For B.Sc. (Zoology), 5th Semester Students of Universities of Assam

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Dr. Kishore Sarma is currently working as Indian Council of Medical Research (ICMR) Postdoctoral Fellow in the Department of Zoology, Gauhati University, Assam, India. He has obtained his PhD from Assam University, Silchar. He obtained his M.Sc (Tech) Bioinformatics & "B" Level Bioinformatics from West Bengal University of Technology & DOEACC Society, Kolkata and pursued his B.Sc in Biotechnology from PES College, Bangalore University. The author has over 12 years of hands on work experience in the field of computational genomics, proteomics, Next-Generation sequence analysis, computer aided drug designing, molecular evolutionary analysis, Gene regulatory network architecture. He is also an expert in molecular modeling, docking, molecular dynamics simulation, QSAR, pharmacophore modeling, analogue designing, Pharmacokinetics prediction etc. The author has published 36 peer reviewed manuscript in journals of repute, two books and one book chapter.

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Aashis Dutta is currently serving as an Assistant Professor and Head of the Department of Zoology in Behali Degree College, Borgang, Biswanath. Recipient of numerous scholarships since childhood, he is a young, vibrant, dynamic, energetic professor who believes in putting every single drop of his blood, sweat and tears in achieving the seemingly impossible and fairly unthinkable. He has published several research and review papers in peer reviewed journals and also book chapters in internationally acclaimed books. From being the Topper of the school way back in 2011 to being the Holder of 1st class 1st position in order of merit in the B.Sc Final examination conducted by Dibrugarh University and also being the Best Graduate (Science, 2017) of Debraj Roy College, Golaghat, the author's hobby and interest also lies in presenting papers in National and International conferences.

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Manas Das
Anuradha Kalita Pritimoni Das
Priyambada Chutia Krishna Das

Toxic Effects of Paraquat Dichloride on Mud Eel (Monopterus Cuchia)

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Paraquat Dichloride is a herbicide and continues to be the third most widely used herbicide in the world and indisputably one of the most extensively employed weed killers in India. The content of this book reveals the toxicological response induced by Paraquat dichloride on the fresh water mud eel (Monopterus cuchia), exploring the effects on physiological, biochemical changes and the expression of molecular chaperones as a marker of oxidative stress.

A researcher and Academician working as Assistant Professor, Department of Zoology, Gauhati University, Assam, India. Research interests include Biochemical Adaptation, Stress Biology and Toxicology. I have Published more than 12 research articles in reputed International and National journals including PLOS One, Fish Physiology and Biochemistry.

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HAZARDOUS EFFECTS OF IONIZING RADIATION (X-RAY) AND COMMONLY USED PESTICIDES ON ANIMAL MODEL SYSTEMS

Dr. Manas Das
Priyambada Chutia
Pritimoni Das
Anuradha Kalita

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As Per CBCS Syllabus

ADVANCED BIOCHEMISTRY

Editor:- Dr. H. K. Sarmah

Manas Das
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KALYANI

Although there are numerous books in the market on the CBCS (Zoology Honors) syllabus covered by this book, Advanced Biochemistry, this one stands out in the following points from the rest of them:-

- ❑ Simplistic concepts have been applied to make the subject matter up-to date.
- ❑ The finest of the books like Biochemistry Lehninger were the backbone behind putting up the detailed concepts in these topics.
- ❑ Important definitions have been italicized for proper emphasis.
- ❑ Research papers have been consulted to put up the brilliant and updated concepts.
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These moot points give an edge to the book over the rest of the ones available in the market and will be beneficial to the students to go through a quick revision prior to exam as handy notes.

Dr Manas Das has over 8 years of teaching and nearly a decade of research experience in the field of Biochemistry, Molecular Biology and Animal Physiology. Currently working as an Assistant Professor in the Department of Zoology, Gauhati University, he pursued his Ph.D. from the Department of Zoology, North Eastern Hill University, Shillong. Dr Das has more than 30 research publications to his name in journals of National and International repute, published four book chapters, has completed about three research projects funded by DST, DBT and UGC and he also has one ongoing research project funded by ASTEC, Assam. Awarded early career research award from DST, SERB Govt of India, he is a member of various societies and also has acted as a resource person and delivered talks in more than 50 academic events so far.

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PROSPECTS OF FOLDSCOPE IN STUDYING INSECTS

Bulbuli Khanikor[1,*], Hridisha Nandana Hazarika[2], Bikash Rabha[3], Sudarshana Mahanta[4], Riju Sarma[5], Kamal Adhikari[6], Kurusar Bay[7]

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ABSTRACT

The foldscope is a very cheap, extremely portable, single lens, flat, light weight optical microscope. It is a new intervention as microscopic tool in this decade. This origami-based microscope can be assembled from a flat sheet of paper within few minutes, required no external power for operation and not easily broken down even in harsh handling and hence is a very convenient tool for biological sample study both in field and laboratory. Insects are the most diverse group of organisms occupying all the spheres on the earth. The present study aims to highlight prospects of using of this foldable microscope in studying insects, their body parts, nature of infestation on food plants both in live and fix state.

Keywords: Foldscope, Insects, Microscope, Morphology, Magnification.

