In: Biological Diversity: Current Status and Conservation Policies
Volume 1 (2021)
DOI: 10.26832/aesa-2021-bdcp-020

Chapter [20]

Insect biodiversity and their conservation for sustainable ecosystem functioning

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Abstract

Insects are the most species-rich group on the Earth, hence it play numerous crucial roles in ecosystem functioning and the global-economy. The conservation of insect diversity is therefore a topic of global importance. Threats to insect bio-diversity are rapidly increasing day by day. Six interrelated principles are emerging from recent research on the possible thanks to manage the landscape for insect and other bio-diversity conservation. A perfect management strategy is to keep up reserves and promote habitat heterogeneity while softening the disturbed matrix immediately surrounding the reserve. Outside reserves, put aside land for biodiversity and simulate natural conditions and disturbance. Link good-quality habitats with corridors, which has both short-term ecological value and long-term evolutionary value and may be a buffer within the face of worldwide global climate change. Permeating these six landscape principles may be a population-level approach, involving the meta-population trio, which are large habitat size, good patch quality, and reduced patch isolation. Overlying these coarse-filter, landscape principles is that the fine-filter, species approach, which recognizes the requirements of particular species under threat.

Keywords Insects, Conservation, Diversity, Management strategies, Threats

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Introduction

Biodiversity is that the basis for human survival. The composition and richness of species assemblages also strongly influences ecosystem functioning and stability (Naeem *et al*., 1994; Tilman and Downing, 1994; McCann, 2000). However, following the commercial revolution, the rapid expanding human population and its economic activities have caused a dramatic loss in global biodiversity, leading to significant disturbance to ecosystems and our living conditions. Accordingly, the conservation of biodiversity has become one in every of the foremost important challenges on our planet.

Biodiversity: "Variety of organisms in any respect levels, from genetic variants belong to the identical species through arrays of species to arrays of genera, families, and still higher taxonomic levels; includes the range of ecosystems, which has communities of organisms within particular habitats and therefore the physical conditions under which they live".

Evolution of insects: Biodiversity isn't static; it's a system in constant evolution from a species, in addition as from a personal organism point of view. The typical half-life of a species is estimated at between one and 4 million years, and 99% of the species that have ever lived on earth are today extinct. Biodiversity isn't distributed evenly on earth; it's evident from fossilized specimens that insects were living 400 million years ago. Evolution of insects in our universe is classed as Silurian, Carboniferous, late carboniferous or early Permian, Paleozoic and Cretaceous periods (Gullan and Cranston, 2014).

Insect diversity: Biologists have long realized the good diversity of insects. But the described insects are unknown fraction of total, no central organized database for the life on earth and also unclear what number described species exist (ZSI, 2012). Approximately 30 million species are found worldwide, of which about 1.4 million are briefly described. (Balakrishnan *et al*., 2014). The kingdom Animalia is represented by 15, 52,319 species that are described thus far globally in 40 phyla in a very new evolutionary classification. The phylum Arthropoda alone includes 12, 42,040 species, constituting about 80% of the full number of species (ZSI, 2012). Insects comprise over 75 you look after all described animal species and exhibit not only a fashionable form of form, color, and shape, but also a variety of ecological adaptations unexcelled by the other group (Springer, 2009). The most successful insect order, Coleoptera, represents about 38% (3, 87,100 species) of the insect species of the planet (Zhang, 2011).

Insects are the largest and most diverse group of organisms on earth. The total number of recorded species stands for about 1 million in number. However, there is some speculations within the scientists that the actual number of insect species may even exceed 20 million. These amazing creatures' makeup about 75% of all described animal species. Irrespective of their abundance yet they are undermined because of their size. Insects are found almost everywhere on the earth surface. They can sustain even in most inhabitable places, it may be deserts or icecaps, land or water, trenches or mountains anywhere we go we can still find the presence of an insect even in most rugged condition. All thanks to their physiological and morphological characters which helps them to adapt themselves in any condition. The general characters of an insects include three segmented body, three pair of legs, small size, short life cycle, protective exoskeleton, presence of functional wings, compound eyes, decentralized nervous

