Integrated Pest Management: Advancement, Adoption and Ecological Challenges
DOI: https://doi.org/10.54083/978-81-986377-3-4_06

Chapter **6**

Eri Silkworm: A Potential Commercial Insect and Its Future Prospects

Hia Kalita[1*], Mahesh Pathak[2], Kennedy Ningthoujam[2], Bimal Kumar Sahoo[3], Sushruta Boruah[3] and Mukesh Sehgal[4]

[1]*Dept. of Molecular, Cellular and Developmental Biology Inter-Departmental Program, Iowa State University, Ames, IA (50014), USA*
[2]*Dept. of Entomology, School of Crop Protection, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya (793 103), India*
[3]*Dept. of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu (641 003), India*
[4]*ICAR-National Centre for Integrated Pest Management, Mehrauli, New Delhi (110 030), India*

Abstract

Silk, a term describing protein fibres secreted by arthropods, is recognized for its softness, luster, strength and durability, outstripping both natural and synthetic fibres. In India, 47 silkworm species are documented, with 24 from the North East region, where Eri silkworm culture thrives due to the abundance of castor plants. Six common Eri silkworm strains are identified: Greenish Blue Plain, Greenish Blue Spotted, Greenish Blue Zebra, Yellow Plain, Yellow Spotted and Yellow Zebra. Eri silkworm larvae, prepupae and pupae, combined with herbs and spices, provide a high-protein food source, presenting a promising alternative amidst rising cereal costs and enhancing food security in rural areas. Recent advances in molecular biology and biotechnology have the potential to significantly impact sericulture by improving silk yield, yarn quality and host plant characteristics. The application of synthetic juvenile hormones has led to notable improvements in larval development, silk gland weight and silk fibre output. However, challenges such as reduced biodiversity, declining wild silk moth populations and environmental fluctuations persist. India's diverse climatic conditions offer opportunities to exploit native silkworm races with valuable resistance genes. Addressing constraints in Eri silkworm rearing, including food scarcity, drought, insufficient training and market access, requires extensive conservation efforts, development of high-yield breeds and improved preservation techniques. Further research should focus on DNA fingerprinting, molecular characterization and transgenic technologies to optimize diets and enhance silkworm growth, ensuring a sustainable future for sericulture.

Keywords Eri by-products, Eri silk, Ericulture, Silkworm

**Corresponding author's e-mail*: hiakalita23@gmail.com

How to cite:
Kalita, H., Pathak, M., Ningthoujam, K., Sahoo, B.K., Boruah, S., Sehgal, M., 2025. Eri silkworm: A potential commercial insect and its future prospects. In: *Integrated Pest Management: Advancement, Adoption and Ecological Challenges*. (Ed.) Sehgal, M. Biotica Publications, India. pp. 87-96. DOI: https://doi.org/10.54083/978-81-986377-3-4_06.

1. Introduction

Silk is a functional term used to describe protein fibers that are secreted by arthropods. It is a natural protein fiber and is very soft, lustrous, smooth, strong and more durable than any other natural or synthetic fiber (Shao and Vollrath, 2002). There are around 80 species of silkworms, according to Jolly *et al.* (1974). There are two kinds of silkworms: mulberry silkworms and wild, or non-mulberry, silkworms. The manufacture of mulberry silk from *Bombyx mori*, a domesticated silkworm that is the main player in the global silk trade, is known as mulberry sericulture. On the other hand, non-mulberry sericulture, also called forest or wild sericulture, is the process of making silk from wild moths that produce silk and are members of many Lepidopteran families. Eri, Tasar and Muga are examples of non-mulberry silks made by non-mulberry or wild silkworms (Peigler, 1993).

Many countries have been involved in sericulture industry development and more than half of these countries are situated in Asia and more than 85% of raw silk is produced by the five major silk producing countries such as China, India, Uzbekistan, Brazil and Thailand (Gu, 1999). Sericulture is an agro-based industry, playing an important role in rural economy of the country. The Northeast region of India is an ideal natural home for a variety of silkworms. A total of 47 species of silkworms are recorded from India, out of which 24 reported from Northeast region (Singh and Suryanarayan, 2003). Out of these only four species of sericigenous insects are cultured which are: Muga, Eri, Tasar and Mulberry. Among these Eri and Muga silkworms are predominantly cultured in NE region. India enjoys a unique distinction of being the only country in the world producing all the varieties of natural silk, *viz.*, Mulberry, Eri, Tasar, Oak tasar and Muga. Sericulture and silk weaving is the part and parcel of cultural heritage of the people of North-East India. The climate of NE India is suitable for growth of non-mulberry silkworms, *i.e.*, Muga and Eri. The number of sericulture village in NE region is about 38,000 and approximately 1.9 lakh families are engaged in this industry in Assam (Unni *et al.*, 2009).

