Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [3] 2017: 101-105

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95

FULL LENGTH ARTICLE **OPEN ACCESS**

Insect Biodiversity: The Teeming Millions- A review

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ABSTRACT
Insects are the world's most diverse group of animals on Earth, in terms of both taxonomic diversity and ecological function accounting 75 % of the known species of animals.Approximately 30 million species are found worldwide, of which about 1.4 million have been briefly described.Less than 3% of all species of insects have aquatic stages in some freshwater biotopes. India is one among the twelve mega biodiversity countries of the world, constitute nearly 7% of the world insect fauna. Current estimate shows that out of nearly 63,760 species of insect species in India, about 21,166 species are endemic. The diversity of insects is greater in the north-eastern states, the Western Ghats and the Andaman and Nicobar Islands, and these areas also have a high level of endemism. Insects are becoming extinct because of habitat loss, over-exploitation, pollution, overpopulation and the threat of global climatic changes. Insect biodiversity has a significant role in the maintenance of the ecosystem. So, there is increasing need for taxonomic information and services in our society, particularly for biodiversity assessment for attaining an environmentally sustainable future. Several biodiversity indices were used to study the species richness in the area. With the recent advancement in science, the new method called DNA barcoding, a tool of DNA-based taxonomy is used to identify known and unknown species on the basis of the pattern of nucleotide arrangement in a fragment of DNA from target species. In order to speed up taxonomic identification, DNA barcoding is now been considered as an alternative tool for insect biodiversity identification in India and the World.
Keywords: *Biodiversity, Insects, Ecosystem, India, Taxonomy, DNA barcoding.*

Received 13.07.2017 Revised 09.08.2017 Accepted 23.08. 2017

INTRODUCTION

Biodiversity in the recent years has acquired considerable importance as focal point ofdiscussion like some other global issues (Ghosh and Singh, 2000). It means the variability among the living organisms from all sources, diversity within species, between species, and of ecosystems. (Harper and Hawksworth, 1994).Usually biodiversity is considered has three levels genetic diversity, species diversity and ecosystem diversity (Solbrig, 1991).Insects represent the vast majority of species in terrestrial and freshwater ecosystem. They have adopted for almost every conceivable type of environment from the equator to the arctic and from sea level to the snowfield of highest mountains, on land, in air and water (Belamkar and Jadesh, 2014).

Evolution of Insects

Biodiversity is not static, it is a system in constant evolution from a species, as well as from an individual organism point of view. The average half-life of a species is estimated at between one and four million years, and 99% of the species that have ever lived on earth are today extinct. Biodiversity is not distributed evenly on earth, it is evident from fossilized specimens that insects were living 400 million years ago. Evolution of insects in our universe is classified as Silurian, Carboniferous, Late carboniferous or earlyPermian, Paleozoic and Cretaceous periods (Gullan and Cranston, 2005).

Diversity of Insects

Biologists have long realized the great diversity of insects. But the described insects are unknown fraction of total, no central organized database for the life on earth and also unclear how many described species exist (ZSI, 2012).Approximately 30 million species are found worldwide, of which about 1.4 million have been briefly described. (Balakrishnan*et al.,* 2014).The kingdom Animalia is represented by 15, 52,319 species that have been described so far globally in 40 phyla in a new evolutionary classification. The phylum Arthropoda alone includes 12, 42,040 species, constituting about 80% of the total number of

species (ZSI, 2012). Insects comprise more than 75 % of all described animal species and exhibit not only a rich variety of form, color, and shape, but also a range of ecological adaptations unexcelled by any other group (Cheng, 1976). The most successful insect order, Coleoptera, represents about 38% (3, 87,100 species) of the insect species of the world (Zhang, 2011).

