ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

STUDY ON THE CONSERVATION OF BIODIVERSITIES & GENETIC EVOLUTION OF TASAR SILK WORM ANTHERAEA MYLITTA D. (SATURNIIDAE: LEPIDOPTERA)

Dr. Md. Tahfizur Rahman 1st a++*,
Dr. Soma Rani Kolay 2nd a# and Dr. Shagufta Nigar 2nd a++

ABSTRACT

Tassar Silk, often referred to as wild silk, comes from the **Antheraea moths**. It is of two types: Tropical and Temperate.China is the largest producer of Tassar silk in the world followed by India. China produces only Temperate Tassar silk while India has got distinction in producing both tropical and temperate varieties. India is the only country where Tropical Tassar silk is produced. Tasar Silk has short and coarse fibre and is hence firm. This makes the Tasar Silk a wrinkle-free fabric. Less shimmery than Mulberry Silk, Tasar has a dull gold or copper sheen and is difficult to dye. Therefore, the silk is available only in its natural colour. Oak Tasar Silk, another fine variety of Tasar, is obtained from the cocoons of Anthrarea proyeli that feed on leaves of wild oak trees. Oak Tasar Silk is commonly produced in India.

Keywords: - Antheraea mylitta, tasar silkworm, sricin fibroin and sericin, Tropical tasar silkworm, genetic diversity of tasar silkworm.

Corresponding authors (dr.tahfiz@gmail.com ; Dr. Md. Tahfizur Rahaman Assistant Professor at Millat College LNMU Darbhanga Bihar India)

INTRODUCTION

Commonly known as wild silk, Tasar is obtained from Antherarea moths that feed on the leaves of Arjun and Asan plants instead of Mulberry trees. It is however processed in the same way as the Mulberry Silk. The resultant fabric is light-weight and airy, which makes it well suited for warmer climates. There are more than 500 species of wild silkworms in India however, only a few are commercially viable to produce silk. Unlike the mulberry silk, which is produced as one long thread, the wild silk is produced in the batches, by cutting the threads at irregular intervals.

Wild silk is also difficult to dye and bleach. However, several modern processes such as demineralization have emerged that remove the mineral reinforcement in the cocoon and can produce similar sheen as the mulberry one. India is the second-largest manufacturer of mulberry silk after China. The major mulberry silk producing states in India are West Bengal; Andhra Pradesh, Karnataka, Jammu and Kashmir and Tamil Nadu.The silkworms are bred indoors and remain on the strict diet of white mulberry trees.

a P.G Department of Zoology, Millat College, LNMU, Darbhanga, India.
++ Assistant Professor;
 # Associate Professor;
*** Corresponding author: E-mail: dr.tahfiz@gmail.com;**

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

VARITIES AND DIVERSITIES OF SILK

Tassar Silk

Tassar Silk, often referred to as wild silk, comes from the **Antheraea moths**. It is of two types: Tropical and Temperate.China is the largest producer of Tassar silk in the world followed by India. China produces only Temperate Tassar silk while India has got distinction in producing both tropical and temperate varieties. India is the only country where Tropical Tassar silk is produced. Mostly tribal people are engaged in the production of Tassar cocoons,which are used, as raw material for production of silk. Out of the total tribal population of about 38 million nearly 30 million (77%) are located in Tasar cultivating states of tropical (25.67 million) and temperate (4.23million) belt. However, 13.2 and 1.32 lakh tribals are engaged in Tassar silkworm rearing in tropical zone. The Basic Tasar Silkworm Seed Organisation (BTSSO) was established by the Central Silk Board in the year 1998-99 with the objective to strengthen the Tassar silkworm seed sector by vitalizing three-tier seed multiplication system on scientific lines. The headquarters of BTSSO is in Bilaspur (Chhattisgarh) and there are 23 nested units.

WILD SILK TYPE

Instead of mulberry leaves, the wild silkworms or moths eat oak leaves and produce wild silk. It is heavier and has an uneven, rough texture to it.Commercially, this silk is also known as tussar silk. It is naturally available in dark brown or grey colour and dyed later for the desired shade. There are four types of tussar silkworm varieties in India namely Indian tusser silkworm (AntheraeamylitteDury), Japanese tussar silkworm (AntheraeayamamaiQuerin) and Chinese tusser silkworm (Antheraeapernyi Guerin). The types of silk produced by these silkworms are as different as chalk and cheese.

MULBERRY SILK TYPE

Bombyx mori silkworms are domesticated silkworms. They feed on mulberry leaves only and the silk produced by them is the finest of them all. The silk has an extraordinaire sheen and has the signature ‘silky’ texture, silk is known for. It is also the most common of silk fabric and currently dominates the world silk market with more than 80 per cent share. It is the highest quality of silk available in the market for purchase. The history of mulberry silk can be traced back to Indus Valley Civilisation, where it was used to craft costumes of the royal family. The original white colour of the mulberry silk is due to the feeding of the host white mulberry plant.

ERI SILK TYPE

Eri silk is produced by the silkworm species called Philosamiaricini. The silkworms are found in Northeast India and in some parts of Japan and China. The term, ‘Eri’ comes from the Assamese word, ‘Era,’ which means castor or arandi in Indian language, referring to their

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

feeding on castor oil plant leaves. Besides Bombyx Mori, this is the only silkworm species that is completely domesticated. In China, the Eri silkworms feed on a different host plant called Borkesseu, Ailanthus excelsa and the silk thus produced is called Ailanthus silk.
The texture of this silk is woolly and the original colour of the silk is white. When the eri silk is processed without killing the silkworms, it is called the silk of peace, referring to its white colour. In India, it is commercially sold as 'Ahimsa Silk' as the silk fabrics are processed when the moths have left the cocoon.