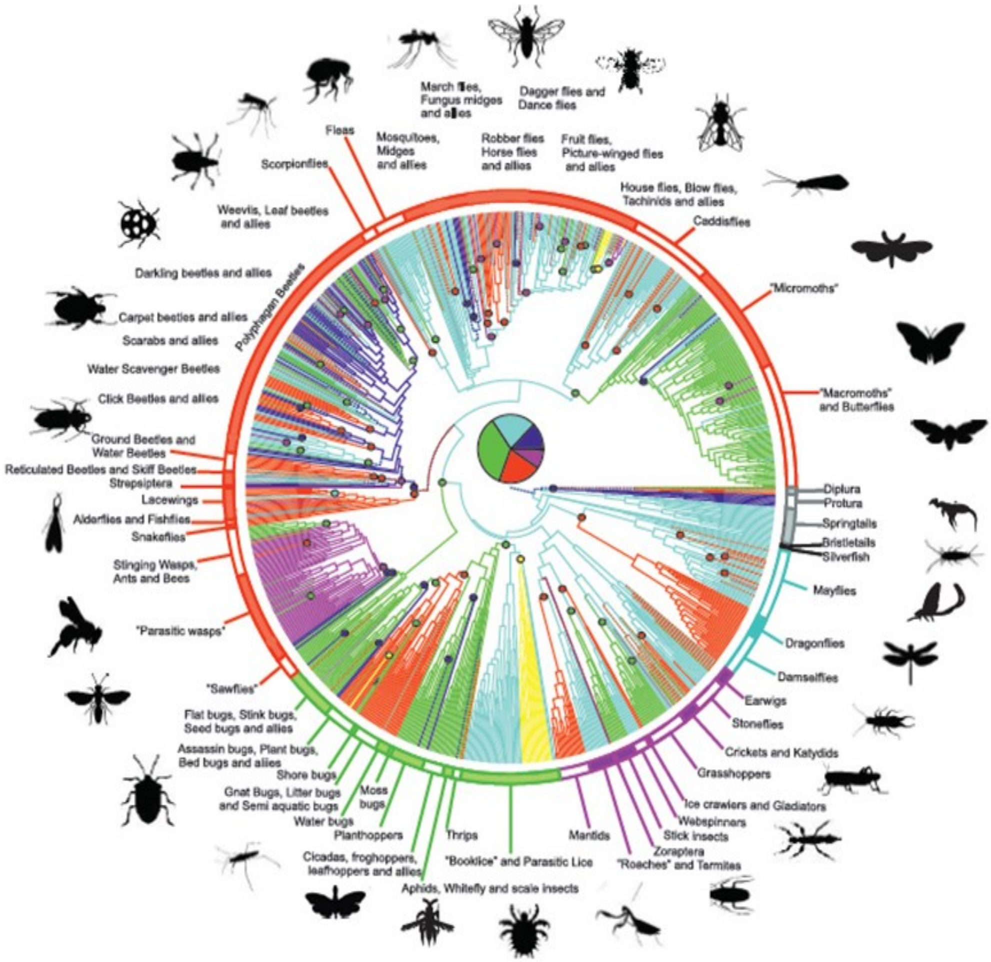

Figure 1. Hexapoda: insect diversity (Bertone *et al*., 2016)

system, open circulatory system, presence of sensory antenna, direct respiration, scattered sense organs, entero-nephric excretion, high fecundity, food specificity, various morphological physiological and behavioural adaptations, etc. These are some of the factors that are responsible for insect abundance and also their humongous diversity. The magnificence of insect species diversity is greatest in tropical region, specifically in neo-tropics (Figure 1).