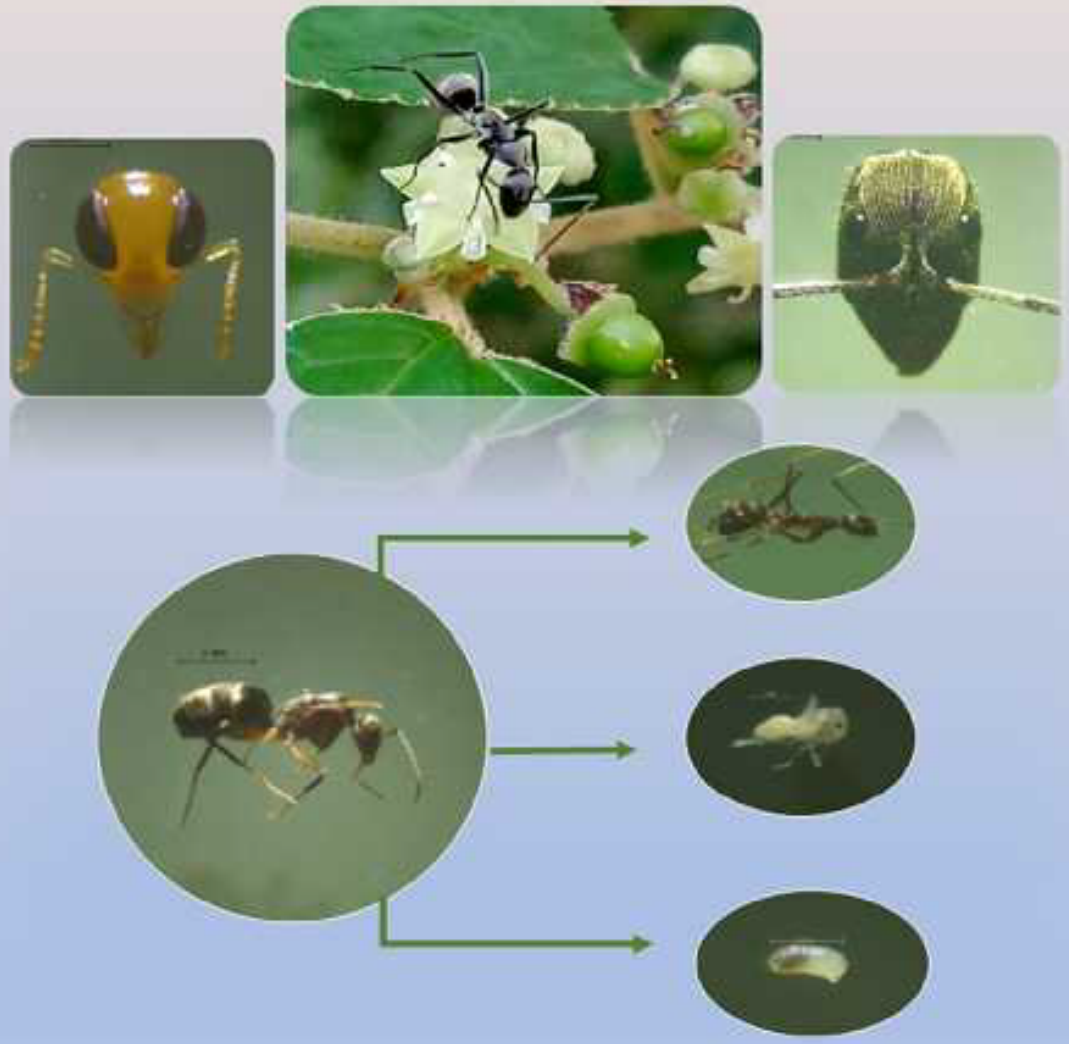
1. INTRODUCTION

Foldscope is a very convenient, cheap and handy optical microscope that can be assembled from a flat sheet of polypropylene paper within 10 minutes. The magnification of foldscope is 140X- 2000X with submicron resolution. Since, the weight of this microscope is very less (8.8g) and the size is small, it can be easily carried in one's pocket. For operation it requires no external energy and even not destroyed if dropped from multi-story building or stepped by a person [1]. The inventor of the microscope (Professor Manu Prakash and his student Jim Cybuluski of Stanford University, California) aimed to make science accessible to all people living on this globe irrespective of economic constraints and also to uncover amazing biodiversity of the entire world. As the cost of this single lens microscope is reasonable (approximately one dollar), it is affordable to users and offers a new eye to the curious world. This tool has already been distributed in more than 135 countries since its invention in 2012 and first launched in India in 2015. Many researchers and amateurs have been using this tool for studying diverse animate and inanimate objects, and most of their findings are shared in a common global platform called microcosmos in the form of still and video pictures. A good number of scientific papers on the use of this microscope for scientific studies are being reported. Interpretation of physical properties like crystallinity of maize starch powder is reported by using this microscope [2]. Foldscope has been used for inexpensive diagnosis of malaria [3], schistosomiasis, and soil-transmitted helminthiasis [4] at the affected area. It was also used to detect tissue antioxidant activity and secondary metabolites in pollen and stomata of *Lantana camara* [5].

Insects are small creatures having more than 400 million years of existence on this earth. This group alone comprises more than 85% species of animal kingdoms with more than 9 lakhs recorded and many more unexplored species. They are the economically important group as they act as seed dispersers, pest, biocontrol agents, bioindicators, pollinators, decomposers, food with high nutritional value etc. They are the potential source of antimicrobial, antiviral, anticancer peptides and untapped source of potential drugs. Contradictorily, they conflict human, other animals and plants by transmitting disease causing pathogens that accounts for large number of untimely deaths. In addition, billions of rupees have been wasted annually for the damage incurred by insect pest in agricultural and other plantation crops both in the field and storage. Thus, insects are unavoidable by humans, other animals and plants. Peoples come across many microscopic as well as macroscopic insects in

Ant Fauna of Assam: A Case Study at Gauhati University Campus, Guwahati, Kamrup, Assam

Dr. Bulbuli Khanikor



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Ant Fauna of Assam: A Case Study at Gauhati University Campus, Guwahati, Kamrup, Assam

