E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; SP-8(9): 55-60
Received: 21-07-2025
Accepted: 23-08-2025

Anna Kaushik
Research Scholar, Department of Sericulture, Forest College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Sumalini Bora
Research Scholar, Department of Sericulture, Forest College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Bidisha Kashyap
Research Scholar, Department of Sericulture, Assam Agricultural University, Jorhat, Assam, India

Priyangana Chetia
Research Scholar, Department of Sericulture, Forest College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Toko Naan
Research Scholar, Division of Sericulture, Sher-e-Kashmir University of Agricultural Science and Technology, Jammu, Jammu & Kashmir, India

Rubi Sut
Research Scholar, Department of Sericulture, Forest College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
Anna Kaushik
Research Scholar, Department of Sericulture, Forest College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Recent advances in muga sericulture: rearing innovations, post-cocoon technologies, and climate-resilient approaches

Anna Kaushik, Sumalini Bora, Bidisha Kashyap, Priyangana Chetia, Toko Naan and Rubi Sut

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i9Sa.3724

Abstract
Muga silk, produced by the endemic silkworm *Antheraea assamensis* Helfer, is one of India's most culturally valued and economically important wild silks, admired for its natural golden sheen and durability. Despite its heritage and livelihood significance, the sector continues to face challenges such as outdoor rearing, climate variability, host-plant stress, and disease outbreaks, while mechanization and standardized post-cocoon processing lag behind mulberry silk. Advances in rearing practices, including semi-controlled rearing, chawki houses, and molecular diagnostics for pebrine, have helped reduce mortality and improve crop stability. Post-cocoon developments like hot-air stifling, multi-end reeling, and eco-friendly finishing treatments have enhanced yarn recovery, uniformity, and value addition. Climate resilience efforts, such as improved host-plant propagation techniques, pollution-tolerance indices, and ecological niche modeling, offer strategies to mitigate environmental stress. However, gaps remain in mechanization adoption, genomic resources for *Antheraea assamensis*, and extension and policy support. Future priorities include mechanization trials validated under field conditions, functional genomics and breeding, integrated plant–insect research, socio-technical adoption studies, and stronger pathogen surveillance. Collectively, these directions highlight the pathway toward a more sustainable, scientifically advanced, and climate-resilient muga sericulture sector.

Keywords: Muga silk, rearing innovations, post-cocoon processing, host plant adaptation, climate resilience

1. Introduction

The muga silkworm, *Antheraea assamensis* Helfer (Lepidoptera: Saturniidae), native to Northeast India, produces a silk renowned for its natural golden sheen, remarkable strength, and enduring association with Assamese culture and tradition, earning it the distinction of being called the 'golden silk' [1, 2]. Its distinctiveness and regional reputation are formally recognized through India's Geographical Indication (GI) registration for "Muga Silk of Assam," which strengthens provenance-linked value and cultural heritage [1, 3]. Beyond heritage, muga sericulture sustains rural livelihoods across Assam and adjoining states through farm-based rearing and decentralized post-cocoon activities such as reeling, spinning, and weaving [1].

Despite these advantages, the sector faces well-documented constraints. Outdoor, multivoltine rearing makes *Antheraea assamensis* highly sensitive to weather variability; recent ecological modeling indicates that projected climate scenarios could shift or constrict suitable habitat and host-plant distributions in parts of Northeast India, underscoring climate risk to production zones.[4] Environmental stress on primary host plants (Som, *Persea bombycina*, and Soalu, *Litsea* spp.) is an added concern; for example, field studies show air-pollution stress measurably alters leaf biochemistry and Air Pollution Tolerance Index in *Persea bombycina*, with implications for larval nutrition and crop outcomes [5] Disease pressure remains another major bottleneck. Pebrine, caused by microsporidia infecting muga, reduces cocoon yield and quality, and has been molecularly characterized from *Antheraea assamensis* populations; transcriptome-level studies further highlight pathogen–host interactions relevant to surveillance and control [6, 7].

Post-cocoon mechanization and process standardization have historically lagged behind mulberry silk. However, targeted innovations are emerging: controlled hot-air stifling protocols and improved handling have been shown to enhance reeling performance and raw silk quality in muga, pointing to scalable post-cocoon gains when adopted [8]. Ongoing R&D on multi-end reeling and other devices for vanya silks (including muga) likewise suggests scope to reduce labor intensity and variability while improving yarn uniformity.[9] Still, uptake is uneven, and traditional devices remain widespread, so bridging the lab-to-field gap is pivotal for impact.