Because castor plants are abundant in rural regions, the Eri culture is practiced throughout the year in traditional communities. For a vast number of rural tribal tribes in India, it is a suitable secondary career. Eri silkworms are disease-resistant and resistant to parasites. There are total 19 species of Eri (genus = *Samia*) all over the world of which only three species are reported from India and out of which two from NE region, they are *Samia canningi* which is a wild species and *Samia ricini*, a totally domesticated species (Pigler and Naumann, 2003). The Eri silkworm feeds mainly on the leaves of castor oil plant, *Ricinus communis* (L.). According to Choudhury (1960), larvae can also survive on Kesseru, (*Herpetopanax fragrans*), Cassava (*Manihot utilissima*), Papaya (*Carica papaya*), Champa (*Plumeria acutifolia*), Gullar (*Ficus glomerata*) and certain other plants, but castor plant proved to be the most favourable. Eri silk yarn is distinguished by its characteristic quality of white silky yarn with thermal qualities, which is created by this worm.

2. Eri Silk Producing Areas

The northeastern Indian states of Assam, Manipur, Meghalaya, Nagaland, Arunachal Pradesh and Mizoram currently produce the majority of the world's Eri silk. Among the non-traditional states where castor is grown as an oil seed crop are Andhra Pradesh, Gujarat, Madhya Pradesh, Chhattisgarh, Tamil Nadu, Karnataka, Maharashtra, Uttaranchal, Uttar Pradesh, Jharkhand, Bihar, West Bengal, Orissa and Sikkim.

3. Biological Study

3.1. Egg Stage

3.1.1. The Incubation Period

Gomma (1973) reported that any increase in temperature shortens the length of the egg stage at a given R.H. At 20, 23 and 25 °C and with all humidities, the mean incubation periods recorded were 14.17, 11.37 and 9.70 days respectively. Means of 11.50, 10.15 and 8.85 days were provided for 50, 70 and 90% relative humidity and all temperatures, respectively. According to Adaire (1931), the incubation period of this insect ranged from 8-13 days. Abdel-Khalik (1967) gave a mean incubation period of 13.46 days ranging from 8-19 days.

3.1.2. Hatchability

High temperature and low humidity appear to have a significant impact on the proportion of hatched eggs. At 25 °C and 90% relative humidity, around 95% of the eggs hatched which may be considered the ideal hatching environment (Gomma, 1973).

3.2. Larval Stage

3.2.1. Duration of Larvae

The Eri silkworm larva goes through five instars, the first of which is the shortest (4.59 days) and the final of which is the longest (8.12 days), with the instars in between being intermediate. The fully developed larva becomes lethargic before pupation and enters a prepupal stage that lasts almost the whole fifth larval instar (Gomma, 1973).

3.3. Pupal Stage

3.3.1. Duration of the Pupal Stage

The pupal stages' lengths under various temperature and relative humidity conditions tend to show that for a given R.H., any increase in temperature appears to reduce the pupal phase. The shortest mean pupal durations were found at 30 °C (14.0 and 14.91 days for males and females, respectively), while the longest were found at 20 °C (24.37 and 24.90 for same sexes, respectively) (Gomma, 1973). Other authors reported pupal stage lengths of 18-13 days (Adaike, 1931), 26.8 days ranging from 14 to 67 days (Bodenheimer, 1931) and 18.55 days ranging from 15 to 19 days (Abdel-Khalik, 1967).

3.3.2. Weight of Pupae

When fed the bloomy red and green variety of castor leaves in the larval stage, male pupae had mean weights of 1.933 and 1.777 g; female pupae weighed 2.378 and 2.244 g, respectively. Female pupae seemed to be heavier than male pupae, comparable to Ibrahim *et al.* (1965) and Gomaa's findings (1973). Between both types and generations, the weight of male and female pupa revealed a strong significant variance (El-Shaarawy *et al.*, 1975).

