Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(4): 269-275

Received: 08-05-2020
Accepted: 10-06-2020

Praban Boro
M.Sc. (Ag.) Department of Sericulture, Assam Agricultural University, Jorhat, Assam, India

Shilpi Devi Borah
M.Sc. (Ag.) Department of Sericulture, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Praban Boro
M.Sc. (Ag.) Department of Sericulture, Assam Agricultural University, Jorhat, Assam, India

Biodiversity of sericigenous insects in north-eastern region of India- A review

Praban Boro and Shilpi Devi Borah

Abstract
Biodiversity means variability and availability of large number of species of a genus in a particular area. In North-Eastern region large number of sericigenous insect species and their host plants are found. This region of India is categorized as one of the major and important hotspot area among 35 biodiversity hotspots of the world and a prominent and comfortable zone for silk producing insects. North-Eastern zone also has a unique position around the world as it is the only homeland of all the four kinds of silkworm *viz.*, eri, muga, tasar and mulberry. Not only the silkworm but also this region is a homeland of large number of silkworm host plants varieties. Presently 31 species of saturniidae and 9 species of bombycidae were reported from North-Eastern region of India. But studies on very few species have made till date. To maintain the tradition of this region as a hotspot area, application of proper strategies should be made for the conservation of sericigenous insect species. Hence this region remains as a hotspot forever to the world.

Keywords: Biodiversity, sericigenous insects, north-eastern region, conservation

Introduction
Biodiversity is often broadly define as the different forms of plants, animals and microorganism that exist, the level at which they occur (e.g., species, population and ecosystem levels) and the different ways in which organisms, climate and geology combine to functioning ecosystems [1].Seri-biodiversity refers the variability in sericigenous or silk producing insects and their host plants [2]. Sericulture comprises of inter-linked activities such as food plant cultivation and maintenance to feed the silkworms, silkworm rearing to produce the silk cocoons, reeling the cocoons for unwinding the silk filament, yarn making, weaving and processing of fabric [3]. Sericulture broadly classified into two distinct sectors – Mulberry and Non-mulberry. Among the commercially exploited non-mulberry silkworms, the eri silkworm, *Samia ricini* Donovan is the only species domesticated completely and adapted to indoor rearing all through the year [4]. India is the only country in the world, producing all the five commercially exploited silk varieties *viz*- eri, muga, mulberry, tropical tasar and temperate tasar. Mulberry silk is produced on large scale throughout the country. Tropical Tasar, temperate/Oak Tasar, produced by tribal inhabiting Central India and Sub-Himalayan Region, Eri Silk (spun silk produced mainly in N. E. Region, now practiced in many other states) and Muga – Golden silk produced only in Brahmaputra valley of Assam province in NE Region [3]. The North eastern region of India, comprising the states of Arunachal Pradesh, Assam, Meghalaya, Tripura, Mizoram, Nagaland and Sikkim can be physiographically categorized as the Eastern Himalayas. North Eastern India is one of 34 world biodiversity hotspots and is a natural abode for insect biodiversity [5]. Assam, the gateway of India is famous for natural silk, particularly for Muga and Eri silk [6]. The mulberry silkmoths are represented by the domesticated *Bombyx mori* L and wild allies of Bombycidae family. The wild silk moths or non-mulberry silk moths mostly belong to the family Saturniidae. Forest fauna of the sub-Himalayan belt of India is the natural abode of large variety of sericigenous insects as reported by various workers like Baruah *et al.* [7], Singh *et al.* [8], Singh and Maheswami [9]. The wild silk moths play an important role in the conservation and utilization of biodiversity as reported by Frankel [10] and Peigler [11]. Singh and Suryanarayan [12] reported that the North East region of India is an ideal natural home for a variety of silkworms. A total of 47 species of silkworms are recorded from India, out of which 24 reported from North East region.

Sericigenous insects

The sericigenous insects are the insects which produces silk of economic value [13]. By considering the economic value of silk, the silk producing insects can be divided into two distinct part i.e commercially important silk producing insect (viz., mulberry, eri, muga and tasar) and other silk producing insect (*viz., Attacus atlus*, *Cricula trifenestrata, Acteas selene* etc).