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ABSTRACT

Ants are the most abundant and successful organisms in the world. They attract human attention for their fascinating teamwork, disciplined movement, division of labor, selfless service to colony members, painful stinging, and unwanted presence in household items. They are the intelligent invertebrates that had initiated the practice of farming of fungi millions of years before human arrival, could build well-protected nests and territoriality, developed collective skills of foraging and mutualistic relationships with hemipteran insects for nutritional rewards, etc. In terrestrial ecosystems, ants play many vital roles that determine the health of the ecosystem as many other fauna and flora are directly or indirectly dependent on the ant community. The rapid changes in forest cover, land patterns, climatic conditions, etc., and over-dependency on pesticides and fertilizers impact on the ant community and diversity. Therefore, it is imperative to study this most dominant fauna at current times at least to document their present status and also to understand the health of the ecosystem and generate baseline information. The state of Assam in India is a part of the Eastern Himalaya biodiversity hotspot of the world but only a few studies on ant fauna have been carried out till now from this part. The existing checklist of ant species in Assam shows the presence of 217 species of ants under 58 genera. However, a detailed study of these ant species is needed. Gauhati University campus, Guwahati, Assam, offers a meeting place of different habitats viz. dense and fringed forests, hilly areas, natural and man-made wetlands, open plain fields, and undulating hilly terrain, grassland, cultivated area, protected botanical garden, human settlement area with concrete and Assam type buildings where chances of occurrence of diverse ant species are more. Hence this area is selected for the case study of ant fauna and recorded the presence of 41 species of ants that account for 18.89% of the total species recorded from the state. In

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the first chapter along with the general introduction about ants, we describe these 41 species of ants mentioning their morphological characteristics, feeding and nesting habitats, pest/predator status, and distribution.

Ants are generally avoided by predators for their equipped defensive strategies. Ant-mimicking spiders mimic ants morphologically to get protection from predators in one way and deceive their prey in another way. They chemically mimic ants to get constant resources and protection in the stable microhabitat that is the ant's nest. As of now, a total of 13 families of spiders are known to show myrmecomorphy of which the majority of the myrmecomorphic spiders belong to Salticidae and Clubionidae families. Many species of the genus *Myrmarachne* of the Salticidae family show ant-like appearance with elongated bodies and narrow anterior abdominal parts giving the apparent shape of the petiole of ants. Mostly the ant species belonging to the sub-families Formicinae, Myrmicinae, Ponerinae, Pseudomyrmecinae, and Dolichoderinae are used as model organisms by different spider species. Some of the mimicry is highly species-specific and some are general. In the second chapter of the book, we discuss the myrmecomorphic spiders and their model ants. Studies about ant-mimicking spiders and their association with the model ants in India are still scanty. On the campus of Gauhati University, we encountered 10 ant-mimicking spiders which show morphological resemblance with different model ants present on the campus. Of the recorded myrmecomorphs, six species are under the genus *Myrmarachne,* and one species each from the genera *Myrmaplata*, *Toxeus*, *Cambalida*, and *Apochinoma*.

Many ant species are often seen visiting flowers. But whether they perform a pollination role has long been a topic of debate. A school of scientists opined that ants are poor pollinators as their body morphology, behavior, and chemical profile are against successful pollen transfer and pollen viability. Rather ants' presence deters other potential pollinators from flowers. Another group of researchers claims that the flower-visiting ants only ward off inefficient pollinators, not the efficient ones. At the same time, in arid and semi-arid zones where winged pollinating insects are minimal or absent, certain ant species solely perform the role of pollination. In the third chapter, we discuss the flower-visiting ants and their functional roles in pollination based on existing literature. A list of flower-visiting ants recorded on the campus of Gauhati University is also presented.

Overall, these three chapters give a comprehensive idea about the ants of Assam, ant-mimicking spiders and their model ants, and the functional role of ants in pollination particularly in the context of the selected study site.

Keywords: Ant-fauna; ecosystem; Assam; ant-mimicking; pollination.

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

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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

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 yarn 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, B9and 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).

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

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

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.	Last instar 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

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

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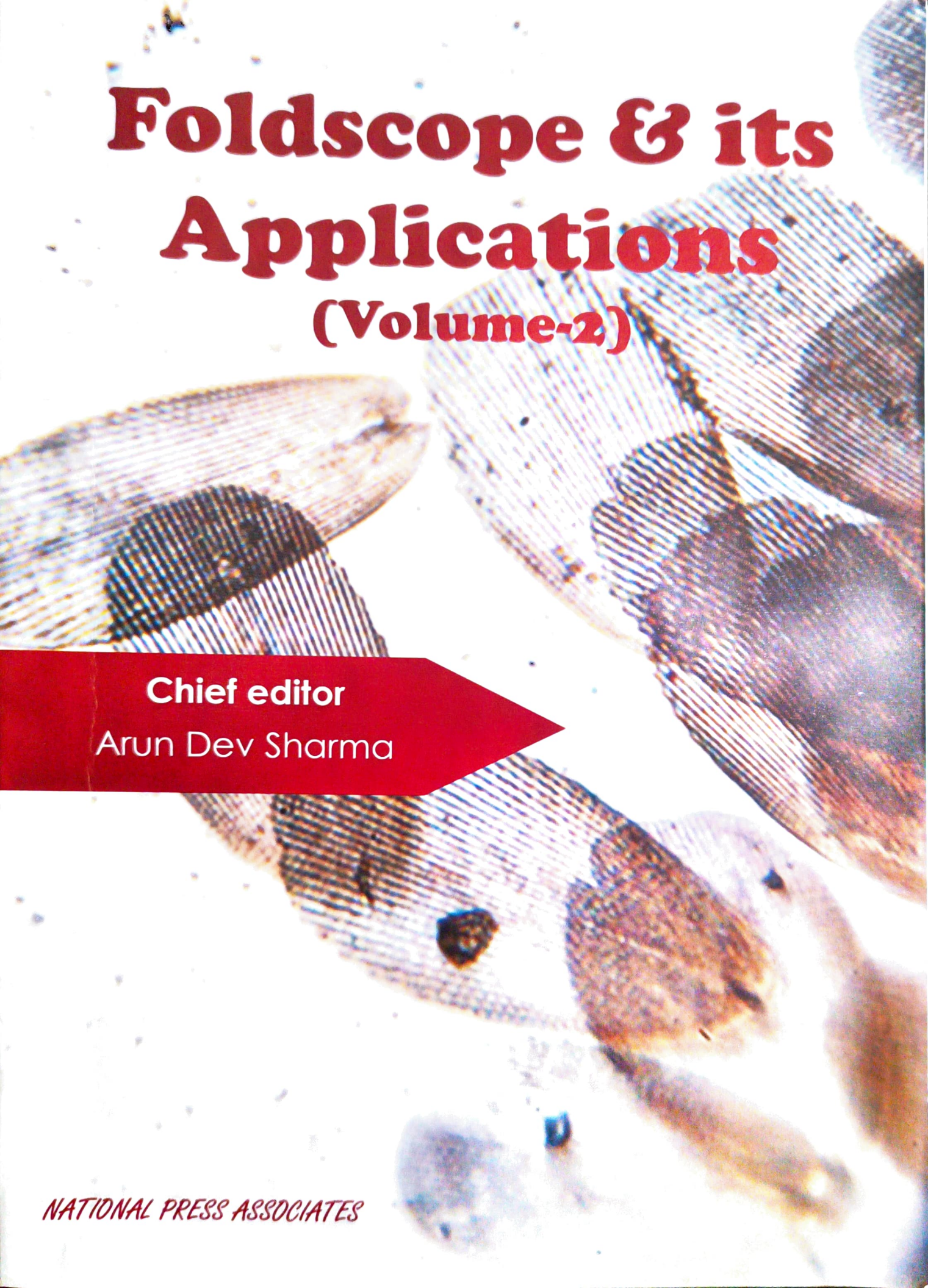