3.4. Adult Stage

3.4.1. Weight of Moths

El-Shaarawy *et al.* (1975) reported that the mean weights of male adult were 0.921 and 0.781 g when insects were fed in the larval stage on the red and green variety of castor respectively. Females' readings were 1.587 and 1.448 g, respectively. The average weight of females was always greater than that of males, which was consistent with Fraise's findings (1953).

3.4.2. Egg-Laying Behaviour of Female Moths

As reported by Gomma (1973) the female moths start egg laying 1-2 days after emergence. The mean pre-oviposition periods were recorded at different temperatures. Females continued egg laying for a certain period depending upon temperature; mean oviposition periods of 3.99 and 6.52 days were given at 30 and 20 °C, respectively. Female moths ceased egg-laying 1-3 days before death, the post oviposition periods were much reduced with rise of temperature.

3.4.3. Longevity of Moths

Moth longevity is strongly influenced by temperature and there seems to be a negative correlation between the two. When the temperature was the same, female moths lived an extra one to three days. There were noticeable differences in the means of the males and females (Gomma, 1973).

3.4.4. Silk Glands

The protein included in silk is made by silk gland cells and is subsequently kept in the lumen of the silk glands. After that, it becomes silk fibers. Liquid silk, secreted by the silkworms during the spinning process, passes via the anterior gland and exits through the spinneret hole. The silk gland produces the natural silk that the silkworm spins into a silk cocoon.

4. Different Strains of Eri Silkworm

Different Eco-races of Eri silkworm can be found from different locations of North-East India, which include Borduar, Titabar, Khanapara, Nongpoh, Mendipathar, Dhanu bhanga, Sille, Kokrajhar, Diphu, *etc.* The six common strains of Eri silkworm are Greenish blue plain (GBP), Greenish blue spotted (GBS), Greenish blue zebra (GBZ), Yellow plain (YP), Yellow spotted (YS) and Yellow zebra (YZ) which were arranged into six groups (Figure 1). Singh *et al.* (2011) carried out study on morphological characters of eco races and six strains of Eri silkworm to find out their rearing performance. In terms of rearing performance, they have identified Yellow Zebra as the best strain. The four distinct Eri silkworm strains are examined in terms of morphological and biochemical criteria. The strain GBS was discovered to have the highest fiber content, as well as the highest shell weight and sericin content. This strain may be mass-reared and used in breeding programs to increase silk output.