Major commercially important sericigenous insect found in North-East India

Eri silkworm (*Samia ricini*):

Eri silkworm, *Samia ricini*, is one of the most commercially exploited and completely domesticated non mulberry silkworms. It has 5 to 6 generations per year & feeds on several host plant species [14]. Among all the host plants, Castor (*Ricinus communis* Linn) is the most preferred host plant for eri silkworm [15]. It is known by different names viz., eri silk, endi silk & vanya silk, ahimsha silk of India [16]. Depending upon availability of seed and leaf the rearing is conducted throughout the year. Unlike other silkworms, Eri silkworm rearing is simple and does not require high skill. Eri silkworms are hardy and less susceptible to diseases. The crops are assured as compared to other sericulture like mulberry, muga and tasar [17]. Based on the morphology 26 eco-races of *Samia ricini* has been identified. These 26 Eri silkworm germplasm are maintained at Central Eri, Muga Research and Training Institute, Central Silk Board. Ladoigarh, Assam. Out of 26 eco-races, 4 are utilizes commercially *viz.*, borduar, titabar, diphu and kokrajhar. The characterization of eri silkworm is mainly based on the heritable morphological characters of *Samia ricini*. Ten(10) descriptors have been utilized for investigation of the 26 eri silkworm germplasm accessions based on larval colour with rearing performance and cocoon colour with economic traits. These include larval colour, cocoon colour, fecundity, hatching percentage, larval weight, larval period, effective rate of rearing, cocoon weight, shell weight and shell ratio [18]. Performance details of all the 26 eco-races of eri silkworm are mention below (Table 1). Pigler and Naumann [19] reported that there are total 19 species of Eri (genus-*Samia*) all over the world of which only three species are reported from India and out of which two from NE region they are *Samia canningi* which is a wild species and *Samia ricini*, a totally domesticated species. Out of these six pure line strains were isolated from both borduar and titabar eco-races on the basis of larval body colour and marking pattern. These are yellow plain (YP) yellow spotted (YS), yellow zebra (YZ), greenish blue plain (GBP) greenish blue spotted (GBS) and greenish blue zebra (GBZ) [16].

Table 1: Morphological traits of silkworm eco-races

S. No.	Name of the Eco-race	Larval body colour	Cocoon colour
1	Borduar	Plain and zebra on yellow and blue	White
2	Titabar	Plain and zebra on yellow and blue	White
3	Khanapara	Plain yellow and blue	White
4	Nongpoh	Plain yellow and blue	White
5	Mendipathar	Plain blue	White
6	Dhanubhanga	Plain yellow and blue	White
7	Chuchuyir	Plain yellow	White and brick red
8	Lahing	Plain and zebra on yellow and blue	White
9	Barpethar	Plain and zebra on yellow and blue	White and brick red
10	Diphu	Plain and zebra on yellow and blue	White
11	Adokgini	Plain yellow and blue	White
12	Lakhimpur	Plain and spotted on yellow and blue	White
13	Dhemaji	Plain and zebra on yellow and blue	White and brick red
14	Kokrajhar	Plain yellow and blue	Brick red
15	Imphal	Plain yellow and blue	White
16	Cachar	Plain yellow and blue	Brick red
17	Dhakuakhana	Plain yellow and blue	White and brick red
18	Genung	Plain yellow and blue	White
19	Jonai	Spotted on yellow	White
20	Dhanustri	Plain yellow	White
21	Sadiya	Plain yellow	White
22	Tura	Plain yellow	White
23	Jona Kach	Plain yellow	White
24	Barpeta	Plain yellow and blue	Brick red
25	Ambageon	Plain yellow	White
26	Rongpipi	Plain yellow and blue	Brick red

Source: Velayudhan *et al.* [18]

Samia canningi:

Samia canningi is a wild spacies of genus *Samia.* Unlike *Samia ricini*, *Samia canningi* is a uni, biand trivoltine wild eri silkworm [20]. The cocoon of *Samia canningi* bears peduncle and the cocoon is brown or chocolate brown in colour. The size and weight of cocoon, larva and pupa are small and less as compared to *samia ricini* but the wing spun of both male and female *canningi* moths are bigger than *Samia ricini* moths [21]. *Samia canningi* also have reported two strains *viz*., Greenish Blue Plain (GBP) and Greenish Blue Spotted (GBS) and both the races produce grey to dark brown coloured compact cocoons with peduncle [20]. *Samia canningi* mainly feed on *Ailanthus altissima*, *Prunus laurocerasus, Ligustrum and Syringa species*. Qualitative difference between *Samia ricini* and *Samia canningi* are shown below (table 2).

Table 2: Qualitative character differentiation of *Samia ricini* and *Samia canningi*

Morphological characters	*Samia ricini*	*Samia canningi*
Egg		
Colour of egg shell	White	Cream
Colour of yolk	Cream	Cream and Green
Larva		
Body colour	Yellow, Cream, Blue and Green	Green
Marking of Skin	Single spot, Double spot, Semi zebra	Single spot, Double Spot
Cocoon		
Colour of cocoon	White, red	Cream, Chocolate
Shape of cocoon	Flossy, No peduncle	Compact with peduncle
Moth		
Wing colour	Brown and black	Chocolate and greenish
Voltinism	Multivoltine	Uni, bi and trivoltine

Source: Singh *et al.* [20]

Muga Silkworm (*Antheraea assamensis*)

Muga culture an age-old traditional industry practiced for production of most costly silk called 'golden yellow muga silk'. It has immense potentiality for sustainable income generation among the rural folk [22]. *Antheraea assamensis* or muga silkworm is endemic and found exclusively in rain forest ecosystems of the Himalayan Foot Hill in North-Eastern India, especially in Assam and Meghalaya, due to their unique climatic conditions. Muga culture is of considerable economic importance and closely associated with the life, tradition and culture of the tribal people [5]. The muga silkworm is a semi domesticated, multivoltine insect with 5-6 generation per year. A part of its life cycle is completed under indoor condition (e.g. cocoon formation and pupal stage, egg stage, moth stage), while the other is under outdoor condition (e.g. larval stage) there are six broods produce each year (Table 3). Kotia and Jethua are the main commercial crops which are produced by pre-seed and seed crop season [23]. Muga silkworm had been domesticated from wildness for their lustrous golden silk fiber from ancient times. However both wild and cultivated population coexists in their respective habitat. Wild stocks have some distinct differences from the domesticated ones in many aspects like voltinism, food plants, morphology of larvae etc (Table 4) [24]. Different biotypes present in different parts of the region have been cultured in semi domesticated condition. Some important biotypes are Halflong green, Kokrapohia green, yellow mutant, wild hibernating type etc.

Table 3: Name of different crops of Muga according to Assamese calendar and their seasons

S. No.	Assamese Name	Season	Months	Remarks
1.	Jarua	Winter	December-February	Seed crop
2.	Chotua	Early spring	March-April	Seed crop
3.	Jethua	Spring	May-June	Second commercial crop
4.	Aherua	Early summer	June-July	Seed crop
5.	Bhodia	Late summer	August-September	Seed crop
6.	Kotia	Autumn	October-November	Main commercial crop

Table 4: Morphometric characters of muga silkworm (*A. assamensis*)

S. No.	Characters	Wild stocks	Cultivated (semi-domesticated)
1.	Voltinism	Bi/Multivoltine	Multivoltine
2.	Number of moults	4/3	4
3.	Food plants	Soalu/Dighloti	Som/Soalu
4.	Incubation period (days)	8-12	8-10
5.	Body colour	Black with yellow streak, Green	Black with yellow streak, Green
6.	Head colour	Light black	Brown
7.	Egg size (mm)	2.5-3.0x2.0-2.5	2.1-2.8x2.0-2.4
8.	Egg weight (mg)	8.36-9.33	5.83-9.83
9.	Larval duration (days)	22-50	22-45
10.	Mature worm weight (g)	9.0-14.0	8.5-13.5
11.	Cocoon colour	Light golden	Light golden
12,	Cocoon shape	Elliptical	Elliptical
13.	Cocoon weight (g)	4.5-8.55	2.90-7.70
14.	Shell weight (g)	0.60-0.96	0.18-0.65
15.	Filament length (m)	410-506	126-398
16.	Filament fineness (denier)	4-6	4-6
17.	Percentage of silk reelable	40-46	37-63
18.	Silk recovery (%)	42-55	40-42
19.	Fecundity (number of eggs)	235	173

