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Review Article

EFFECT OF DIFFERENT HOST PLANTS ON REARING AND GRAINAGE ACTIVITY ON MUGA SILKWORM (*Antheraea assamensis*)

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Abstract: Muga silkworm, (*Antheraea assamensis*) is a polyphagous insect that is endemic to the northeastern parts of India. Semi-domesticated muga silkworm is multivoltine in nature and commercial rearing is conducted during the spring and autumn seasons. Muga silkworms feed on different kinds of host plants. These host plants are divided into three categories as Primary, Secondary, and tertiary host plants. Som (*Persea bombycina*) and Soalu (*Litsea polyantha*) are the primaries, dighloti (*Litsea salcifolia*), mejankari (*Litsea citrata*) are secondary and *Cinnamomum obtusifolium, Cinnamomum glaucescens, Actinodaphane obovbata, Michelia champa, Zizyphus jujube, Xanthoxylem rehsta*, *Celastrus monosperma etc*. are tertiary host plants. All food plants are distributed in India's Northeastern states (Assam, Meghalaya, Nagaland, Manipur, Arunachal Pradesh, and Mizoram). A healthy host plant is needed for getting a good quality of leaves, these good qualities of leaves play a very important role in larval growth and development. These reviews mainly focus on the performance of muga silkworms on different host plants.

Keywords: *Muga silkworm (Antheraea assamensis), Primary host plant, Secondary hostplant, Tertiary host plant, Rearing performance*

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Introduction

Muga silk is termed the “Golden silk” with India being the only region producing all four varieties *i.e*., Mulberry, Eri, Muga and Oak Tasar silk in the entire world. India is also the second largest consumer and producer of silk in the world. Muga silkworm *Antheraea assamensis* Helfer belongs to Lepidoptera of the Saturniidae family and, is geographically isolated only to the NE region of India. The geographical isolation of this silkworm is indicative of its special requirements for geo-climatic conditions that prevail in this region. Muga silk is produced by *Antheraea assamensis* and feeds on certain primary, secondary and tertiary host plants [1].

The muga silkworm is polyphagous on certain plants as most of the Lepidoptera tend to have a wider range of host plant acceptability [2]. The colour morphs and the wild counterparts vary in their phenotypic characters depending upon the host plant selection or seasonal changes. As primary food plants preferred by the silkworm are som (*Persea bombycina*) and soalu (*Litsea monopetela*). Som is naturally abundant in upper Assam (Dibrugarh, Sibsagar, Lakhimpur, Jorhat and Golaghat districts) as well as the large plantations in the forests and hilly regions of lower Assam (Darrang, Kamrup, Karbianglong and Goalpara districts), which is commercially exploited for reeling cocoon production [3].

Soalu is distributed in the foothills of lower Assam extending up to the Garo hill ranges of Meghalaya and is utilized for muga seed production. Moreover, more than 22 plants have been reported that are used as the secondary host plants of muga silkworm rearing. These plants are scattered in forests, wastelands, and some plantation areas of villages. The food plants are found in warm and humid conditions with high rainfall and acidic soils [4]. They prefer high iron content in the soil. These food plants are naturally abundant in north-eastern India both in the plains of the Brahmaputra basin and in the eastern Himalayan ranges, but all the food plants are not fully exploited commercially due to a lack of proper knowledge. Presently, because of deforestation and urbanization, the natural habitat of the wild population of these food plants is shrinking, which requires immediate attention for conservation [5].

According to Choudhury (1992) [6] relative contribution of such factors responsible for a successful crop harvest has been estimated as a 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 host plants play a major role in successful cocoon production, it is important to evaluate the best host plant out of the primary and secondary host plants to propagate the best one for commercial utilization.

Primary food plants

Collection of muga plant genetic resources was initiated in 1988 by the Regional Muga Research Station (RMRS), Boko, Kamrup, Assam, only fourteen cultivars of som and ten cultivars of soalu could be collected from Assam and Meghalaya. After the initial evaluation, 8 som and 10 soalu genotypes were selected for further studies. These genotypes were characterized based on morphology, floral biology, propagation, chemo-assay, and bioassay [8].