The diversity of insects today as far as we know is the richest it has ever been. Variety is so great that the insects make up three-quarters of all species. Insects have radiated into so many diverse forms that we have not been able to describe a large chunk of their population. They are a major part of this huge ecological machinery we observe around us. Insects are one of the earliest life forms that continued to radiate through the process of variation and selection, to flourish the earth with a fantastically rich

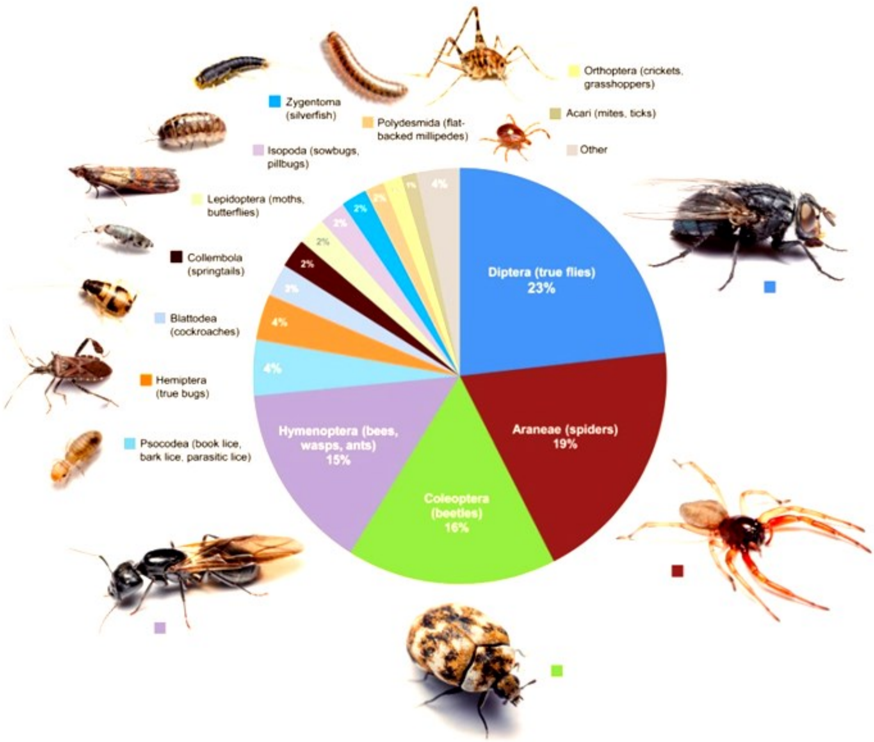

Figure 2. Dominant wise diversity of insect orders (Bertone *et al*., 2016)

assortment of life forms which is quite mesmerizing to scrutinize. Humans are a latter-day arrival who hold in their palms the future of the insect mosaic. This fascinating insect variety is losing its special and compositional integrity as we enter the new era, the homogenocene, which is a mere blink of a geological eyelid (Figure 2).

Taxonomic classification 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 per cent of the insect fauna. The remaining 21 orders are represented by small numbers 6 per cent of species (ZSI, 2012).

Forest insect biodiversity: About 67,000 species of insects are recorded from various ecosystems in India. Of these, 16,000 species are specifically recorded from the forests (Beeson, 1941; Nair and Mathew, 1993). However, this estimate might not hold true considering the actual fact that a lot of species found in other ecosystems also occur within the forests. The forests of India range from the snow-clad boreal forests of Himalayas to the wet evergreen forests of the Western Ghats. Many parts of those forests are still not explored.

Aquatic insect biodiversity

Freshwater lakes are integral a part of urban ecosystem and supply numerous benefits to groups of people directly or indirectly. Aquatic insects are extremely important in ecological systems for several reasons and are the first bio-indicators of freshwater bodies like lakes, ponds, wetland, and rivers. The presence or absence of certain families of aquatic insects can indicate whether a specific water body is healthy or polluted (Majumder *et al.*, 2013) but 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 *et al.*, 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 could be a remarkable phenomenon within the organisms living on this earth, were the energy is release by a reaction within the sort of light emission. There are not any luminous flowering plants, birds, reptiles, amphibians or mammals in nature. Though bioluminescence is generated by various organisms, it's highly developed in insects. The samples of true or self-luminescence are found in Collembola, Diptera, Coleoptera and Homoptera. The Coleoptera constitutes the biggest bioluminescent group during which several hundred species are known to contain highly developed photogenic organs. the simplest 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 for attracting the winged male (Babu and Kannan, 2002). This biological phenomenon has been exploited in space and medical research, insect pest management, and is additionally a useful tool in biotechnology.