The review focuses on three major themes: recent improvements in muga rearing practices that strengthen crop stability and reduce disease risks; technological advances in the post-cocoon sector that enhance yarn quality and production efficiency; and climate-resilient strategies, including host-plant management and adaptive practices, that can safeguard muga sericulture in a changing environment [4, 5]. The discussion integrates current findings to present a clear, practice-oriented roadmap for researchers, extension workers, and producers.

2. Rearing Innovations

2.1 Improved Rearing Techniques and Seasonal Management

Muga silkworms (*Antheraea assamensis*) are traditionally reared outdoors on Som (*Persea bombycina*) and Soalu (*Litsea monopetala*) trees. This age-old practice ties production directly to natural cycles but also makes crops highly vulnerable to rainfall variation, temperature extremes, and pest infestations [5, 10]. To stabilize yields, semi-controlled rearing practices have been encouraged in recent years. Nylon net enclosures help reduce predation and parasitism while maintaining ventilation, which is essential for larval health [11].

Farmers now follow seasonal calendars that match rearing with the best weather conditions, which helps them avoid sudden changes in climate that can harm the silkworms [10]. Proper host plant management is critical for muga silkworm rearing, like pruning, manuring, and timely leaf harvest ensure that larvae receive high-quality, nutrient-rich foliage, directly influencing cocoon weight and silk yield [11, 12]. Another significant innovation is the use of chawki rearing houses for early instars. Young larvae are particularly delicate, and controlled conditions during the first two instars reduce mortality, enhance uniformity, and increase the chances of a successful crop [13, 14]. A summary of recent innovations in Muga silkworm rearing, their reported benefits, and the scale of adoption is presented in Table 1.

Table 1: Recent Innovations in Muga Silkworm Rearing

Innovation	Reported Benefits	Stage/Scale	Reference
Indoor/chawki rearing for early instars	Improved survival and uniform growth; higher cocoon yield under managed conditions	Institute trials	[15]
Nylon net enclosures and leaf shading during 3rd–5th instar	Reduced predator/parasitism damage; stabilized survival under fluctuating humidity	Farmer trials	[6,11]
Seasonal crop performance & rearing calendar use	Aligns larval demand with host leaf flush; stabilizes cocoon outcomes	Field study	[15,16]
Host plant stress screening (Air Pollution Tolerance Index (APTI) for Som)	Helps select suitable sites and manage microclimate stress	Lab & field study	[5]
Micropropagation of Som (*Persea bombycina*)	Rapid multiplication of elite stock; ensures leaf availability	Nursery/lab protocols	[17]
Microsporidian pathogen surveillance	Early detection and management of *Nosema* in muga silkworm	Lab & molecular tools	[7,18]

2.2 Disease Management and Hygienic Practices

Disease remains one of the biggest constraints in muga sericulture, with pebrine caused by microsporidia being the most dreaded. Pebrine outbreaks can devastate entire generations if not detected early [6]. To address this, molecular diagnostic tools have been refined, allowing detection of microsporidian spores at much earlier stages than traditional microscopic screening [7]. This has made preventive culling and sanitation measures more effective.

Alongside diagnostics, strict hygienic practices are increasingly emphasized. Disinfection of rearing equipment, careful selection of disease-free leaves, and scheduled disinfection of rearing spaces with lime or formalin have been shown to lower incidence rates [19, 20]. Biological approaches are also gaining traction. Some studies report that microbial antagonists and eco-friendly disinfectants can suppress pathogenic loads without harming the larvae or the environment [2]. Together, these interventions mark a shift from reactive treatment toward proactive prevention, which is crucial for smallholder farmers who cannot afford heavy losses.

2.3 Biological Insights: Pathogens and the Microbiome

Beyond visible disease symptoms, researchers have begun exploring the internal biology of *Antherarea assamensis* to better understand resilience and vulnerabilities. A major focus has been the gut microbiome**,** which plays a vital role in digestion and immunity [21, 22, 23]. Metagenomic and culture-based studies show that muga larvae harbor a diverse bacterial community dominated by genera such as *Enterobacter*, *Bacillus*, and *Pseudomonas*, many of which contribute to nutrient assimilation and immune defense [24].

