Bhotiya Tribe belonging to Uttarakhand uses 39 animal species, out of which only 2.564% are amphibians, and in another report from Uttaranchal (Pithoragarh District) out of 38 used species by the indigenous people only 1 amphibian is reported for ethnomedicinal purposes (C. S. Negi & Palyal, 2007; T. Negi & Kandari, 2017).

Conclusion

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The current study reveals that 9 different Anuran species are used for their medicinal properties throughout India. This review also reveals that these species were used to treat around 22 different diseases, including some that were life-threatening. Knowledge of these Anurans, which are used for medicinal purposes by various tribes throughout India's various states, is invaluable. These facts must be brought to the attention of the world in order to gain a better understanding of their medicinal properties as well as their anthropological, social, and environmental relationships. These ethnic practices need to be evaluated systematically to get detailed evidence about their therapeutic values since hunting any animal species without proper scientific evidence may lead to extinction. However, getting concrete detail of their medicinal qualities might lead to the discovery of a novel treatment method for modern medicine. A massive amount of data will be required to achieve such feats, but only a small amount of documentation has been completed, and a vast amount of traditional knowledge remains hidden from the rest of the world. As a result, more effective research is required to gather accurate information about those traditional knowledges before they vanish from the modern world.

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Chapter 2

Eri Silkworm (*Samia ricini*) of North East India: Its Multifaceted Applications and Advantages

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Abstract

The eri silkworm is an economically important sericigenous insect naturally present in North Eastern part of India. The culture of eri silkworm is also being practiced commercially in China, Japan, Thailand, Vietnam etc. Ericulture is a sustainable agro based industry generating employment opportunities at different levels. For upliftment of the rural economy, ericulture is one of the best approaches. In North East India, ericulture is traditionally practiced since time immemorial and became an integral part of their culture. Eri silkworms in this region are mainly

done for silk and food. The silkworm is not only delicious but also very rich in protein and other nutrients. The silkworm is polyphagous and hence continuous culture is ease. However, different host plants may influence their growth and development. The products and byproducts have enormous emerging scopes in the global textile, pharmaceutical and cosmetic market. The demand of eri silk and byproducts can be met by combining indigenous traditional knowledge with modern scientific technology to enhance its all-round productivity. Here in this chapter, we discuss some of the important nutritional and economical aspects of eri silkworm including some traditional practices adopted by the indigenous communities of the North Eastern region of India.

Keywords: Samia ricini, delicacy, traditional practice, silk, host plants

Introduction

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The eri silkworm, Samia ricini (Lepidoptera: Saturniidae) is an economically important sericigenous insect found specially in the North Eastern part of India. Different ethnic groups of North East India traditionally culture eri silkworm since time immemorial. Eri silkworms in this region are mainly reared for production of eri silk varn and for food. For food, people use the larval, prepupal and pupal stages for consumption. A few therapeutic uses are also found to be associated with this insect (Dutta et al., 2016). In addition to the delicious taste, eri silkworms are very rich source of good quality protein and other essential macro and micro nutrients (Longvah et al., 2011). Some age old believes and practices are associated with this silkworm and its rearing. Other than North East India, nowadays ericulture is being practiced in a few non-traditional states like Bihar, Orissa, West Bengal, Tamil Nadu etc. of India. Moreover, different countries like China, Japan, Nepal, Thailand, Vietnam, Cambodia, Kenya, Ethiopia etc practice

ericulture commercially (Oduor et al. 2016; Tuan et al., 2019; Banale, 2017). In general, the culture of eri silkworm provides a subsidiary income source for rural people (Chakravorty et al., 2010). As it is an agro-based industry, it plays a valuable role in rural development offering employment opportunities to all section of people irrespective of gender at different levels. The products and by-products of eri silkworm are very versatile in terms of their applications. In different industrial sectors including textile, food, cosmetic etc. its products and by-products are of increasing emerging demands. The Eri silkworms are multivoltine in nature completing 4-5 generations per year. There are about twenty-six eco-races of the species as has been reported by Directorate of sericulture, Government of Assam. The insect is polyphagous, which is an added advantage of its rearing. However, the different host plants influence their growth and development to some extent (Kumar & Elangovan, 2010). Here we discuss comprehensively about the traditional knowledge associated with ericulture in North East India, different host plants and its impact on growth and development, uses of eri silkworm as food, applications of eri products and by-products in different industrial sectors.

Traditional Knowledge Regarding Eri Silkworm

Long back ethnic groups of North East India choose eri silkworm as food even before knowing the great nutritional benefits associated with this insect. With time, generation after generation, it became a traditional practice within these groups and many beliefs and experiences became associated with the insect and also became part of their culture. We have compiled the various traditional uses of eri silkworm among the indigenous communities of North East India along with their vernacular names from literature and presented in Table.