Source: Sahu [25]; Tikader [26]

Tasar Silkworm (*Antheraea mylitta*)

Antheraea mylitta Drury is a semi domesticated Indian tasar silkworm exploited commercially for production of tasar silk. It is trivoltine, reared three times a year in July-August (Rainy cocoon crop), September-October (autumn cocoon crop) and November-December (winter cocoon crop). The silkworm is polyphagous feeding on a number of foodplants, of which Asan (*Terminalia tomentosa* W. & A.), Arjun (*Terminalia*

arjuna W. & A.) and Sal (*Shorea robusta* Gaertn.) are considered primary and the remainder secondary food plants ([27, 28]. The Indian tasar silkworm, *Antheraea mylitta* is a natural fauna of tropical India. It has a wide distribution range both within the country and beyond it. In India the range of distribution of the species covers- Himachal Pradesh, Sikkim, Assam, Meghalaya, West Bangle, Odisha, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Tamil Nadu and Pondicherry [29]. All together 44 eco-races of tasar silkworm *Antheraea mylitta* have been reported till date from 17 different states of India [30] out of the enlisted eco-races, only very few are known to exist in wild and being commercially exploited. They are Raily, Laria, Daba, Modal, Nalia, Sarihan. Besides eco-races like Sukinda, Bhandara and Andhra Local have become endangered and many other known to exist earlier might have extincted (Table 5).

Table 5: Eco-races of Tasar silkworm with their collection sites and their host plants