Morphologically the som and soalu genotypes showed wide variations in the number of rachis per inflorescence, rachis length, several flowers per rachis, flower size, perianth and peduncle length [Table-2] & [Table-3] [9]. The propagation of som and soalu is primarily through seed. Since the parental trees are highly heterozygous, the seedlings showed wide variations, resulting in unequal leaf production.

Table-1 *Food plants of Muga silkworm and their distribution in India [7]*

Food plants	Family	Distribution in India	Used in farming
Primary			
Persea bombycina Kost.	Lauraceae	Northeastern India	+++++
Litsea monopetala (Roxb.) Pers.	Lauraceae	Assam, Odisha, Eastern Himalayas, Maharashtra	++
Secondary			
Litsea salicifolia (Roxb. ex Nees.) Hook. f.	Lauraceae	Northeastern India	++
Litsea cubeba (Lour.) Pers.	Lauraceae	Assam, Manipur, Nagaland	+
Michelia champaca L.	Magnoliaceae	Assam, Andaman & Nicobar Island, Andhra Pradesh, Odisha, Southern India	-
Cinnamomum camphora (L.) J. Presl.	Lauraceae	Assam, Meghalaya, Maharashtra	-
Cinnamomum tamala (Buch.- Ham.) *T. Nees* & C. H. Eberm.	Lauraceae	Assam, Meghalaya, Maharashtra	-
Tertiary			
Actinodaphne angustifolia (Bl.) Nees.	Lauraceae	Assam, Meghalaya, Arunachal Pradesh, Central India, Peninsular India	-
Actinodaphne obovata (Nees.) Bl.	Lauraceae	Sikkim, Assam, Manipur, Meghalaya, Arunachal Pradesh	-
Actinodaphne sikimensis Meissn.	Lauraceae	Sikkim, Assam, Manipur, Meghalaya, Arunachal Pradesh	-
Celastrus hindsii Benth.	Celastruceae	Sikkim, Arunachal Pradesh, Assam, Nagaland, Meghalaya	-
Cinnamomum bejolghota (Buch. Ham) Sweet	Lauraceae	Assam, Meghalaya	-
Cinnamomum glanduliferum (Wall.) Meisn.	Lauraceae	Assam, Meghalaya	-
Cinnamomum glaucescens (Nees.) Hand.-Mazz.	Lauraceae	Northeastern India	-
Gmelina arborea Roxb.	Verbenaceae	Throughout India	-
Lindera latifolia Hook.	Lauraceae	Assam, Meghalaya	-
Litsea glutinosa Lour.	Lauraceae	Northeastern India	-
Litsea nitida (Roxb.) Hook.	Lauraceae	Northeastern India	-
Magnolia pterocarpa Roxb.	Magnoliaceae	Assam, Meghalaya	-
Michelia oblonga Wall. ex.f. & Thomas	Magnoliaceae	Assam, Manipur, Madhya Pradesh, Rajasthan, Uttar Pradesh, Bihar	-
Machilus odoratissima Nees.	Lauracae	Northeastern India	-
Persea duthei King.	Lauraceae	Northeastern India	-
Persea glaucescens(Nees.) D.G. Long	Lauraceae	Assam, Meghalaya, Kerala	-
Phoebe lanceolata (Nees.) Nees.	Lauraceae	Assam, Meghalaya	-
Plumeria acutifolia Poiret	Apocynaceae	Northeastern India	-
Polyalthia simiarum Benth. & Hook.	Apocynaceae	Andaman & Nicobar Islands, Assam, Meghalaya, Odisha, Sikkim, West Bengal	-
Sarcostemma brevistigma Wight & Arn.	Apocynaceae	Northeastern India, Kerala	-
Symplocos grandiflora Wall. ex A.DC.	Symplocaceae	Northeastern India	-
Symplocos paniculate Miq.	Symplocaceae	Northeastern India	-
Symplocos ramosissima Wall. ex G. Don	Symplocaceae	Northeastern India	-
Zanthoxylum armatum DC.	Rutaceae	Northeastern India, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Orissa, Andhra Pradesh	-
Zanthoxylum rhetsa (Roxb.) DC.	Rutaceae	Assam, Karnataka, Kerala, Meghalaya, Manipur, Odisha	-
Ziziphus mauritiana Lam.	Rhamnaceae	Throughout India except for Jammu & Kashmir, Himachal Pradesh	-

