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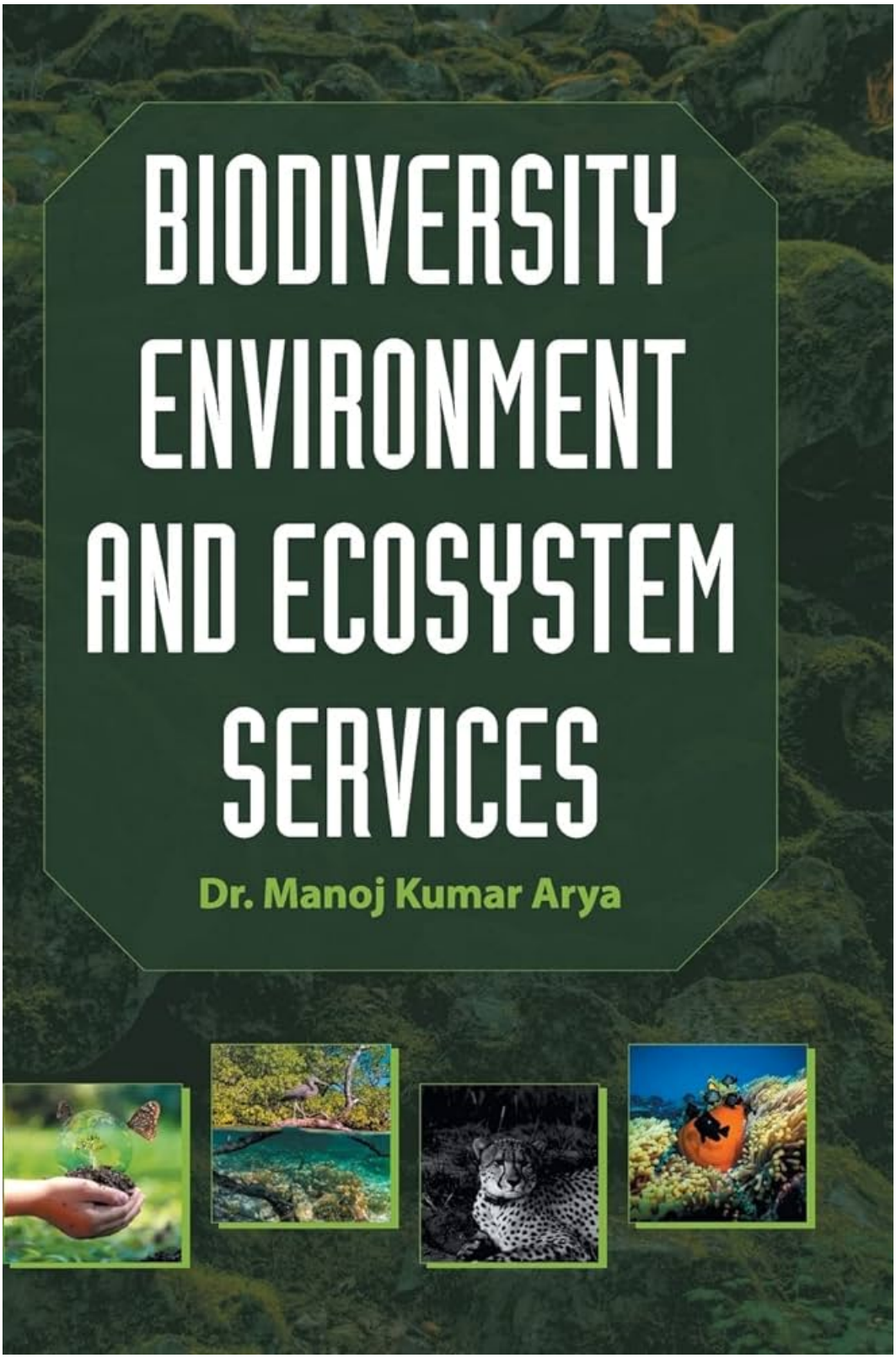
