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BIODIVERSITY OF WILD SILKMOTHS IN NORTH EASTERN INDIA

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ABSTRACT

Northeast India constitutes a part of Indo-Burma biodiversity hotspot, an ideal home for many wild sericigeneous insects. Non mulberry silk moths are wild or semi-domesticated "charismatic fauna" which produce lustrous silk. Defferent species were collected and identified from different places in Northeast India.Of these, maximum species belong to the Genus *Antheraea*, followed by *Loepa*, *Samia*, *Bombyx*, *Actias*, *Attacus*, *Cricula, Dendrolimus, Lebeda* and *Rhodinia* etc. The distribution pattern of the species in hill (above 1000m ASL) indicates the species richness and more individuals than in the valley region (below 990m ASL). Many important genetic resources of sericigeneous insects may become extinct due to large-scale deforestation, threat from various pests and predators, soil and air pollution by chemical insecticides and adverse climatic change. Therefore, it's high time that efforts are made for proper conservation and population enhancement of sericigeneous insects for wild silk production, primarily for the upliftment of the tribals and to safeguard the rich biodiversity along with conservation of valuable genetic resources.

***Keywords*:** Wild sericigeneous insects, identification, distribution, and conservation.

Introduction

North East region of India is considered as the flora and fauna gateway for main Asian land to Indian Peninsula. North East India is one of the major and important hot spot among 35 biodiversity hotspots of the world. Due to unique climatic condition and varied topography, it occupies a distinct and diversified ecosystem, which becomes the natural abode for silk yielding silk moths of the world. It is the centre of seri-biodiversity because majority of the sericigeneous insects of India are available in north eastern India and the neighbouring areas of Himalayan region (Devi *et al.,* 2011). Wild sericigeneous insects not only yield valuable silk but also play an important role in the ecosystem, conservation, genetic resources and utilisation of biodiversity. The saturniids which include some of the largest and most spectacular species of all Lepidopterans are univoltine to multivoltine depending upon the climatic conditions and are distributed in both temperate and tropical region (Regier *et al.,* 2008). Majority of the wild silk moths belong to the family Saturniidae, that includes the largest Lepidoptera comprising of 2010 described species in 176 genera and nine subfamilies (Lemaire & Minet, 1998; Nässig *et al.*, 1996). Forty seven species were reported from India (Singh and Suryanarayana, 2005) and 24 species in Northeast India (Singh and Chakravorty, 2006). Wild silk moths play an important role in the conservation and utilization of biodiversity (Frankel, 1982; Peigler, 1993).

The exploration of wild sericigeneous or silk producing insects from Northeast India is reported by several workers (Thangavelu *et al*., 1987; Singh *et al*., 2000; Singh and Maheswari, 2003; Singh *et al*., 2008). However, detail and distribution information of these sericigeneous insects available in North East regions are meagre. Further, genetic resources are facing major threat due to rapid transformation of original vegetation and change of climate. It is essential to characterize, classify and document the status of these precious fauna species in the region. The conservation links genetic diversity for utilization, protection, habitat or ecosystem for human socioeconomic needs (Metzler and Zebold, 1995).Therefore, an attempt has been made to survey, collect, characterize and identify the sericigeneous insects and their host plants of North East regions to link their conservation with socioeconomic enhancement.

Materials and Methods

North Eastern region is a mixture of plain and mountainous states in the extreme border of Northeast India which lies between 20.59°N to 25°57N latitudes and 92°58'E to 94°45'E longitudes and constitutes a part of Indo-Burma biodiversity hotspot (Figure-1). This region has an area of 2,62,230 sq km and bounded by China in North, Bangladesh in south, Myanmar in East and Nepal in West. The topography of the state is characteristically hilly, showing rugged terrain broken by deep gorges and steep slopes at various places and plain areas. These regions manifest great ecological and biological diversity with terrain that ranges from tropical and subtropical forests to sparse alpine meadows.

A survey and collection of wild sericigeneous insects and their food plants were conducted at different states of North East regions in different seasons. The natural habitats and undisturbed forests areas were surveyed extensively to record the existence of wild silk moths, worms, cocoons and their host plants. During the survey, the tribal folk, farmers and private rearers were interviewed for gathering information on occurrence of wild sericigenous insects, host plants and attempts were made to rear the wild silk moths.

