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PRESERVING ASSAM'S GOLDEN LEGACY (MUGA SILK) THROUGH SCIENCE AND SUSTAINABILITY: A REVIEW

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ABSTRACT

Muga silk, renowned for its natural golden sheen, is a unique product of the semi-domesticated silkworm *Antheraea assamensis*, endemic to Assam and parts of Northeast India. Deeply woven into the region's cultural and economic fabric, Muga sericulture faces growing challenges due to climate change, ecological limitations, pest and disease outbreaks, and declining interest among younger generations. The narrow geographic distribution, labour-intensive rearing practices, and reliance on specific host plants such as *Persea bombycina* (Som) and *Litsea monopetala* (Soalu) further constrain its scalability. This review highlights the historical significance and current status of Muga silk production while examining recent scientific developments, including genetic characterization, hybridization, and identification of high-yielding biotypes. Studies reveal substantial genetic diversity within Muga populations, which holds promise for breeding programs aimed at enhancing cocoon yield, silk quality, and disease resistance. However, key bottlenecks such as low fecundity, poor seed availability, traditional reeling techniques, and lack of quality host plants continue to hinder progress. Addressing these issues through improved research, technology transfer, and policy support is essential. This paper emphasizes the need for an integrated approach to sustain and promote Muga culture, ensuring its survival as both a rural livelihood and a heritage silk of global distinction.
***Keywords*: *Antheraea assamensis*, Assam, Sericulture, Muga silkworm, Breeding, Selection**

Introduction

Sericulture, the art and science of silkworm rearing for silk production, is an age-old practice. Silk has remained a symbol of luxury and fashion from ancient times to the present. In countries like India, sericulture is a vital agro-based industry that combines agriculture and small-scale industry, providing rural employment and entrepreneurial opportunities such as host plant cultivation, silkworm seed production, reeling, weaving, and silk trading (Bukhari *et al.*, 2019). It plays a key role in rural development, particularly for the economically weaker sections (Best and Maier, 2007), and promotes inclusive growth across communities (Kasi, 2013).

India's silk production is dominated by *Bombyx mori* (mulberry silk), which contributes nearly 80%, while non-mulberry species such as *Antheraea* and *Samia* are mainly reared in forested regions of Northeast India. These wild or semi-domesticated silkmoths differ widely in biology and are part of the families Saturniidae and Bombycidae (Nässig *et al.*, 1996; Arora & Gupta, 1979; Jolly *et al.*, 1974; Reiger *et al.*, 2008).

Northeastern states like Assam, Nagaland, Meghalaya, and others are key centers of wild silk culture, especially Muga silk from *Antheraea assamensis Helfer*, which is endemic to the region and highly prized for its golden colour (Singh & Chakravorty, 2006). These silkworms feed on various host plants and breed year-round. Previous studies

(Thangavelu & Borah, 1986; Thangavelu *et al.*, 1987, 1988; Kakati & Chutia, 2009; Thangavelu, 1991; Tikader, 2001a, b, 2011, 2012) stress the need for documentation and conservation of these valuable genetic resources.

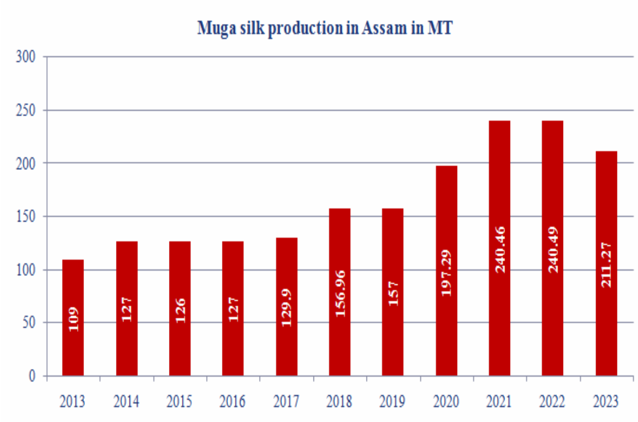
In Muga culture, seed production remains a major concern. Despite the potential to lay 250–280 eggs, only 120–150 are typically viable, even in favourable seasons like Jethua and Kotia. This low fecundity compared to *eri* (440–470) and *mulberry* (450–550) is partly due to physiological issues such as high egg retention, making it difficult to meet the demands of large-scale Muga silk production.