S. No.	Collection site	Eco-races	Host plants
1.	West Singhbum (Jharkhand)	Daba	*T. arjuna, T. tomentosa*
2.	Santhal Paragana (Jharkhand)	Sarihan,	*T. arjuna, T. tomentosa*
3.	Santhal Paragana (Jharkhand)	Munga	*Shorea robusta*
4.	Dhanbad (Jharkhand	Modia	*Shorea robusta*
5.	Peterbar, Hazaribagh (Jharkhand)	Laria	*Shorea robusta*
6.	Ranchi (Jharkhand)	Lodhma	*Shorea robusta*
7.	Ranchi (Jharkhand)	Palma	*Shorea robusta*
8.	Palamau (Jharkhand)	Japla	*Ziziphus jujuba*
9.	Palamau (Jharkhand)	Kowa	*Shorea robusta*
10.	Simdega (Jharkhand)	Barharwa	*Shorea robusta*
11.	Keonjhar (Odisha)	Modal	*Shorea robusta*
12.	Sundergarh (Odisha)	Nalia	*Shorea robusta*
13.	Sundergarh (Odisha)	Sukinda	*T. arjuna, T. tomentosa*
14.	Phulbani (Odisha)	Baodh	T. arjuna, T. tomentosa
15.	Simlipal (Odisha)	Simlipal	*Shorea robusta*
16.	Kalahandi (Odisha)	Omarkote	*Shorea robusta*
17.	Khairpali (Odisha), Beramkela (Chhattisgarh)	Sulky	*Shorea robusta Anogeissus latifolia*
18.	Bastar (Chhattisgarh)	Raily	*Shorea robusta*
19.	Kurudh (Madhya Pradesh)	Kurudh	*Terminalia tomentosa*
20.	Multai (Madhya Pradesh)	Multai	*T. arjuna, T. tomentosa*
21.	Mandala (Madhya Pradesh)	Mandalla	*Shorea robusta*
22.	Jhabua (Madhya Pradesh)	Jhabua	*Shorea robusta*
23.	Bhopalpatnam (Madhya Pradesh)	Bhopalpatnam	*Shorea robusta*
24.	Piprai (Madhya Pradesh)	Piprai	*Shorea robusta*
25.	Seoni (Madhya Pradesh)	Seoni	*Lagerstroemia parviora*
26.	Bastar (Chhattisgarh)	Janghbhir	*Shorea robusta*
27.	Korba (Chhattisgarh)	Korbi	*Shorea robusta, Terminalia spp.*
28.	Purulia (West Bengal)	Tira	*Lagerstroemia parviora*
29.	Bankura (West Bengal)	Bankura	*Lagerstroemia parviora*
30.	Dadar & Nagar Haveli (UT)	Dadar & Nagar Haveli	*Terminalia crenulata*
31.	Batote (J&K), Palampur (Himachal Pradesh)	Shiwalika	*Ziziphus jujube*
32.	Bhandara (Maharashtra)	Bhandara	*Terminalia arjuna, T. tomentosa*
33.	Karimnagar (Andhra Pradesh) Adilabad	Andhra Local	*Terminalia arjuna, T. tomentosa*
34.	Deoria (Uttar Pradesh)	Monga	*Terminalia arjuna, T. tomentosa, Ziziphus jujuba*
35.	Mirzapur (Uttar Pradesh)	Mirzapur	*Ziziphus jujuba*
36.	Sultanpur (Uttar Pradesh)	Sultanpur	*Terminalia arjuna, T. tomentosa*
37.	Sahabad (Rajasthan)	Tesera	*Ziziphus jujuba*
38.	Nowgong (Assam)	Nowgong	*Ziziphus jujuba*
39.	Boko (Assam)	NE1, 95	*Ziziphus jujuba, Careya arborea*
40.	Mendipathar, Resubelpara (Meghalaya)	NE2, 95	*Ziziphus jujuba, Careya arborea*
41.	Jiribam (Manipur)	Jiribam	*Ziziphus jujuba*
42.	Dimapur (Nagaland)	NG, 94	*Ziziphus jujuba*
43.	Moorkanparamba (Kerala)	KE 02	*Anacardium occidentale*
44.	Belgaum (Karnataka)	Belgaum	*Hardwickia binata*

Source: Alam *et al.* [31]

Table 6: Morphogenetic variability of Tasar eco-races

Stage	Character	Variatio
Egg	Colour	Creamy, white, brownish, bluish
Larvae	Body colour	Yellow, green, blue, almond
	Lateral tubercle colour	Dark violet, light violet, white
	Colour of dorsal shining spots	Brick red, white
	Prothoracic hood marking	Red, white
Cocoon	Colour	Dark, grey, light grey, yellow

Source: Alam *et al.* [31]

Mulberry silkworm (*Bombyx mori*):

The mulberry silkworm, *Bombyx mori*, is a domesticated and monophagous insect, which feeds only on the leaves of mulberry for its nutrition. The mulberry leaves mainly constitute proteins, carbohydrates, vitamins, sterols, phagostimulants and minerals. Such nutritional requirement in food consumption have direct impact on the all genetic traits such as larval and cocoon weight, quantity of silk production, pupation and reproductive traits [32]. Domestic mulberry silk moths are very different from most members in the genus *Bombyx*; not only have they lost the ability to fly, but their color pigment have also been lost. Mulberry silkworms can be categorized into three different but connected group or types. The major groups of silkworms fall under the univoltine and bivoltine categories. The univoltine categories found in the cold climate region, bivoltine categories are found in slightly warmer region and polyvoltine categories are found only in tropical region. Domesticated mulberry silkworms races can be divided based on three categories *viz.*, based on place of origine- Indian race, Japanese race, European race and Chinese race. Based on voltinism- univoltine, bivoltine and multivoltine, based on occurrence- indigenous and exotic race [33].