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Citrus Essential Oils: A Suite of Insecticidal Compounds

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Bulbuli Khanikor, Kamal Adhikari and Bikash Rabha

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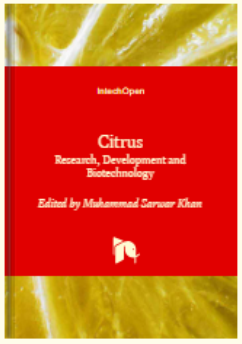

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Chapter

Citrus Essential Oils: A Suite of Insecticidal Compounds

Bulbuli Khanikor, Kamal Adhikari and Bikash Rabha

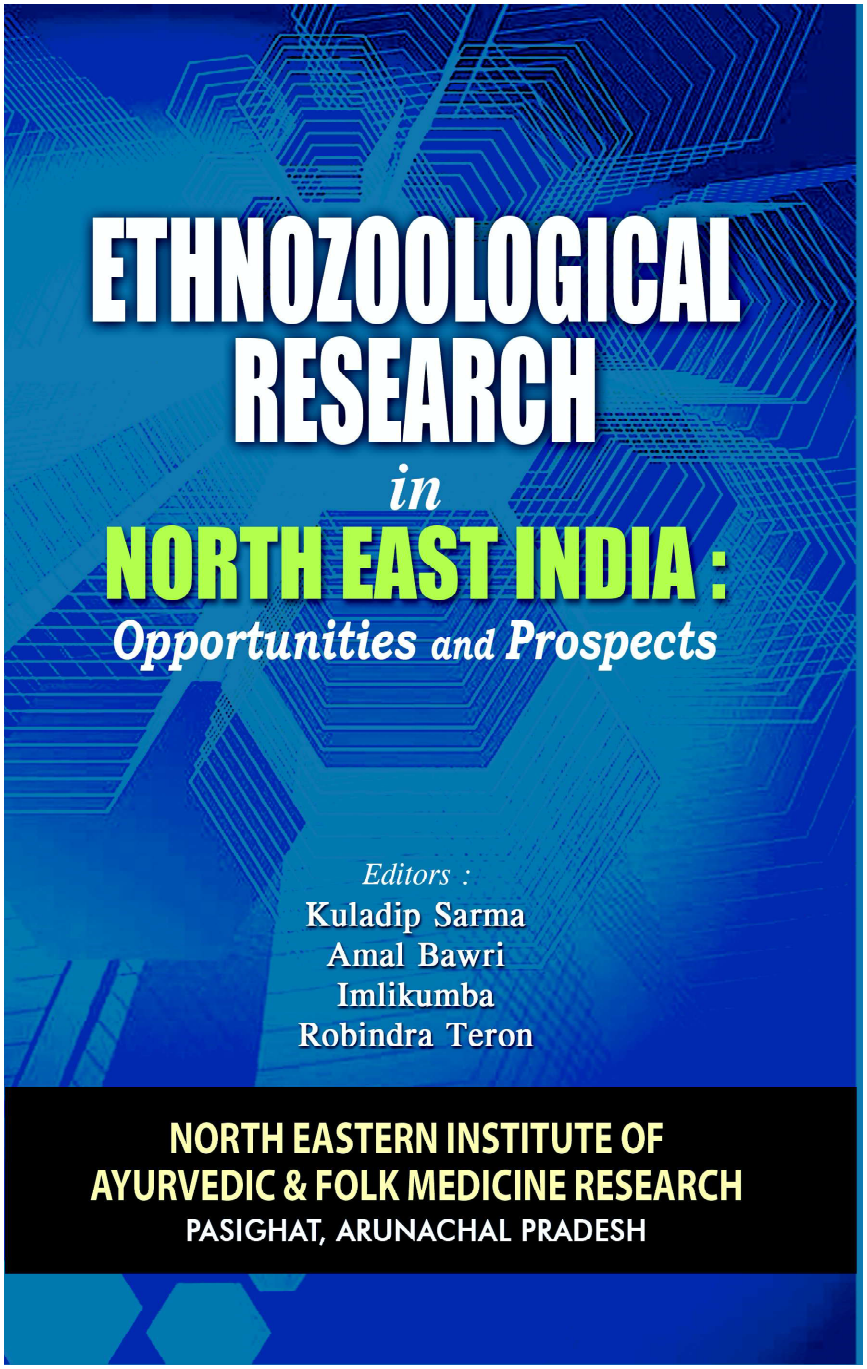
Abstract

Citrus essential oils (CEOs) and their constituent compounds are being reported to have multifarious activities. In this chapter an attempt is made to discuss the insecticidal activities, as well as CEO profile of different vegetative part of *Citrus* species and biocidal potentiality of their constituent compounds against diverse insect pests. It is observed that in most of the CEO constituent profile, limonene is the major constituent compound. Other important constituents present in different percentages in different CEOs are β-citronellal, linalool, pinene, β- caryophyllene, β-myrcene, terpinene, citral etc. These plant EO constituents are reported to have insecticidal effects against diverse insect species. Taking the four peel EOs of *Citrus limon, Citrus paradisi, Citrus medica, Citrus maxima* commonly grown in North Eastern part of India, study on their insecticidal effects against *Dolichoderus affinis* (Hymenoptera: Formicidae) was made and result is presented showing higher fumigant toxicity of *C. medica* and *C. limon* oil against the ant sp. With the increasing awareness for using safe insecticidal products among consumers, the citrus EOs with their attracting terpene compounds having good insecticidal potency bear all attributes to be used as commercial green pesticides in coming days both in indoor and outdoor management of insect pests.

Keywords: essential oils, limonene, *Dolichoderus*, *Citrus medica*

1. Introduction

The genus Citrus has tremendous industrial value all over the globe not only for its nutritive juicy high valued fruits but also for the essential oils present in its different vegetative parts. Thus, both the Citrus fruits and citrus essential oils bear potential to generate livelihood & to boost the country's economy. Citrus essential oils (CEOs) with diverse biologically active compounds of terpene groups with pleasant aroma have already achieved significant positions in flavor, food, cosmetic industries. At the same time, because of their antimicrobial activities as well as anticancer, antioxidant, anti-inflammatory, metabolic disorder alleviating activities etc. these oils and their compounds have been getting importance in pharmaceutical and medical sectors for the last few decades [1]. A good number of studies also reported insecticidal potential of citrus EOs extracted from different citrus sp. and their constituents at different times, a few of which are commercialized to be used by the consumers against insect pests. There are 33 recorded species of citrus worldwide (ThePlantList.org) with many recorded and unexplored varieties present in different parts of the world. The essential oil profile of different citrus species varies although some of the constituent compounds are common but present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3

Ethnozoological Research in North East India : Opportunities and Prospects

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This edited volume is dedicated to
Late Dr. Kenjum Bagra

Dr. Kenjum Bagra,
was a Zoologist, in NEIAFMR, Pasighat. He did his Ph.D in Zoology from Rajiv Gandhi University, Rono Hills, Itanagar, Arunachal Pradesh. Dr. Bagra was a recipient of "Research Fellow in Science for Meritorious Scholars" from University Grants Commission, New Delhi. His first book entitled "*Biology and Habitat Ecology of Kingfisher*" was published by Lambert Academic Publishing, Germany. His latest book "*Industrial use of bioresources of Arunachal Pradesh*" was published by Arunachal Pradesh Biodiversity Board, Itanagar. Dr. Bagra has published 15 Research articles in peer reviewed national and international journals. Actively engaged in Ichthyofaunal research, he has good publications on Fish Biodiversity of Eastern Himalayas.