Fig. 1 : Map of North East regions of India

Results

North east India consists of eight states *viz.*, Assam, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Mizoram, Sikkim and Tripura. During the survey 28 different species were collected and out of which 23 species were identified from different states of North Eastern region. The distribution patterns of species in different states of North Eastern regions are shown in (Figure-2).

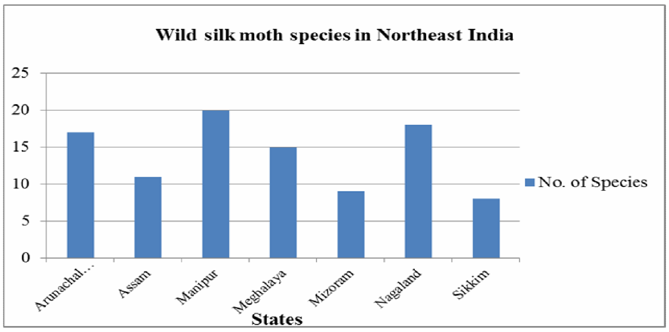

Fig. 2 : Distribution patterns of species in North East India.

During the survey, maximum species were collected from Manipur, Nagaland and Arunachal Pradesh while minimum species were collected from Sikkim and Mizoram states.

Twenty three species belong to three families- Bombycidae, Saturniidae and Lasiocampidae, under twelve genera, *Antheraea, Actias, Andraca, Archaeoattacus, Attacus, Bombyx, Cricula, Dendrolimus, Lebeda, Loepa, Rhodinia* and *Samia* (Fig. 3).

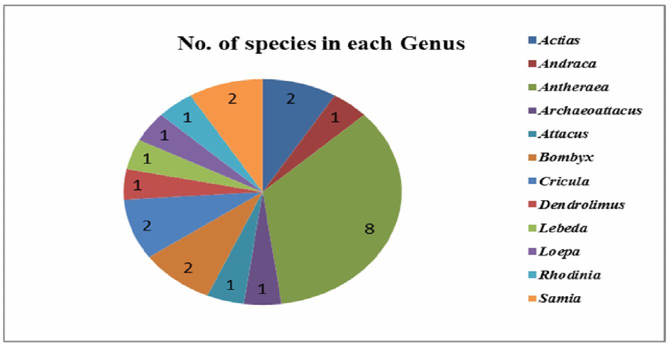

Fig. 3 : Composition of species in each Genus

Eight species belong to genus *Antheraea*, two species each to *Actias*, *Attacus*, *Cricula* and *Samia* and one each to *Actias*, *Andraca, Bombyx*, *Cricula, Dendrolimus, Lebeda* and *Rhodinia*. More than 25 different host plants were noted by diverse sericigeneous insects (Table-1).

Table 1 : Wild silkmoth and Host plant distribution in North Eastern region of India.

Silkworms	Host Plant	Distribution
Antheraea assamensis	*Persea bombycina, Machilus bombycina, Litsaea polyantha,*	North East States, West Bengal
A. mylitta	*Shorea robusta , Terminalia arjuna, Terminalia tomentosa*	Central India, South West India and Eastern India
A. pernyi	*Quercus alba, Q. macrocarpa, Q. lyrata, Q. falcata, Q. mongolica, Q. griffithii, Q.acuttisima, Q. robur*	China, Korea, North East States India
A. proylei	*Q. incana, Q. semicarpifolia, Q.semiserrata, Q. himalayana, Q.serrata, Q.acutissima and Q. grifithii*	North East States, Uttarkhand, Himachal Pradesh, J & K
A. yamamai	*Q. acutissima, Q. serrata, Q. semicarpifolia, Q. ruber and Q. turneri and Q. grifithii*	Japan, Korea.
Bombyx mori	*Morus alba, M. indica, M. nigra, M. levigata*	Mainly China and India (Distributed in 44 countries)
Samia ricini	*Castor,Ricinus communis; Kesseru, Heterpanas fragrans Ro; Ailanthus grandis, A. exels* Roxb.; Tobioca, *Manihot esculanta;* Payam, *Evodia flaxinifolia*; Gamari,*Gmelina arborea, etc.*	North East States, Orissa, Andhra Pradesh, Uttar Pradesh, Tamil Nadu

Maximum number of species occurrence was recorded on *Lithocarpus dealbata*, *Litsea polyantha and Ricinus communis*. The wild eri silk, *S. canningi* feeds on more than eight host plant species.