***Insect fauna of states and union territories of India**:* India's insect fauna is distributed over a good range of ecosystems, climatic regions and altitudes. The insect distribution is principally influenced by the ecological, climatic and edaphic factors, like the vegetation, rainfall and temperature. The insect fauna within 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 because of variation in warm temperature in these states. The tropical humid forests of the Western Ghats and also the eastern Himalaya are different from the island ecosystems of the Andaman and Nicobar Islands, but the best numbers of endemic species occur in these ecosystems (ZSI, 2012).The tropical evergreen forests of the eastern Himalaya and also 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 best number of insect species, followed by the states within which the Western Ghats fall, like Kerala, Tamil Nadu, Karnataka and Maharashtra. The third biodiversity-rich areas in terms of insects are the western Himalayan region and also the Andaman and Nicobar Islands (ZSI, 2012).There are still many inaccessible areas within the country that haven't been adequately explored for assessment of the insect wealth.

Why Insect diversity is important: Insects have important economic roles, supporting and providing livelihoods for various people, from the silk trade to beekeeping and also the pollination of most of our fruit and a variety of other agricultural produce. The outline of insects and their colourful body patterns have initiated prominent contributions to our art, literature and culture and offer great educational tools (Pyle *et al.*, 1981). In many regions, insects also form a vital component of the human diet. Some insects have great value in Chinese medicine. For example, the Chinese fungal drug Dong chongxiacao (*Cordyceps sinensis*), is that the plant organ of a parasitic fungus which develops inside the caterpillar of a ghost moth and features a very prominent role and really long history in traditional Chinese medicine. Another important application of insects is biological pest management. Insect predators are known to be more practical than many chemicals in controlling economically damaging insects. Thanks to their conspicuousness and susceptibility to environmental factors many insect taxa may be used as bio indicators (Kati *et al.*, 2004*). As an example, butterfly* population dynamics are suggested as indicators of species richness for pollinators overall and of the structural and floristic diversity of habitats, as indicators of temperature change and further ecological parameters, and of landscape distinctiveness (Peter and Settele, 2008). Ground beetles also are commonly used as bio-indicators for changes in environmental conditions because of their sensitivity to habitat change and since carabid studies are being highly cost efficient (Rainio and Niemela, 2003). In addition to their intellectual and quantity, insects are vital ecosystem components. Many of the key ecosystem functions that insects fulfil relate to interactions with vegetation. This includes various styles of herbivorous links, but also many mutualistic relationships like pollination, seed dispersal or predator defence in exchange for shelter (Qin and Wang, 2001). Plants provide the key habitat parameters for several insect species starting from shelter to breeding sites. Plant-insect interactions have direct effects, as an example on the storage and cycling of carbon and nutrients, moreover as strongly influencing succession and competition patterns in plant communities and organic phenomenon interactions (Weisser and Siemann, 2004).

Relationship between insect diversity and plants*:* Relationships between insect assemblages and plant communities are another key topic requiring urgent research attention. Insect diversity might be plagued by parameters associated with vegetation structure like plant height, plant size or leaf form (Axmacher *et al*., 2004). Insect species richness often increases with an increase in vegetation height, with the very best diversity recorded in full-grown forests (Poyry *et al*., 2006). This has been associated with greater resource availability in mature forest ecosystems. Nonetheless, interactions are highly complex, and better diversity has also been observed in open habitats as compared to closed forests, potentially in reaction to changes in microclimatic conditions (Axmacher *et al*., 2004 and 2009*)*