Preface

The north-eastern states comprise of Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland, Sikkim and Tripura are very rich in floral and faunal elements along with its cultural and ethnic diversity owing to its unique geographic and physiographic location. The region is located in the transitional zone between Indo-Myanmar and Indo Chinese biogeographic region. The amazing fabric of people and biodiversity and has a long history of utilization of natural resources. The pattern and types of such usage however have not documented properly due to many socio-political reasons. With the advancement of science and technology, now it is well realised that all the traditional practices by different tribes and subtribes of NE region in particular and people of these states in general are not deleterious and harmful in the context of biodiversity conservations. There are many examples explaining protection of plants and animals by virtue of the cultural and religious beliefs of the people inhabited in the region. The age-old practice of traditional medicine based on beliefs and taboos are though not all scientifically proven, but most of such knowledges are basis of new scientific discovery of medicine. Thus, Ayurveda has got most of the attention of the world recently. We as Indian fortunate enough to claim it as our part of civilization.

This book comprised of 11 edited chapters is an attempt to document some of the ethnozoological studies carried out by

various researchers of NE India. Although, scattered, there have been published reports on ethnozoology in the region. As conservation of natural resource has been focused in the northeast India since the realization of depletion of the same, we have given little attention to traditional ecological knowledge related to ethnozoological practices. Keeping these on mind, NEIFMR, Pasighat has prioritize the documentation process in the form of organized way, this book is one such small step towards the greater goal.

To authenticate traditional practices are notoriously difficult and there is little opportunities but not to believe the key informants. Therefore, while editing the chapters of the book, we have look into the approach of the studies.

We gracefully acknowledge the contributions of the different authors for sharing their valuable research outputs. The editors express their sincere gratitude to the Ministry of AYUSH, Government of India for constant support.

Editors

Contents

Chapter 1

A Review on Ethnozoological Practices related to order Anuran (Class: Amphibia) in Northeast India

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Abstract

The utilization of the faunal resources is at the fullest by the indigenous tribes living in India in general and northeast India in particular. The present study is a review on ethnozoological practices of order Anuran with the help

of published articles and reports, out of which 88% are published after the year 2005. This review highlighted around 9 different Anuran species were utilized by several indigenous tribes for 22 distinct human ailments comprising 14 different states of India in general and including all states of northeast India. Out of these 22 different diseases that are treated by different species of frogs including diabetes which is one of the most prevalent and ninth leading deadly diseases across the world. Besides that, some of the ailments like a wound, blood loss, gastritis is treated with three different species while Asthma is treated with two distinct species. Again, the distribution of uses of certain species is not uniform. Some of them are utilized in multiple states while others are endemic to only one state. From the data, Rana sp. is found to most uniformly used (40%) Anuran species in 10 different states in India followed by Buffo sp. and Hoplobatrachus tigerinus which is used by 4 states that cover 16% each of total usage. However, a huge amount of data will be required to document the traditional knowledge that is prevailing related to the ethnozoological importance of Anurans.

