A Field Survey Of The Silk Moths (Lepidoptera: Saturniidae) In West Siang District, Arunachal Pradesh And Threats To Their Population

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Abstract

A field survey on Saturniid moths in West Siang district, Arunachal Pradesh was conducted from September, 2013 to August, 2014. Adult moths were recorded using compact fluorescent light of 18 W operated with a 230 V rechargeable battery. A total of 12 species viz., *Attacus atlas* Linn, *Archaeoattacus edwardsi* White, *Samia canningii* Hutton, *Samia cynthia* Drury, *Actias selene* Hübner, *Actias maenas* Doubleday, *Actias parasinensis* Brechlin, *Antheraea assamensis* Helfer, *Antheraea frithi* Moore, *Loepa katinka* Westwood, *Cricula trifenestrata* Helfer and *Saturnia thibeta* Westwood were recorded. The population of the wild Saturniids was found very less with a record of only 20 wild adults, 100 larvae and 200 cocoons. Felling of host plants for timber, anthropogenic forest fire, indiscriminate collection of the adult moths and dominance of parasitoids were identified as threats to the wild population of the saturniids.

Key words: Eastern Himalaya, Saturniid, Wild, Host plant, Threats

Introduction

The giant silkmoths (Lepidoptera: Saturniidae) possess bipectinate antennae, coloured large "eyespots" and often translucent areas on their wings and are well known for the silk. Though primarily tropical, comprising over 3719 species, the Saturniids has worldwide distribution (BOLDSYSTEMS, 2014). Available literature from Indian subcontinent enlisted only around 50 species from the region extending from Himalaya to Srilanka and 24 species from north-east India (Nassig *et al.*, 1996; Singh and Chakravorty, 2006). However, published survey of Saturniid moths in Arunachal Pradesh is very incomplete (Chandra and Sambath, 2013; Sondhi and Kunte, 2014).

Therefore, the objectives of the work were focused on documenting the moths of family Saturniidae from West Siang district, Arunachal Pradesh and to identify the threats to the population of these species. The district comprises diverse habitats extending from the temperate lower altitudinal foothills to cold higher altitudinal foothills of the Himalaya with important vegetation patterns including the tropical evergreen, tropical semi-evergreen forest, mixed-moist deciduous forest, subtropical evergreen, temperate broad leaved evergreen, subalpine, alpine scrub, pine forest, rhododendron forest, riverine forest (Singh *et al.*, 2002). Moreover, muga *(Antheraea assamensis)* culture is also practiced in som *(Persea bombycina)* plantations of the low altitudinal foothill areas of the district. For this reason, the district was chosen for the present study.

The studied area falls in the easternmost state of Eastern Himalaya lying between 26°30′ N and 29°28′ N latitude and 91°31′ E and 97°30′ E longitude, within the Himalaya biodiversity hotspot of the world which has a remaining vegetation of 185,427 km^2 compared to original extent of 741,706 km^2 (Chatterjee, 1965; Conservation International, 2014). The hotspot is also drawing the attention

of the naturalist due to the presence of 3160 endemic plants, 4 endemic threatened amphibians, 8 endemic threatened birds, 4 endemic threatened mammals and human population density of 123 per km^2 (Conservation International, 2014). However, with the exception of a few studies that have documented the Himalayan lepidoptera (Haribal, 1992; Mani, 1986), little else is available on the insect fauna of the region.

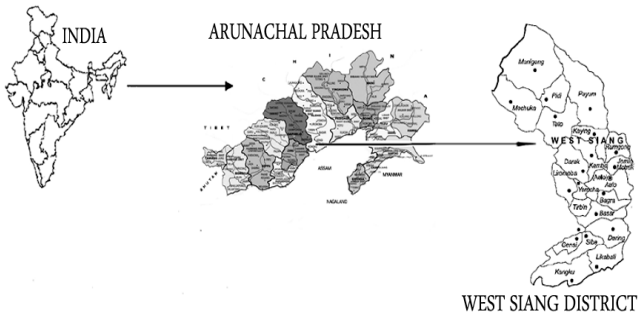

Fig 1. West Siang district and its location.