The occurrence of *R. newara*, *D. grisea* and *A. helferi* were reported for the first time from Manipur. *Dendrolimus grisea* is regarded as a pest of pine trees. The diapausing character of these wild silkworms in their natural habitat is an important feature and reflected in their seasonal incidence. The voltinism of the wild silk moths is varied, as *A. proylei* and *A. pernyi* are considered weak bivoltine. *Antheraea royblei*and *A. frithi* are bivoltine. Whereas *A. selene* and *S. canningi* are trivoltine. However, *Bombyx*. sp. (*var. Leimaren)*, *S. ricini* and *A. assamensis* are multivoltine in nature.

Morphometric Characterization:

The morphometric characters of the wild adult moths revealed a wide variation in colour, size and shape (Table-2). Antenna character is one of the important parameters for distinguishing male and female individuals. The antennae of male moths have broad fringe and female moths have narrow fringe except *S. canningi* both the sexes have broadantennae.

Attacus atlas is the largest moth having average wingspans of 215.16 mm in males and 221.61mm in females. The smallest average wing span is observed in *B. huttoni*as 35.47mm in male and 53.22mm in female (Table-2).

Generally, the cocoon weight of female is more than the male whereas the male shell ration is more than female. It was observed that the entire wild silkworm spins its cocoon on the host plants except *A. assamensis*. All the wild silk cocoons are single layered, except *A. roylei* that produces a double layered cocoon. *Cricula trifenestrata* is conspicuous by having perforated cocoon while others are compact. The cocoon of *Actias selene* shows perforation.

Table 2 : Morphometric characterization of wild adult silk moths (M±SD)

Sl. no	Species	Colour	Moth Wing span (mm)				
			Forewing			Hind wing	
			L (mm)	B (mm)	Total wing span	L (mm)	B (mm)
1	*Actias selene*	Bluish green, pink & Bluish green	83.94 ±1.77	41.8 7±1.58	169.11 ±6.83	74.73 ±2.14	39.40 ±1.34
2	*Antheraea assamemsis*	Deep brown & Light brown	53.35 ±3.61	29.27 ±1.68	106.70 ±7.23	32.91 ±2.53	21.56 ±2.84
3	*Antheraea compta*	Pale yellowish brown & Yellow	63.16 ±0.82	36.52 ±1.11	126.33 ±4.65	39.54 ±0.73	34.42 ±1.02
4	*Antheraea frithii*	Brick red & Light brown	70.10 ±3.05	39.65 ± 2.62	140.20 ±6.01	39.34 ±2.63	23.09 ±2.56
5	*Antheraea helferi*	Copper red & Yellow	72.01 ±1.20	36.75 ± 1.15	144.01 ±2.41	42.89 ±2.43	29.89 ±1.99
6	*Antheraea pernyi*	Camel brown	59.83 ±2.27	34.67 ±0.84	119.88 ±3.10	34.02 ±1.46	19.62 ±0.54
7	*Antheraea proylei*	Greenish brown	64.31 ±3.49	38.92 ±2.54	128.92 ±19.69	38.15 ±3.12	24.93 ±3.64
8	*Antheraea roylei*	Greenish grey	72.90 ±1.95	46.22 ±0.70	145.80 ±1.74	36.27 ±0.95	24.98 ±1.10
9	*aAttacus atlas*	Reddish brown	109.19 ±11.31	6.93 ±10.41	218.39 ±22.63	58.18 ±4.63	57.39 ±4.69
10	*Bombyx huttoni*	Blackish brown	22.18 ±1.06	10.74 ±1.30	44.35 ±2.11	13.02 ±0.90	7.05 ±1.04
11	*Bombyx* sp. ver. *leimaren.*	Dirty white & Dull white	17.71 ±0.79	8.67 ±2.04	35.42 ±1.61	11.03 ±1.11	6.12 ±0.77
12	*Cricula trifenstrata*	Metallic Yellow brown	36.74 ±1.51	25.39 ±0.77	50.78 ±1.54	26.92 ±1.05	23.39 ±1.03
13	*Dendrolimus grisea*	Brown	36.36 ±0.90	17.82 ±0.47	72.73 ±1.80	23.26 ±0.82	11.06 ±0.30
14	*Lebeda nobilis*	Whitish with spotted black	23.33 ±1.00	10.76 ±0.40	46.66 ±1.99	14.77 ±0.26	7.39 ±0.22
15	*Rhodinia newara*	Yellow & brown	60.33 ±2.78	35.00 ±0.57	120.66 ±5.56	36.90 ±0.41	26.85 ±0.60
16	*Samia canningi*	Greenish brown to pinkish white	53.87 ±3.78	38.49 ±3.11	107.74 ±7.56	48.63 ±1.10	34.00 ±4.27
17	*Samia ricini*	Creamish white	62.34 ±0.77	45.57 ±0.84	124.67 ±1.54	45.39 ±1.24	48.63 ±1.10