***Keywords** : Amphibians, Ethnomedicine, Indigenous, Tribes, Zootherapy*

Introduction

Humans have had a close relationship with animals and their surroundings since the dawn of civilization. Archaeological studies have revealed that humans have been consuming a diverse range of animals for as long as 1500-4000 years, including fish, mollusks, birds, mammals, reptiles, and amphibians (Alves & Souto, 2015). These animals are hunted for defense as well as utilizing their products. These products were used for food, clothing, making tools as well as

medicinal and many religious purposes (Alves & Souto, 2015). From primitive times animal and animal-based products were widely used as a source of medicinal practices and such practices are still used in traditional medicine(Verma et al., 2014b).

Zootherapy is related to curing human ailments using animal and animal-based products (Verma et al., 2014b). According to the World health organization (WHO), 8.7% of 252 essential chemicals are obtained from animals (Marques, 1997). Again 27 out of 150 prescribed drugs in the US are animal in origin (Mahawar & Jaroli, 2008). Although zootherapy is an intriguing topic, it is also one of the least researched. As a result, many researchers have been drawn to zoo-therapeutic studies in recent years because of their potential to contribute to many modern therapeutics, conservation biology, and so on.

India is a habitat for about 450 tribal communities having great cultural values (Saikia et al., 2021). These communities mainly rely on natural resources for their traditional medications as well as other primary needs. Most of these communities use traditional therapeutics as an alternative or parallel source for modern medicine (Hussain & Tynsong, 2021). Although very few traditional therapeutic are documented and used as modern medicine, most of them are remain undocumented. These unique healthcare practices are handed over from generation to generation verbally but due to the urbanization and development of village areas, the young generations are started to attract towards more profitable career options. This creates a decline in the practice of those traditional therapeutics. Therefore, it is necessary that the local ethnobiologist as well as local people to understand and document all the traditional knowledge before it died off (Hussain & Tynsong, 2021).

Comprising more than 3 million km square of the total area, India is one of the ten largest countries and one out of eight megadiverse countries around the world. Although it occupies only 2% of the total surface area of the world, it has nearly 7% of the global faunal diversity (Jimenez & Lindemann-Matthies, 2015). However, only 109 species are only used for traditional practices out of which only 2% are amphibians mainly the anurans (Mahawar & Jaroli, 2008). Although lesser in number it has great ethnic value and is widely used for medicinal purposes. Along with that, it has great ecological value in the food chain. It fed upon different disease-causing insects like a mosquito. along with that, it becomes prey for other larger vertebrates. These anurans have very sensitive skin that makes them vulnerable to environmental pollution (Jimenez & Lindemann-Matthies, 2015). Therefore, it is very necessary to study their ethnic medicinal uses to make them more valuable for the present-day world and this might lead to the conservation of these ecologically sensitive species.

Method

Study area

The content of the paper is based on published papers and reports concerning ethnozoological applications of order Anuran in most of the Indian states. According to the national portal of India, the area of this region is 32,87,263 sq. km becoming the 7th largest country all over the world, situated between latitudes 8^{0}4 and 37^{0} 6 North, longitudes 68^{0}7 and 97^{0}25 East. It has been reported that India is the present home for about 450 tribes, out of which about half of them are connected to the North-Eastern region of this country (Saikia et al. 2021)

Google Scholar, Science Direct, PubMed as well as ResearchGate are used to search the required contents with the help of some key terms – "Ethnomedicine", "Zootherapy", "Tribes" from the relevant databases. The study includes only peer-reviewed publications of relevant work.

Results and Discussion

The present review reveals that there are 14 states in India where ethno-zoological surveys are conducted on Anurans and most of them belong to the northeastern states of India. Details of those ethnozoological surveys are compiled and presented in Table 1. These compiled data also reveal that around 22 diseases are treated by utilizing these 9 different anuran species across India (Figure 1 & Figure 2). The study on the zootherapeutic activity of anurans across India discloses around 22 different diseases are treated by different species of frogs. These diseases include diabetes which is one of the most prevalent and ninth leading deadly diseases across the world (WHO, 2021). Besides that, some of the ailments like a wound, blood loss, Gastritis is treated with three different species while Asthma is treated with two distinct species. Again, the distribution of uses of certain species is not uniform. Some of them are utilized in multiple states while others are endemic to only one state. From the data, *Rana sp.* is found to most uniformly used (40%) Anuran species in 10 different states in India followed by *Buffo sp*. and *Hoplobatrachus tigerinus* which is used by 4 states that cover 16% each of total usage. *Duttaphrynus melanostictus is* used in 2 different states and uses of *Polypedates leucomystax*, *Euphylctis cyanophlyctis, Limnonecties limnocharis, Nanorana leibigii, Euhlyctis cyanophlyctis* remain endemic to one state only.

Table 1: List of states along with their Tribes using Anuran species in India for ethno-zoological practices