The Insect Fauna

There are about 7, 51,000 known species of insects, which is about three-fourths of all species of animals on the planet (Choudhary, 2015).The greatest concentration of insect species lies in tropical areas of the globe. One hectare of Amazonian rainforest contains more than 1, 00,000 species of arthropods (Erwin, 2004) of which roughly 85% are insects (May, 1998). About 1, 27,000 species of plants, animals and microorganisms have been reported so far from India. Of these, animal species (about 89,500 species) including Protozoa, constitute the major share. The insects are predominant biota on all components including Antarctica. In India biological diversity is observed in the large number of insect species. Compilation of data reveals that about 59,353 species of insects are known from India. Indian insectsconstitute nearly 7% of the world insect fauna(Ghosh and Singh, 2000).

Taxonomic account of Insects

Presently, 63,760 species of insect (Hexapoda) in 658 families representing 27 orders and three class are reported from India. Of these, eight orders, *viz.* Coleoptera, Lepidoptera, Orthoptera, Diptera, Hemiptera, Odonata, Hymenoptera and Thysanoptera, constitute the bulk 94 percent of the insect fauna.The remaining 21 orders are represented by small numbers (6 percent of species (ZSI, 2012).

Importance of Insect Biodiversity

Insects are closely associated with our lives and affect the welfare of humanity in diverse ways (Srivastava and Basera, 2010).At the same time, ecosystems depend heavily on insect activity. Insects play critical roles in ecosystem function, nutrient recycling, pollinate plants, disperse seeds, maintain soil structure and fertility, control populations of other organisms, provide a major food source for other taxa(Majer, 1987). Certain insects can damage our health, domestic animals, agriculture, and horticulture. Others greatly benefit our society (Gullan and Cranston 2005), some insects such as predatory beetles or parasitic wasps, control pests by keeping their populations in check. Insect predators comprise approximately 10% of all insects and parasitic insects include approximately 15% of all insects, which plays a vital role in biological control.Insects are the oldest and most important pollinators of the angiosperms. Insect began pollinating flowering plants approximately 140 million years ago. At least one-third of the world's agricultural crops depends upon pollination provided by insects and other. Among the insects, hymenopterans are largest and diversified assemblages of beneficial insects constitute the most important group of pollinating insect (Pannure, 2016).

Some insects are producing productive materials like lac and silk. The lac insect ecosystem is a complex multi-trophic web of flora and fauna. It represents a rich biodiversity, which includes besides lac insects, lac-host plants, and several predators of lac insects, beneficial parasites, harmful parasites, microbes and a variety of pests of host plants. Over 3 million tribals inhabiting the Indian states are engaged in lac cultivation. India, accounting for about 50–60% of the total world lac production (20,000 metric tonnes/annum) (Sharma *et al.,* 2006). Seri-biodiversity refers the variability in sericigenous or silk producing insects and their host plants.The North-Eastern region of India makes ideal home for a number of wild sericigenous insects. Biodiversity survey of Sericigenous insects in Assam, a total of 12 species belonging to 8 genera and 2 families were recorded (Kalitaand dutta, 2014). Because insects are so numerous they have an important impact on our environment and our lives, an understanding of the flora and fauna and their interrelations is very essential for the sustainable utilization of biodiversity to the advantage of mankind.

Aquatic biodiversity

Freshwater lakes are integral part of urban ecosystem and provide numerous benefits to human beings directly or indirectly.Aquatic insects are extremely important in ecological systems for many reasons and are the primary bio-indicators of freshwater bodies such as lakes, ponds, wetland, and rivers. The presence or absence of certain families of aquatic insects can indicate whether a particular water body is healthy or polluted(Majumder*et al.,* 2013). Less than 3% of all species of insects have aquatic stages in some freshwater biotopes.Aquatic insects are used for monitoring the health of aquatic environments because of their differential responses to stimuli in their aquatic habitat and determining the quality of that environment (Merritt Cummins and Berg, 2008).There are so many different kinds of aquatic insects, but the major groups includes, mayflies, stoneflies, true bugs, dobsonflies, water beetles, tricopterans, true flies,dragonflies and damsenflies(Voshell, 2002).