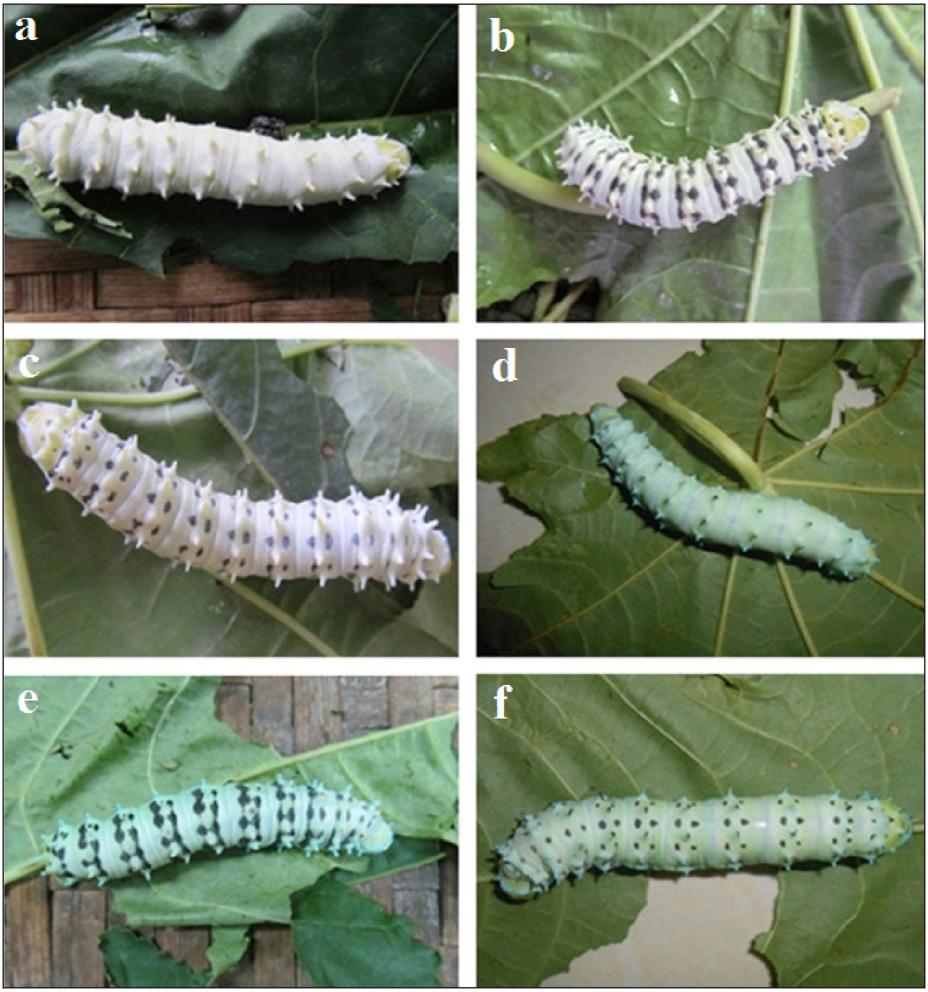

Figure 1: (a) Yellow Plain (YP), (b) Yellow zebra (YZ), (c) Yellow spotted (YS), (d) Greenish blue plain (GBP), (e) Greenish blue zebra (GBZ), (f) Greenish blue spotted (GBS) [Saikia and Devi, 2019]

5. Host Plants

Neelu Nangia *et al.* (2000) reported the host plant preference of Eri silkworm in the order of merit, *viz.*, Castor > Tapioca > Papaya > Barkesseru > Gulancha. The two most significant host plants for Eri silkworms are castor and tapioca, while other perennial tree species, such as Kesseru and Payam in the northeastern regions, can also serve as additional food sources during the off-season. Kumar *et al.* (1993) reported that leaves of Kesseru were next to the Castor leaves in terms of cocoon harvest and other economic parameters in south India, the match wood tree species, *Ailanthus excelsa* is common in the plains and hills is also a alternative host for Eri silkworm.

6. Development of Eri Food Products

Sirimungkararat *et al.* (2002) reported the rearing of Eri silkworm larvae, prepupae and pupae. The main raw materials for Eri food dishes were late fifth instar larvae, prepupae and pupae, which were blended with herbs, vegetables and spices. They created recipes that were registered as intellectual property in the form of a patent. Crispy basil flavour, herb flavour, spicy salad flavour, traditional spicy flavour, tom yam crispy flavour, chilli paste flavour, original flavour and classic flavour are among the dishes that contain larvae, prepupae, or pupae.

6.1. Analysis and Contents of Processed Eri Food Products

Using the same raw materials used in the Eri food product development study, the nutritional value and other significant ingredients of Eri processed foods were examined. The larvae (Duan-KKU) and pupae (Sab-KKU) studied exhibited good nutritional value and high protein content, with 76.22% and 67.64% protein, respectively, in the processed larvae and pupae. Moisture values, ash, crude fibre, ether extract and nitrogen free extract was present. These findings are comparable to those of Sirimungkararat *et al.* (2004), in prior research.

7. Future Prospects for Eri Food

Most countries in the world are witnessing an increase in the cost of consumables, including cereals. Eri meal's high protein content makes it a promising security food and source of protein for adults and schoolchildren living in rural areas. Eri food can gain greater recognition when it receives long-term promotional support from both the public and commercial sectors. Consumer awareness campaigns should be used to quickly and widely market food and merchandise from Eri. In this approach, the Eri silkworm's potential to promote government food security initiatives and expand the availability of edible insects as commodities may be achieved. The Eri silkworm is being pushed in India's northeastern area as one of the possible commercial wild silk moths (Sirimungkararat *et al.*, 2010).

8. Application of Molecular Biology and Biotechnology

According to Unni *et al.* (2009) recent advancements in molecular biology and biotechnology may have a significant impact on the sericulture industry. Some potential applications in this regard include the use of biotechnology to increase silk yield, yarn quality and the qualitative and quantitative improvement of host plants, among other things. Another problem related to sericulture is the sharp decline in the biodiversity and population density of wild silk moths. Because of their unique climate, India's native silkworm races are well known for being excellent archives of diverse resistance genes. These genetic resources could be employed in sericulture to create disease-resistant hybrids and molecular markers could be used to study the inheritance of complex traits. Enhancing the genetics of the silkworm is best accomplished using molecular markers.

