SERICIGENOUS INSECTS

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Abstract

Silk is nature’s gift to mankind and a commercial fiber of animal origin other than wool. Being an eco-friendly, biodegradable and self-sustaining material; silk has assumed special relevance in present age. Silk producing insects are commonly referred to as sericigenous insects. Silkworm is a common name for the silk-producing caterpillar larvae of silk moths. Silk moths belong to Phylum - Arthropoda, Class - Insecta, Order - Lepidoptera, Super family - Bombycoidea. Bombycoidea comprises eight families of which only Bombycidae and Saturniidae are the two important families, the members of which produce natural silk. A mulberry silkworm is a domesticated variety which has been exploited for over 4000 years. Generally the term silk refers to mulberry silk, because it contributes to 95 per cent of world silk production. A large number of species (400-500) are used in the production of non mulberry silks. But only eight have been commercially exploited in Asia and Africa tribal communities. They are Tasar silk, Muga silk, Eri silk, Anaphe silk, Fagara Silk, Coan silk, Mussel silk and Spider silk. The continuous deforestation resulted in depletion of non-mulberry food plants. One should not forget that non-mulberry sericulture holds great pledge for the world forestry as a supplementary activity.

Keywords: Silk Producing Insects, Mulberry, Eri, Tasar, Muga, Anaphe, Fagara, Coan, Mussel, Spider, Wild Silk.

Introduction

Silk is the most precious and beautiful textile fiber and is regarded as the ‘Queen of Textiles’. India occupies the second position in the world raw silk production next to China. Production of raw silk in India during the year 2015-16 (April to November- 2015) has been 19,070 MT in which, mulberry and Vanya raw silk output amounts to 12,954 MT and 6,116 MT, respectively. (CSB report, 2015-16). Silk has unmatched structure, softness and rich appearance. Even today, no other fabric can match it in luster and elegance. It is so fine that a kilometer long thread would weigh only a quarter of a gram. It has good dye ability,
durability and draping qualities. As a natural fiber, it is very light, elegant, smooth and beautiful luster. Silk may be defined as ‘Yarn reeled’ from the cocoon spun by the caterpillars of silk producing insects.

Silks are produced solely by arthropods and only by animals in the classes Insecta, Arachnida, and Myriapoda. Collectively, insects produce many different types of silk proteins, although individual species produce only one type. Spiders also produce a variety of silks, but in contrast to insects, an individual spider may produce as many as eight different types of silk thread. Nevertheless, the purposes for which insects and spiders use silks are similar. The silks produced by myriapods are uncharacterized.

Non mulberry silk moths are wild or semi-domesticated “charismatic fauna” which produce lustrous silk and exhibit a great range of variation in life history from egg to adult with characteristically different physiological, morphological and feeding parameters. Fairly good numbers of references are on record about seri-biodiversity and their potential as a source of natural silk in Indian subcontinent (Srivastava and Thangavelu, 2005). India is second largest producer of wild silk in the world. The wild Indian silks like Tasar *Antheraea mylitta*, Muga *A. assamensis*, Eri *Philosamia ricini* are well known in the world as far as rearing technology is concern (Kavane, 2014). The wings of many species of the wild silk moths are variously and differently marked and coloured making these lepidopterans strikingly beautiful (Shangpliang and Hajong, 2015).

The sericigenous insects are the insects which produces silk of economic value. The mulberry silk moths 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 Jolly, (1985), Jolly *et al.* (1976), Singh *et al.* (2000), Singh and Maheswami, (2003) and Thangavelu, (1991). The wild silk moths play an important role in the conservation and utilization of biodiversity as reported by Frankel (1982), Peigler (1993; 1999) and Kioka (1998). Among the various wild silk moths reported in India only four are commercially exploited for production of silk (Jolly *et al.*, 1976). At present many important genetic resources of wild silk moths are facing major threats due to large area of forest under shifting cultivation (Sharma, 1997).
Types of silk

Silk is a fibrous protein of animal origin. A number of animals secrete silk which is used by them for anchorage (muscles), entangling their prey (spiders), or forming a protective sheath with or without other material (Lepidopteron cocoons). Nearly 400-500 species are known to produce silk but only very few are commercially exploited. They are mulberry silk, Tasar silk, Muga silk, Eri silk, Anaphe silk, Fagara silk, Coan silk, Mussel silk and spider silk. Mulberry silk is the finest followed by Eri, Tasar and Muga. Mulberry silk also has the highest density, indicating a relatively more compact structure compared to the non mulberry silk fibers. Wild silks are duller and have a more coarse hand and texture. The cross section of mulberry silk is near triangular whereas the cross sections of all the non mulberry silk fibers are near rectangular (Gupta et al., 1999).