Other silk producing insect found in North-Eastern region of India

Besides these four kinds of commercially important silk producing insects (eri, muga, mulberry and tasar) some more kinds of silk producing insect which are not so important for commercial point of view are also found in North-Eastern region of India. They are mention below along with their distribution:

Genus	Species	Family	Distribution
Antheraes	*frithii*	Saturniidae	N.E. Region
Antheraes	*knyvett*	Saturniidae	N.E. Region
Antheraes	*roylei*	Saturniidae	N.E. Region
Antheraea	*pernyi*	Saturniidae	A.P., Manipur, Meghalaya
Antheraea	*helferi*	Saturniidae	A.P., Manipur, Nagaland
Antheraea	*compta*	Saturniidae	N.E. Region
Attacus	*atlas*	Saturniidae	N.E. Region
Attacus	*edwarsi*	Saturniidae	Meghalaya
Acteas	*selene*	Saturniidae	Meghalaya
Acteas	*leto*	Saturniidae	Meghalaya
Cricula	*trifenestrata*	Saturniidae	Assam
Cricula	*andrei*	Saturniidae	Assam
Leopa	*katinka*	Saturniidae	N.E. Region
Leopa	*anther*	Saturniidae	N.E. Region
Salassa	*lola*	Saturniidae	N.E. Region
Salassa	*megastica*	Saturniidae	Meghalaya
Salassa	*masosa*	Saturniidae	Meghalaya
Caligula	*zuleika*	Saturniidae	Khasi Hills
Caligula	*extensa*	Saturniidae	N.E. Region
Caligula	*simla*	Saturniidae	Meghalaya
Caligula	*cachara*	Saturniidae	Assam
Theophila	*religiosae*	Saturniidae	N.E. Region
Andraca	*bipunctata*	Saturniidae	N.E. Region
Ocinara	*diaphana*	Saturniidae	Meghalaya
Mustilia	*phaepara*	Saturniidae	Meghalaya
Samia	*kohlli*	Saturniidae	Arunachal Pradesh and manipur
Bombyx	*incomposita*	Bombycidae	Arunachal Pradesh, Meghalaya
Triuncina.	*sp*	Bombycidae	Arunachal Pradesh, Meghalaya
Triuncina	*religiosae*	Bombycidae	N.E. Region
Trilocha	*varians*	Bombycidae	N.E. Region
Andraca.	*Sp.*	Bombycidae	Arunachal Pradesh, Meghalaya
Norasuma	*javanica*	Bombycidae	Arunachal Pradesh, Meghalaya
Gunda	*ochracea*	Bombycidae	Arunachal Pradesh, Meghalaya
Gunda	sp.	Bombycidae	Arunachal Pradesh, Meghalaya
Ocinara	*bifurcula*	Bombycidae	Arunachal Pradesh, Meghalaya

Source: Kumar *et al*. [34]

Conservation need of sericigenous insects

Diversity of sericigenous insects needs to be conserved through well planned and sustainable use of natural resources. Proper eco-development measures and strategies for ecological restoration of degraded jhum fallows would be needed to ascertain the continued existence of the valuable entomofauna among other components of biodiversity [35]. Increasing urbanization, lopping of trees and lack of awareness about wild silk worms and their host plants among the local farmers are likely to result in local extinction of few species. Therefore, there is a need to initiate conservation awareness programmes for the local communities in the state by introducing the concept of silkmoth farming, the practice of which not only provides substantial economic gain to tribal people but also helps to conserve forests and regional biodiversity. Wild silkmoth farming (sericulture) as a cottage industry offers many advantages to poor communities, in that it requires minimal expenditure when compared with other agricultural endeavours; it is labour intensive and suitable to the rural farmer. Hence, efforts are needed to revitalize the age old tradition of non-mulberry sericulture especially in the tribal belts. Conservation of wild population of sericigenous

moths is much easier than that of domesticated ones provided it can be carried out in-situ [10]. Efforts should be made for enhancing *ex-situ* and *in–situ* conservation, protection and proliferation of wild silk moths along with other semi domesticated and domesticated silk insects through planned and collaborative efforts of state and central government industries. Seed production centers should be established in different areas of the state and attempts of cloning of food plants may help to conserve maximum diversity at species level. Knowledge of breeding system, biology and biological characters of the species is the pre –requisite for *ex-situ* conservation. Hence, characterization of seribiodiversity in Assam is the most essential need for conservation purpose [13].