Materials and methods

Sampling and identification: The field survey was conducted from September, 2013 to August, 2014 in West Siang district of Arunachal Pradesh to document the Saturniid moths and the threats to their population. Adult moths were recorded through survey using compact fluorescent light of 18 W operated with a 230 V rechargeable battery against a background of white sheet of cloth from 7 to 9 pm. Moths were collected with sweep net and were identified with the available literature (Hampson, 1894-96; BOLDSYSTEMS, 2014) and their current nomenclature is based on Beccaloni *et al.* (2003).). After identification, moths were released to their native habitat without any damage with the objective to conserve their biodiversity. Villagers were also interacted for guidance during site selection for sampling.

Study area: West Siang district (Fig. 1) was situated at an altitude of 200-4900 m MSL. The area receives an average annual rainfall of 3000 mm. Air temperature ranges from 5°C to 38°C in foothills and plains whereas it varies from below freezing point to 25°C at higher reaches (IMD, 2013-2014).

Results

Twelve species of saturniid lepidopterans belonging to 8 genera viz., giant atlas moth, *Attacus atlas* Linn 1758; Edward's atlas moth, *Archaeoattacus edwardsi* White 1859; wild eri silk moth, *Samia canningii* Hutton 1860, eri silkmoth, *Samia cynthia* Drury 1773, Indian moon moth, *Actias selene* Hübner 1807; Malaysian moon moth, *Actias maenas* Doubleday 1847; Western Chinese moon moth, *Actias parasinensis* Brechlin 2009; wild as well as semi-domesticated strains of *Antheraea assamensis* Helfer 1837, giant tasar moth, *Antheraea frithi* Moore 1859; golden emperor moth, *Loepa katinka* Westwood 1848; three windowed cricula moth, *Cricula trifenestrata* Helfer

Table 1. Species of Saturniid moths and their numbers recorded.

Sl. No.	Name of the Species	Month	No. of moths recorded		No. of cocoons /larvae recorded
			Male	Female	
1	*Attacus atlas* Linnaeus	September	01	0	0
2	*Archaeoattacus edwardsi* White	September	0	01	0
3	*Samia canningii* Hutton	September		02	0
4	*Samia cynthia* Drury	Annual	Domesticated strain		
5	*Actias selene* Hübner	August	01	01	0
6	*Actias maenas* Doubleday	August	02	0	0
7	*Actias parasinensis* Brechlin	August	02	0	0
8	*Antheraea assamensis* Helfer (semi-domesticated strain)	Annual	Semi-domesticated strain		
	Antheraea assamensis Helfer (wild strain)	August	01	01	0
9	*Antheraea frithi* Moore	April, September	03	02	200 cocoon
10	*Loepa katinka* Westwood	November	01	0	0
11	*Cricula trifenestrata* Helfer	January	0	01	100 larvae
12	*Saturnia thibeta* Westwood	September	01	0	0

1837 and higher-Himalayan emperor moth, *Saturnia thibeta* Westwood, 1853 in the studied area of Arunachal Pradesh (Table 1, Fig. 2).

During the study soalu *(Litsea polyantha)*, dighloti *(Litsea salicifolia)*, bonsom *(Phoebe goalparensis, P. hainesiana)* and gonsorai *(Cinnamomum glaucescens, C. cecicodaphne)* were recorded as host plants of wild strain of *Antheraea assamensis*; giant crape-myrtle *(Lagerstroemia speciosa)* was recorded as host plant of *Antheraea frithi* and castor *(Ricinus communis)* and keseru *(Heteropanax fragrans)* were recorded as the host plant of *Samia canningii* in wild habitats.

Morphological characters the adults of the silk moth species as observed in field condition are presented herewith:

Genus *Actias* Leach, 1815

This genus is best defined by the long anal tail like extension of the hind wing.