Table-2 *Variability in the reproductive biology of Som (Persea bombycina King)*

	Morphotypes							
Distinguishing characters	I	II	III	IV	V	VI	VII	VIII
Bud development period (days)	35	46	60	82	30	52	34	43
Rachis per inflorescence	6-7	3-4	3-5	6-8	5-6	4-6	10-13	3-6
Length of the rachis (cm)	9.9	7.1	3.6	8.1	2.7	2.1	6.3	3.4
Flowers per rachis	19.6	23.3	13.3	38.8	11.4	13.5	9.1	9.6
Perianth length (cm)	0.56	0.50	0.41	0.66	0.60	0.40	1.07	0.52

Table-3 *Variability in leaf morphology of soalu (Litsea monopetala)*

Morphotype	Leaf wt.(g)	Leaf length (cm)	Leaf breadth (cm)	L x B cm^2	Vein no.	Petiole length (cm)
Morph-1	1.7	15.4	7.0	108.0	21.9	1.6
Morph-2	2.1	15.1	9.1	138.4	19.1	1.7
Morph-3	1.4	12.2	7.7	95.1	18.9	1.2
Morph-4	2.7	14.7	10.4	153.9	21.0	1.6
Morph-5	2.3	17.3	8.9	155.7	19.6	1.4
Morph-6	2.3	15.4	8.6	133.9	20.0	1.7
Morph-7	1.8	13.7	8.5	116.7	18.1	1.6
Morph-8	2.0	16.8	6.8	116.1	19.3	1.7
Morph-9	1.9	12.8	9.0	116.7	18.7	1.7
Morph-10	2.6	18.6	8.9	168.1	21.1	1.4

To avoid such variations in the orchard, selected trees were propagated through vegetative means to get true to the type of plant. Vegetative propagation can be done through stem cuttings, leaf bud cuttings, grafting, layering *etc* [10]. Since, vegetative propagation is awkward method so one should take utmost appropriate heed throughout the beginning establishment. According to Mech *et al.,* (2019) [11] about 10000 ha of land is used for cultivation of Muga silk food plants and about 34 000 families are actively involved with the Muga culture. Almost all the Muga silkworm farmers mainly prefer *P. bombycina* for plantation on their farms. *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 the nursery or plantation of this plant because it defoliates and has poor leaf quality during winter [12]. Golden muga silkworms are chiefly fascinated to partially matured leaves of som plants as compared to other host plants. However, the pupal weight and oviposition rate were higher when the silkworms fed on *L. monopetala* leaves than *P. bombycina, L. salicifolia,* and *C. glaucescens* (Nees.) Hand.-Mazz. [13]. Larval duration did not vary when Muga silkworms fed on *P. bombycina* and *L. monopetala* leaves in different seasons [14].

There were no significant differences observed in fecundity, hatching %, effective rate of rearing and cocoon:dfl ratio, shell weight, shell ratio, filament denier and length, when compare between som and soalu food plants. The primary food plant Soalu (*Litsea monopetela*) is mostly utilized for production of seed cocoons purpose. The plant is distributed on plains as well as hills, and the propagation occurs by falling seeds. Although three varieties of 'Soalu' existed in this region [15], the Central Muga and Eri Research and Training Institute, Lahdoigorh and Regional Muga Research Station, Boko, Assam have collected, identified, and maintained about 10 genotypes of Soalu. Proteins and amino acids are important for silkworm larvae as they are utilized for the synthesis of silk protein [16]. Yadav and Goswami (1992) [17] 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.