L=Length and B=Breadth

Table 3 : Economic parameters of wild silk cocoons

Species	Cocoon character							
	Colour	Shape	Length (mm)	Breadth (mm)	Cocoon wt. (g)	Shell wt. (g)	Shell ratio (%)	Peduncle (mm)
Actias selene	Light brown	Oval	58.65 ±1.57	28.25 ±1.04	7.02 ±0.20	1.02 ±0.18	14.56 ±2.13	33.63 ±1.22
Antheraea assamensis	Light brown	Oval	46.18 ±2.11	21.05 ±0.53	5.01 ±0.38	0.40 ±0.06	8.31 ±1.36	32.68 ±5.71
Antheraea compta	Yellow	Oval	40.59 ±2.58	17.92 ±0.95	3.69 ±0.49	0.33 ±0.05	9.65 ±0.60	68.06 ±17.78
Antheraea frithi	Greenish yellow	Oval	39.92 ± 1.10	20.05 ±0.63	5.62 ±0.50	0.72 ±0.15	13.52 ±2.08	68.67 ±26.02
Antheraea helferi	Light brown	Oval	46.95 ±2.02	22.46 ±0.71	7.75 ±0.94	0.85 ±0.15	11.15 ±1.73	56.73 ±18.79
Antheraea pernyi	Camel brown	Oval	42.04 ±3.31	23.64 ±1.37	6.07 ±1.30	0.72 ±0.18	11.85 ±1.15	50.52 ±8.04
Antheraea proylei	Greenish brown	Oval	45.36 ±3.22	24.18 ±1.55	6.77 ±0.94	0.67 ±0.21	10.11 ±2.34	68.51 ±34.62
Antheraea roylei	Creamish white	Oval	52.19 ±3.97	36.59 ±2.96	6.63 ±0.56	0.69 ±0.05	10.66 ±0.77	83.21 ±32.57
Attacus atlas	Light brown	Oval	74.34 ±3.49	29.99 ±1.59	10.31 ±0.41	1.26 ±0.07	12.26 ±0.44	95.37 ±39.25
Bombyx huttoni	Creamish yellow	Oval	27.81 ±1.12	12.46 ±0.70	2.01 ±0.17	0.22 ±0.04	12.78 ±1.21	NA
*Bombyx*sp. (var. *Leimaren)*	Golden yellow	Oval	36.47 ±1.65	14.37 ±0.61	1.36 ±0.19	0.21 ±0.03	15.62 ±2.49	NA
Cricula trifenestrata	Light brown	Oval	34.84 ±0.27	12.49 ±0.46	2.05 ±0.12	0.16 ±0.04	7.89 ±1.54	98.26 ±11.24
Dendrolimus grisea	Brown	Oval	61.29 ±6.17	17.78 ±1.11	3.43 ±0.51	0.27 ±0.03	7.96 ±0.79	NA
Lebeda nobilis	Creamish white	Oval	±	±	±	±	±	NA
Rhodinia newara	Green	Dumbbell with slid	45.47 ±2.00	31.82 ±0.98	5.49 ±0.67	0.66 ±1.15	11.91 ±0.77	70.37 ±24.49
Samia canningi	Light brown	Oval	35.60 ±3.16	14.38 ±0.39	2.90 ±0.35	0.39 ±0.35	13.38 ±1.31	97.12 ±22.84
Samia ricini	Creamish white	Oval	48.25 ±2.93	20.44 ±1.93	3.68 ±0.18	0.53 ±0.05	14.49 ±1.60	NA