Conclusion

North eastern states are the only place in world where all the four kinds of silkworm are found *viz.*, eri, muga, mulberry and tasar. Among these eri and mulberry are domesticated, muga is semi domesticated and tasar is completely wild in nature. Besides these other silk producing insects which are not so important in economical point of view are also found in north eastern states. Now a day's human population increases continuously and to fulfill the human needs forest land, natural resources are harm by human being which badly affect the habitat of sericigenous insect species. So we need to apply the methods of culturing the wild sericigenous insects before it conceive forest limitation. To culture the wild insects we need to conserved forest land areas by balancing there flora and fauna. We need to provide room for insects to multiply themselves in its preferable sites. The wild species are comfort in their zone while domestic and semi domestic species are comfortable in the provided favorable condition where they can adjust themselves up to certain level and develop generation after generation. Hence it is necessary to convey our heart towards the appropriate strategies so that it can uplift the sericigenous insects into huge numbers in different species and made this region as reknown hotspot in the world.

Reference

1. Wilson EO. The Diversity of Life. Harvard University Press, Cambridge, 1992.
2. Srivastava PK, Thangavelu K. Sericulture and Seri-biodiversity. Associated Publishing Company, New Delhi, 2005.
3. Ahmed SA, Ranjan RK. Exloration of *vanya silk* biodiversity in north eastern region of India: sustainable livelihood and poverty alleviation. In: International conference on Management, Economics and Social Sciences, Bangkok, 2011; 485-489.
4. Mangammal P. Performance of eri silkworm, *Samia cynthia ricini* Boisduval on artificial diet. M.Sc. (seri.) Thesis, UAS, Bangalore, 2008.
5. Kumar R, Rajkhowa G. Muga silkworm, *Antheraea assamensis* (Insecta: Lepidoptera: Saturniidae): rearing and insect predators. Conference: *Biodiversität und Naturausstattung im* Himalaya IV, At Erfurt, Germany. 2012; 4:187-194.
6. Saikia NJ. Supply chain linkages & constraints in natural silk sector of Assam:A study of muga & eri silk. Int. J. of Multidisciplinary Manag. Studies. 2011; 1:2249-8834.
7. Baruah AB, Duarah D, Chakraborty D. Performance of wild Muga silkworm (*Antheraea assama*). Int. J.Wild Silkmoths and Silk. 2000; 5:376-378.
8. Singh NI, Singh NI, Keisa T, Singh YR, Singh KC. Conservation and utilization of the Indian Oak fed *Antheraea* fauna. Int. J. Wild Silkmoth and Silk. 2000; 5:330-331.
9. Singh RN, Maheswami M. Conservation and utilization of sericigenous insects in north east region of India. *Sericologia*. 2003; 43(1):1-15.
10. Frankel OH. Can genetic diversity survive? In: R.B. Singh RM. Singh & BD. Singh (eds.) Advances in Cytogenetics and Crop Improvement. Kalyani Publication. New Delhi, 1982.
11. Peigler RS. Wild silks of the world. American Entomologist 1993; 39: 151-163.
12. Singh KC, Suryanarayan N. Wild silk moth wealth of India, 2005, 419.
13. Kalita T and Dutta K. Biodiversity of sericigenous insects in Assam and their role in employment generation. J. Ento. Zoo. Stud. 2014; 2(5):19-125.
14. Singh BK, Das PK. Prospects and problems for development of Eri culture in non-traditional states. In: Proceeding of Regional Seminar on Prospects and Problems of Sericulture: An Economic Enterprise in North West India, November Dehradun, India, 2006, 11-12,
15. Kumar R, Elangovan V. Assessment of the volumetric attributes of eri silkworm (*Philosamia ricini*) reared on different host plants. Int. J. Sci. Natur. 2010; 1(2):156-160.
16. Sharma P and Kalita JC. A comparative study on six strains of eri silk worm (*samia ricini;* donovan) based on morphological traits. G.J.B.B. 2013; 2 (4): 506-511
17. Sarmah MC, Ahmed SA, Sarkar BN, Debaraj Y, Singh LS. Seasonal variation in the commercial and economic characters of Eri Silkworm, *Samia ricini* (Donovan). Munis Entomology & Zoology. 2012; 7(2):1268-1271.
18. Velayudhan K, Balachandran N, RadhaKrishnan S, Singh BK, Jayaprakash P. Biodiversity in eri silkworm *Samia ricini* (DONOVAN) genetic resources and its conservation. J. Aquatic Bio. Fisheries. 2014; 2:817-824.
19. Peigler RA, Naumann S. Revision of the silkmoth genus Samia. University of Incarnate Word, San Antonio, Texas, 2003; 1-242.
20. Singh BK, Kumar R, Ahmed SA, Pathania PC. Diversity and their clarification on species of genus *Samia* (Lepidoptera: Saturniidae) in India and their Prospects for utilization. 2017; 30(1):43-52.
21. Brahma D, Neli S, Saikia P, Choudhury S, Dutta K. Morphological and productivity differences between *Samia ricini, Samia canningi* and their cross. Int. J. Env. Scie. 2011; 1:287-290.
22. Mech D, Das SC, Ahmed M. Comparative study of muga cocoon yield in improved and traditional practice. Int. J. Agri. Sci. 2019; 11(3):7818-7820.
23. Chakravorty R, Dutta P, Ghose J. Sericulture and traditional craft of silk weaving in Assam. Indian J. Traditional Knowl. 2010; 9(2):378-385.
24. Tikader A. *Cricula trifenestrata* Helfer feed on different host plants – A new report. Geobios. 2011; 38:151-155.
25. Sahu AK. Biodiversity of muga silkworm *Antheraea assamensis* Helfer. Present status and constraints of muga silkworm host plant germplasm conservation. In: Proceedings of the Workshop on Strategies for Maintenance of Non-Mulberry Silkworm and Host Plant Germplasm Held at Central Muga Eri Research &