Biodiversity of Bioluminescence Insects

Bioluminescence or living light is a remarkable phenomenon in the organisms living on this earth, were the energy is release by a chemical reaction in the form of light emission. There are no luminous

flowering plants, birds, reptiles, amphibians or mammals in nature. Though bioluminescence is generated by various organisms, it is highly developed in insects. The examples of true or self-luminescence are found in Collembola, Diptera, Coleoptera and Homoptera. The order Coleoptera constitutes the largest bioluminescent group in which several hundred species are known to contain highly developed photogenic organs. The best understood luminous insects belong to the families Lampyridae, Elateridae and Phengodidae. In some lampyridae species female are wingless and sedentary, light production is therefore important forattracting the winged male (Gajendra and Kannan, 2002). This biological phenomenon has been exploited in space and medical research, insect pest management, and is also a useful tool in biotechnology.

Insect fauna of states and union territories of India

India's insect fauna is distributed over a wide range of ecosystems, climatic regions and altitudes. The insect distribution is mainly influenced by the ecological, climatic and edaphic factors, such as the vegetation, rainfall and temperature. The insect fauna in the Himalayan Zone, including the mountains in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, north-west Bengal, Meghalaya and Arunachal Pradesh, is influenced by the Palearctic elements. However, the insect fauna of the desert areas of Rajasthan, Gujarat and Ladakh (cold desert) varies due to variation in extreme temperature in these states. The tropical humid forests of the Western Ghats and the eastern Himalaya are different from the island ecosystems of the Andaman and Nicobar Islands, but the greatest numbers of endemic species occur in these ecosystems (ZSI, 2012).The tropical evergreen forests of the eastern Himalaya and the hills of north-east India including the states of Sikkim, Meghalaya, Arunachal Pradesh, Manipur, Nagaland, Tripura and Mizoram and north-west Bengal harbor the greatest number of insect species, followed by the states in which the Western Ghats fall, such as Kerala, Tamil Nadu, Karnataka and Maharashtra. The third biodiversity-rich areas in terms of insects are the western Himalayan region and the Andaman and Nicobar Islands (ZSI, 2012).There are still many inaccessible areas in the country that have not been adequately explored for assessment of the insect wealth.

Biodiversity of Insects in Northeastern India

Northeastern India has been considered as one of the mega biodiversity hot spots. Because the climatic condition of the region are highly conducive for the growth and multiplication of the insects (Azad-Thakur *et al.,* 2012).The Biodiversity Strategy and Action Plan for Northeast Eco-region recorded 3,624 species of Insects. Butterflies and moths are by far the best-studied invertebrate organisms of the region, which contributes the maximum number of species for this group in the country. One of the largest known tropical Lepidoptera is the Atlas Moth (*Attacus atlas*), is very common in many parts of Northeast India. Apart from that, *Princeps polyctorganesa*, a beautiful butterfly and *Erysmiapulchella*and *Nyctalemonpatroclus*two beautiful moths also occur in the region.(Chatterjee *et al.* 2006). Honey bees, another important insect, that render very valuable ecological services like pollinating wild and cultivated plant species. Four indigenous species of honey bees are recognized from India, these are *Apiscerana,A. dorsata*, *A. florae* and *A. andreniformes*.Of these, *Apisandreniformis*is only known from a few specimens collected from Northeast India where the species is exceedingly uncommon. Unfortunately, the bee pollination in the region under threat, because the people in certain parts of Northeast India not only consume the honey and larvae of this insect, but also fry and eat the adult honey bees. (Azad-Thakur *et al.,* 2012).Sikkim is one of small Himalayan state of northeast India covering the area of 7,096 sq. km.The state of Sikkim with 0.21% of the geographical area of whole India, represents 9.63% of all known insect species diversity of the country, which reveals that the Sikkim possess very high species biodiversity in comparison to any other state in India. Despite the fact, that the study of insects in Sikkim is still not very exhaustive (ZSI, 2012).