MUGA SILK TYPE

Muga silk is produced only in Assam and nowhere else. This makes this silk yarn one of the most coveted and rarest silks in the world. The word, 'Muga' means 'golden yellow' in Assamese, referring to its original colour. The origin of the Muga silk can be traced back to the times of Ahom rulers. The rulers patronized this silk and preferred to wear clothes made from muga silk fibres only. It is one of the most expensive too! The silkworm, Antheraeaassamensis is semi-cultivated. It is believed that the silkworm can't even tolerate the slightest of pollution level and is extremely sensitive to climate changes.
Muga silk is known for its resilience. Besides being organic and natural, it is known for its longevity and often is a part of an heirloom. The lustre of the silk increases with the age and the silk gets finer, like old wine. The muga silk is preferred in its natural yellow colour but it is compatible with dyes and embroidery threads. Muga silk can be ironed damp for a smooth feel or can be worn with wrinkles and creases with equal panache.

The exquisiteness of muga silk can be guessed from the fact that more than 1,000 cocoons are needed to produce 125 grams of silk fibre. For one six-yard muga silk saree, more than 1,000 grams of silk is needed. When you order one muga silk saree, it takes at least two months to cultivate the silkworms and then, two weeks to complete the weaving of the saree. In Assam, the Garo community cultivates the silk and provides the fabric to the weavers.
Apart from these silk fibres mentioned above, these are a few exotic and rare silk fibres available all across the global.

SPIDER SILK TYPE

The spider silk is said to be the next big thing in fashion. It is said to be five times stronger than steel and even more tensile than an elastic band. It is also speculated that the spider silk as strong as the toughest man-made polymer, Kevlar. The spider silk is essentially a protein fibre that the spiders use to spin a web, catch prey, and suspend themselves in air, to float through or even glide away from predators.
It is very expensive and as per an estimate, it can come with a price tag of $40,000 per kilogram. However, it is not commercially viable yet as unlike silkworms, it difficult to farm spiders. Besides, every single spider produces a different type of silk.

SEA SILK TYPE

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

Sea silk is derived from a clam. It is one of the much rarer and most expensive silk fibres that come from now a protected species. There is only one woman, Chiara Vigo, who dives into the sea, harvests it and spins it. This sea silk is also known as byssus, which is also mentioned on the Rosetta stone. It is believed that God told Moses to lay this sea silk on the first altar. It is considered to be the finest fabric in Egypt, Rome and Greece. The sea silk fibre is treated with spices and juice initially. After the treatment, the silk just shines and glistens in the sunlight.

The sea silk fibre comes from the solidified saliva of Pinna Nobilis and is considered sacred. It is believed to bring good luck, prosperity, fertility and blessings of God. It is not for sale commercially and Vigo never makes a penny for it. She does it for the kids, newlywed couples and people who are outcast and in dire need of a miracle from God.

TYPES OF SILK ON THE BASIS OF SILK YARN

Silk Blends

Silk blends are derived from mixing silk with other fibres. The silk blends are the best of both worlds! They have the lustre, sheen and wonderfully smooth texture of silk minus the reactive properties and maintenance issues of silk. Some of the much-liked silk blends are:

Cotton Silk

A blend of cotton and silk, cotton silk is a synergy of positive characteristics of these two fibres. It is lightweight, comfortable and silky. A fabric that comes with the versatility of silk and comfort of cotton, a piece of fabric that has the matte side of cotton and shine of silk! The silk-cotton blend can be washed manually at home.

Silk Wool

Silk wool is a blend of wool and silk fibre. This blend is lightweight, has better moisture absorption and is wrinkle resistant minus the scratchiness of pure wool. The blend is used for bridal lingerie, home décor and high-end sportswear. This blend is highly durable and gives a crisp fit. The bodice of silk wool is very popular among celebrities and brides.

Art Silk

Art silk or artificial silk a synthetic fibre that resembles silk for its sheen but is basically rayon as a functional alternative to silk. However, it is not as durable or elegant as silk. It is also called bamboo silk or viscose. The imitation silk can be made with mercerized cotton, polyester or rayon. The famous Banglori silk is actually polyester that has silk-like sheen but actually is a cheap and fake version of silk.

DIFFERENCE BETWEEN GENUINE SILK AND ARTIFICIAL SILK

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved**, **UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023**