Indian moon or luna moth

***Actias selene* Hübner, 1807**

Wing span- 130-166 mm

Male: Body white with pink coloured legs. Prothorax with a dark pink band. Fore wing very pale green, white at base. Costal band dark pink. Sub-marginal line is wavy. Eyespot with an inner dark brown and outer pale brown-pinkish lunule covering a brown coloured spot at the centre.

Female: The outer margin less excised than that of the male. The yellow markings are less developed. The ante-medial line of fore wing lies nearer to the base while that on hind wing is absent. Eyespot with inner dark pink crescent mark that covers the rest three quarter whitish area. Tail like extension of the hindwing shorter than male.

Malaysian moon moth

***Actias maenas* Doubleday, 1847**

Wing span -158-172 mm

Male: Collar pink. Thorax and abdomen blotched with pink above. Fore wing pink at base. Antemedial band broad. Lunule ochreous (moderate yellow-orange to orange colour) with dark brown mark inside. Lunule extends from the costal band to the lower angle of cell. Afterwards, lunule pointing inwards. Two pink postmedial diffused wavy lines. Dark pink blotches one at the anal angle and the other near apical angle of forewing. Hind wing with the antemedial band narrower than on fore wing. Waved postmedial line present. Tails longer, broader and all pink except the spatulate end.

Female: Pink blotches on thorax and abdomen absent. Wings without the broad pink markings. Fore wing with a nearly erect antemedial line. A waved postmedial line is seen which may be slightly developed. Both wings with a marginal pink hue. Tails broad and only pink at middle.

Western Chinese moon moth

***Actias parasinensis* Brechlin, 2009**

WS- 75-100 mm

Male: Body yellow with legs dark pink. Prothorax with a dark pink band. Fore wing bright greenish yellow. Costal area with dark pink band. Eyespot with an inner dark brown and outer pale brown-pinkish lunule covering a brown coloured spot at the centre. A dark pink coloured almost triangular mark extends from the costal band pointed towards the eyespot and touches it distinctly. Antemedial line slightly wavy. Postmedial line pinkish and wavy. Sub-marginal band dark grey, broad and diffused.

Anal angle of hind wings produced into tail like extension. Sub-marginal band distinct and brighter. Hindwing ocellus V-shaped.

Female: Body and fore wing pale green. No antemedial line. The wavy greenish sub-marginal band diffused.

Genus *Attacus* Linn, 1766

Forewing postmedial is convex. The apical area of the forewing excised and rounded. Hind wing rounded.

Giant atlas moth

***Attacus atlas* Linn, 1758**

WS- wingspan 224-250 mm

Body red-brown, legs brown. Basal segment and abdomen pale and each segment with a pale fringe. Fore wing with costa brown. Basal area gray, tinted with red and edged by red, pale and black coloured band, curved from the costa to median nervure, then oblique to near base of inner margin. A large triangular hyaline area appears at end of discoidal cell

with a rounded black edge. One hyaline oval shaped area above it touch the postmedial line. The post-medial line is red flanked by inner white and outer brown band. Sub-marginal area yellowish and tinted with red-brown. Apical area yellow with pink shade. The membrane below the costa is crimped and suffused outwardly with gray and ends in a black spot. Single marginal band is yellow-brown with a highly waved black line on it.

Hind wing similar to fore wing. The antemedial line is nearly straight. No streak above the hyaline triangular mark. The postmedial line angled towards inner margin but not curved. Apical area not variegated. A series of black spots appears within the black sub-marginal line which is less waved.

Genus *Archaeoattacus* Watson, 1914

Forewing postmedial is concave.

Edward's Atlas moth

***Archaeoattacus edwardsi* White, 1859**

WS- 250 mm

The first segment of the abdomen white. Paired dorsal and longitudinal white segmental streaks appear from the third segment to the extremity. Two lateral and two ventral white lines appears on the abdomen. Forewing is dark-brown in colour. The ante-medial line is outwardly oblique to the middle of the wing and then bent back to the base of the wing. The triangular hyaline spot is edged with yellow-brown and is not touching the postmedial line. The postmedial line is white and broad. The sub-apical streak is black and short and a black spot appears at end of crimped membrane. A prominent wavy white line appears between these spots. The marginal band is yellow at the apical region and brownish behind. Within the marginal band is a wavy dark brown line.

