal, and protozoan diseases that result in heavy crop losses up to 40% for individual diseases (Veeranna, 1999). It is estimated that 20–30% of the loss is due to pebrine (microsporidian) disease, which sometimes kills an entire silkworm culture (Chakrabarti *et al*., 2008). Flacherie is another common disease of muga silkworm. It is caused by a virus followed by a secondary infection with bacteria. The incidence of this disease is highest in summer and this is thought to be due to sudden fluctuations in temperature coupled with poor food quality (Aruga *et al*., 1963). Grasserie disease is caused by a virus and can cause heavy crop losses. It infects larvae mainly in summer and rarely in winter. Muscardine is a less prevalent disease caused by a fungus (*Fusarium* spp.). It infects larvae mainly in winter (Tikadar *et al*., 2013). Patnaik, 2008 also stated that fungal infection is rare in muga crops.

Incidence of Pest

Muga Silkworm is attacked by several parasitoids and predators (ants, wasps, birds etc) (Singh et al., 1993). Among these *Exorista. Sorbillans* is one of the serious larval end parasitoids of muga silkworm (*Antherea assamensis*). It causes extensive damage to the sericulture industry. During Jarua (December-January) and Chotua (February-March) crop seasons and reported 20-90% loss in Jarua and Chotua season (December-March) and 50-70% cocoon rejection during February-March (Baruah & Kalita, 2020). The mature maggots come out of the larvae/pupae and undergo pupation in the rearing field or grainage hall. The uzi infested muga silkworm dies during the larval or pupal stage. This parasitoid was also reported on 95 species of insects belonging to 20 families of Lepidoptera and one family of Hymenoptera worldwide in the absence of silkworm (Narayanaswamy & Devaiah, 1998). (Thangavelu and Sahu, 1986) reported that the maggots of the Uzi fly exhibited considerable variation in their body size. The maggots developed within B. mori larvae were generally smaller than those developed within *A. assamensis* larvae were larger. They also suggested that the much larger muga silkworm might have provided a better niche for the uzi fly maggot than the smaller silkworm. The recent survey results indicate that the maximum infestation of uzi fly was recorded in 5^{th} instar larvae (43.0%) and harvesting of cocoons (35.0%) during Chotua crop (March-April) followed by Jarua crop,(19.0%) infestation at larval stage & 27.50% at harvesting stage of cocoons reported in upper Assam (Eswara, 2011). The muga cocoons are also infested by yellow fly. The fly completely fed on the head region of the pupae and emerged from the same by making a hole that is about 1cm in diameter (Baruah & Kalita, 2020). Instances of a pupal parasitoid Ichneumon wasp (*Xanthopimpla pedator*) on muga silkworm have been reported for the first time from various muga growing locales in West Garo Hills, Meghalaya, during various muga summer crops (Majumdar *et al*., 2021).

Quality of Muga Silkworm Seed

The foundation of the sericulture industry is the seed. Silkworm seed of high quality means that the laying is disease-free, that there are more viable eggs, that the hatching is uniform, and that the crop is stable. Healthy seed production is indeed the primary requisite for the conducive growth of the entire silk industry (Majumdar *et al*., 2020). A timely supply of superior quality silkworm seed can alone sustain sericulture as a commercial crop in competition with other cash crops. Not only is the augmentation of silkworm food plants under suitable climatic conditions important for the success of the sericulture industry, but so is the timely supply of superior quality silkworm seed to farmers. The quality of silkworm seed may be defined as to the one where the layings are entirely free from diseases, has maximum nos., of viable eggs, gives uniform hatching and assures a stable crop (Saikia *et al*., 2016).

Preservation of Seed Cocoon

Species of *Antheraea* undergo diapause in the pupal stage, except *A. yamamai*, which undergoes diapause in both the egg and pupal stages (Khanikor & Dutta, 1997). For rearing commercial crops (either *Kotia* or *Jethua*) four seed broods are to be maintained in a year. Because seed broods are reared during unfavorable seasons, inducing pupal diapause to delay moth emergence by storing seed cocoons at low temperatures may aid in avoiding the unfavorable seasons. Domesticated muga silkworm did not either over winter or diapause at high altitude (Prasad & Sinha, 1982). (Haniffa and Thatheyus, 1992) reported that increase in the duration of preservation led to the aging of male moths which was also attributed to less pairing efficiency and less productivity. (Khatri, 2003) also reported that the rearing and grainage performance of muga silkworm during four crops, namely Aherua, Jarua, Bhodia, and Kotia, were found to be better in Doon valleys than in Assam from 1998 to 2000. Preservation of seed cocoons at 5 °C beyond 30 days led to detrimental effects on economic characteristics in muga silkworms (Sengupta & Singh, 1974). Tolerance of this temperature beyond 30 days was fully detrimental, but its tolerance beyond 120 days showed almost complete pupal mortality (Choudhury *et al*., 1987). (Sahu *et al.,* 1999) preserved cocoon from *Jethua* crop (April–May) at 10± 1.5 °C and RH of 80-85% for 25, 30, and 35 days and observed that reproductive physiology was affected when cocoons preserved beyond 30 days. They also observed that the hatching percentage in the treated lot was 16-46%, compared to 5% in the control. Whereas, long-term seed cocoon preservation for up to 42 days was achieved by (Rajkhowa *et al*., 2011) following the double-step preservation method without affecting the grainage parameters. Several other studies also revealed that refrigeration of muga seed cocoons at 5-12 °C for 10-120 days gave satisfactory results in terms of moth emergence, pairing, fecundity, and hatchability (Bora *et al*., 1992).

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