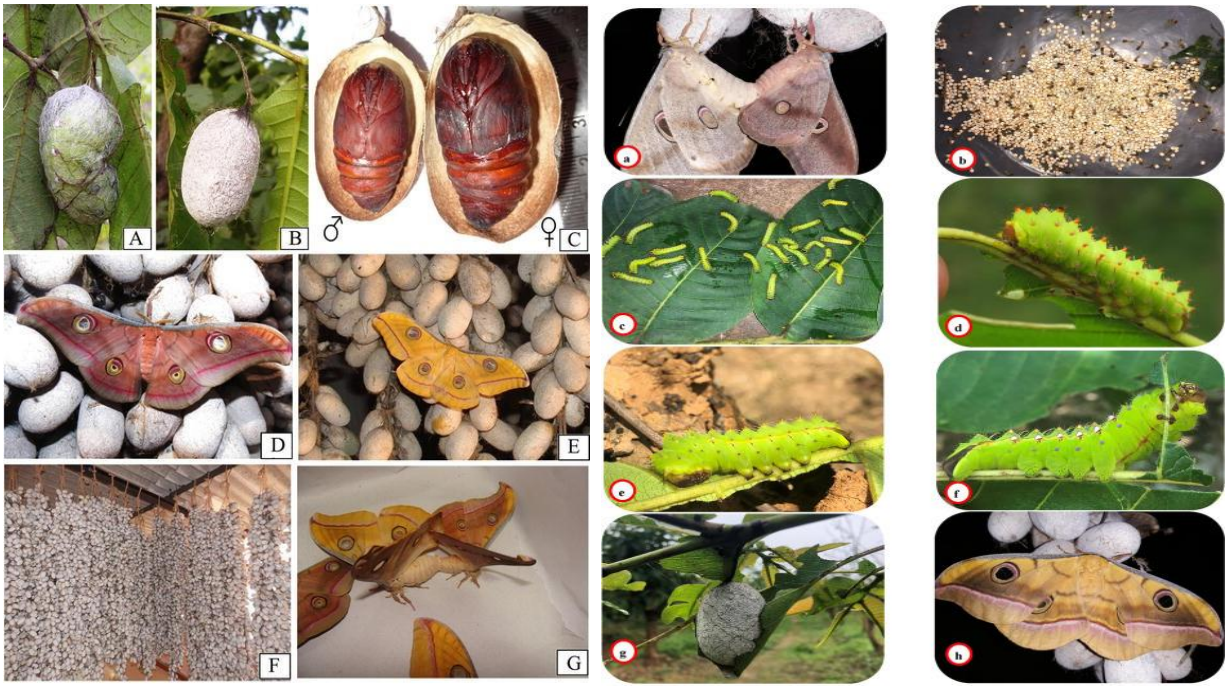
The sheen itself bears testimony to the authenticity of silk. Besides, the pure silk sarees come with Silk Mark India Certification by the Government of India. You can rub a handful of it together to determine the fabric makeup of the drape and assess the smoothness of the silk.

TYPES OF SILK ON THE BASIS OF GEOGRAPHICAL INDICATION

A geographical indication is a sign for a product originated from a specific area or have a reputation of originating from the said place. A GI tag prevents third-parties from using the product name without conforming to the technical standards or code of practice.

BIODIVERSITY OF TASAR SILKWORM

Around 124 species belongs to Antheraeaare distributed in various countries such as United States, Mexico, India, Bhutan, Cambodia, Russia, China, North Korea, Indonesia, Japan, Laos, Brunei, Timor, Taiwan, North Korea, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand and Vietnam. Among 124 species, India comprised of thirteen species, A. mylitta, A. frithi, A. assamensis, A. roylei, A. compta, A. helferi, A. rubicunda, A. paphia, A. andamana, A. insularis, A. cernyi, A. knyvetti and A. meisteri(Table 1). Major production of tasar silk is from tropical tasar silkworm, A. mylitta. A. mylittahas a wide distribution within the country. In India the range of distribution of this species covers Assam, many of which were treated as distinct species though they are ecological populations of the same species (Singh and Srivastava, 1997).



Seri-bio-diversity: Among 34 mega biodiversity countries in the world, India is home to many species of insects with a diverse silk moth fauna. In addition to the diverse silkworm races, there are vast genetic resources of mulberry, tasar, muga and eri host plants spread over diverse geographical locations. This offers a great opportunity for economic utilization of the natural flora and fauna. However, due to deforestation and destruction of habitats, there is a challenge to bring about development without disturbing the ecological balance.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved**, **UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023**

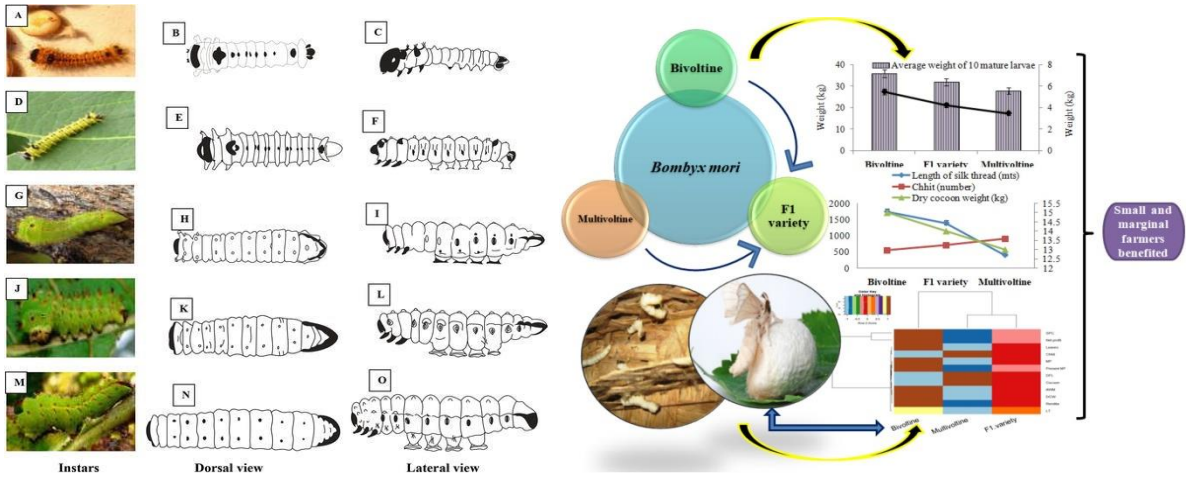


IMAGE SHOWING Diversity in A. mylitta is the result of adaptation of a species to a variable eco factor and interaction of genetic constitution.