The black spots on marginal band of the hind wings are much larger.

Genus *Samia* Hubner, 1819

Striking display of pink, brown and olive tone in the adult.

Wild eri silk moth

***Samia canningii* Hutton, 1860**

WS- 136-144 mm

Collar and metathorax fringed with white. Paired dorsal and longitudinal white segmental streaks appear from the third segment to the extremity. Two lateral and two ventral white lines appears on the abdomen. Wings yellowish brown. Forewing with a white antemedial line, outwardly oblique from the costa to vein 2, which then bent back to the base of the inner margin. A narrow lunule on the discocellulars, inwardly fuscous, outwardly yellow. A post medial fuscous, white, pink and pinkish white band, generally curved and angled at the lunule. A white and dark ocellated mark in the apical area and with a waved white line from it to costa. Marginal line gray. Sub-marginal area white. Hindwing similar, the antemedial line oblique and not angled.

Eri silk moth

Samia cynthia Drury, 1773 **(Domesticated)**

WS- 100-116 mm

Abdomen covered with white fur. Wings are more darker than that of *canningii*. Ante-medial line more angled and generally joins the post-medial band. The lunules much shorter. The post-medial band fuscous (of any of several colors averaging a brownish gray) replacing the pink, generally more curved and angled at the lunule. A white and dark ocellated mark in the apical area and with a waved white line from it to costa. Marginal line gray.

Hindwing similar, the antemedial line oblique and not angled.

Genus *Antheraea* Hubner, 1818

Fore wing with the costa incurved near base, excurved towards apex, which is rounded. Outer margin highly excised. Hind wing rounded.

Giant tasar moth

***Antheraea frithi* Moore, 1859**

WS- 134-170 mm.

Male: Reddish or yellowish. Costa is brown. Large rounded transparent ocellar mark edged with brown and blackish mark outward and brown, white and pinkish inward. Two post medial reddish wavy line, the outer being darker. The sub-marginal line of the hind wing lies much nearer to margin. No marginal yellow line.

Female: Bright yellowish in colour. Sub-marginal band less-wavy and broadens at the apical area. A crescent shaped arc arises from the middle position of costa. The trasparent ocellated spots are larger than in the male.

Muga silk moth

***Antheraea assamensis* Helfer, 1837**

Semi-domesticated strain

WS- 120-140 mm

Male: Ochreous brown to dark chestnut brown in colour. The ocellus of the forewing entirely yellow or inner margin of the ocellus with a black spot, rest yellow. Post medial line not waved nor so much curved. Forewing tips sharply curved. Hind wing rounded. The inner margin of the ocellus with a black spot, rest yellow.

Female: Sub-marginal line of both wing grey. Sub-marginal area pale brown.

Wild strain

WS- 150-170 mm

Moths are larger in size compared to the domesticated strains. Wings are more yellowish and brighter. Black spots on the inner margin of the ocellus are darker and more distinct. White areas of the wings more conspicuous than the semi-domesticated strains.

Genus *Loepa* Moore, 1858

Golden emperor moth

Loepa katinka Westwood, 1848

WS- 90-124 mm

Bright yellow. Fore wing with the costa gray, suffused with brownish gray. Single sub-basal line is more or less angled and pink. A large rounded or oval ocellus is located at end of cell, which is pinkish brown, containing white and black lunulate marks. The post-medial line is highly wavy and dark. Two gray coloured sub-marginal lines, the inner angled below the costa and the outer terminates in a black spot, above which is a pinkish patch on the costa, edged exteriorly with white and pink. A series of pale lunules are present almost marginally. Hind wing differs from the fore wing in the ante-medial line being further from the base, narrow and dark. The sub-costal patch and spot absent.

Genus *Cricula* Walker, 1858

Fore wing with the costa evenly arched. Outer margin highly excised. Hind wing rounded.

Three windowed cricula moth

***Cricula trifenestrata* Helfer, 1837**

WS- 62-92 mm

Adults are brown, ochreous, yellowish, or reddish in colour and with three irregularly shaped hyaline spots on the fore wing.