Training Institute, Lahdoigarh, Jorhat, Assam, India on March. 2005; 10-11:77-87.
26. Tikader A. Feed performance of muga silkworm (*Antheraea assamensis* Helfer) on different host plants. Geobios. 2012; 39:104-108.
27. Jolly MS. Tasar Research Scientific Brochure No. 4, Central Tasar Research Station, Central Silk Board, Ranchi, 1966, 144.
28. Jolly MS, Sen SK, Ahsan MN. Tasar Culture, 1st Ed. Central Silk Board, Bombay, 1974; 266.
29. Arora GS, Gupta IJ. Taxonomic studies onsome of the Indian non-mulberry silk moths (Lepidoptera: Saturniidae). Memoirs of the Zoological Survey of India. 1979; 16:1-63.
30. Suryanarayana N, Srivastava AK. Monograph on tropical tasar silkworm. Central Tasar Research and Training Institute, Central Silk Board, Government of India, Ranchi, India, 2005, 1-134.
31. Alam K, Bhattacharjya D, Chowdhury T, Saha S, Kar PK. Biodiversity status and conservational requirements of tropical Tasar (*Antheraea mylitta* D.). Eco. Env. & Cons. 2018 24;(4):1887-1894.
32. Ramesha C, Anuradha CM, Lakshmi H, Sugnana Kumari S, Seshagiri SV, Goel AK *et al*. Nutrigenetic traits analysis for the identification of nutritionally efficient silkworm germplasm breeds. Biotechnology. 2010; 9:131-140.
33. Singh A, Kumar R. Sericulture Handbook. Biotech books. New Delhi, 2013.
34. Kumar R, Chutia P, Ahmed M, Rajkhowa G and Singh N. I. Checklist of wild silk moths of north east india (lepidoptera: saturniidae, bombycidae). *Mun. Ent. Zool.* 2016; 11(2): 508-514
35. Mohanty PK. Tropical Tasar Culture in India. Daya Publishing House, Delhi, 1998.