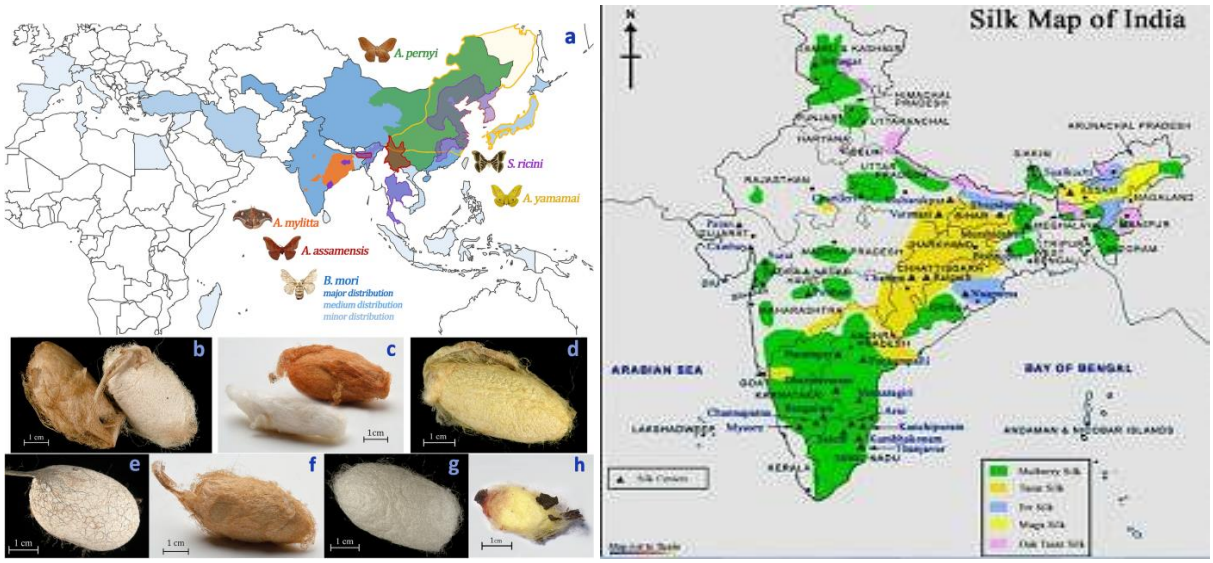
Diversity in A. mylitta is the result of adaptation of a species to a variable eco factor and interaction of genetic constitution. So far, 44 ecoraces of tasar silkworm have been reported (Table 2). It can be seen from the table that maximum number of ecoraces are available in Jharkhand followed by Chhattisgarh. Odisha is also bestowed with six known ecoraces.

A .mylitta is widely distributed over a wide range of Indian subcontinent of varied topography, climatic conditions, vegetation and soil conditions it exhibits diversity in the phenotypic, physio-genetic, behavioural and commercial characters (Sengupta and Sengupta 1982; Sengupta et al.,1993; Singh and Srivastava, 1997; Thangavelu et al.,2000; Srivastava et al.,2002 and 2003).

Diversity of A. mylittain relation to primary and predominant food plants is presented in Table-4. Wide range of phenotypic variation is observed in nature grown cocoons. It may be appropriate here to mention that since a long time proper survey and collection has not been done, so there is the chance that many of the ecoraces might have been extinct due to deforestation and habitat loss. On the other hand, tasar populations may also be available in new zones or ecopockets which need to be surveyed and documented because the natural populations are the treasure of genes and alleles developed through centuries through the process of natural evolution.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023



Distribution of Antheraea species World wise

S.NO	COUNTRY	ANTHERAEA SPECIES
1	Indonesia	A. alorensis, A. banggaiana, A. billitonensis, A. borneensis A. cadioui ,A. celebensis, A. cihangiri, A. cordifolia, A. diehli, A. expectata , A. fickei, A. frithi javanensis etc
2	Brunei	A. alleni, A. brune
3	India	A. assamensis, A. compta , A. frithi, A. helferi, A. mylitta, A. paphia, A. rubicunda , A. knyvetti, A. roylei , A. andamana, A. cernyi, A. insularis, A. meisteri
4	Cambodia	A. angustomarginata
5	Malaysia	A. broschi, A. pahangensis , A. ulrichbrosch
6	Bhutan	A. castanea
7.	Srilanka	A. cingalesa
8	China	A. crypta, A. discata , A. harndti, A. harti, A. pernyi, A. yamamai titan, A. yunnanensis
9	Myanmar	A. myanmarensis paukstadt , A. platessa, A. steinkeorum
10	Thailand	A. frithi pedunculata, A. ranongensis, A. semperi
11	Japan	A. sergestus, A. yamamai, A. yamamai yoshimotoi
12	Taiwan	A. superb
13	North Korea	A. yamamai bergmanni
14	Vietnam	A. frithi tonkinensis, A. luteofrithi, A. rubicunda rubiorientalis
15	Philippines	A. gschwandneri zwicki A. gulata A. hagedorni A. halconensis
16	Laos	A. larissoides
17	Timor	A. lorosae
18	North Korea	A. yamamai bergmanni
19	Russia	A. yamamai ussuriensis
20	America	A. oculea , A. polyphemus
21	Mexico	A. godmani A. Montezuma

CONSERVATION OF TROPICAL TASAR SILKWORM

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved**, **UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023**

Conservation biology is tied closely to ecology in researching the dispersal, migration, demographics, effective population size, inbreeding depression, and minimum population viability of rare or endangered species. To better understand the restoration ecology of native plant and animal communities, the conservation biologist closely studies both their polytypic and monotypic habitats that are affected by a wide range of benign and hostile factors. Conservation biology is concerned with phenomena that affect the maintenance, loss, and restoration of biodiversity and the science of sustaining evolutionary processes that engender genetic, population, species, and ecosystem diversity.