Genus *Saturnia* Schrank 1802

Forewing with the costa evenly arched. The apex is rounded. The outer margin is slightly excised. Hind wing rounded. Tarsi naked.

Higher-Himalayan emperor moth

***Saturnia thibeta* Westwood 1853**

WS- 124-146 mm

Body gray-brown. Ante-medial line of the forewing is inwardly oblique. Eyespots are with black spot at the centre and a crescent shaped white mark. Triangular area from the below half of the ante-medial line is pale brown with two highly wavy lines. Sub-marginal area is dark brown with two highly wavy lines. A black oval shaped eye spot between the wavy lines near apical area. A white band separates the marginal and sub-marginal areas.

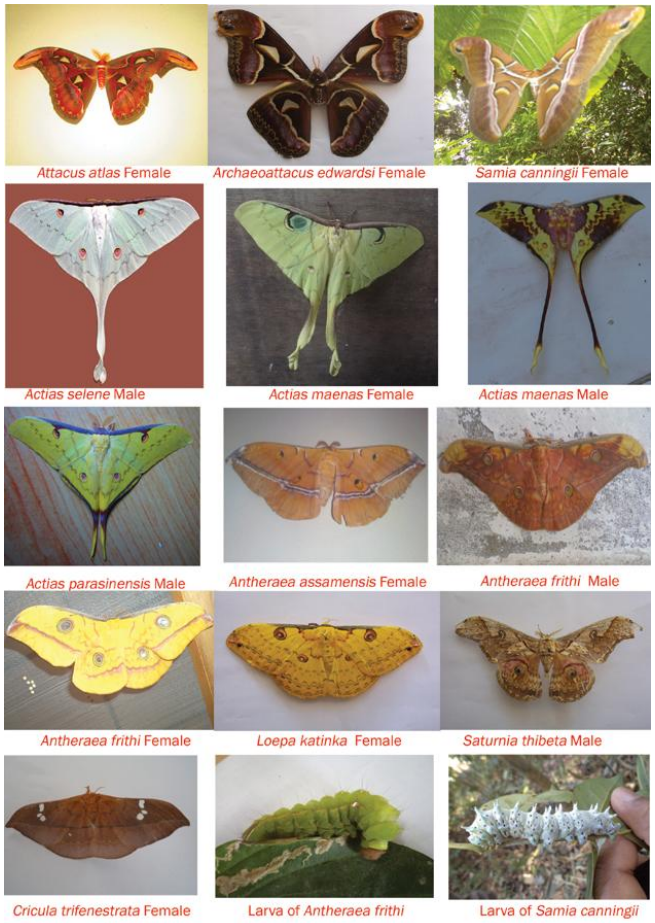

Fig 2. Wild Saturniid moths in West Siang district, Arunachal Pradesh.

Large eyespot at the middle of the hindwing. The eyespot has black spots at the centre on the upper side of which is a brown crescent shaped mark bordered with white area. Below of the black centre are brown area and a black crescent shaped mark. Brownish-gray crescent shaped mark surrounds half of the eyespot. Base of the hind wing and the outer area near the eyespot is pinkish. Hind wings are provided with one post-medial and two sub-marginal wavy dark brown lines. Sub-marginal area is dark brown followed by white marginal band.

Threats to the population of wild Saturniids

The population of the wild Saturniids recorded in the present study was found very less with a record of only 20 wild adults, 100 larvae and 200 cocoons. While trying to study the possible threats to these populations, we have identified the felling of bonsom *(Phoebe goalparensis, P. hainesiana)* and gonsorai *(Cinnamomum glaucescens, C. cecicodaphne)*, host plants of wild strain of *Antheraea assamensis* for timber, anthropogenic forest fire, indiscriminate collection of the adult moths and dominance of parasitoids as major causes of population decline.