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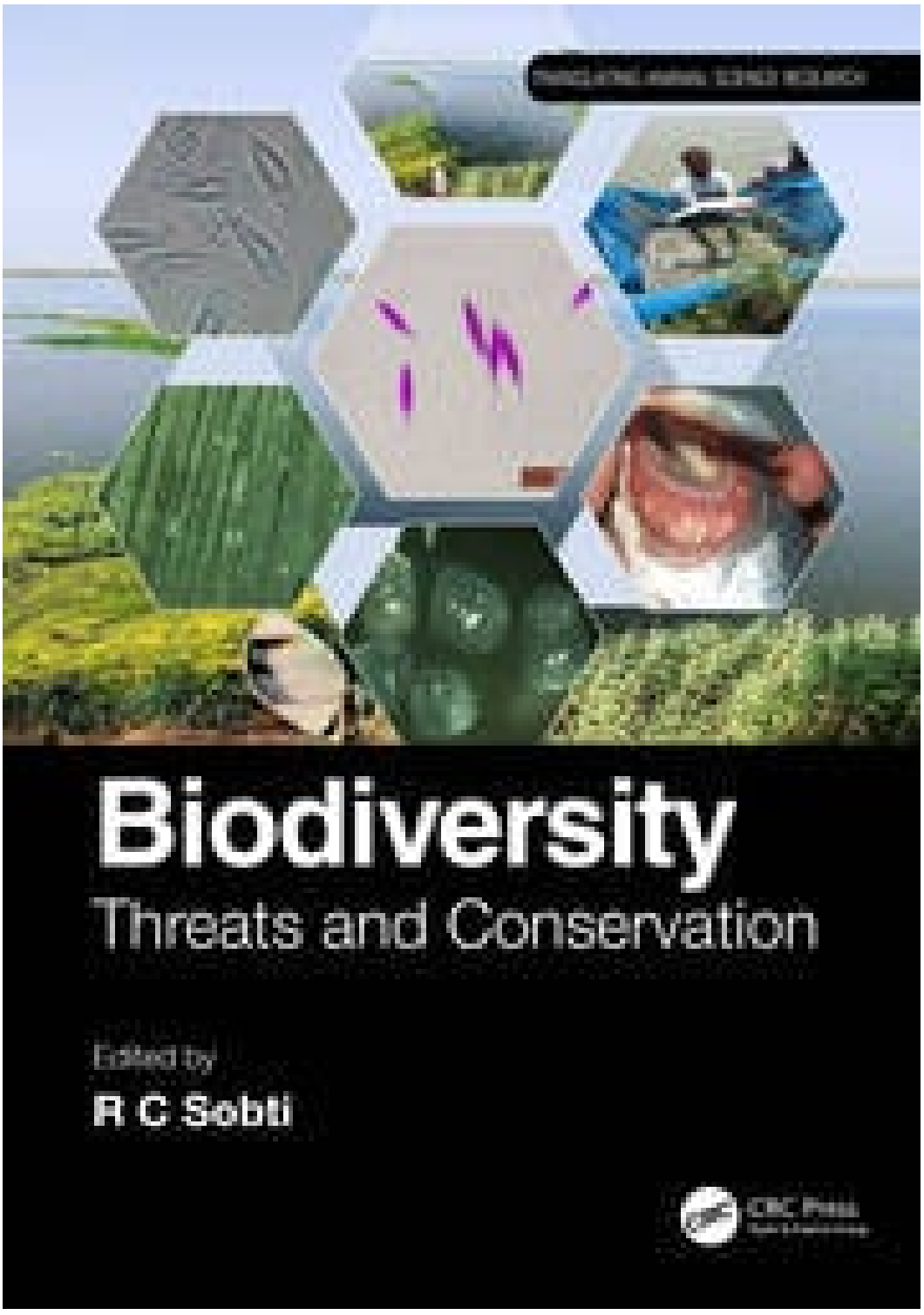