10. Application of Tissue Culture Technique

Unni *et al.* (2009) tried a successful *in vitro* strategy to study the brain of silkworms. Silkworm brain RNA was extracted and RT-PCR tests revealed the existence of an Allatostatin type neuropeptide in the brain. In terms of juvenile hormone production, the relationship between neurosecretory cells, neurosecretory materials, peptides and proteins has also been proven. In addition, synthetic juvenile hormones and analogues were used to demonstrate its influence on silk production within the silk gland in silkworms. The use of these elements to silkworms in laboratory and field trials resulted in a substantial response in terms of improved larval development, silk gland weight and silk fiber output of 3-6%. The advancement has sparked attention in the Northeastern area, which may be used in sericulture to improve silk production in terms of quality and quantity.

11. Byproduct Management

Eri culture can provide additional revenue through waste and byproduct control (Sarmah, 2010). Furthermore, it will add significant value to the product while also creating extra jobs. Both the on-farm and off-farm sectors of the culture can turn their wastes into commercially valuable byproducts. In nations like China, there are various industrial units dedicated to transforming sericultural wastes into usable goods that may be used not only in research and medicine, but also by the public. The dried pupae comprise around 25% oils and 50% protein. The nitrogen content of de-oiled pupa is around 11%. It may be fed to animals, fish, poultry and pigs, among other things. In the soap-making industry, oil can be utilized. Castor seeds contain 50% oil and are used to make soap, medication, lubricants and detergents, among other things. Oil cable contains around 4.5 percent nitrogen and can be used as manure as well as a field remedy for white ants. The stem of the castor plant can be utilized in the paper industry. Tapioca is one of the most photosynthesis-efficient plants on the planet. The tuber stores 25-35% of its dry weight as starch in storage. Eri silkworm litter may be utilized as manure and the ash from Eri litters is an efficient pesticide.

12. Constraints of Silkworm Rearing

The main constraints to silkworm rearing, according to respondents, were a lack of food or host plants, drought, a lack of knowledge such as training, lack of modern house, lack of market availability, lack of governmental and non-governmental support, lack of a large area, lack of silk worm production materials and seasonal environmental condition fluctuations such as temperature drops below 10 °C, especially from October to January, which allows plant leaves to fall off. These issues may result in reduced silk output and poor quality. At the regional and federal levels, the government and other interested authorities must provide silkworm farming instruction, financial assistance to private silkworm rearing operations, create market-friendly circumstances and remove other key barriers to maximize silk output potential.

Rearing is mostly done in NE India for Eri pupae, which have a high protein content and oil and silk layers are utilized to make spun yarn. Furthermore, they are oblivious to the fact that it pays well. The following are the obstacles that are impeding the culture's correct development:

- In Northeast India, there is no planned planting of eri food plants to ensure a consistent supply of leaves for raising.
- The biggest impediment is people's unwillingness to abandon their long-held traditions to accept the proposed technology.
- Farmers' egg laying is not thoroughly checked, resulting in a lack of guaranteed Eri dfl supply.
- Disease outbreaks frequently result in crop loss.
- Lack of competence in removing pupa from non-traditional states and non-use of Eri pupa.
- Lack of understanding of the importance of producing a variety of items.
- Lack of reliable marketing facilities for end-product disposal.

14. Conclusion and Future Prospects

Extensive wild Eri silkworm conservation is needed to be done, both *in-situ* and *ex-situ*, to prevent extinction of the species. Development of a high-yielding Eri silkworm breed which will be compatible with India's various agro-climatic zones. The need for developing a good Eri silkworm cocoon/egg preservation process is required which will ensure prolongation of hatching and harvesting good crops. Development of low-cost raising and grainage technologies tailored to a certain location. Emphasis must be observed on determining the best Tapioca/Kesseru variety for Eri silkworm rearing. The focus area should be DNA fingerprinting of currently accessible Eri silkworm genotypes. Molecular characterization of the Eri host plant and silkworm gene pools, as well as transgenic plant/silkworm development must be done for finding out the best possible diet for higher yield and better growth of the silkworms. A biotechnological strategy to developing a high-yielding disease-tolerant Eri silkworm race or strain should be constructed. The virus and bacterial diseases of the Eri host plant/silkworm identification and isolation, as well as molecular characterization of the pathogens to be done to prevent future spread of the disease. Intensive implementation of research and development of an integrated pest control strategy for the primary Eri host plant, Castor. Eri textiles' product variety should be emphasized to open market for local products. Increased compensation for consumption of pupa or use of pupa in poultry, fisheries and piggery feed, particularly in non-traditional states.