Plant species richness and community composition affect insect diversity. Despite the unimodal model often accustomed describe relationships between diversity and productivity a rise in plant diversity could monotonically improve ecosystem productivity (Hooper *et al*., 2005). Ecosystem productivity could potentially enhance diversity at higher trophic levels and likewise increase the variety of herbivorous insects, parasites and predators. a rise in plant diversity would have a stronger positive effect on species richness at higher tropical levels. However, a recent review found that lower trophic species responded more strongly to a rise in plant diversity than higher trophic levels in grassland (Scherber *et al.*, 2010). Increases in plant diversity would decrease the results of biological invasion, pathogen and hyper-parasitism (Scherber *et al.*, 2010). This pattern also means that increasing plant diversity could potentially enhance ecosystem stability (Tilman *et al.*, 2006). Predators are simpler in controlling herbivores in low habitat stability ecosystems than in highly stable ones (Southwood and Comins, 1976). As positive relationship been found between plant diversity and habitat stability (Tilman *et al.*, 2006), plant diversity then would likely affects the connection between herbivorous insects and predators. Additionally, consistent with the resource concentration hypothesis by Root (1973), herbivores are more likely to search out and remain on hosts in monocultures. Reduced plant diversity therefore increases the potential damage to vegetation by pest species, while simultaneously reducing overall insect diversity. Supported by experiments, it's been predicted that herbivorous insect diversity is positively correlated with plant species diversity (Lewinsohn and Roslin, 2008). Increasing diversity in herbivores could further enhance the range of predators and parasites (Root, 1973). However, the connection between plant diversity and bug diversity isn't always positive, and a few studies investigating natural habitats have found an opposite trend.

Threats to insect 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).

Effects of global climate change on insects: The worldwide climate has changed significantly during the 20th century, the typical global air temperature near the Earth's surface and oceans rose by 0.74°C between 1906 and 2005 (Parry *et al.*, 2007). At a worldwide level, global climate change is predicted to be a key factor affecting future developments in biodiversity (Beck *et al.*, 2010), with wide-ranging effects on forest structure and native spatial distribution patterns (Sang and Bai, 2009). Insect species richness and species composition are known to be particularly strongly tormented by environmental factors like temperature and moisture (Axmacher *et al.*, 2009). Global temperature change is accordingly predicted to alter the distribution and so also diversity patterns of insect communities. Many insect species have already observed to be spreading northwards within the hemisphere, some cashing in on warmer temperatures, e.g. the silver spotted skipper buttery (*Hesperia comma*), Roesel's bush cricket (*Metrioptera roeselii*), (Thomas *et al.*, 2001); however, most species have declined in reaction to climatic change (Warren *et al.*, 2001).

Research needed for insect conservation

Operational levels of insect conservation research: The research scope should enhance to search out new and effective ways for maintaining insect diversity, insect species, and bug populations. The interaction of environmental factors like abiotic (temperature, fire intensity, rainfall patterns and intensity, insolation, elevation, rockiness, water, pH, dissolved oxygen, also as contaminants, pollutants, pesticides) and biotic including vegetation structure and composition, pollen and seed, host availability directly and indirectly affect insect diversity, Although an insect's habitat is embedded in an ecosystem, some require quite one ecosystem to sustain them (Figure 3). With anthropogenic modification of the landscape, not only are conditions changed within their habitat, but also around it (Mathew *et al*., 1990).