This deeper view of host - microbe interactions has revealed that imbalances in the gut flora can predispose larvae to infections, while beneficial strains may offer protection against pathogens. The idea of probiotic-based rearing is emerging from this work: supplementing larvae with beneficial microbes to boost health and disease resistance [7, 18]. Although still experimental, these approaches point to a future where eco-friendly microbial management could complement traditional hygiene, reducing reliance on chemical disinfectants. Together, innovations in rearing practices, disease management, and biological understanding are gradually transforming muga sericulture from a fragile, high-risk system into one that is more stable, predictable, and scientifically guided.

3. Post-cocoon technologies and climate-resilient approaches

3.1 Reeling and Stifling Machine Innovations

Electrified, controlled stifling and better cocoon handling have measurably improved reliability and yarn quality in muga. Hot-air stifling in an electrical dryer, at optimized temperature–time combinations, reduces filament breaks, raises raw silk recovery, and improves evenness compared with traditional smoke stifling and sun-drying, while also shortening the safe storage window before reeling.[8] These process gains align with the Central Silk Board's (CSB) push to replace smoke stifling with clean, thermostated dryers and to diffuse wet-reeling equipment appropriate for vanya silks, including muga, in small and medium units [25, 26]. Beyond stifling, recent materials work shows that native cocoon architecture and mineral incrustations influence reeling behavior; characterizing these features helps target pre-reeling treatments and machine settings [27]. Together, these studies support a shift toward standardized stifling protocols, wet-reeling lines, and calibrated end counts to stabilize quality and reduce waste in muga reeling [8, 26].

3.2 Quality improvement and value addition

Downstream fabric handle and appearance can be tuned with post-wash and finishing steps that respect the chemistry of wild silk fibroin and its mineral load. Demineralization used judiciously softens muga yarn by removing surface calcium oxalate while preserving strength and luster, improving reelability and fabric hand [28]. For consumer-facing attributes, an activated-charcoal-based wash increased gloss without damaging the fiber, outperforming traditional washes and detergents on instrumental gloss and color metrics offering a simple, scalable finishing route for premium muga products.[29] At the earlier stage, autoclave-assisted degumming and related controlled processes from silk science can be adapted to wild silks to balance sericin removal with filament cohesion, helping reduce reeling breaks and improving raw-silk grade [8, 30]. Collectively, these interventions targeted demineralization, gentle finishing, and controlled degumming provide a toolbox to raise uniformity, sheen, and feel while protecting the intrinsic golden hue. A summary of recent advances in post-cocoon and silk-processing technologies relevant to muga is presented in Table 2, highlighting their reported benefits and application scale.

Table 2: Advances in Post-Cocoon and Silk-Processing Technologies for Muga

Technology	Key Outcome	Scale	Reference
Hot-air stifling	Better reelability and raw silk quality vs. sun/smoke stifling	Applied trials	[8]
Enzyme-assisted degumming	Gentler sericin removal, reduced filament breakage	Lab / translational	[30]
Demineralization pre-treatment	Reduced filament abrasion, improved reelability	Textile research	[28]
Waste valorization (pupae, fibers)	Protein/lipid-rich pupae; feed, oil, antioxidant potential	Pilot studies	[31]
Wet-reeling & adapted reeling lines	Higher throughput, less handling variability	Tech transfer	[32]

3.3 Host-plant improvement and adaptation strategies

Leaf quality and phenology of primary hosts, Som (*Persea bombycine*) and Soalu (*Litsea monopetala*) drive cocoon quality and crop reliability. Recent field work documents how seasonal shifts in leaf biochemistry correlate with rearing performance in the Kotia crop, reinforcing the need for crop-wise leaf assessment and timely harvest to maintain filament quality [16]. On the resilience side, urban and peri-urban stress diagnostics using the Air Pollution Tolerance Index (APTI) show differential tolerance of host trees, guiding site selection and planting in stress-prone zones [5, 16]. Propagation studies report micropropagation/aseptic seedling protocols for *Persea bombycina*, supporting rapid multiplication and rejuvenation of elite planting stock under nursery control [17]. These plant-side advancements support consistent cocoon quality and provide a buffer against erratic rainfall or heat spells by providing a consistent supply of appropriate-quality leaves throughout seasons [5, 16].