1. It was come to know that the Ao Naga tribe of Nagaland had a long-standing custom of not allowing the larvae to form a cocoon. To create a silken sheet of the necessary size, they

controlled the worms' movement around a bamboo mat, although the custom is not maintained recent times (Pongener et al., 2019). Some ethnic tribes employ eri silkworm as a traditional medicine. Certain indigenous groups in the Dhemaji district of Assam utilise the larvae and pupae of eri silkworms to treat the infection known as Dudmur in young children's mouths and tongues (Dutta et al., 2016). There is also information on the Sema Naga tribe of Nagaland using eri silkworm pupa as a medicine to treat back pain (Senthilkumar and Barthakur, 2008; Ao & Singh, 2004). In an effort to ward off evil spirits, Rengma Nagas are known to wear rings crafted from eri-silkworm cocoons on their fingers. The Karbi tribe of Assam has a belief to get protected from evil spirit like Chekema, and hang eri silkworm cocoon at door seals. They also use to believe that applying ashes of burnt cocoons of eri silkworm all over the body of those suffering from sickness and diseases would keep off evil spirits (Sangma et al., 2016).

Importance of Eri Silkworm as Food

Consumption of eri silkworm is an age-old traditional practice in North East India. Larvae, pupae and pre-pupae of eri silkworms are very popular traditional delicacy among different ethnic groups of this region. In Assam, consumption of eri silkworm is reported to be the highest (87.7%) compared to other silkworm species (Lokeshwari et al., 2019). Other than being delicious in taste, scientific investigations revealed the presence of potential essential nutrients in eri silkworms for humans and other livestock. Prepupae of eri silkworms contain 49.74% protein, 7.78% carbohydrate, 22.23% fat, 8.24% crude fibre and a high calorific value of 430.19 Kcal (Choudhury et al., 2020). The defatted eri silkworm meal contains 75% protein and 44% total essential amino acids (Longvah et al. 2011). A total of 17 amino acids including almost all the essential and Sulphur containing amino acids are found to be present in eri pupal protein (Gangopadhyay et al., 2022). Silkworm is the

only animal source containing high amount of á-linolenic acid, an amino acid with high medicinal property (Mahesh et al., 2015).Oil of eri silkworm pupae with 44.73% á-linolenic acid and 50.23% polyunsaturated fatty acids is nutritionally equivalent to certain commonly used vegetable oils and also safe to use (Longvah et al., 2012). High amounts of vitamin A, B1, B2, B9 and E are found in the prepupae and pupae of the eri silkworm (Gangopadhyay et al., 2022). The prepupae and pupae are also a good source of minerals like phosphorus, calcium and magnesium (Longvah et al., 2011). Pupae of eri silkworms can also be used as an ingredient of the feed of livestocks. Pupae of eri silkworm in appropriate amount can also be added to the diet of broiler chickens as an alternate source of protein (Kongsup et al., 2022). Its enormous protein source may open a new dimension for biomedical science.

Polyphagy and Influence of host plants on growth and development of Eri Silkworm

Out of all the non-mulberry sericigenous insects found in north east India, eri silkworm is the one responsive to domestication. It is multivoltine and polyphagous in nature. It feeds on over 29 species of food plants and among them Castor, Ricinus communis (known as 'Era' in Assamese), is the primary host plant of eri silkworm (Lefroy and Ghosh, 1912; Das et al., 2020). Besides Castor, Kesseru (*Heteropanas fragrans*) is also considered as a primary host plant. The host plants have a profound influence on the growth and development of eri silkworms (Kumar & Elangovan, 2010). Different larval parameters are directly influenced by both the amount and quality of food intake of the larvae (Rahmathulla, 2012). Nutrition also plays a critical role in immune response (Vogelweith et al., 2016). Castor is a monotypic species under the family Euphorbiaceae with considerable variations in plant height, leaf and stem color, dehiscence, etc. (Singh et al., 2015).

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Castor leaves are not abundant throughout the year. Since it is a warm season crop, during winter season the leaf yield gets lowered. Different pests like Achoea janata, Euprotis linita, Empoasca flavescens and diseases like Alternaria leaf blight, wilt, Cercospora leafspot, Powdery mildew etc. also affect the castor leaves. To prevent these, chemical pesticides are used as a control measure (Gogoi et al., 2013). These leaves with chemicals are harmful to eri silkworm (Naik et al., 2010). The castor plant is adapted to a wide range of climates. However, increased atmospheric CO2 may show effect on leaf quality of castor ultimately showing effect on phytophagous insects (Rao et al., 2009). This may also affect the silkworm biology and quality of silk. In addition to this, due to the voracious feeding behaviour the larvae require a large number of leaves daily. In this regard, alternative host plants can contribute for continuous rearing of eri silkworm.Borkesseru (Ailanthus excels), Barpat (Ailanthus grandis), Payam (Evodia Flaxinifolia), Gulancha (Plumeria acutifolia), Tapioca (Manihot esculanta), Gamari (Gmelina arborea) etc. are some of the alternative host plants. Plant leaves that are hairy and too hard to eat are generally avoided by the larvae (Tangjitwitayakul & Tatun, 2017).