History of muga: Assam's golden silk

History of sericulture relates to way back 2640 BC in China. First weavable silk fibre was discovered by the Chinese Empress Xi Lingshi. This culture of silkworm and weaving technology was kept secret for 2500 years to the world. Silk was a valuable trade commodity for China, and it was traded to various places of the old world mostly by the Persian traders (Gangopadhyay, 2008). In Assam sericulture, particularly Muga culture, is a very ancient practice and is rooted to the cultural and socioeconomic life of people of this region. Exact period of origin of *Muga culture* is lacking due to absence of any authentic historical account. However, there are some references of silk during the time of Ramayana and Arthashastra. Kautilya mentioned that a kind of silk fabric produced from cocoons of certain insect is called dukula (Assam Gazzeteer 1999; Goswami, 2006). Different scholars have put forward different opinions regarding the origin of Muga culture in the state. It was believed that knowledge of culture practice of Muga silkworm may come from China as it is mainly confined to the Tibeto-Burman and Indo-Mongoloid tribes of this region. The Golden Era of Muga culture was during the Ahom regime. Garments made of fine Muga silk were used by the royal families and higher officials and common people used cotton and coarse silk for garment. However, in some special occasions with proper permission from kings, they were allowed to wear Muga silk cloths. Muga worms raised on mejankori leaves produce best-quality silk which were worn by royal families. Ahom kings also maintained royal looms and appointed expert weaver for weaving royal cloths. They took special interest on promoting Muga silkworm culture as well as weaving of Muga cloths resulting in significant growth in this industry. Muga silk trade was also contributing to the state economy as interstate trade between neighbouring states like Bengal, Bhutan and Khasi Hills flourished considerably. Under the patronage of the royal family, spinning and weaving had become an indispensible part of Assamese society. David Scott, an agent to the Governor General of Fort William, had been pressing the British government for the development of silk industry in Assam. He believed that Muga silk, due to its durability and strength, might capture the European market. Muga contributed a large share of trade during British rule. Muga culture faced massive challenge from cheap British factory making cotton and synthetic silk cloths and declined considerably. However, it was so deeply rooted in the socio-cultural life of Assam that it survived and revived considerably in modern time which captured a big share in modern economy. The golden thread of Muga is a pride of Assam and assigned protection of geographical indication (GI) in the year 2007. This helps in production as well as commercialization of this unique silk throughout the world (Goswami, 2006; Phukan, 2012).

Present status of muga silk in the economy

Sericulture is an inseparable part of Indian cultural heritage and a mean of livelihood to many rural families. About 7.85 million people of rural and semiurban areas mostly belonging to economically weaker sections are dependent on sericulture. India continues to be the second largest producer of natural silk next to China and one of the largest consumers of natural silk. India is the only country which produces all five commercial natural silks, viz. mulberry, tropical Tassar, oak Tassar, Eri and Muga. Exotic golden-coloured Muga silk is the prerogative and pride of India. Muga contributes only 2 % of total raw silk produced in India as its culture is confined only to a limited geographical area (Gangopadhyay, 2008; Note 2014. Muga culture in India is mainly confined to the state of Assam and some other eastern and north-eastern states. Assam contributes more than 95 % of Muga silk produced in India. There are about 30,000 thousand families involved in Muga culture in Assam (Directorate of Sericulture, 2022) and total annual production of Muga is 211.27 MT in the year 2022-23. In recent years yield of Muga silk has increased considerably due to continuous efforts of farmers and government agencies. At present business value of Muga silk worth around Rs. 200 Cr, moreover, there is vast scope and economic potential in Muga culture to increase its business manifold (Phukan, 2012). Fig 1 shows the total silk production in Assam in the past 10 year (2013-23).