3.4 Climate modeling and eco-friendly practices

Species-distribution modeling now offers a quantitative picture of how climate change could shift the suitable range for *Antherarea assamensis* and its host *Litsea monopetala*, under multiple CMIP6 scenarios [4]. These projections identify emerging suitability in some districts and contraction in others, informing long-term zoning, plantation siting, and extension priorities. At the rearing–disease interface, seasonal modulation of immune gene expression in muga larvae has been documented, implying that bio-security calendars and hygiene SOPs should be synchronized to seasonal immune lows to pre-empt losses [33]. Taken together, landscape-scale niche modeling and seasonally tuned health management support a climate-ready package: i) shift and diversify plantations toward modeled refugia, ii) deploy tolerant host genotypes and urban-stress screens (APTI), and iii) institutionalize clean stifling and wet-reeling to cut smoke exposure and variability in post-cocoon processing [4, 5, 26].

4. Challenges, Gaps, and Future Prospects

4.1 Limitations to Adoption and Mechanisation

Mechanization for vanya silks (muga, eri and tasar) has progressed in recent years, but adoption remains modest due to several interrelated constraints. First, most mechanized designs and process innovations are developed at research institutes or as prototypes; end-user adaptation is limited by cost, repairability, and lack of local manufacturing ecosystems that can produce low-cost spares and provide maintenance.[34,35] Second, the labour structure of muga production smallholder households, women-dominated labour, and seasonal work creates a mismatch between capital-intensive equipment and variable cash flows; this reduces farmers' willingness or ability to invest in mechanized reeling or controlled dryers [34] Third, mechanization trials are often reported in technical manuals or institute reports but lack large-scale field validation studies that demonstrate sustained yield, quality gains, and return on investment under farmer conditions; this evidence gap constrains policy support and credit flows for broader dissemination.[35,36] Addressing these challenges will require cost-appropriate designs, local fabrication and service models, and robust field demonstrations that quantify benefits for smallholders.

4.2 Limited Genomic and Molecular Studies in *Antherarea assamensis*

Compared with *Bombyx mori*, molecular resources for *Antheraea assamensis* have been relatively scarce until very recently. Early omics efforts produced useful but partial resources: a de novo transcriptome provided gene-expression data for developmental and silk-related genes, and mitochondrial genome sequencing offered phylogenetic context.[37,38] Pathogen-focused transcriptomics have improved understanding of microsporidian (*Nosema*) infections and candidate pathogenicity factors[7] Notably, a high-quality draft nuclear genome for *Antherarea assamensis* was reported only recently, opening the door for genomic breeding, population-genomics studies, and marker-assisted selection [39]. Nevertheless, high-quality reference panels for population diversity, genome-informed breeding programs, and functional genomic resources (annotated gene families linked to silk quality, stress tolerance, or disease resistance) are still scarce. Work to create robust strains or molecular diagnostics specific to the biology of muga is hampered by the lack of applicable genomic investigations [18].

4.3 Policy and Extension Gaps

Policy instruments and extension mechanisms are crucial for translating R&D into field-level change, yet several weaknesses persist. Central and state bodies (Central Silk Board and State Departments of Sericulture) have historically supported technology transfer and subsidy programs, but manpower constraints, organizational restructuring, and uneven outreach have limited effective coverage and follow-through at the village level.[40,41] Independent analyses indicate that extension-service shortfalls, insufficient demonstration units, weak farmer–researcher feedback loops, and limited training on machine maintenance are key reasons why promising interventions do not scale.[40,42] Additionally, credit and input-subsidy schemes are often skewed towards mulberry systems, leaving vanya producers with less tailored financial support. Strengthening extension capacity, embedding local service entrepreneurs for equipment maintenance, and designing finance instruments suited to seasonal, smallholder cashflows are necessary policy responses [43].

4.4 Future Research Priorities

The identification of gaps in mechanization, molecular studies, and extension practices highlights several priority research directions for strengthening muga sericulture in the coming decade. First, field-validated mechanization trials are urgently required. While several small-scale reeling and stifling devices have been designed, very few have been rigorously tested across multiple seasons and farmer contexts. Carefully structured trials at the smallholder level should document productivity, cocoon quality, labour displacement, and return on investment for low-cost reeling, stifling, and drying technologies. Such evidence would be critical for building a case for policy uptake, subsidies, and scaled financing support [34, 44].