Need for Conservation

1. Rampant collection of Cocoons, Threat of complete genetic erosion, Environmental stress changes the climate/environment/ forest ecosystem, Irrational collection & marketing of nature grown cocoon, Deforestation for fuel, livelihood earning by tribal's1, Increase in anthropogenic activities, Unawareness among the tribal on restriction of collection, Extensive losses due to parasite and predators, Climatic attacks of heavy rains, storms, drought etc.
2. Human interference for industrial and housing areas, with increasing human population, Untested/diseased seeds to the core buffer area homeland, To protect and maintain essential tasar host plants in the forest ecosystem, To preserve the existing wild ecoraces and their population in natural habitat, To ensure sustainable utilization of the ecoraces and ecosystem, Large scale collection of cocoons from their ecological ,niches without giving any heed towards natural breeding process for self-perpetuation.

Need of Wild daba Conservation

High value of commercial characters & zero pebrine status, Highly amenable can transform into cultivated ruling , Daba unlike other in situ bred eco-race, Thus the high trait values & pebrine zero can be utilized for tasar seed system, and In situ conservation strategies will multiply the wild Daba in it native eco-niches.

Collection of nature grown cocoons

Harvesting of cocoons raised through rearing of Laria silkworm In the former, there is no human andling and all the life cycle activities like moth emergence, coupling, decoupling, egg laying, hatching and growth of larvae, cocoon formation are fully dependent on natural environmental conditions without human interfernce, whereas in case of later, feed and growth of larvae and cocoon formation are out-doors and remaining activities are indoor wherein large scale pupal mortality, erratic emergence, unsynchronised emergence and pairing were noticed in the model grainage house. Observations revealed that Laria seed cocoons preserved under Sal forest of Bhusur, regular moth emergence was significantly delayed, emergence period was reduced and emerged male and female moths were more synchronised for coupling. The present study may lead to change in preservation methodology of seed cocoons of Laria. This concept came to solve the problem of large scale preservation of seed cocoons of Laria in outdoor conditions under shade, in or nearer to Sal forest Genetic analysis.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved**, **UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023**

Thus, it can be concluded that information generated from the above study may pave the way for future planning of preservation of seed cocoons and preparation of Laria seed to suit the requirement of the farmers. Cultivation of Laria is an important co-discipline of applied forest biology that needs special attention to promote conservation and sustainable utilization of its host plant. Since, A. mylittaprimarily inhabits forested habitats, it is expected that with the gradual depletion of forest cover due to surge in the human activities the habitat lost its continuity and resulted in geographic isolation. This isolation might have allowed the populations to continue separately for generations, result-ing in different ecoraces. There is quite a bit of ambiguity in naming of these ecoraces. As the boundaries between the ecoraces are often fuzzy and the races do not obey the concept of static boundaries, the racial identity seems to be arbitrary at times. Quite surprisingly, two crops of the same population are sometimes named as two different ecoraces .
There is a lack of well-characterized molecular markers to study A. mylitta ecoraces. Although few studies have been carried out with RFLP 13, RAPD 14 , SCAR 15 , ISSR 12,16 and other DNA markers 17 , except for RFLP, the rest are dominant markers, and hence the estimation of allele frequencies are based on the assumption that the loci are in Hardy-Weinberg equilibrium. Also, barring a couple of reports on Antheraea assama 18–20, there are no reported studies that describe the detailed population genetics of saturniid silkmoths, using SSR markers.

Genetic Evolution.

Descriptive statistics. Considerable variation was observed at all microsatellite loci. Except Bhandara, which was monomorphic at the locus Amysat013, all other populations showed polymorphism at all the 10 loci Supplementary data 1). (Number of alleles ranged from 1 (Locus: Amysat013, Population: Bhandara) to 15 (Locus: Amysat023, Population: Modal) across the ten micro-satellite loci studied among the eight ecoraces. The average number of alleles per locus ranged between 2.5 ± 0.76SD (Amysat013) and 11.75 ± 2.05SD (Amysat023). The minimum average number of alleles for a population across all 10 loci was 3.7 ± 1.77SD for Sukinda and the maximum was 6.6 ± 4.24SD for Modal. Average observed heterozygosity per locus (Ho) taking all the populations together ranged from 0 (Amysat013) to 0.81 ± 0.12 (Amysat023). The minimum average Ho across all the loci was observed in the population Daba Trivoltine (0.25 ± 0.32) and maximum in Sukinda (0.37 ± 0.34).