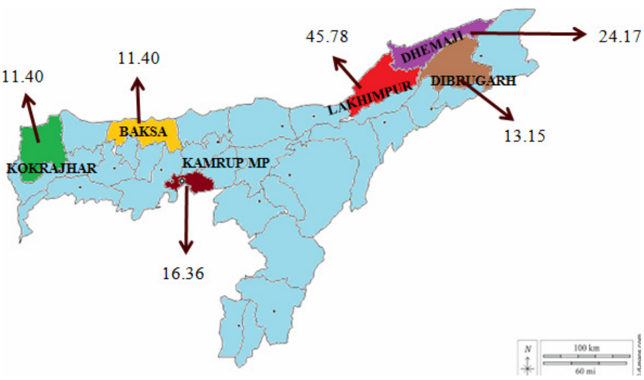


Source: Statistical Handbook of Assam 2022-23

Fig. 1: Muga production in Assam from 2013-23

Distribution of the muga silkworm

Muga silkworm has relatively very narrow range of distribution. It is mainly found in Brahmaputra valley in Assam and other north-eastern states in selective geoclimatic conditions including the areas like East, West and South Garo hills of Meghalaya, Mokokchung, Tuensung, Kohima and Wokha districts of Nagaland, Lohit and Dibang valleys, Chanlang and Papumpare districts of Arunachal Pradesh, Tamenglong district of Manipur and Coochbehar district of West Bengal (Singh & Mishra, 2003). It is also found in Northern Myanmar and the Kumaon and Kangra Valleys in the western Himalayan Hills, Sikkim, Himachal Pradesh, Uttar Pradesh, Gujarat, Pondicherry, Bangladesh, Indonesia and Sri Lanka. However, commercial cultivation of Muga silkworm is mainly confined to north-eastern states particularly Assam (Tikader *et al.* 2013). Fig 2 shows the major distribution of Muga silk in Assam.



Source: Statistical Handbook of Assam 2022-23

Fig. 2: Map of Assam showing Muga silk production more than 1000 Kg

Its geographical isolation indicates its special requirement for survival such as high humid temperate climate, availability of different host plants and other climatic factors. This indicates its ecological isolation making it phylogenetically less adaptive (Tikader *et al.*, 2013).

The primary host plants of Muga silkworm are *Persea bombycina* (King ex Hook. f.) Kost. (Som, local name) and *Litsea monopetala* (Roxb.) Pers. (Soalu, local name) of the family Lauraceae. Fig 3 and 4 shows the primary host plant of Muga silkworm.

Fig 3: *Persea bombycina* **Fig 4:** *Litsea monopetala*

In addition to the primary host plants, *Litsea salicifolia* (Roxb. ex Nees) Hook. f. (Dighloti), *L. cubeba* (Lour.) Pers. (Mejankori), *Persea odoratissima* (Nees) Kost. (Jati-sum), *Melastoma malabathricum* L. (Melastomaceae: Phutuka), *Averrhoa carambola* L. (Averrhoaceae: Kordoi), *Meyna laxiflora* Robyns. (Rubiaceae: Kotkora) and *Barringtonia acutangula* (L.) Gaertn. (Barringtoniaceae: Hijal) are also used as secondary host plants.

Som plant is found all over Assam; hence, it is mainly used for commercial rearing of Muga silkworm. Depending on the leaf morphology, three different morphotypes of Som plant have been identified. Silkworms prefer to feed on less pubescent small leaves having short petiole; hence, feeding rate of larvae depends a lot on leaf morphology. Another primary host plant Soalu is mainly abundant in lower Assam side and is used for producing disease-free eggs. Dighloti plant occurs mostly in Upper Assam and is an important secondary host plant. Ahom kings preferred Muga silk reared on Dighloti plant; however, larvae reared on it grow slowly and produce less amount of silk (Phukan, 2012; Tikader *et al.*, 2013). Studies have shown that hybrid host plants produced better result in terms of larval health rearing time and production of silk. Tetraploid Som plant produces best results, but its commercial exploitation is still at infant stage. Much research is needed in this area for improving the Muga culture scenario in the present time and future (Tikader *et al.*, 2013).

Naming of muga crops

Silkworms completing their life cycle many times a year are called multivoltine worms. Muga is a multivoltine silkworm which completes its life cycle 5 to 6 times a year. Duration of the lifecycle of the muga silkworm may vary from 50 days in summer to 150 days (maximum) in winter. Each life cycle takes about two months on an average making it possible to organize 5 or 6 crops in a year. In Assam, muga farmers have named the crops as Katia (October to November) in the autumn season, Jarua (November to January) in the winter season, Chotua (February to April) in the early spring season, Jethua (April to May) in the spring season, Aherua (June – July) in early summer and Bhodia (August – September) in late summer season. The Katia is the main commercial crop and the Jethua is the second commercial crop whereas Jarua and the Aherua are the two pre-seed crops and the Bhodia and the Chotua are the seed crops of muga silkworm farming practice. Table 1 shows the naming and the respective seasons of the muga crop.