Second, functional genomics and molecular breeding represent an untapped frontier in muga research. The availability of a draft genome for *Antheraea assamensis* has opened opportunities for annotating key gene families associated with silk biochemical properties, stress physiology, and immunity. Future studies should employ genome-wide association studies (GWAS) and targeted marker-assisted selection to enable the breeding of strains with higher disease tolerance and greater climate resilience [37, 39]. Such approaches, long used in mulberry silkworm (*Bombyx mori*), remain underexplored in muga and could yield significant advances in both productivity and stability.

Third, integrated plant–insect research must become a central focus. Muga silkworm performance is tightly coupled with the nutritional quality of its host plants, primarily Som (*Persea bombycina*) and Soalu (*Litsea monopetala*). Climate variability often alters leaf nutrient profiles, leading to inconsistent cocoon characteristics. Coordinated studies combining host-plant genetics, larval physiology, and nutritional ecology could stabilize cocoon quality under stress. Propagation and deployment of elite clonal host genotypes, together with spatial planning informed by ecological niche modeling, would reduce fluctuations in leaf supply and improve production consistency [4, 45].

Fourth, socio-technical adoption research is needed to ensure that innovations reach end users. Studies integrating agronomy, rural finance, and gender perspectives can help design credit models and service-delivery systems that enhance adoption of mechanized and post-cocoon technologies. This is particularly relevant in muga sericulture, where women-led households constitute a significant proportion of producers but face systemic constraints in accessing finance and technology [14, 46].

Finally, strengthening pathogen surveillance and biosecurity should be treated as a research and extension priority. Microsporidia (Pebrine), baculoviruses, and emerging pathogens continue to pose catastrophic risks to crop cycles. The development of rapid diagnostics both molecular assays and portable field-deployable kits combined with seasonal immune profiling of silkworm populations, would enable targeted prophylaxis and reduce losses. Strengthening biosecurity frameworks through farmer-level training and diagnostic networking will be crucial for sustaining muga culture in the face of changing climatic and ecological conditions [6, 7, 18].

4.5 Conservation and Sustainable Utilization of Muga Silkworm and Host Plants

Ensuring the long-term viability of muga sericulture hinges not only on technological innovation but also on the conservation of both the silkworm (*Antheraea assamensis*) and its essential host plants. The endemic nature of *Antheraea assamensis* in Northeast India renders it particularly vulnerable to habitat loss, genetic erosion, and environmental change. Recent genomic advances now allow us to characterize and preserve its diversity more effectively. The completion of a high-quality draft genome serves as a crucial foundation for marker-assisted conservation, enabling the identification of gene variants linked to silk quality, immunity, and stress response [23, 39]. Earlier molecular studies including mitochondrial genome sequences and de novo transcriptomes have already begun to unravel population structure and functional gene expression, which can guide targeted germplasm maintenance [37, 38].

Compounding this situation, climate projections based on CMIP6 data suggest shifting suitability zones for both *Antheraea assamensis* and its primary host *Litsea monopetala*, necessitating proactive planning for in situ conservation and breeding nucleus placement [4]. This integrative, landscape-level approach will be critical to preserve the species in future changing environments. Equally vital is the secure germplasm and propagation of the host plants such as Som (*Persea bombycina*) and Soalu (*Litsea monopetala*), which underpin larval nutrition and silk quality. Field surveys demonstrate that rising pollution and land-use change are already undermining Som availability, threatening rearing stability [17, 47]. To address this, studies have developed micropropagation and nursery protocols for Som to facilitate rapid multiplication of elite genotypes for plantation and rejuvenation [17]. Additionally, the use of Air Pollution Tolerance Index (APTI) screening helps in selecting resilient planting sites and tolerant genotypes in peri-urban zones, enhancing both germplasm longevity and environmental adaptability [5].

Finally, linking germplasm efforts to national conservation infrastructure offers sustainable assurance. The ICAR-NBPGR manages national gene-banking and cryopreservation protocols that can be leveraged to store both Som and Soalu germplasm, ensuring genetic backup and support for restoration or breeding programs [48]. By aligning in situ plantation efforts with ex situ germplasm banking and periodic genetic monitoring, stakeholders can create resilient supply systems that preserve ecological, economic, and cultural continuity.