During our study in the natural habitat we encountered 200 cocoons of *Antheraea* frithi. Out of these, 198 cocoons possessed the emergence slits of hymenopteran parasites and we have recorded only single hymenopteran parasitoid, Ichneumon fly *Xanthopimpla pedator* inside some of the cocoons. Similarly, more than 200 larvae of uzi fly were found dropping on the ground from three newly spinned cocoons of *A. frithi*.

Another possible major factor causing threats to the survival of the wild silkmoths recorded was the anthropogenic forest fires lighted with an objective to clear the forest for shifting cultivation or without any reasons as revealed by the interaction with the local personnel.

Discussion

During the present study, 12 species of Saturniid moths (Table 1) were recorded from West Siang district, Arunachal Pradesh. The presence of these species may certainly be due to (i) the diverse topography in the Himalayan mountain region that favour the growth of different types of host plants and helps to escape from the predators, (ii) favourable climatic condition (rainfall, humidity, temperature and wind) and (iii) favourable microclimatic variations on and around the host plants resulting from the variations in precipitation and solar energy receipt due to different aspects of steep slopes that increases the growth and survival of different life stages these insects.

Earlier, Seitz (1933) recorded 19 species of wild sericigenous insects from the entire north eastern India including Sikkim. During later period Chowdhury (1983) reported 10 numbers of species while, Thangavelu (1991) reported 9 species of sericigenous insects from this region. Among the northeast Indian states, 14 species of wild silkmoths were recorded in Nagaland and Manipur, 11 species in Mizoram and 12 species in Assam by Kakati and Chutia (2009), Devi et al. (2011), Lalhmingliani et al. (2014) and Kalita and Dutta (2014) respectively. The presence or success of an organism or a group of organisms depends upon complex conditions. Any alteration of the condition, particularly temperature, rainfall, fire, prevalence of predators and parasites and deforestation which approaches or exceeds the limits of tolerance of these insects may affect their distribution or existence. Light, temperature and rainfall are ecologically important environmental factors on land. In all the environments, the chemical nature and cycling rates of basic mineral nutrients are basic considerations. Besides these physical factors, biological factors especially the host plants and the natural enemies are just as important in controlling the actual distribution and abundance of organisms in nature (Odum, 1996). The north earstern states, posses almost similar species composition of the sericigenous insects. This may due to the occurrence of similar type of forest patterns like the temperate broad leaved forest, tropical semi-evergreen forest and conifer forests and the similar climatic conditions. However, slight variation in diversity of the sericigenous insects may occurs in different parts of the region due to variation in

forest patterns like tropical evergreen forest prevalent in Arunachal and Assam, tropical moist deciduous forest distributed in strips along the foothills of Himalayas and due to microclimatic variations (Joshi *et al*., 2006).

As presented in the result, the population of the wild Saturniids recorded in the present study was found very less and were recorded rarely. This may be due to the density independent biotic factors, the hymenopteran and dipteran parasites as recorded in this study. Most of species were recorded in the months of August and September after rain. This may be due the favourable temperature, rainfall and humidity during these period that may induce their diapause eggs or cocoons to the active state or it may be due to synchrony of their life stages with the host plant leaf phenology, particularly the deciduous host plants like *L. speciosa* in which new, soft foliage appears after the rain. In such cases, as found in this study, both the larvae of *A. frithi* and the leaves *L. speciosa* matures simultaneously, an evolutionary adaptation of most of the insects (Russell and Louda, 2004).

Though, the plants like Rhododendron *(Rhus semialata)*, Birch *(Betula alnoides)*, Schima *(Schima wallichii)*, *Canarium resiniferum, Barringtonia asiatica, Citrus hystrix, Citrus spp., Averrhoa carambola, Macaranga hyeni, Macaranga denticulata*, *Maesa indica*, Ailanthus *(Ailanthus altissima)*, *Ailanthus integrefolia*, kasha holly *(Ilex chinensis)*, privet *(Ligustrum ovalifolium)*, poplar *(Populus cilata)*, cherry *(Prunus triflora), willow (Salix), oak (Quercus lamellosa), Cissus discolor, C. quadrangularis, Saurauia roxburghii, S. nepaulensis (Actinidaceae)*, *Dillenia indica, D. pentagyna (Dilleniaceae), Vitis himalayana, Mangifera sylvatica, M. indica, Machilus bombycina,M. globusa, M. villosa, Ziziphus mauritiana, Z. nummularia* and *Ligustrum ovalifolium* etc. were listed as host plants of wild silk moths in earlier literature and were recorded from the region, during the present study, these plants were not recorded utilizing by the larvae of silk moths as food resource (FSI, 1998, Singh *et al*., 2002, Robinson *et al*., 2010).