Table 1: Name of Muga crops & their characteristics

Assamese name of crops.	Month	Season	Cocoon characteristics.	Quantity of silk per 1000 cocoons	Remarks
Katia	Oct-Nov.	Autumn	Best cocoon, good for reeling, 612 mtr per cocoon.	250 gm reeled silk, 125 gm silk waste.	Main commercial crop
Jarua	Nov, Dec, Jan	Winter	Poorest cocoon, 265 mtr thread per cocoon.	150 gm reeled silk.	Pre seed crop
Chotua	March - April	Early - Spring	Used for seed	--------------	Seed crop
Jethua	April-May	Spring	Good cocoon, next to Katia, 546 mtr threads per cocoon.	200 gm reeled silk.	Second commercial crop.
Aherua	June-July	Early Summer	Poor cocoon, not suitable for reeling, 460 mtr thread per cocoon.	180 gm reeled silk	Pre seed crop
Bhodia	Aug-Sept	Late summer	Poor cocoon, difficult for reeling, 448 mtr thread per cocoon.	150 gm reeled silk	Seed crop

Biotypes of Muga Silkworm

Although muga silkworm has not been successfully domesticated, attempts have recently been made to maintain it under semi-domesticated conditions and improve its economic traits (Thangavelu & Subba, 1982). The main reason for this is the marked inbreeding and their hibernating over winter. In particular different biotypes have been collected from various locations and maintained in culture. Some muga biotypes, like Halflong green, yellow mutant, Kokrapohia green and wild hibernating type, were collected from different areas and kept in off-site conditions and hybridized in order to determine whether their offspring show hybrid vigour. The biotypes were collected from Bhaktapara in lower Assam and Senchoa, Kamarbandha and Titabar in upper Assam. Choudhury (1981) reports three biotypes of muga silkworm namely Sarubhagia, Barbhagia and Bor or Lebang. Different colour forms were also collected from farmer's fields. A survey was conducted in the foothills of Arunachal Pradesh, Assam, Meghalaya and Nagaland and the muga silkworms collected grouped into five biotypes (Type-W1: 24, Type-W2: 16, Type-W3: 12, Type-W4: 10 and Type-W5: 81). Other *Antheraea* species were also collected during this survey from north-eastern and central India (*A. assamensis, A. mylitta, A. frithii, A. pernyi and A. roylei*). Recently during surveys in different districts of Assam (Golaghat, Jorhat, Sibsagar, Lakhimpur, North Cachar Hills, Kamrup, Goalpara, Nalbari, Bongaigaon and Kokrajhar, Karbianglong), Meghalaya (East, West and South Garo hills, East Khasi and West Khasi hills), Manipur (East and West Imphal, Churchandpur, Tamenglong and Chandal), Mizoram, Nagaland (Wokha, Mokokchung, Zunhebotto, Tuensung, Kohima), Arunchal Pradesh (Changlang, Lohit, Debang Valley, Papumpari) valuable wild silkworm biotypes were collected and are being maintained at Regional Muga Research Station (RMRS, Boko) and CMER&TI, Lahdoigarh, Jorhat, Assam.

Characterization and Evaluation of Muga Silkworm

The muga silkworm has been characterized in different ways depending on the wing expansion by Arora & Gupta (1979), features of cocoons, moths, eggs and larval traits by Choudhury (1981). The haploid number of chromosomes of this species is 15 (Sengupta *et al*., 1975). In order to conserve the genetic diversity available in different populations, efforts are being made to develop a germplasm at Central Muga and Eri Research and Training Institute, Lahadoigarh. Recent findings indicate that there is significant genetic erosion occurring in wild populations and therefore there is an important need to conserve germplasm. However, due to its monophyletic nature and lack of information on the genetic structure of the different populations of muga silkworm, there has been little progress. There are 8 different biotypes collected from Assam, Meghalaya, Manipur and Nagaland are currently in culture and are being reared to assess their performance (Singh *et al.,* 2012). The biotypes are as follows: Aa-SD, Aa-Blue, Aa-MM, Aa-GM, Aa-TM, Aa-IM, Aa-KA, Aa-SM. Table 2 shows the biotypes and their performance.