Discussions

The Northeast is the natural abode of many wild sericigenous species that feeds on naturally grown plants. Saturniidae or wild silkmoths of the world was reported approximately 1861 species in 162 genera and nine subfamilies (Regier *et al*., 2008). In the present observations, 23 species belonging totwelve genera viz., *Antheraea, Actias, Andraca, Archaeoattacus, Attacus, Bombyx, Cricula, Dendrolimus, Lebeda, Loepa, Rhodinia* and *Samia* were recorded from North East. Thangavelu, (1991) reported nine species in three genera viz. *Antheraea, Samia* and *Attacus* in the sub-Himalayan region and Northeast India. Kakati and Chutia (2009) reported 14 species belonging to eight genera, *Antheraea, Attacus, Archaeoattacus, Actias, Cricula, Loepa, Samia, Sonthonnaxia* from the Nagaland. The total number of wild silk moth species collected in this study was more than those reported from the other state of Northeastern region. Among the silk moth species, the overall highest population was occurred with *S. canningi* except during the extreme severe winter months of December and January. Consistent availability indicated that it has high adaptability in the region, becoming a promising candidate that can be introduced as a promising species in future. The natural populations of *R. newara, A. helferi, A. roylei* and *A. compta* were scanty. If these species are not properly conserved at the right time, there are chances of wiping out certain species from this region. Hence, the urgent need is conservation and population multiplication of sericigenous species for silk production and scientific advantage.

Economic parameters of wild silkworm cocoons revealed the highest shell ratio in *A. frithi* (13.85%) indicating the highest silk content. The cocoon of wild silk moths indicated a promising future for novel silk with high economic value. The variability in qualitative and quantitative characters of the cocoon depends on the food plants used for feeding (Sharma *et al*., 1995). The filament length and reliability in the wild species *A. frithi* showed best and higher value than the commercially exploited oak tasar, *A. proylei* (Table-1). These observations provide additional evidence that *A. frithi*is the progenitor of the tropical tasar silkmoth (*A. paphia* = *A. mylitta*), which has been artificially selected for larger cocoons by humans for millennia (D'Abrera, 2012). The diapausing character of this wild silkmoth in its natural habitat indicated their adaptability during severe winters. India is the largest consumer of silks in the world, and consumers are increasingly interested in the wild silks fabrics, that have unique property. Raw silk reeled from *A. yamamai* is expensive and 40 times costlier than *B. mori* silk, because of its characteristically green colour and lustre (Akai, 1998). *Bombyx* raw silk is the most popular and best known textile material for high class fabrics, and it is well-known for its unique sheen. However, the wild silks of *A. yamamai* and *A. assamensis* are even shinier than *B. mori* silk (Akai, 2005). *A. assamensis* produces golden silk and its fabric is unique and expensive. Golden cocoon produced by *C. trifenestrata* is appreciated for its natural colour, though considered harmful insect. It has become a producer of high price silk in Indonesia (Akai, 2005). In West Africa, wild silkmoth fabric from various *Anaphe* and Epanaphe (Notodontidae) is highly valued for its special soft feeling and antibacterial function (Akai, 1998). Thus, the silk generated by wild silk cocoons have their unique identity and position in world commerce.

Conservation of this precious genetic resource would be imperative for breeding of better adaptability and more desired genotypes. Therefore, there is a need to begin conservation awareness program for the local communities in North Eastern regions of India by introducing wild silkworm farming. This practice not only provides substantial economic gain to tribal people, but also conserves the forest and regional biodiversity. Many important genetic resources of sericigenous insects may become extinct due to large-scale deforestation, threat from various pests and predators, soil and air pollution, chemical insecticides and adverse climatic change. Therefore, proper conservation and utilization of the wild silk moths are the need of the hour to boost the silk production, thereby helping in the conservation and utilization of biodiversity. The descriptive characterization of wild silk moths, cocoons and yarns will help in adopting conservation measures and selecting the prospective wild silk moth suited in the region.

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