India is the only country in the world which is producing all the four varieties of silk viz., Mulberry, Tasar, Eri and Muga. It has the world monopoly for Muga, a golden yellow silk, produced mainly in the state of Assam. Singh et al. (2000) reported on the exploration of wild sericigenous or silk producing insects from North-eastern India.

Mulberry silk

Nearly 95 per cent of the commercial silk comes from the mulberry silkworms Bombyx mori. Mulberry silkworm is a holometabolous insect and passes through four morphologically different stages in its life cycle egg, larva, pupa and adult. The silkworm larval life is divided into five instars, separated by four moults. Mulberry silkworm is a monophagous insect. There are over 20 species of mulberry, of which four are common: Morus alba, M. indica, M. serrata and M. Latifolia.

Tasar silk

Important species of silk insects exploited for Tasar silk production are:

a. Tropical Tasar – Antheraea mylitta (India)
b. Temperate Tasar - A. proylei (India)
c. Chinese Tasar- A. pernyi (China & Russia)
d. Japanese Tasar- A. yamamai (Japan)

The tasar silk constitutes nearly 95 per cent of the global production and is produced in China, India and Japan. The Indian Tasar worm is polyphagous and feeds on Asan, Sal and Oak. The tasar silkworms are reared in the tropical and temperate zones. The Tasar cocoon,
unlike the *Bombyx mori* is very large, measuring 5 x 3 cm and is generally oval in shape. The cocoons have hard and long peduncles with a ring at the end. The weight of the cocoon varies from 7 to 14 gm according to variety, season, food plant etc. The filament length varies between 800 m to 1500 m with a denier of 5 to 13.

**Tropical tasar**

These are in dense, humid tropical forest of central and southern plateau of India. The major cocoon-producing districts are Singhbhum and Santhal Pargana in Bihar, Raigarh and Jagdalpur in Madhya Pradesh; Mayurbhanji and Keonjhar in Orissa; Purulia and Bankura in West Bengal; Bhandra in Maharashtra; Adilabad, Warangal, Karimnagar, Khammam, Mahaboobnagar, Visakapatnam of Andhra Pradesh; Belgaum in Karnataka. *A. mylitta* feeds on *Terminalia* and produces a special type of silk. Cocoon is single shelled, pendent, oval, closed and reelable, non-flossy with fine grains. The anterior end has dark brown peduncle with a ring at the distal end. Cocoons are yellow or grey. The primary food plants of tropical tasar is *Terminalia tomentosa, T. arjuna, Shorea robusta, Roxb., Lagerstroemia parviflora, Roxb., L. Speciosa, Pers., L. indica, Linn., Zizyphus mauritiana, Lam., Hardwickia binata* Roxb.

**Temperate tasar**

The oak tract extending from Jammu and Kashmir in the West to Manipur in the east, embracing Himachal Pradesh, Uttar Pradesh, West Bengal, Sikkim, Assam, Arunachal Pradesh, Meghalaya, Mizoram and Nagaland inhabits the temperate tasar silkworm. The food plant is oak plant. There are five species in temperate tasar. *A. proylei*, Jolly; *A. roylei*, Moore; *A. pernyii, A. yamamai*, Guerin Meneville; *A. polyphemus*, Cramer. The primary food plants of temperate tasar are *Quercus incana, Q. Serrata, Q. delabata, Q. himalayana, Q. semiserrata*.

**Muga silk**

The Muga silkworm is present only in the North-Eastern region of India. Muga silk is obtained from the cocoon of silk insect belong to the species of *A. assamensis* (India). The host plants play an important role in production of quality silk (Borgohain, 2015). The Muga silkworm primarily feeds on Som (*Persea bombycina*) which is an aromatic non deciduous tree with alternate leaves that are varying size and shape;
besides this Soalu (*Litsea polyantha*) also the primary host plants while Dighloti (*Litsea salicifolia*) and Mejankori (*Litsea citrata*) is the secondary host plants of this silkworm (Bhattacharya *et al.*, 1993; Tikader and Rajan, 2012). These plants are abundantly distributed in Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura due to availability of favourable climate.

Muga culture is closely related with the culture and heritage of Assam (Tikader *et al.*, 2013). The cocoon is golden or light brown in appearance, 4.5-6 cm long by 2.2 to 2.7 cm broad with rudimentary peduncle. Each cocoon is composed of a single continuous filament of about 350-400 meters in length and a denier of 4.5. The popular items made from this silk are ‘dhoti’, ‘chaddar’, ‘chapkan’, ‘pugree’ and ‘mekhala’. Commercial rearing is practiced in Sibsagar, Lakhimpur, Nowgong, Darrang and other districts.