Table 2: Different biotypes and their performance

Biotypes	Fecundity (nos)	Hatching (%)	ERR %	Female		Male		Single cocoon filament length (m)
				Cocoon wt. (g)	Shell wt. (g)	Cocoon wt. (g)	Shell wt. (g)	
Aa-SD	138	76.0	93.0	6.71	0.50	4.28	0.35	289
Aa-Blue	140	75.0	91.0	6.30	0.54	4.13	0.35	302
Aa-MM	172	80.0	81.0	6.80	0.48	4.70	0.49	388
Aa-GM	135	77.8	82.0	6.28	0.52	4.50	0.46	350
Aa-TM	168	83.3	77.0	6.54	0.75	5.05	0.52	411
Aa-IM	165	70.0	85.0	6.54	0.47	4.39	0.47	328
Aa-KA	145	74.5	83.0	7.22	0.72	4.86	0.47	393
Aa-SM	170	70.0	79.0	6.99	0.57	4.39	0.45	343

Genetic Diversity of Muga Silkworm

Antheraea assamensis Helfer is confined mainly in the narrow ecological range of north-eastern India. As it is being commercially exploited for its highly priced golden-coloured silk, it becomes extremely important to study its genetic structure and its relation to various environmental factors. The reasons for its narrow ecological range, specific type of host plant and semi-domesticated behaviour, etc. are still to be figured out which require attention for better commercialization of the prized product and conservation of dwindling population of this species. Only a few studies have been carried out to estimate the genetic diversity of Muga silkworm using molecular markers. High genetic diversity was observed among different wild and cultivated populations of *A. assama* which may be linked to its distribution in diverse climatic conditions (Arunkumar *et al*., 2012). Studies carried out using RAPD primers revealed that high genetic diversity among the individuals irrespective of their morphological similarities (Neog *et al*., 2010). Population studies based on inter-simple sequence repeat and simple sequence repeat among different cultivated and wild stocks of different regions of north-eastern states revealed marked genetic diversity. Wild populations showed higher diversity than the cultivated populations and they also harbour private allele. Again among the cultivated strains, diversity varies considerably between different regions. Some cultivated strain also showed mixing with wild stock which may be due to anthropogenic induction or due to natural migration. Analysis of sequence data suggests transposition as a mechanism for maintenance of genomic diversity (Singh *et al.,* 2012). Diversity studies using microsatellite marker also presented similar type of findings, i.e. high diversity among individuals belonging to different populations of different areas. Based on the results, it might be possible to use interpopulation hybridization for improvement of commercial brood having higher productivity and better survivability (Arunkumar *et al.,* 2009).

Maintenance of Stocks of Muga Silkworm

Unlike domesticated *B. mori* it is not easy to rear the muga silkworm in captivity. In the wild this silkworm is found on som (*Persea bombycina*), soalu (*Litsea monopetala*) and dighloti (*Litsea salicifolia*) trees. Of these trees, soalu is semi-deciduous and sheds most of its leaves during winter. Thus, in the field muga silkworm hibernate in winter when there is a shortage of fresh leaves. However, the muga silkworms that feed on som trees do not hibernate (Arunkumar *et al.* 2022). From a commercial point of view, it is important to isolate diapausing stock during Jarua (Nov–Jan) and Chotua (Feb–March) when they are subject to high mortality due to fungal diseases and parasitization by uzi fly (*Exorista bombycis*) and wasps. Moreover there is no shortage of eggs during Jethua (April–May) as sufficient eggs are produced by the Kotia (Oct–Nov) commercial crop. The optimum conditions for rearing of muga silkworm are 20–31°C temperature and 65 to 95% relative humidity.