Conclusion

A. Mylittaand used them to study the genetic structure of its different ecoraces. Like most other species studied, we observed dinucleotide microsatel-lites to be the most abundant, followed by tri- and tetra nucleotide. Among the dinucleotide microsat-ellites, those with (CA) motifs were the most abundant. CA/GT repeats are generally the most common dinucleotide repeat in a wide variety of vertebrates and arthropods25,26. Insects 27,28, including lepidopter-ans 29–37 are no exception. There have been studies investigating the nature and distribution of genetic variation in wild lepidop-terans. However, these have mainly focused on threatened or declining species 38–40 or pests 41–44. Among other silkworms the genetic structure of A. assama, a species with a very restricted distribution, has been studied and its populations were found to be reasonably differentiated 18,20. Different strains and lines of the domesticated silkworm B. morihave also

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

been subjected to this kind of analysis , however these studies are arguably not comparable to wild lepidopteran species. In this current work, we present a detailed genetic study of eight different ecoraces of a wild silkworm A. Mylitta. However, one should keep in mind that we do not have replicates of the ecoraces in our data-set, i.e., each ecorace has been sampled only from a single locality and hence the effect of ecorace and locality might be confounded in the pattern we have observed.

References

1. Zhao, H.P.; Feng, X.Q.; Yu, S.W.; Cui, W.Z.; Zou, F.Z. Mechanical properties of silkworm cocoons. Polymer 2005, 46, 9192–9201. [CrossRef]

2. Zhao, H.P.; Feng, X.Q.; Cui, W.Z.; Zou, F.Z. Mechanical properties of silkworm cocoon pelades. Eng. Fract. Mech. 2007, 74, 1953–1962. [CrossRef]

3. Chen, F.; Porter, D.; Vollrath, F. Silk cocoon (Bombyx mori): Multi-layer structure and mechanical properties. Acta Biomater. 2012, 8, 2620–2627. [CrossRef] [PubMed]

4. Chen, F.; Porter, D.; Vollrath, F. Morphology and structure of silkworm cocoons. Mater. Sci. Eng. C 2012, 32, 772–778. [CrossRef]

5. Chen, F.; Porter, D.; Vollrath, F. Structure and physical properties of silkworm cocoons. J. R. Soc. Interface 2012, 9, 2299–2308. [CrossRef] [PubMed]

6. Chen, F.; Hesselberg, T.; Porter, D.; Vollrath, F. The impact behaviour of silk cocoons. J. Exp. Biol. 2013, 216, 2648–2657. [CrossRef] [PubMed]

7. Moriwaki, H.; Kitajima, S.; Kurashima, M.; Hagiwara, A.; Haraguchi, K.; Shirai, K.; Kanekatsu, R.; Kiguchi, K. Utilization of silkworm cocoon waste as a sorbent for the removal of oil from water. J. Hazard. Mater. 2009, 165, 266–270. [CrossRef] [PubMed]

8. Tulachan, B.; Meena, S.K.; Rai, R.K.; Mallick, C.; Kusurkar, T.S.; Teotia, A.K.; Sethy, N.K.; Bhargava, K.; Bhattacharya, S.; Kumar, A.; et al. Electricity from the silk cocoon membrane. Sci. Rep. 2014, 4, 5434. [CrossRef] [PubMed]

9. Roy, M.; Meena, S.K.; Kusurkar, T.S.; Singh, S.K.; Sethy, N.K.; Bhargava, K.; Sarkar, S.; Das, M. Carbondioxide gating in silk cocoon. Biointerphases 2012, 7, 1–11. [CrossRef] [PubMed]

10. Kaur, J.; Rajkhowa, R.; Tsuzuki, T.; Millington, K.; Zhang, J.; Wang, X. Photoprotection by silk cocoons. Biomacromolecules 2013, 14, 3660–3667. [CrossRef] [PubMed]

11. Kusurkar, T.S.; Gangwar, A.; Bawankar, M.; Mandal, A.; Dethe, D.; Thakur, A.K.; Singh, S.K.; Bhargava, K.; Khurana, S.; Sethy, N.K.; et al. A glowing antioxidant from Tasar silk cocoon. RSC Adv. 2015, 5, 104563–104573. [CrossRef]

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

12. Tulachan, B.; Srivastava, S.; Kusurkar, T.S.; Sethy, N.K.; Bhargava, K.; Singh, S.K.; Philip, D.; Bajpai, A.; Das, M. The role of photo-electric properties of silk cocoon membrane in pupal metamorphosis: A natural solar cell. Sci. Rep. 2016, 6, 21915. [CrossRef] [PubMed]

13. Horrocks, N.P.; Vollrath, F.; Dicko, C. The silkmoth cocoon as humidity trap and waterproof barrier. Comp. Biochem. Physiol. Part A Mol. Integr. Physiol. 2013, 164, 645–652. [CrossRef] [PubMed]

14. Zhang, J.; Rajkhowa, R.; Li, J.; Liu, X.Y.; Wang, X.G. Silkworm cocoon as natural material and structure for thermal insulation. Mater. Des. 2013, 49, 842–849. [CrossRef]

15. Kusurkar, T.S.; Tandon, I.; Sethy, N.K.; Bhargava, K.; Sarkar, S.; Singh, S.K.; Das, M. Fluorescent silk cocoon creating fluorescent diatom using a "Water glass-fluorophore ferry". Sci. Rep. 2013, 3, 3290. [CrossRef] [PubMed]

16. Blossman-Myer, B.; Burggren, W.W. The silk cocoon of the silkworm, Bombyx mori: Macro structure and its influence on transmural diffusion of oxygen and water vapor. Comp. Biochem. Physiol. Part A Mol. Integr. Physiol. 2010, 155, 259–263. [CrossRef] [PubMed]

17. Xu, J.; Zhang, W.; Gao, X.; Meng, W.; Guan, J. Strain rate and anisotropic microstructure dependent mechanical behaviors of silkworm cocoon shells. PLoS ONE 2016, 11, e0149931. [CrossRef] [PubMed]

18. Guan, J.; Zhu, W.; Liu, B.; Yang, K.; Vollrath, F.; Xu, J. Comparing the microstructure and mechanical properties of Bombyxmori andAntheraea pernyi cocoon composites. Acta Biomater. 2017, 47, 60–70. [CrossRef] [PubMed]

19. Shah, D.U.; Vollrath, F. 6—Silk for sustainable composites. Nat. Fiber-Reinf. Biodegrad. Bioresorbable Polym. Compos. 2017, 91–109.