As evident from the explanation of the local people on the rich abundance of the plant species like bonsom *(Phoebe goalparensis, P. hainesiana)*, mezankori *(Litsea cubaba)* and gonsorai *(Cinnamomum glaucescens, C. cecicodaphne)*, host plants of wild strain of *Antheraea assamensis* and the wild silkmoths 30-40 yeas back and decline of the number of these plants and the moths to near extinction from the wild habitat in the region at present, it may be assumed that over-utilization due to wood cuttings may cause scarce presence of the wild strain of muga silkworm *(A. assamensis)* and other wild silkmoths in the studied area.

Among the biotic factors that may threaten the population of the wild silk moths was the dominance of the natural enemies of the silkworm which were recorded. As presented in the result, 99% cocoon damage by the hymenopteran parasitoids was recorded during the present study, while Bhatia and Yusuf (2013) has recorded 14.52% pupal mortality of *A. mylitta* due to the parasitoid *X. pedator* alone. Peigler (1994) catalogued 350 parasitoid species from 175 species of Saturniids. However, we have not recorded any dipteran parasitoid in our present study.

Another possible major factor causing threats to the survival of the wild silkmoths are the forest fires. As explained by the local people, the fires were lighted with an objective to clear the forest for shifting cultivation or sometimes without any reasons behind. Pupa is highly apparent and sessile stage of the Lepidopteran insects and is the most prone stage to forest fire. Hence, the forest fire may damage the cocoons of the wild silkmoths in the region resulting in complete eradication or loss of these insects from a particular locality.

Besides these factors, the Saturniids also suffer from their popularity, as the young collectors are seemed to be attracted for their size, colour and beauty. This may result in decrease of the population due to collection of virgin female moth before egg laying, which we have recorded in our study as well as alteration of sex ratio may become a barrier in continuing their next generation.

Brood of *A. assamensis* is known to degenerate after one or two generations in plain. To eliminate this limitation, muga seed producers invite wild male moths by tying the virgin females on stick for natural hybridization in order to infuse vigour to the next generation larvae (Tazima, 1958). Therefore, if the threatening processes prevail, these will not only cause extinction of these Saturniids from the region, but will also create problem to the existence of the muga silk industry of Assam and its adjoining areas. Hence, the traditional muga silk industry will suffer a lot if wild eco-strains of *A. assamensis* have to be extinct from the wild of the region.

The semi-domesticated eco-strains of *Antheraea assamensis* has been recorded from five som *(Machilus*

bombychina) farms in West Siang district of Arunachal. Though *Litsea polyantha*, another host plant of *A. assamensis* was found widely distributed in the studied area, we have not recorded the presence of the insect in these host plants and not found utilizing for rearing the insect.

Similarly, we have recorded wearing of cloth made from eri *(Samia cynthia)* silk by the Nyishi people in traditional Nyokum festival and found utilizing the larvae and pupa of the insect as food widely. However, though selling of the insect was a common scene in the market, rearing of the insect was recorded very rarely in spite of the availability of the host plant castor *(Ricunus communis)* and keseru *(Heteropanax fragrans)* in the wild.

From the study, we can conclude that threats to the population of host plants of wild silkworms, anthropogenic forest fire, collection of moths and natural enemies are the major factors for low population and rare occurrence of the wild Saturniids in the region. Therefore, creating awareness about values of the natural silk, the scope of rearing these insect in the region, conservation of host plants and the adverse effects of the specimen collection is the call of time for the region to conserve and population increase of these economically exploitable insects harnessing of which can be a good source of income generation for rural livelihood.

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