If the larvae are fed on mejankori leaves (*Litsea citrate*), *A. assamensis* produces mejankori silk. This silk is very much admired for its durability, luster and creamy white shade. The muga reeling and weaving are done at Sualkuchi village.

Cricula trifenestrata: Like Muga, it also spins golden coloured silk of high value (Akai, 2005).

**Eri silk**

Eri silk is obtained from the silk insect *Samia cynthia ricini*. Eri is also produced in India and to a lesser extent in some parts of Burma and Africa. The eri silkworm feeds mainly on *Ricinus communis* (Caster oil plant). Other important secondary food plants are *Heteropanax fragrans*, Seem; *Manihot utilissima*, Phol; *Carica papaya*, L; *Evodia faxinifolia*, Hook; *Ailanthus excelsa*, Roxb.

Eri silkworm spins open mouthed cocoons and the filament is not continuous. Therefore the Eri cocoons can only be spun and not reeled. The adult moths are allowed to emerge and only the pierced cocoons are used for spinning purposes. The white or brick – red eri silk (endi, errandi) is produced by *Philosamia ricini*, B. a domesticated multivoltine silkworm. It is widespread in Assam and also practiced in Bihar, West Bengal, Manipur, Orissa and Tripura. Among the non-mulberry varieties, eri has the disadvantage of higher production costs because it is made from domesticated silkworms.
Anaphe silk

Anaphe silk is produced by species of the genus Anaphe, in the Southern and Central Africa and is used in velvet and plush. It is more elastic and stronger than mulberry silk. The species spin cocoons in communes or groups. The fluffy material is spun to produce Anaphe silk. It is distributed in intertropical regions of continental Africa (Nigeria, Uganda, Cameroon, the Congo and Togo). The important species used in the production of anaphe silk are *A. infracta*, Walsingham; *A. venata*, Butler; *A. panda*, Boisduval; *A. reticulate*, Walker; *A. carteri*, Walsingham; *A. moloneyi*, Duce and *A. ambrizia*, Butler. The Anaphe are polyphagous. So far twenty two food plants are recorded (*Albizzia fastigiata; Sterculia tragacantha; S.setigeri; S. rhinopetala* etc., are found in Nigeria and *Bridelia micrantha; Cynometra alexandri; Triumfetta macrophylla* are in Uganda).

The anaphe silkworm is univoltine and undergoes diapause at the pupal stage. The silkworms from the cocoons communally, the cocoon is large nest like (spun by 1000 worms) weighs about 3.5 kg. Generally 12-100 worms collectively spin cocoon for about 4 months. These cannot be reeled and looks like mulberry 7 cocoons.

*Eucheria socialis*: Like Anaphe, it also spins cocoon in commune and thus known as social insect (Akai, 2005).

Fagara silk

*Fagara* silk is produced from the pedunculate cocoons of the giant silk moth *Attacus atlas* inhabiting in the Indo-Australian bio-geographic region, China and Sudan. Ahmed (2013) recorded the natural incidence of the saturniid wild silk moth, *Attacus atlas* L. feeding on “Tree of Heaven”, *Ailanthus excelsa* Roxb. plantations at Jorhat, Assam, India. The incidence of the wild silk moth recorded throughout the year with peak incidence during May-October. The average cocoon weight was 14.11g and 10.29g for male and female, respectively. The average shell weight of single cocoon recorded 2.04 g and 1.84 g for female and male, respectively which is five times more than shell weight of domesticated Eri silkworm, *Samia ricini*.

The caterpillar of *Attacus atlas* is quite polyphagous and reports suggested that it feeds on a variety of leaves including *Muntingia calabura, Annona murricata, Cinnamomum verum, Nephelium lappaceum, Psidium guajava, Sandoricum indicum, Citrus sp.*, *Cinchona officinalis* (Cinchona tree), *Cinnamomum camphora* (camphor laurel), *Coffea arabica* (Arabica coffee), *Curcuma longa* (turmeric), *Elettaria cardamomum, Persea americana*
(avocado), *Litsea polyantha* (Soalu plant) and other evergreen trees (Ahmed, 2013). Over 100 plant species belonging to 90 genera in 48 families as host plants for *Attacus* spp. have been reported (Peigler, 1989). The presence of *Attacus* in mangrove habitats, stating that *A. atlas* occurred once on *Avicennia alba* Bl. (Avicenniaceae) and simultaneously with many other trees and it occurred at low levels on *Bruguiera gymnorrhiza* (L.) Lamk. (Rhizophoraceae) has been reported (Murphy, 1990). The rearing of the fagara silk moth *A. atlas* was done on *T. catappa* under indoor rearing condition. *A. atlas* completed its life cycle from egg to adult within 62 days. Incubation period, larval (Six instars), and pupa period 10 days, 27.5 days 25 days respectively (Kavane, 2014).