Secondary food plants

Four food plants were categorized as secondary: *Litsea salicifolia, L. cubeba, Cinnamomum camphora* (L.) *J. Presl.,* and *C. tamala* (Buch.-Ham.) *T. Nees* & *C. H. Eberm*. [4]. Many wild silkworm races are found on the Dighloti plant. This may help in the collection of wild races and maintained in the Dighloti farms for breeding and further improvement of muga and other silkworm races [18]. This may ultimately help in developing the ever-important muga germplasm bank and silkworm biodiversity. It has also been proved by previous researchers that *Litsaea salicifolia* Roxb. can profitably be used in the muga silk industry since the worm reared on it produces cocoons which are in no way inferior to cocoons produced on other food plants. There is a general opinion of the private rearers that the weak muga worms of a brood could be transferred from other muga food plants to Dighloti to retrieve its vigour and strength and thereby keep production equally high. Due to its evergreen nature, *Litsaea salieifolia* Roxb. can probably replace Soalu (*Litsaea polyantha* Juss) for the whole rearing period, particularly during the winter months, *i.e*., November to February every year to maintain the continuity of muga silkworm rearing [12]. During the winter season, muga silkworm rearing on the Soalu plant becomes unsuitable due to defoliation and poor-quality leaf. A tree locally called "mejankari" in Assam is a secondary food plant of the muga silkworm. The silk produced by the silkworm grown on this plant is very attractive and several times costlier than the silk produced by silkworms from other host plants [19]. The Mezankari (*Litsea cubeba*) is an aromatic plant growing in the shady environment of upper Assam and producing glossy white silk. The silk from this tree is priced more than that obtained from other plants. Now a day there is no regular cultivation of this tree; it grows from seeds carried through the excreta of birds. The seed has a hard coat; therefore, it is highly restricted to some pocketsof Jorhat and Sibsagar districts only [20].

Sometimes, *L. salicifolia* is utilized as a primary food plant both for commercial and seed cocoon production purposes. This plant is also fed by other wild silkworms besides the Muga silkworm [18]. During winter, *L. salicifolia* can be used to replace *L. monopetala* to cope with the defoliation and poor leaf quality later in winter [12]. Gogoi (1999) [18] reported that the traditional silkworm farmers fed *L. salicifolia* leaves to weak Muga worm to retrieve its vigour and strength. Muga larvae fed on *L. salicifolia* during early age rearing (1^{st} & 2^{nd} in stars) and subsequently transferred to *P. bombycina* leaf produced healthier (disease-free) cocoons [18].

Wang *et al.,* (2016) [21] indicated as *L. salicifoliai* having bioactive compound with antimicrobial activities it may defend the silkworm larvae from aggressive pathogens. As such, *L. salicifolia* is a good choice and can be raised in conservation sites to protect the Muga silkworms from diseases in their natural habitat. Kakati *et al.,* (2015) [22] reported high crude fibre content in *L. cubeba* (18.8%) than in *P. bombycina* (16.6%) in the hilly areas of Nagaland. Neog *et al.,* (2007) [23] observed a higher amount of crude fibre content in *P. bombycina* than in *L. monopetala* and *L. salicifolia* and it was the lowest in *L. cubeba* in plain. Rajjou *et al.,* (2012) [24] stated seed germination and well establishment of seedlings are very important parameters for plant propagation. Although *L. cubeba* has potential as an industrial crop [25], no systematic plantation of *L. cubeba* is available in the country for silkworm farming.