Rearing of eri silkworm in red variety of Castor is best in terms of larval duration and healthy larval growth in comparison with Kesseru and Tapioca (Deka et al., 2011). Kumar and Gangwar (2010) recorded the maximum larval weight (g) in Castor plant (7.45 and 7.60) followed by Tapioca (6.82 and 6.80). Swathiga et al. (2019) reported the lowest larval duration of 26.45 and 26.60 days and highest larval weight of 9.20g and 9.18g in the larvae reared on the castor genotype GCH4 and DCH519, respectively. The nutrient and mineral content analyses of eri silkworm prepupae and pupae reared on both Castor and Tapioca have shown that these are good source of proteins, fats and minerals (Longvah et al., 2011).

We have also studied the effects of two alternative host plants Gulancha (*P.acutifolia*) and Tapioca (*M. esculenta*) and primary host plant Castor (R. Communis) on certain important larval as well as pupal parameters of eri silkworm, S. ricini (Results unpublished). From our results it was observed that larval parameters were found highest in larvae reared in Castor, followed by Gulancha and Tapioca respectively. Larval weights were found in the range of 6.94-11.54g and larval durations in the range of 17-20 days. The highest pupal weight was found in Gulancha, followed by Castor and Tapioca. Total haemolymph carbohydrate and total protein contents were observed in the same pattern the three host plants. Therefore, Gulancha (P. acutifolia) and Tapioca (M. esculenta) can be considered as potential alternate host plants for continuous rearing without compromising the growth and development of the eri silkworm. Dinata & Gde (2019) also suggested that Tapioca leaves very suitable to be used as an alternative food plant for eri silkworm as the larvae showed good growth and digestibility of nutrients.

Production and Composition of Eri Silk

Eri silk is also known as 'Peaceful Silk' or 'Fabric of Peace' as it can be processed without killing the silkworm. This is possible because the eri silkworm produces open ended cocoons. About 96% of the world's Eri silk is produced in India, which accounts for 17% of India's total silk production, and about 90% of the country's eri silk production comes from the North Eastern region (Baishya et al., 2015; Das et al., 2020). According to the Statista Research Department, India's production volume of eri silk was 6.95 thousand metric tons in the financial year of 2021. Assam contributes almost 65% of the total eri silk production of India (Sangma et al., 2016). Limited information is available about production particularly of eri silk in countries other than India. The silk production in Kenya is reported to increase by two hundred percent since 2014 (Banale, 2017). According to the report of Statista Research

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Department, the silk and silk spun fabric in Japan shows a decreasing trend in production volume from 2012 till 2020.

Eri silks have very good thermal properties. The eri silk fibroin has higher thermal stability and tensile strength than the mulberry silk fibroin (Muthumanickkam et al., 2013). One fascinating property of eri silk is that it is cool in summer and warm in winter. The eri cocoons possess a very high ultraviolet production factor before and after degumming (17.8% and 9.7%, respectively), which are found to be higher than those of the *Bombyx mori* cocoon (15.3% and 4.4%, respectively) (Zhou & Wang, 2020). The percentage cocoon shell composition eri silk is 82-88% fibroin, 11-13% sericin, 1.5-2.2% wax, and 2-3% minerals, ash and others (Padaki et al., 2015). Eri silk has tremendous blending possibilities with other fibres like wool which can increase the physio-mechanical properties of the fabrics (Borah et al, 2019).

Uses of eri by-products in different industries

By-products of eri silkworms are multifarious in terms of their uses. In the textile industry, eri silk is used for making dress materials, shawls, jackets, chaddar, scarves, quilts, and bed covers etc. Eri silk is skin-friendly and can be used in the manufacture of underwear and thermal wear (Kumar & Ramachandran, 2016). Eri silk is also used in the manufacture of various sports wear. Eri silk, as denim knitted fabric, has very good moisture control and is suitable for use as active wear and functional wear (Kumar et al., 2022). Eri silks are generally white or gold in colour depending on the diet of the larvae (Mazzi et al., 2014). Moreover, to improve the quality as well as aesthetic value of eri silk yarns various natural dyes obtained from Datura stramonium, Camellia assamica, Camellia sinensis, Allium cepa, Curcuma longa, Lacciferlacca etc. are suggested to be used (Banerjee et al., 2018; Bhuyan & Gogoi, 2013; Boruah & Kalita, 2015; Gogoi et al., 2019).