**Indian moon moth silkworm**

Indian moon moth, *Actias selene* (Hubner) a wild sericigenous insect is widely distributed in western Maharashtra. A total of 29 species of host food plants have reported from India. The most dominant species of *A. selene* food plants were *Rhizophora* sp., *Terminalia arjuna*, *T. tomentosa*, *Hibiscus* sp., and *Prunus amygdalus*, etc. Rajadurai and Thangavellu (1998) studied the life cycle of *Actias selene* and reported that *A. selene* was distributed widely all along the mixed forests plants such *Terminalia arjuna*, *T. tomentosa* and *Zizipus* spp.

Indian moon moth silkworm is not reared in indoor rearing condition, in spite of good rearing potential and conducive climate of western Maharashtra, moon moth culture business is neglected totally from western Maharashtra. Several workers (Arora and Gupta, 1979; Nissig and Peigler, 1984; Rajadurai and Thangavellu 1998; Kavane, 2010; Kavane and Sathe 2011) have attempted the work related to Indian moon moth silkworm in India.

**Coan Silk**

Coan silk is used to make the crimson-dye and apparel worn by the dignitaries of Rome is produced by the larvae of *Pachypasaeotus* found in the mediterranean region. This silk has now remained as a historical importance of Italy, Greece, Romania, Turkey, Israel, etc. where the ancient people used to rear it on pine trees (*Pinus cipress*) and the fabric produced by this silk was used by dignitaries during auspicious occasions. The silkworm producing this silk is *Pachypas* with two species namely; *P. otus* D. and *P. lineosa* Vill.
Mussel Silk

This is a non-insect silk. The byssus threads (filamental structures) of the mussel *Pinna squamosal* are spun into silk called fish wool in Italy. Mussels attach to the substratum by means of a byssus, which is an extracellular, collagenous structure secreted by the foot and is composed of three distinct parts (Brown, 1952). Root which is embedded in the byssus gland at the basal region of the foot and links the entire structure to the byssus retractor muscles, the stem which extends outwards from the root and supports each byssal thread, and the byssal threads which extend from the stem in many directions and attach to the substratum. Typically, 20–60 byssal threads are involved in tethering an animal to its substratum (Bell and Gosline, 1996).

Spider silk

The silk secreted by some spiders including *Nephila madagascarensus* and *Miranda aurentia* is used to produce spider silk. Though not exploited in textile industry, spider silk is used to produce the cross bars in optical instruments. The spider webs can take a variety of forms but the most common type is the orb web. Different families of spiders like *Araneus*, *Nephila* builds orb web and other families of spiders construct tangle and sheet webs (Jensen et al., 2005). Orb web spiders invest little energy in searching the prey and majority in silk synthesis and construction of the webs.

Spider dragline silk is Nature’s high performance biopolymer and is tougher than the best synthetic materials made by man. It is thought that spider webs have good clotting properties due to the fine size of its threads and that it also could have bactericidal properties. In order to function as a potential biomaterial, biocompatibility is obviously an important prerequisite, and *in vivo* studies have shown that spider silk is biodegradable and evoke a comparable defense reaction as materials routinely used in surgery. Orb-web weaving is characteristic of species in two lineages of spiders: Araneoidea and Deinopoidea. Silks from orb-web weaving spiders are produced in opisthosomal (abdominal) glands that through a secretory duct connect to modified setae called spigots, which in turn are located on reduced abdominal appendages, the spinnerets.
Conclusion

The natural silks are broadly classified as mulberry and wild or non mulberry. Non-mulberry sericulture is universally known as forest or wild sericulture. Tropical and temperature tasar, eri, muga and anaphe are the principle non-mulberry silks. Other varieties i.e., fagara, coan, mussel and spider silks are limited interest, nearly 95% of the global production of non-mulberry silk is tasar. Non-mulberry sericulture is a forest-based industry uniquely suited to the economy and social structure of developing countries because of its minimum investment requirement, high employment, and foreign exchange earning potential. So, an attempt has to be made to conserve the wild silk moths and their host plants from deforestation with protect the extinct species of silk producing insects and provide more importance to the bio-diversity.

References