5. Conclusion

Muga sericulture stands at a crossroads where tradition and innovation must converge. The past decade has produced tangible scientific and technological advances from improved rearing protocols and microbial insights to stifling and reeling innovations, host-plant adaptation strategies, and climate modeling. Yet, the translation of these innovations into practice remains uneven. Mechanization is still concentrated in research settings, pathogen threats continue to destabilize crops, and genomic resources for *Antheraea assamensis* remain far behind those available for mulberry silk. Moreover, extension bottlenecks and limited policy support constrain the adoption of proven technologies by smallholder farmers, many of whom are women-led households that form the backbone of the sector.

To safeguard the heritage and economic value of muga silk, research must now move beyond isolated innovations toward integrated, field-tested solutions. Mechanization trials validated under farmer conditions, genome-enabled breeding for stress and disease resilience, coordinated plant-insect studies, and inclusive adoption frameworks will be essential. Equally, strengthening pathogen diagnostics, biosecurity training, and extension systems will be critical for sustaining productivity in a changing climate. If these directions are pursued systematically, muga sericulture can evolve from a fragile, climate-exposed system into a robust, knowledge-driven enterprise that preserves its cultural identity while securing livelihoods across Northeast India.

References

1. Das N. Geographical Indication (GI) as a means of craft tourism: a case of muga silk in Assam, India. Rev Bras Ecotur. 2022 Aug 1;15(4).
2. Narzary PR, Manimegalai S, Shanmugam R, Vinothkumar B, Suganthi A, Radha P. Golden Threads of Tradition: The Endurance and Evolution of Muga Culture and Silk Weaving in Assam. J Survey Fish Sci. 2023;10(3):63-70.
3. Kalita P. Role of Muga Silk-Gi of Assam in the Sustainable Development of Assam. Issue 6 Int'l JL Mgmt Human. 2022;5:588.
4. Sarma K, Chetry V, Bawri A, Borah KJ, Khanikor B, Kalita T, *et al*. Ensemble distribution model of Muga Silkworm (*Antheraea assamensis*) and its primary host plant Soalu (*Litsea monopetala*) in defined climate space. Sci Rep. 2025 Jul 1;15(1):22080.
5. Jigyasu DK, Kumar A, Shabnam AA, Begum R, Singh S, Malyan SK, *et al*. Air pollution tolerance index of *Persea bombycina*: Primary food plant of endemic muga silkworm (*Antheraea assamensis*). Heliyon. 2023 Nov 1;9(11).
6. Subrahmanyam G, Esvaran VG, Ponnuvel KM, Hassan W, Chutia M, Das R. Isolation and molecular identification of microsporidian pathogen causing nosemosis in muga silkworm, *Antheraea assamensis* Helfer (Lepidoptera: Saturniidae). Indian J Microbiol. 2019 Dec;59(4):525-9.
7. Jagadish A, Dubey H, Kamatchi I, Pradeep AR, Subrahmanyam G, Mishra RK, *et al*. Transcriptome analysis of Nosema assamensis infecting muga silkworms (*Antheraea assamensis*) reveals insights into candidate pathogenicity related genes and molecular pathways required for pathogenesis. Ann Parasitol. 2021a;67(4).