In the food industry, eri silkworms have very high potential. The protein-rich eri silkworm pupae are ideal candidates for the preparation of protein-concentrated isolates (Longvah et al., 2011). While silkworm waste is a useful source of biogas, litter and excrement when combined with cow dung provide a good source of manure. Due to their increased protein content, abnormal, rejected, damaged, and dead larvae make excellent poultry feed. Cast-off larval skin makes a very good meal for chickens. Pupal skin is a commercially viable raw material for several businesses, including the pharmaceutical industry (Singh et al. 2017).

Eri silks are useful in the pharmaceutical industry as well. Another benefit of using eri silk as a biomaterial is its high rate of production and low cost. Antimicrobial properties are also known to exist in the cocoons of eri silkworms (Zhou & Wang, 2020). It has been demonstrated that the "protein papers" made from homogenised eri silk nanofibers have excellent application possibilities in healthcare, including wound healing (Liang et al., 2020). Tissue engineering uses eri silk fibroin scaffolds, which exhibit superior performance to those made of mulberry silk (Muthumanickkam et al., 2013). Sponges made from eri silk fibroin can be utilised for biomedical procedures involving cartilage and controlled drug release (Silva et al., 2016).

Eri silks are another ingredient that can be used in the cosmetics industry. Due to their glossy, elastic, and flexible coating capabilities as well as their powerful adhesive and spreading properties, silk fibroin peptides can be employed in cosmetics (Jaiswal et al., 2021). Cosmetics for the skin, hair, and nails have either used silk sericin alone or in conjunction with silk fibroin. Lotion, cream, and ointments containing sericin exhibit improved skin elasticity, anti-wrinkle, and anti-aging properties (Butkhup et al., 2012). According to reports, sericin-containing nail cosmetics (0.02-20%) reduce nail chapping and brittleness and give nails an innate sheen (Rangi & Jajpura, 2015). Thus,

traditional sericulture practises have demonstrated their promise for a wide range of unique emerging commercially significant fields.

Conclusion

It is apparent that eri culture has tremendous potential to play an impactful role in the global market in future. The two main exceptional qualities are the peaceful nature of eri silk and tremendously nutrient rich food quality. Eri pupae with its good quality of protein and other nutrients have potential to provide food safety and security to human as well as to livestocks. Eri culture is mainly practiced traditionally on a small-scale basis in North East India. Presently it is practiced as a subsidiary occupation in this region. More start-ups with novel innovations combining traditional knowledge in this field can provide enormous employment opportunities. It will be helpful in social reconstruction providing gender equality and social equity.

Table 1: Uses of Eri Silkworm *S.ricini* by Different ethnic tribes/communities of North East India

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Tribe/Community (State)	Vernacular Name	Uses	Stages used	References			
- (Manipur)	-	Food	-	Lokeshwari &Shantibala, 2019			
- (Manipur)	-	Relief of bronchitis and Pneumonia	Larvae, Pupae	Singh, 2014			
All Naga tribes (Nagaland)	Eri	Food	Larvae, Pupae	Mozhui et al., 2020			
Ao Naga tribe (Nagaland)	Eri mesen/ Lota mesen	Food	Larvae, Pupae	Pongener et al., 2019			
Bodo (Assam)	Endiamphow	Food	Prepupae	Choudhury et al., 2020			
Deori tribe (Arunachal Pradesh)	-	Food	Late instar larvae, Pupae	Chakravorty et al., 2013			
Mishing (Assam)	Eri leta, AneraPolu	Diet supplement, Protect the liver, Cocoon and cocoon ash used to protect children from evil spirit, Animal feed.	larvae, Pupae, Cocoon and Cocoon ash	Borah et al., 2020; Doley&Kalita, 2012			
Mising, Lalong, Koch, Ahom (Assam)	Eri	Cure infection of tongue and mouth	Larvae, Pupae, Adult	Dutta et al., 2016			
Rengma, Karbi, Naga, Bodo (Assam)	-	Food, Protection from evil spirit such as Chekema (Karbi)	Larvae, Pupae	Sangma et al., 2016			

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Sema (Nagalai		Erimesen, Allishimesen	Medicinal use during back pain	Pupae	Senthilkumar&Barthakur, 2008; Ao & Singh, 2004
Tangsa	(Arunachal	Raijung	Regular food	Larvae, Pupae	Gogoi et al., 2021
Pradesh))				

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The Book

The book is a collection of 09 articles on ethnozoologyand other related aspects of zoological research in North Eastern India authored by different experts in their respective fields. The book is a noble attempt to compile the research articles on ethnozoological research to identify gaps of research works in the field of traditional medicine and ethnozoology in North Eastern India.

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