18

Seasonal Abundance, Status, and Diversity of Hymenopterans (Insecta: Hymenoptera) in a Protected Landscape

Manoj Kumar Arya, Hem Chandra, Surabhi Bisht, and Aman Verma

CONTENTS

18.1 Introduction

The global diversity of hymenopteran fauna is about 1,53,088 species (Zhang, 2013) of which approximately 10,605 species are known from India. Hymenopterans not only play crucial role in maintenance of ecosystem but also boots up human economy by, for example, providing honey and wax (Hussain et al., 2019). These insects originated in the Triassic Period and are adapted to specific habitats or host, predators, and parasitoids. Hymenopteran insects, due to their economic and biological importance, are considered to be one of the most beneficial animal groups. Majority of these insects are valuable to both man and environment, as they make food and pollinate flowers, and small number of them are pests of fruits, crops, and forests (Gupta, 1995, 1997). Hymenopteran insects are also well recognized for providing valuable ecosystem services in the form of pollination for the successful fertilization of flowers, the formation of fruits and seeds, and the sustainable production in the forest and agro-ecosystems (Kumar et al., 2019). Several species of bees and other associated pollinators are responsible for the successful fertilization and production of approximately 87 species of the world's leading food crops (e.g., fruits, vegetables, and seeds), comprising 35% of global food production (Losey and Vaughan, 2006; Klein et al., 2007; Gallai et al., 2009). Various environmental factors, such as habitat structure, abiotic and biotic factors, altitude, seasonality, vegetation types, flowering resources, and microclimatic conditions also influence the abundance, richness, and diversity of hymenopteran insects (Wardell et al., 1998; Klein et al., 2002; Tylianakis et al., 2006; Kumar et al., 2019). In recent past, studies on hymenopteran species' composition, richness, abundance, and diversity in the different ecosystems of the world have been carried out by various workers (Singh and Singh, 1993; Jonathan, 1995; Gupta, 1995, 1997; Uniyal and Singh, 1996; Joshi, 1997; Ent and Shaw, 1998; Singh et al., 2010; Arya and Joshi, 2011; Kannagi et al., 2013; Arya et al., 2013; Gupta, 2013; Azim et al., 2014; Sharma et al., 2016; Sheeja and Jobiraj, 2017; Rajamohana et al., 2018; Hussain et al., 2019; Kumar et al., 2019). Despite the fact of their large

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CHAPTER 5

DIVERSITY AND ECOSYSTEM SERVICES OF MAJOR GROUPS OF INSECT FAUNA IN THE PROTECTED AREA NETWORKS (PANs) IN THE UTTARAKHAND

Manoj Kumar Arya, Surabhi Bisht, Aman Verma, Hem Chandra, Dayakrishna, and Prachi Tamta

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ABSTRACT

The Himalayan state of Uttarakhand beholds several environmentally sensitive and biologically diversified protected areas networks. There exists an information gap on the ecological significance of these insect groups. The present study aims to explicate differences in diversity and richness of insect fauna from six different protected areas from the Kumaon region of Uttarakhand, along the ecosystem services provided by them. During the study period, 412 insect species belonging to 70 families and nine taxonomic orders viz., Lepidoptera, Coleoptera, Hymenoptera, Odonata, Orthoptera, Hemiptera, Diptera and Isoptera and Neuroptera were recorded across all protected areas. Considering the overall percentage of species, Lepidoptera was again the prominent order (154 species), followed by Coleoptera (81 species), Hymenoptera (58 species), Orthoptera (33 species), Hemiptera (31 species), Odonata (28 species), Diptera (23 species), Isoptera and Neuroptera (2 species each). The diversity and richness of insect species varied throughout different protected areas with highest Shannon Wiener Diversity (4.95) recorded from Nandhaur Wildlife Sanctuary (NWLS), and lowest (3.99) from Naina Devi Himalayan Bird Conservation Reserve (NDHBCR). Identified ecosystem services provided by recorded species under different insect orders were tabulated into four major ecosystem services viz. regulating, provisioning, supporting and cultural. Therefore, rich insect diversity with total diversity index of 5.154 in heterogeneous landscapes from these protected areas of Uttarakhand are important in sustaining long-term delivery of ecosystem services and functions in them.