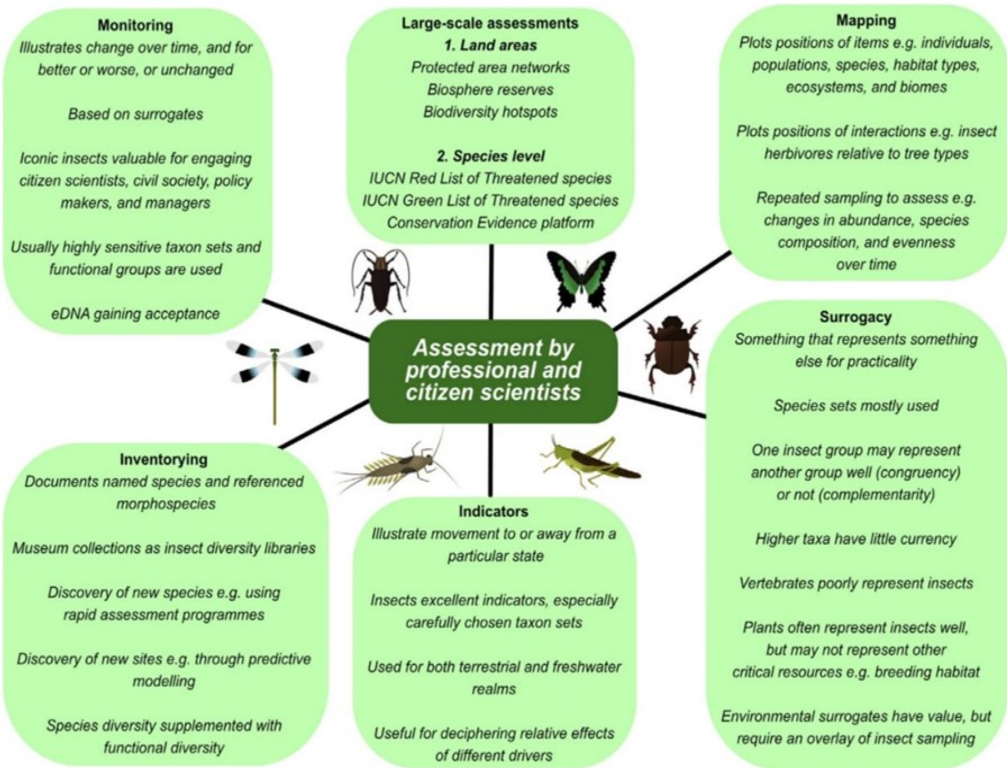

Figure 3. Essential components of assessment for insect conservation (Samways *et al*., 2020).

Species-level insect conservation: The range of genetic variation in populations and the way it's shared among individuals that determines the adaptability of a population to environmental change, whether for the higher or the more severe, and whether in response to local (landscape fragmentation, pollution) or global (climate change) impacts or both. The viability of meta-populations depends on the flow of genes that provide high value for adapting to prevailing conditions.

Insect conservation planning at the regional scale: At the regional scale, insects have a job in systematic conservation planning, which aims to spot locations and landscapes that are a priority for conservation action. the main focus is also totally on endemic hotspots, areas that are zones of ecological transition and areas that have evolutionary potential (Spector, 2002). These reserve selection procedures are : Coarse-filter (The landscape or community approach to conservation) Fine-filter (The species approach to conservation, within which the main focus is on a specific species or small number of species) and Corridor (A linear strip of land connecting one high-value conservation patch with another (also called a linkage or greenway approach) (Michael and Lindenmayer, 2018).

Surrogates in conservation planning: This shortcoming are often addressed by using surrogates of insect species diversity. Such surrogates could also be alternatives or complements, like higher taxa, species richness, rarity, endemism, threat status, and/or alternative taxa. Other kinds of surrogates include vegetation types, land systems or classes, and environmental domains. the utilization of environmental surrogates can embrace a variety of taxonomic diversity, this broad-scale approach can overlook critical small-scale habitats and special features (such as large logs sure enough saproxylic species, hills for hill topping behaviour, mud for mud-puddling, and sun-basking sites) essential to small animals like insects. the most effective to mix both environmental and species surrogates for systematic conservation planning, consensus being reached (Ripple *et al.*, 2019).

Conclusions

Although we are unable to conserve every insect population or maybe every species, civil society is now becoming responsive to the precipitous decline in insects and its severe consequences for planetary survival. As insects are braided into ecosystems, their plight is actually integrated with more expansive movements like global biodiversity conservation and global climate change mitigation. By conserving as many naturally-intact ecosystems as possible, alongside more extensive softening food- and fibre-producing landscapes, together we will get on track for leaving a sound legacy to future generations.

Acknowledgement

The authors are thankful to the Department of Entomology, MSSSOA, Centurion University of Technology and Management (CUTM), odisha for valuable time and suggestions in formulating this book chapter.

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Cite this chapter as: Nayak, S.B., Elango, K. and Rao, K.S. (2021). Insect biodiversity and their conservation for sustainable ecosystem functioning. In: Biological Diversity: Current Status and Conservation Policies, Volume 1, Eds. Kumar., V., Kumar, S., Kamboj, N., Payum, T., Kumar, P. and Kumari, S. pp. 304-314, https://doi.org/10.26832/aesa2021-bdcp-020