State	Place	Tribe	Genus/species	Part used	Purpose/used for	Application method	Reference
Assam	Gibbon Wildlife Sanctuary, Jorhat	Ahom, Chutiya, Koch-Rajbonshi, Kalita, tea tribes	*Polypedates leucomystax* (Gravenhorst,1829)	Flesh/meat	Asthma	With proper seasoning (with cinnamon, clove) meat is boiled and consumed	(Borah & Prasad, 2017)
			Bufo spp. (Linnaeus, 1758)	Heart with blood	Bronch pneumonia	Taking fresh blood along with heart and making a paste with pepper, cardamom and then consume	
			Rana spp. (Linnaeus,1758)	Meat	Asthma	Cooked meat is consumed	
	Kokrajhar District	Bodo tribe	*Duttaphrynus melanostictus*	Skin	Ringworm disease as well as Paronychia disease	Removed skin is washed and wrapped around infection for 2-3 days	(Narzary & Bordoloi, 2014)
			Hoplobatrachus tigerinus	Thigh flesh	Stomach problems as well as High pressure	Normal cooked with local vegetables or fried in oil	
	Karbi-Anglong	-	*Rana spp.*	Skin and flesh	Healing wound and tongue blister	Oil from the skin is extracted and used, the cooked flesh is consumed	(Verma et al., 2014a)
		-	*Bufo spp.*	Hind legs	Urinary retention, acne	Flesh from the thigh is cooked and consumed	
Nagaland	-	Naga tribe	*Hoplobatrachus tigerinus* *Euphylctis cyanophlyctis*	Meat and skin	Skin burns, gastritis and prevention in blood loss	-	(Talukdar et al., 2020)
		Chakhesang tribe	*Limnonecties limnocharis*	Skin and flesh	Skin burns, in children it is used for tongue blister	Meat/flesh is cooked and consumed	(Kakati & Doulo, 2002)
			Bufo melanostictus	Gall bladder	Wound by thorns in the flesh	For easy take out, the gall bladder is applied to the thorn affected region	
		Ao Tribe	*Rana spp.*	Skin	Wound healing	Skin is thoroughly washed and applied	(Kakati et al., 2006)
		Apighi, Paoaium, Hanijek, Maruh,	*Limnonecties limnocharis*	Skin and fat	Burn wound, massaging rheumatic joints	Cooked flesh is consumed and fat is directly used	(Jamir & Lal, 2005) (HUSSAIN &

		Apighi, Paoaium, Hanijek, Maruh, Anechi, Niugam, Pu, Ao	*Limnonecties limnocharis*	Skin and fat	Burn wound, massaging rheumatic joints	Cooked flesh is consumed and fat is directly used	(Jamir & Lal, 2005) (HUSSAIN & Tynsong, 2021)
Manipur	Tamenglong District	Rongmei tribe	*Rana tigrina*	Whole-body	Prevention in blood loss	Boiled properly and consumed	(Ngaomei & Singh, 2016)
Sikkim	-	-	*Nanorana leibigii*	Meat/flesh	Cough/cold and Dysentery/Diarrhoea and piles	Frog is skinned and boiled after cutting it into small pieces with salt till broth consistency and consumed	(Dhakal et al., 2020)
Tripura	Khowai District	-	*Rana tigrina*	Flesh	Wound healing	Flesh is crushed and then applied to the wound	(Das 2015)
Mizoram	-	-	*Bufo melanostictus*	Bile	Diabetes	Fresh bile is orally taken	(Chinlampianga et al., 2013)
Arunachal Pradesh	-	Nyishi tribe	*Rana spp.*	Whole-body	Wound healing	Live crushed frog is applied on wound caused by insect bite (twice a day)	(Chakravorty et al., 2011)
Meghalaya	East Khasi Hills District	-	*Rana spp.*	Whole-body	Postpartum pain and ache	The frog is de-gutted and smoked on fire and consumed	(*Turnia & Prasad* 2017)
West Bengal	Pokhribong of Darjeeling hills	-	*Nanorana leibigii*	Whole-body	Fever, infertility, measles, Diarrhoea, piles	Meat is cooked and consumed during infertility. For 2-3 months old baby suffering from fever, boiled meat soup is given. It is also given for measles treatment.	(Chhetri et al., 2020)
Andhra Pradesh	Warangal District	Koya tribe, Guthikoya tribe	*Rana tigrina*	Whole-body	Burn wound	The frog is boiled in oil and applied	(Benarjee et al., 2010)
Tamil Nadu	Kolli Hills in Namakkal District	-	*Rana tigrina*	flesh	Wound healing	Body massaging	(Latha et al., 2018)
Orissa	Western part (Gandhamardan hills)	Munda, Goondo, Bhumia, Binjhal,	*Duttaphrynus melanostictus*	Whole-body, skin, flesh, fat	Insect bite, tonsilitis, gastritis	Live crushed toad is applied to wounds from insect bites twice a day. Skin and flesh are cooked and taken for gastritis. Melted fat is applied to tonsils	(Pradhan et al., 2014)
Uttarakhand	-	Bhotiya tribe	*Hoplobatrachus tigerinus*	Flesh	Wound healing	Crushed flesh is applied to wound	(T. Negi & Kandari, 2017)
Uttaranchal	Pithoragarh district	Shoka tribe	*Rana tigrina*	Whole-body	Wound healing due to burn	Frog boiled in oil is used for healing wounds due to burn	(C. S. Negi & Palyal, 2007)

The "-" shows unavailable data

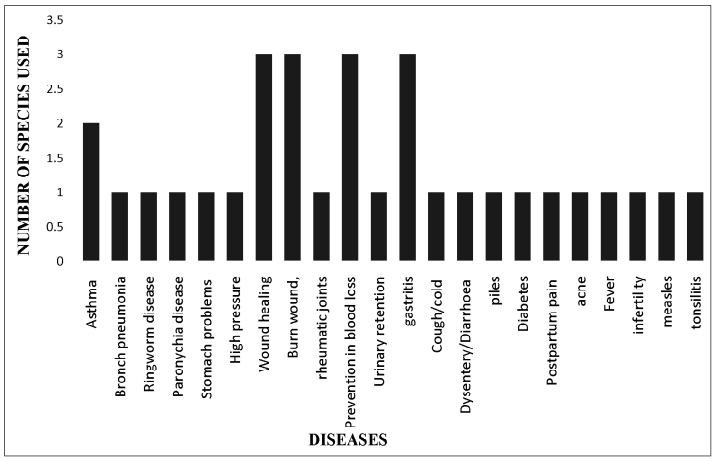

Figure 1: 22 different diseases treated by different Anuran species across India

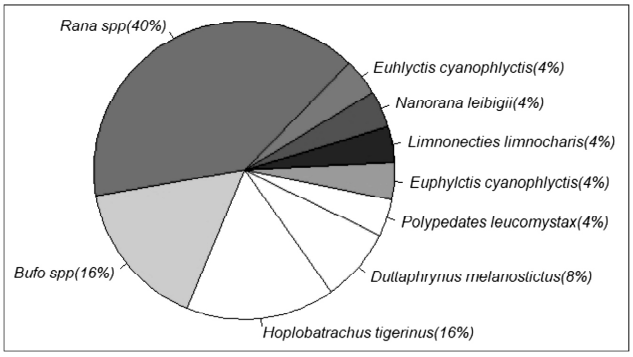

Figure 2. Percentage use of 9 different species across different states of India

Assam is one of the major ethnologically active states of India. The practice of zootherapy remains active as many indigenous groups are connected with this place. In a recent report, a collective as well as broad study about ethnozoological applications of animal-based products adopted by various communities like Ahom, Chutiya, Koch-Rajbonshi, Kalita, Tea-