20. Acharya, A., Majhi, J., Patra, G.C., Mohanty, N., 2017. Analysis of nutritional contents of primary host plant leaves of tropical tasar silk moth, Antheraea mylitta in Mayurbhanj district of Odisha. Indian J. Appl. Res. 7 (11), 202–203.

21. Aramwit, P., Damrongsakkul, S., Kanokpanont, S., Srichana, T., 2010. Properties and anti-tyrosinase activity of sericin from various extraction methods. Biotechnol. Appl. Biochem. 55 (2), 91–98.

22. Banerjee, S.K., Bonde, C.G., 2011. Total phenolic content and antioxidant activity of extracts of Bridelia retusa Spreng Bark, Impact of dielectric constant and geographical location. J. Med. Plant Res. 5, 817–822.

23. Barth, A., 2007. Infrared spectroscopy of proteins. Biochim. Biophys. Acta. 1767 (9), 1073–1101.

ISSN PRINT 2319 1775 Online 2320 7876

23.Bartholomaeus, A.R., Bolton, R., Ahokas, J.T., 1994. Inhibition of rat liver cytosolic glutathione S -transferase by silybin. Xenobiotica 24 (1), 17–24.

24. Blois, M.S., 1958. Antioxidant determinations by the use of a stable free radical. Nature 181 (4617), 1199–1200.

25. Byler, D.M., Susi, H., 1986. Examination of the secondary structure of proteins by deconvolved FTIR spectra. Biopolymers 25 (3), 469–487. Cavalieri, E.L., Li, K.M., Balu, N., Saeed, M., Devanesan, P., Higginbotham, S., Zhao, J., Gross, M.L., Rogan, E.G., 2002.

26. Catechol ortho-quinones: the electrophilic compounds that form depurinating DNA adducts and could initiate cancer and other diseases. Carcinogenesis 23, 1071–1077.

27. Chen, F., Porter, D., Vollrath, F., 2012. Structure and physical properties of silkworm cocoons. J. R. Soc. Interface 9 (74), 2299–2308.

28. Chlapanidas, T., Farag` o, S., Lucconi, G., Perteghella, S., Galuzzi, M., Mantelli, M., Avanzini, M.A., Tosca, M.C., Marazzi, M., Vigo, D., Torre, M.L., Faustini, M., 2013.

29. Sericins exhibit ROS-scavenging, anti-tyrosinase, anti-elastase and in vitro immunomodulatory activities. Int. J. Biol. Macromol. 58, 47–56.

30. Das, M., Bickers, D.R., Mukhtar, H., 1984. Plant phenols as in vitro inhibitors of glutathione S-transferase. Biochem. Biophys. Res. Co. 120, 427–433.

31. Dash, A.K., Nayak, B.K., Dash, M.C., 1992. The effect of different food plants on cocoon crop performance in the Indian tasar silkworm Antheraea mylitta Drury (Lepidoptera, Saturniidae). J. Res. Lepid. 31, 127–131.

32. Dash, R., Acharya, C., Bindu, P.C., Kundu, S.C., 2008. Antioxidant potential of silk protein sericin against hydrogen peroxide-induced oxidative stress in skin ibroblasts. BMB Rep. 41 (3), 236–241.

33. Deka, M., Kumari, M., 2013. Comparative study of the effect of different food plant species on cocoon crop performance of tropical tasar silkworm (Antheraea mylitta Drury). Int. J. Res. Chem. Environ. 3 (1), 99–104.

34. Fan, J.B., Wu, L.P., Chen, L.S., Mao, X.Y., Ren, F.Z., 2009. Antioxidant activities of silk sericin from silkworm Bombyx mori. J. Food Biochem. 33, 74–88.

35. Bray, F ., Ferlay, J., Soerjomataram, I., Siegel, R. L., Torre, L. A., & Jemal, A. (2018) . Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: A Cancer Journal for Clinicians, 68(6) , 394–424.

36. Ferlay J, Ervik M, Lam F , et al. Global Cancer Observatory: Cancer Today. Lyon, France: IARC, 2018. Available f rom: https:/ /gco.iarc.f r/today.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

37. Yun, H., Oh, H., Kim, M. K., Kwak, H. W ., Lee, J. Y ., Um, I. C., Vootla, S. K., & Lee, K. H. (2013) . Extraction conditions of Antheraea mylitta sericin with high yields and minimum molecular weight degradation. International Journal of Biological Macromolecules, 52, 59–65.

38. Kunz, R. I., Brancalhão, R. M. C., Ribeiro, L. de F . C., & Natali, M. R. M. (2016) . Silkworm sericin: properties and biomedical applications. BioMed Research International, 2016.

39. Silva, S. S., Kundu, B., Lu, S., Reis, R. L., & Kundu, S. C. (2019) . Chinese oak tasar silkworm antheraea pernyi silk proteins: Current strategies and future perspectives for biomedical applications.