Improvement of Muga Silkworm by Breeding and Selection

The genetic diversity of muga silkworm in culture, in which there are more than two or three generations per year, rapidly decreases. The offspring of crosses between green and yellow coloured individuals from different regions showed a 30–40% increase in characters such as larval weight, cocoon weight, shell weight and filament length. The yellow mutant can easily be crossed with the green mutant (Green × Yellow and Yellow × Green). The hibernating stocks perform better when crossed with yellow. In the intra population crosses, the reproductive vigour of the yellow mutant lines M3BP, M3PB, M3P, MK1 and MK2 gradually decreased and they died out as a result of poor larval survival and inbreeding depression, with only a few lines surviving for 6–8 generations. Thangavelu *et al.* (1987), collected muga silkworm genetic stocks and isolated the following five variants: yellow morph, one with yellow lateral lines, one in which the moths were black, the winter diapausing wild type and non-diapausing wild type. Siddiqui & Das (2000) found that genetic variation, expressed in terms of the genotypic co-efficient of variation, was low and most of the traits varied little, and they concluded that there was a need to isolate pure lines and use these in a future breeding program. At the research stations RMRS, Boko the following wild stocks: RMRS-Aa-001, Aa-002, Aa-003 and Aa-004, have been crossed and strains with improved cocoon traits, such as cocoon weight, shell weight and fecundity, produced. Thus, it is possible to exploit hybrid vigour by crossing genetically different lines (Tikader *et al.* 2013). Singh *et al.* (2012) report that quantitative traits like cocoon weight and fecundity have a high PCV, GCV and heritability. The GCV was near to PCV for most of the economic cocoon traits indicating a highly significant effect of genotype on phenotypic expression, with the environment having very little effect. High heritability estimates indicate the presence of a large number of fixable factors and hence it may be possible to improve these characters by selection. Thus, by progeny testing and further selection it should be possible to improve the cocoon traits that are of economic importance. Recent research on molecular markers has resulted in the generation of 87 microsatellite markers from 35,000 expressed sequence tags and a microsatellite-enriched sub-genomic library (Arunkumar *et al.*, 2009). In the future these microsatellite markers are likely to be widely used in genetic studies of *A. assama* and other closely related species. In this context Neog *et al.* (2010) have assessed eleven populations, comprising four from cultivated and seven from wild stocks with different geographical origins, using 50 RAPD primers. This study revealed that the populations are highly polymorphic, which is associated with their being able to survive in the diverse climatic conditions prevailing in north-eastern India. Arunkumar *et al.* (2012) used EST-SSRs and genomic SSRs to analyze 97 individuals from natural population collected from six different geographical locations in the Meghalaya states. This study revealed that one of the populations was genetically very different from the other populations. These studies indicate it might be possible to use inter population hybridization to improve the muga silkworm.

Constraints of Muga Culture

Muga silk production remains significantly lower than other silks in India due to multiple challenges. Despite its high value (Rs. 20,000/kg), issues like low productivity, costly reeling, erratic climate, floods, and deforestation of key host plants (Som, Soalu, Dighloti) have hindered growth. The culture faces severe seed shortages due to the multivoltine nature of the silkworm, seasonal failures, and logistical difficulties in transporting seed cocoons from lower to upper Assam. Reproductive inefficiencies such as high unlaid egg rates, low hatching percentages in summer, and mismatched emergence of male and female moths further affect seed quality. Outdoor rearing exposes larvae to harsh weather and predators, leading to high mortality. Muga silkworms are highly vulnerable to pests and diseases like Pebrine and Uzi fly infestations. Moreover, many rearers lack access to healthy food plants, relying instead on tall, aged trees that offer poor nutrition. Traditional reeling techniques like the 'Bhir' are inefficient, producing inconsistent silk quality and increasing production costs. Without advancements in seed supply, disease control, host plant management, and reeling technology, the industry's sustainability and profitability remain at risk.

Conclusion

Muga silk, with its unmatched golden sheen and deep cultural significance, is not just a product but a legacy of Assam. Despite its immense potential, Muga culture faces numerous challenges climatic unpredictability, ecological constraints, genetic limitations, outdated practices, and declining interest among the younger generation. The industry's future hinges on urgent and sustained efforts in scientific research, genetic improvement, seed availability, and post-harvest technology, alongside policy-level support and farmer engagement. With coordinated interventions, Muga sericulture can not only overcome these hurdles but also evolve into a globally competitive, sustainable rural enterprise honouring tradition while embracing innovation. The golden thread of Assam must not fray; it must flourish.

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