tribes in Jorhat district (Gibbon Wildlife Sanctuary region) have been described and pointed out about 7.1% of amphibian species among their 44 listed species which are used in medicinal purposes, and all of the amphibian species come under Order Anuran (Borah & Prasad, 2017). Apart from this, the Bodo tribe and Karbi from Kokrajhar district and Karbi Anglong district respectively have also been reported to use frog skin and flesh to prevent some diseases like Ringworm disease, Paronychia disease, and some stomach problems by consuming cooked meat of frog as well as by applying frog skin on the infective area (Narzary & Bordoloi, 2014; Verma et al., 2014a).

Nagaland is inhabited by 14 major indigenous Naga tribes like Ao, Angami, Phom, Sangtam, Lotha, Rengma, Zeliang, Chakhesang, yumchunger, khaiamniumgan, Pochury, Konyak, Sema and many other sub-tribes (Zhimomi, 2004). Studies conducted by Jamir & Lal, 2005, Kakati & Doulo, 2002, Kakati et al., 2006, Hussain & Tynsong, 2021 reported that around 26 animal species are used for traditional practices out of which only three Anuran species are majorly utilized for ethnozoological practices. All of these Anuran species are used for wound healing purposes, along with that, *Limnonecties limnocharis* is also applied for massaging rheumatic joints. Part of animals that are utilized for zoo therapy mainly includes skin, fat and gall bladder (Jamir & Lal, 2005).

Manipur, an oval-shaped valley of northeast India, is a habitat for numerous native flora and fauna ((Devi et al., 2015). It is also inhabited by many ethnic tribes out of which a study organized by Ngaomei & Singh, 2016 shows that the Rongmei tribe, inhabitant of Tamenglong district consumes *Rana tigrine* as a traditional medicine to prevent blood loss.

Sikkim, the smallest foothill state of northeast India, is represented by three major tribes- Lepcha, Bhutia, and Nepali

are best known for their ethnic culture, food delicacy and ethnozoological practices (Anon, 2017(Dhakal et al., 2020). Around 42 different animal species and 12 different body parts are used by these tribes for their medicinal and religious practices. *Nanorana leibigii* is one of the most valuable species used by the locals because of its therapeutic properties and taste. It is mainly used for the victims of Diarrhoea, Dysentery, Vomiting, loss of appetite, etc (Dhakal et al., 2020).

Mizoram is inhabited by two major local tribal communities-Chakma and Mara along with Lia, Paite and Hmar (Hussain & Tynsong, 2021). Chinlampianga et al. in 2013 documented that the Zomi-paite community uses 48 faunal species for medicinal practices that include treatment of Diabetes, one of the major disorders in India. The bile of *Bufo melanostictus* is orally taken by the patients of the tribes to control diabetes (Chinlampianga et al., 2013).

Arunachal Pradesh, the largest state in northeast India covers a maximum portion of the Eastern Himalayan biodiversity hotspot. This area is not only rich in natural diversity but also home to 26 major tribes and 110 sub-tribes. Ethnological studies reveal that these communities, especially the Nyishi tribes use *Rana* spp. for wound healing purposes. They crush the whole body of the frog and apply twice a day over the wounded area that might be due to some insect bite (Chakravorty et al., 2011).

Khasi, Garo, and Jaintia, three indigenous tribes in Meghalaya have a profound relationship with their nature. A survey carries forward by Turina and Prasad in 2017 recorded that a total of 13 animal groups were in use for the traditional customs and zoo-therapeutic uses. These locals use *Rana* sp. frogs for curing some post-partum pain/ache. One of the interesting things is that they are used to remove the intestine before it is smoked in fire and boiled. The patient consumes the whole boiled flashy body of that frog (Prasad & Turina, 2017).

Tripura is another ethnomedically diverse northeast Indian state. Tripura is home to approximately 19 different tribes, which together utilize 25 different species in their ethnomedicinal practices. Out of these 25 species, one species of amphibia that is *Rana tigrina* is used for wound healing practices in which the whole frog is crushed and applied over the wounded area (Das, 2015).

Apart from the North-Eastern states, the South region of India, for example, Tamil Nadu is considered as a greatest diversity hotspot state which included Eastern and Western Ghats, occupied by many ethnic tribal populations(Latha et al., 2018). In the same report, they reported 45 species, out of which only 2% belong to amphibians and which are directly applied to the wound to enhance the healing process. Andra Pradesh is another state present in the South region of India and the tribes of this region are also use frogs to enhance the healing effect when applied to the wound (Benarjee et al., 2010).

Ethnozoological study reveals that communities of Pokhribong, Darjeeling, West Bengal use about 26 different faunal species in 33 different ethnic medicinal therapies. 74% of these animals belong to vertebrates and 26% to invertebrates. Out of these 8% is amphibians that include only one species, *Nanorana leibigii*, which is used for several diseases like Fever, infertility, measles, Diarrhoea, piles (Chhetri et al., 2020). They use the whole body in a different way for different diseases as recorded in Table 1.

According to Pradhan et al., the tribes (Munda, Gondo, Bhumia, Binjhal, Mirdha, Kandha and Saharas) belonging to the Western region of Orissa state-provided information of using 3 amphibian species for different illnesses like pain during insect bite, wound healing, tonsilitis as well as gastritis.

Moreover, some reports have been also found from regions like Uttaranchal and Uttarakhand. It has been reported that