Threats to biodiversity

Changes in habitats all across the country, particularly in fragile ecosystems, freshwater ecosystems and forests areas has impacted the insect diversity of India. Pollution of streams, particularly through drainage and siltation, has resulted in profound changes in aquatic insect communities. The introduction of exotic insects for the control of pests or weeds directly or indirectly affects the population of native insects. However, the major factor responsible for the loss of insect populations during the last few decades is the widespread use of organic pesticides (ZSI, 2011).

Endemism in insect fauna of India

Insect diversity in India is characterized by a high level of endemism (Chandra, 2011). A high percentage of endemism is noted in the primitive insect groups such as Protura (85%), Diplura (66%) and Thysanura (60%), followed by Collembola (15 %). Among the exopterygotes, Thysanoptera has the highest percentage of endemism (75%), followed by Phasmida (68%), Ephemeroptera (58%), Plecoptera (57%), Orthoptera (54%), Embioptera (45%) and Isoptera(44%), and there is less than 40% endemism in the remaining orders. Among the endopterygotes, the endemism in species level is the highest in Mecoptera

(86%), followed by Neuroptera (76%), Strepsiptera (71%), Hymenoptera (71%), Trichoptera (60%), Diptera (35%) and Coleoptera (17 %), while the order Lepidoptera shows only 10% endemism since the moth fauna is widely distributed in the Indo-Pacific region.

The Indian Wildlife (Protection) Act, 1972 lists a total of 493 species of insect, including 454 species of Lepidoptera (Danaidae, Hesperidae, Lycaenidae, Nymphalidae, Pieridae), 38 species of Coleoptera (Carabidae, Chrysomelidae, Cucujidae, Inopeplidae) and 1 species of Odonata (Epiophlebiidae) has threatened species (Sharma, 2010).The relict Himalayan dragonfly species of Anisozygoptera, *Epiophlebialaidlawi*occurring in isolated hill streams in Darjeeling is a great taxonomic curiosity. This species has characters that link the two suborders of the Odonata, namely Zygoptera an Anisoptera (Sharma and Ramamurthy, 2010). So, overall current estimate shows that out of nearly 63,760 species of insect species in India, about 21,166 species are endemic. (ZSI, 2011).

DNA barcodes and insect biodiversity

Simpson's index and Shannon-Wiener index are the widely used biodiversity indices to study the species richness and evenness in the area (Kumar and Pathak, 2017).To describe approximately 1.4 million species, using the traditional approaches has taken two centuries. DNA-assisted species discovery has the potential to rapidly accelerate this process, in the light of current biodiversity crisis affecting our planet.

Insect pests are major concern for farmers across the world and accurate identification of the pest is an important issue because of wide variation in their morphology. Among the animals, insects are the most numerous group and its taxonomy is primarily based on morphological characters (Gholamzadeh and Incekara, 2016). With the existence of millions of species and significant variations in their life-stage, the correct identification becomes a challenge task for taxonomy. DNA based identification by using mitochondrial gene cytochrome oxidase subunit 1 (COI) helps in resolving the problem (Hebert *et al.,* 2003). Molecular techniques have been developed in recent years to discriminate closely related species (Gholamzadeh and Incekara, 2016). DNA barcoding can be regarded as a 'tremendous tool' to accelerate species discovery and initiate new species descriptions (DeSalle*et al.,* 2005; DeSalle, 2006). In order to speed up taxonomic identification, DNA barcoding is now been considered as an alternative tool for insect biodiversity identification in India and the World (Jalali*et al*., 2015).

CONCLUSION

Systematic will continue to debate the number of insect species that exist and the levels of past and likely future extinctions. With further environmental degradation and increasing deforestation, several taxa of insects will be endangered soon if they are not protected. Many species will become extinct before they are made known to the world. The number of taxonomists is declining and the output of taxonomic research has slowed. To counteract these challenges, it is necessary to conduct further detailed surveys, including seasonal surveys and other scientific techniques like DNA barcoding, to investigate the insects in this area for the promotion of biodiversity conservation and management of habitats.

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CITATION OF THIS ARTICLE

E. Sankarganesh. Insect Biodiversity: The Teeming Millions- A review. Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [3] 2017: 101-105