Even though 'mejankari' is the costliest silk with high demand, farmers usually do not prefer this plant because seedlings are too difficult to obtain for cultivation. This is mainly due to the low seed germination rate (7-9%) even under ideal conditions [26]. The *L. cubeba* plant is not only popular for silkworm rearing but also its medicinal and industrial value. All parts of the plant are used for medicinal purposes [25]. The essential oil extracted from the plant (leaf and seeds) has demonstrated antifungal and antibacterial properties [21].

Tertiary food plants

Less knowledge is available about other food plants of the Muga silkworm. Many of these plants are found in wild habitats in forests and foothills of northeastern India. *Litsea nitida* (Roxb.) Hook, *Actinodaphne angustifolia* (Bl.) Nees, *Actinodaphne obovate* (Nees) Bl., *C. glaucescens,* and *C. tamala* were reported as potential food plants for the silkworm [20]. *Gmelina arborea* Roxb. serves as an alternate food plant for both Muga and Eri silkworms [4]. *Ziziphus mauritiana* Lam.is preferred as a food plant by both Muga and Tasar silkworms, which are widely distributed in the region.

Bindroo *et al*., (2009) [27] reported *Litsea glutinosa* (Lour.) as a new food plant with potential for Muga seed crop rearing, although *L. glutinosa*-fed cocoons are smaller, having low shell weight and less silk content as compared to cocoons from larvae-fed *P. bombycina* or *L. monopetala*. However, pupal and grainage periods were comparable in all three species. *Litsea glutinosa*-fed cocoons had a good hatchability (92%) and high oviposition index [27]. All these secondary and tertiary food plants have not been exploited for commercial utilization and hence they are very little known to the farmers. Due to habitat degradation, the populations of these food plants are decreasing day by day. Hence, there is a wide scope as well as an urgent need for researchers to exploit the hidden potentials of these food plants for Muga rearing, which will eventually help the farmers and uplift the entire Muga industry

Other improved host plant studies

Tikader (2012) [28] selected two food plants of Muga silkworm, *L. monopetala* and *L. salicifolia*, for cross-breeding. The hybrids were fertile and showed encouraging results when their leaves were fed to Muga silkworm larvae: they grew faster, moulted faster, and cocoon characters were better. As such, classical breeding techniques may be suitable for the crossing of primary food plants with other wild counterparts to get improved and productive varieties. Gogoi, *et al*., (2010) [29] developed tetraploid varieties of *P. bombycina* and *L. monopetala*. The tetraploid variety of *P. bombycina* produced more branches with shorter internodal distance and bigger leaves. The leaves were rich in total crude protein, reducing sugar, total soluble sugars, and moisture and they were more palatable [29]. The rearing performance of silkworms was also better concerning larval growth and cocoon yield, with higher cocoon and shell weight. However, little information is available on the commercial exploitation of these improved food plants. Having multiple food plants for the Muga silkworm may prove to have an ecological advantage to adapt to changing climates over time [30]. Therefore, it will be a valuable approach to evaluate the nutritional status and silkworm rearing performance of already reported food plants other than the primary plants, to popularize the superior ones among farmers.

Prospective food plants research

All the Muga silkworm food plants are wild and as such they possess both desirable and undesirable traits [4]. It is necessary to evaluate plants with suitable traits for further improvement. Through breeding programs, improved food plants can be developed to produce quality leaves with increased biomass that are tolerant to biotic and abiotic stresses [31]. Improvement of the genetic base of food plants can be carried out through collection, characterization, evaluation of new germplasm accessions, and their utilization in breeding programs.

Future strategies

The genetic studies on all the host plants have not been studied in detail. Molecular characterization of the host plant has not been carried out to select genetically divergent parents for breeding purposes.

Appropriate agronomical practices have not been developed to obtain quality leaves in unfavourable seasons. An improved standard method for vegetative propagation of the plants is still not available, especially for secondary host plants. Further efforts must be made to enrich the gene pool of the host plants, utilization at the farmer (commercial) level for better yield and the development of disease-resistant varieties to enhance the production of raw silk.

Research Category: Sericulture and Agronomy

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