15. References

Abdel-Khalik, I.G., 1967. Biological studies on the Eri silkworm, *Attacus ricini* Boisd. (Lepidoptera, Saturinidae). Nl. Sc. Thesis, Faculty of Agriculture, Ain-Shams University, Egypt.

Adaire, E.W., 1931. The introduction of the Eri or Castor-oil silkworm into Egypt. *Bulletin of the Entomological Society of Egypt*, 140-156.

Bodenheimer, F.S., 1931. Beobachtungen an dem Eri-Seidenspinner *Philosamia cynthia ricini* Boisd. *Bulletin of the Entomological Society of Egypt*, 20-41.

Fraise, R.M., 1953. Alimentation et croissance de la larvae chez *Bombyx mori* L. Rev. *du ver a Soie*, 5.

Gomaa, A.A., 1973. Biological studies on the Eri silk worm, *Attacus ricini* Boisd. (Lepidoptera, Saturniidae). *Zeitschrift für Angewandte Entomologie* 74, 120-126.

Gu, G., 1999. Study on the output of cocoon and raw silk and distribution of sericultural area in the world. *Sericulture Science* 25, 105-114.

Ibrahim, M.M., El-Shaarawy, M.F., El-Garhy, A.T., 1965. A note on rearing the Eri silk worm, *Attacus ricini* Boisd. in Egypt. *Congress Mondial Pour La Production de La Soie, Commission Sericigenes*, pp. 1-7.

Jolly, J. Sen, S., Ahsan, M., 1974. *Tasar Culture*, 1st Edition. Central Silk Board, Bombay. pp. 1-266.

Kumar R., Gargi, Prasad D.N., Saha L.M., 1993. A note on secondary food plants of eri silkworm. *Indian Silk* 31(9), 20-21.

Peigler, R., 1993. Wild silks of the world. *American Entomology* 39, 151-161.

Saikia, M., Devi, D., 2019. Analysis of genetic diversity and phylogeny of *Philosamia ricini* (Lepidoptera: Saturniidae) by using RAPD and internal transcribed spacer DNA1. *Molecular Biology Reports* 46(3), 3035-3048.

Sarmah, M.C., 2010. The Silkworm Saga. *The Assam Tribune* Sunday Reading.

Singh, K.C., Suryanarayana, N., 2003. Eri pupae: A popular cuisine too. *Indian Silk*. 41(12), 57-58.

Sirimungkararat, S., Atthathom, T., Saksirirat, W., 2002. Development of eri silkworm rearing technique using cassava leaf as food plant and its textile production. In: *Proceedings of the XIXth Congress of the International Sericultural Commission*, 21-25 September 2002, Queen Sirikit National Convention Center. Bangkok, Thailand.

Sirimungkararat, S., Khacharoen, Y., Polthani, A., 2004. Nutritional value of eri silkworm (*Philosamia ricini* B.) fed with cassava leaf. Presented at Annual Agricultural Seminar, 26-27 January, 2004, Faculty of Agriculture, Khon Kaen University, Khon Kaen.

Sirimungkararat, S., Saksirirat, W., Nopparat, T., Natongkham, A., 2010. Edible products from eri and mulberry silkworms in Thailand. *Forest Insects as Food: Humans Bite Back*, p. 189.

Shao, Z., Vollrath, F., 2002. Surprising strength of silkworm silk. *Nature* 418, 741-742.

Unni, B.G., Goswami, M., Kakoty, Y., Bhattacharjee, M., Wann, S.B., Rajkhowa, G., Chutia, A.D., 2009. Indigenous knowledge of silkworm cultivation and its utilization in North Eastern region of India. *Indian Journal of Traditional Knowledge* 8(1), 70-74.