8. Mishra SN, Ravikumar D, Reddy A, Naik SV. Influence of cocoon stifling and storage on silk reeling performance and quality of muga raw silk. Indian J Fibre Text Res. 2020 Jan 10;45(3):359-61.
9. CSTRI R&D Portal. Research & Development: technologies for tasar/muga/eri including multi-end reeling, cocoon drying and reeling process studies. [Internet]. [accessed 2024]. Available from: https://cstri.res.in/
10. Borah A, Borah MB, Sharma N. Relationship between Climate and Muga Silk Production. Int J Multidiscip Educ Res. 2024 Feb 29;13(3).
11. Singh A, Kumar V, Majumdar M, Guha L, Neog K. A comprehensive review of insect pest management in muga silkworm (*Antheraea assamensis* Helfer): Current scenario and future prospects. J Exp Agric Int. 2024 Mar 7;46(5):47-55.
12. Kumar VI, Singh AB, Indirakumar K, Majumdar M, Guha LO. Effect of different host plants on rearing and grainage activity on muga silkworm (*Antheraea assamensis*). Int J Agric Sci. 2022;14(8):11559-62.
13. Neog K, Dutta P, Das R, Sivaprasad V. Effects of commonly used plant protection formulations on rearing and cocoon production of muga silkworm *Antheraea assamensis* helfer. Munis Entomol Zool. 2021 Jul 13;16(1):331-50.
14. Jigyasu DK, Patidar OP, Kumar A, Shabnam AA. Muga silk insect (*Antheraea assamensis*). In: Commercial Insects. CRC Press; 2023b Dec 22. p. 126-45.
15. Barman H, Rajan RK. Muga silkworm (*Antheraea assamensis* helfer) indoor rearing by integrated "leaf freshness technology"-A new technology. Afr J Agric Res. 2012 Jun 19;7(23):3490-7.
16. Borpuzari SP, Das MR, Rahman A. Comparative study on the Rearing performance of muga silkworm (*Antheraea assamensis* Helfer) on two primary host plants Som (*Persea bombycina* Kost) and Soalu (*Litsea monopetala* Roxb) in different rearing seasons. Eco Env Cons. 2022;28(1):568-73.
17. Boruah J, Sahu JB. *In vitro* propagation of som plant (*Persea bombycina* king): A primary food plant of muga silkworm. J Entomol Zool Stud. 2020;8(4):07-11.
18. Subrahmanyam G, Das R, Debnath R, Chutia M, Ponnuvel KM, Sathyanarayana K. Characterization of bacterial pathogens in muga silkworm, *Antheraea assamensis* Helfer (Lepidoptera: Saturniidae). J Environ Biol. 2023 May 1;44:479-84.
19. Tayal MK, Chauhan TP. Silkworm diseases and pests. In: Industrial Entomology. Singapore: Springer Singapore; 2017 Feb 14. p. 265-89.
20. Shifa K, Ibrahim MTA, Tilahun A. Evaluation of some disinfectants against mulberry silkworm (*Bombyx mori* L.) (Lepidoptera: Bombycidae) diseases in Melkassa Agricultural Research Center, Ethiopia. Int J Agric Biosci. 2020 Dec 12;9(5):263-8.
21. Narzary PR, Das A, Saikia M, Verma R, Sharma S, Kaman PK, *et al*. Recent trends in Seri-bioscience: its prospects in modern sericulture. Pharma Innov. 2022;11(1):604-11.
22. Gandotra S, Kumar A, Naga K, Bhuyan PM, Gogoi DK, Sharma K, *et al*. Bacterial community structure and diversity in the gut of the muga silkworm, *Antheraea assamensis* (Lepidoptera: Saturniidae), from India. Insect Mol Biol. 2018 Oct;27(5):603-19.