40.Macromolecular Bioscience, 19(3) , 1800252. ½. Sasaki, M., Kato, N., Watanabe, H., & Yamada, H. (2000) . Silk protein, sericin, suppresses colon carcinogenesis induced by 1, 2-dimethylhydrazine in mice. Oncology Reports, 7(5) , 1049–1101.

41. Zhaorigetu, Siqin, Sasaki, M., Watanabe, H., & KA To, N. (2001) . Supplemental silk protein, sericin, suppresses colon tumorigenesis in 1, 2-dimethylhydrazine- treated mice by reducing oxidative stress and cell proliferation. Bioscience,

42. Biotechnology, and Biochemistry, 65(10) , 2181–2186. ¾. Zhaorigetu, Siqin, Yanaka, N., Sasaki, M., Watanabe, H., & Kato, N. (2003) . Silk protein, sericin, suppresses DMBA-TP A- induced mouse skin tumorigenesis by reducing oxidative stress, inflammatory responses and endogenous tumor promoter TNF-α. Oncology Reports, 10(3) , 537–543.

43. Kaewkorn, W ., Limpeanchob, N., Tiyaboonchai, W ., Pongcharoen, S., & Sutheerawattananonda, M. (2012) . Ef fects of silk sericin on the proliferation and apoptosis of colon cancer cells. Biological Research, 45(1) , 45–50.

44. Kumar , J. P ., & Mandal, B. B. (2019) . Silk sericin induced pro-oxidative stress leads to apoptosis in human cancer cells. Food and Chemical Toxicology, 123, 275–287.

45. Zhang, W . M., Lai, Z. S., He, M. R., Xu, G., Huang, W ., & Zhou, D. Y . (2003) . Ef fects of the antibacterial peptide cecropins f rom Chinese oak silkworm, Antheraea pernyi on 1, 2-dimethylhydrazine- induced Page 14/19 colon carcinogenesis in rats. Di 1 Jun Yi Da Xue Xue Bao= Academic Journal of the First Medical College of PLA, 23(10) , 1066–1068.

46. Kar, P. K. et al.Genetic Variability and genetic strucuture of wild and semi-domestic populations of tasar silkworm (Antheraea mylitta) ecorace Daba as revealed through ISSR markers. Genetica 125,173–183 (2005).

47. Mahendran, B., Padhi, B., Ghosh, S. K. & Kundu, S. Genetic variation in ecoraces of tropical tasar silkworm, Antheraea mylitta D. using RFLF technique. Curr. Sci. 90,100 (2006).

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 4, 2023

48. Mahendran, B., Acharya, C., Dash, R., Ghosh, S. K. & Kundu, S. C. Repetitive DNA in tropical tasar silkworm Antheraea mylitta. Genetica 370,51–57 (2006).

49. Arunkumar, K. P. et al.Genetic diversity and population structure of Indian golden silkmoth (Antheraea assama). PLoS One 7, e43716, D:10.1371/journal.pone.0043716 (2012).

50. Singh, Y. T. et al.Genetic variation within native populations of endemic silkmoth Antheraea assamensis(Helfer) from Northeast India indicates need for in situconservation. PLoS One 7,e49972, doi: 10.1371/journal.pone.0049972 (2012).

51. Beckmann, J. S. & Weber, J. L. Survey of human and rat microsatellites. Genomics 12,627–631 (1992).

52. Tóth, G., Gáspári, Z. & Jurka, J. Microsatellites in different eukaryotic genomes: survey and analysis. Genome Res. 10,967–981 (2000).

53. Schug, M. D. et al.The mutation rates of di-, tri- and tetranucleotide repeats in Drosophila melanogaster. Mol. Biol. Evo.l 15,1751–1760 (1998).

54. Butcher, R., Hubbard, S. & Whitfield, W. Microsatellite frequency and size variation in the parthenogenetic parasitic wasp Venturia canescens(Gravenhorst) (Hymenoptera: Ichneumonidae). Insect Mol. Biol. 9,375–384 (2000).

55. Keyghobadi, N., Roland, J. & Strobeck, C. Influence of landscape on the population genetic structure of the alpine butterfly Parnassius smintheus(Papilionidae). Mol. Ecol. 8,1481–1495 (1999).

56. Meglécz, E., Nève, G., Pecsenye, K. & Varga, Z. Genetic variations in space and time in Parnassius mnemosyne(L.) (Lepidoptera) populations in north-east Hungary: implications for conservation. Biol. Conserv. 89,251–259 (1999).

57. Packer, L. et al.Population biology of an endangered butterfly, Lycaeides melissa samuelis(Lepidoptera; Lycaenidae): genetic variation, gene flow, and taxonomic status. Can. J. Zool. 76,320–329 (1998).

58. Nagaraju, J., Reddy, K. D., Nagaraja, G. M. & Sethuraman, B. N. Comparison of multilocus RFLPs and PCR-based marker systems for genetic analysis of the silkworm, Bombyx mori. Heredity 86,588–597 (2001).

59. Furdui, E. M. et al.Genetic Characterization of Bombyx mori(Lepidoptera: Bombycidae) Breeding and Hybrid Lines With Different Geographic Origins. J. Insect Sci. 14(1)doi: 10.1093/jisesa/ieu073 (2014).

60. Pereira, N. et al.Biological and molecular characterization of silkworm strains from the Brazilian germplasm bank of Bombyx mori. Genet. Mol. Res. 12,2138–2147 (2013).