23. Sivaprasad V, Sangannavar PA, Lingaiah K. An Introduction to Biotechnology Driven Advances for Silkworm Improvement and Sustainable Perspectives. In: Biotechnology for Silkworm Crop Enhancement: Tools and Applications. Singapore: Springer Nature Singapore; 2024 Oct 16. p. 1-20.
24. Subrahmanyam G, Thirupathaiah Y, Vijay N, Debnath R, Arunkumar KP, Gadwala M, *et al*. Contrasting gut bacteriomes unveiled between wild *Antheraea assamensis* Helfer (Lepidoptera: Saturniidae) and domesticated *Bombyx mori* L. (Lepidoptera: Bombycidae) silkworms. Mol Biol Rep. 2024 Dec;51(1):666.
25. CSTRI / Central Silk Board. Technology Descriptor (wet reeling and vanya post-cocoon technologies). 2017. https://cstri.res.in/wp-content/uploads/2023/08/TechnologyDescriptor-June2017.pdf
26. CSTRI / Central Silk Board. Technology Descriptor (updated; wet reeling machine for vanya silk). 2024. https://cstri.res.in/wp-content/uploads/2023/08/TechnologyDescriptor.pdf
27. Manjunath RN, Khatkar V. Investigation of structural morphology and mechanical behavior of muga silkworm (*Antheraea assamensis*) cocoons. J Nat Fibers. 2022 Aug 3;19(8):2836-48.
28. Choudhury M, Devi D. Demineralization of cocoons of *Antheraea assamensis* Helfer (muga) for effective reeling. J Textile Inst. 2018 Apr 3;109(4):552-9.
29. Ahmed M, Saikia JP. A Novel Activated Charcoal Based Wash to Make Muga Silk Shiny. J Nat Fibers. 2023 Apr 24;20(1):2145407.
30. Anand P, Pandey JP, Pandey DM. Study on cocoonase, sericin, and degumming of silk cocoon: computational and experimental. J Genet Eng Biotechnol. 2021 Dec 1;19(1):32.
31. Ghosh A, Ray M, Gangopadhyay D. Evaluation of proximate composition and antioxidant properties in silk-industrial byproduct. Lwt. 2020 Oct 1;132:109900.
32. Central Silk Technological Research Institute (CSTRI), Central Silk Board (CSB). Technology descriptor: Technologies for mulberry silk reeling sector. 2023. https://cstri.res.in/wp-content/uploads/2023/08/TechnologyDescriptor.pdf
33. Keot D, Dutta A, Das M. Seasonal variation in expression patterns of anti-microbial peptides and activity of anti-oxidant defence enzymes in muga silkworm larvae, *Antheraea assamensis* Helfer: Deepshikha Keot *et al*. J Biosci. 2024 Oct 10;49(4):93.
34. Marak M, Singha TA, Saikia D. Mechanization in Sericulture: An Overview. J Adv Biol Biotechnol. 2024 Aug 2;27(8):820-5.
35. Halagundegowda GR, Kumaresan P, Manjunatha GR, Sangannavar P, Saheb NA, Moorthy SM, *et al*. Growth and instability in vanya silk production in India: An econometric analysis. Int J Stat Appl Math. 2023;SP-8(3):175-81.
36. CSB / CSTRI technical descriptors and official documents on vanya post-cocoon technologies and extension programs. (Central Silk Board / Central Sericultural Research & Training Institute). https://texmin.nic.in/sites/default/files/note-on-sericulture2017-18-ThirdQtr.pdf
37. Chetia H, Kabiraj D, Singh D, Mosahari PV, Das S, Sharma P, *et al*. De novo transcriptome of the muga silkworm, *Antheraea assamensis* (Helfer). Gene. 2017 May 5;611:54-65.
38. Singh D, Kabiraj D, Sharma P, Chetia H, Mosahari PV, Neog K, *et al*. The mitochondrial genome of Muga silkworm (*Antheraea assamensis*) and its comparative analysis with other lepidopteran insects. PLoS One. 2017 Nov 15;12(11):e0188077.
39. Dubey H, Pradeep AR, Neog K, Debnath R, Aneesha PJ, Shah SK, *et al*. Genome sequencing and assembly of Indian golden silkmoth, *Antheraea assamensis* Helfer (Saturniidae, Lepidoptera). Genomics. 2024 May 1;116(3):110841.
40. Pant K, Singh U. Need for revamped extension approaches to overcome the constraints in transfer of technologies. Indian Res J Ext Edu. 2014;14(1):109-11.
41. Kalpana R, Mithilasri M, Karthick Mani Bharathi B, Susikaran S, Sabarish M, Parthiban KT. Bridging tradition with innovation: revolutionzing sericulture through biotechnological advancements. Int J Zool Appl Biosci. 2024 Aug 21;9(4):78-82.
42. Gaikwad NS, More SS, Munde TB. Constraints perceived by farmers in adoption of sericulture technologies in Solapur district of Maharashtra. The Pharma Innov J. 2023;12(1):420-2.
43. Hosamani V, Yalagi M, Sasvihalli P, Hosamani V, Nair KS, Harlapur VK, *et al*. Constraints and economics of sericulture: A. IJCS. 2020;8(1):746-50.
44. Hussain A, Sarma TR, Barua P. The Indian Muga silk industry: an integrative review of its business ecosystem and a management perspective. Int J Indian Cult Bus Manag. 2024;33(4):533-69.
45. Tikader A, Vijayan K, Saratchandra B. Improvement of host plants of Muga silkworm (*Antheraea assamensis*) for higher productivity and better adaptation-A Review. Plant Knowledge J. 2013;2(2):83-8.
46. Goswami NK, Nath D, Saharia D. A study on socio-economic assessment and adoption of scientific technologies by the muga rarers of Assam. Int J Sci Res. 2015;4(2):349-53.
47. Devi B, Chutia M, Bhattacharyya N. Food plant diversity, distribution, and nutritional aspects of the endemic golden silk producing silkworm, *Antheraea assamensis*–a review. Entomol Exp Appl. 2021 Mar;169(3):237-48.
48. Singh K, Gupta K, Tyagi V, Rajkumar S. Plant genetic resources in India: management and utilization. Vavilov J Genet Breed. 2020 May;24(3):306.