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CHAPTER 6

DISTRIBUTION, DIVERSITY AND RELATIVE ABUNDANCE OF INSECT POLLINATORS IN TEMPERATE FRUITS ORCHARDS OF CHAUBATIA GARDEN, RANIKHET HILLS, WESTERN HIMALAYA

Manoj Kumar Arya, Fasuil Farooq and Surabhi Bisht

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ABSTRACT

The present study was investigated in orchards of temperate fruits at Chaubatia garden area in the Ranikhet hills of Uttarakhand, Western Himalaya. The study with appropriate methodology was conducted in this region to provide information on diversity and species composition of insect pollinators of different temperate fruit orchards along their distributional status and relative abundance. There were 2265 different insect pollinators in all, representing 77 species, 57 genera, 23 families, and four orders. Based on the species richness among all recorded orders, Lepidoptera appeared as the most prominent order constituting 45 species of insect pollinators found in the fruit blocks, accounting 58.44% of total pollinator species, followed by Hymenoptera with 14 species (18.18%), Diptera with 12 species (15.58%) and Coleoptera with six species (7.79%). The results of the current investigation showed that *Pieris brassicae* Linnaeus showed highest majority in terms of abundance, followed by *Apis cerana* Fabricius, *Pieris canidia* Sparrman, *Aglais caschmirensis* Kollar and *Apis dorsata* Fabricius, respectively. On the other hand, *Colias erate* Esper, *Lasiommata schakra* Kollar, *Eurema laeta* Boisdual, *Amata cyssea* Stoll, *Psilogramma* sp., *Spoladea recurvalis* Fabricius, *Eristalis himalayensis* Brunetti and *Philoliche longirostris* Hardwicke were found to have least majority among all insect pollinators surveyed during the entire study period. Margalef's index was used to calculate

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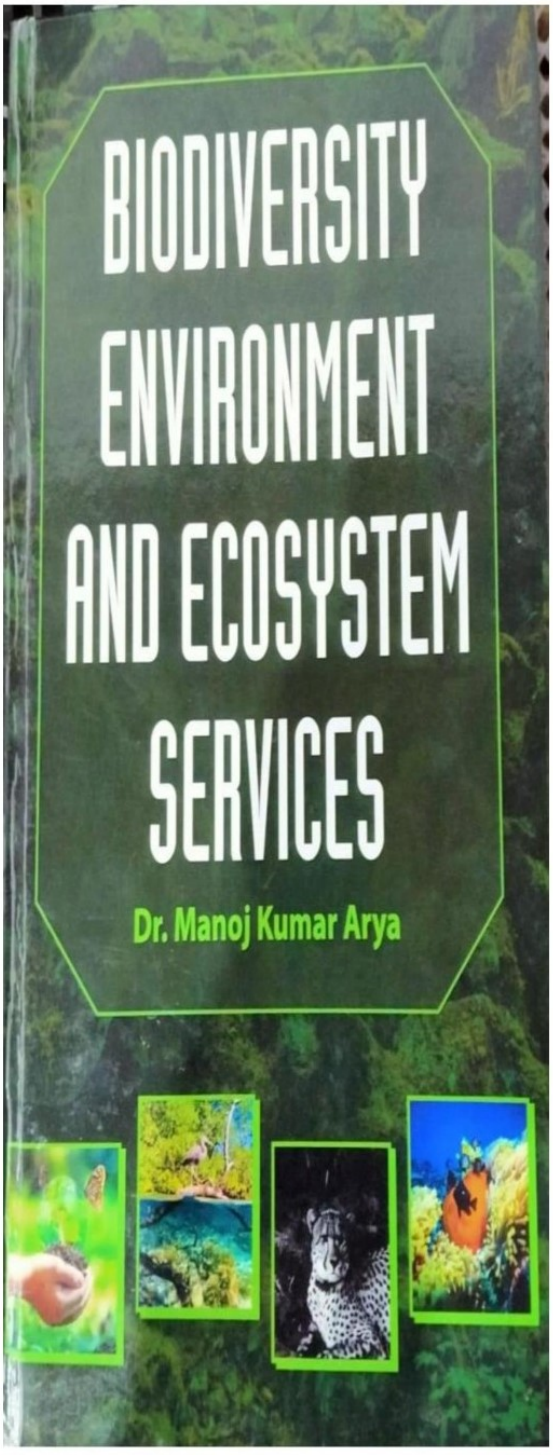

1

Pyracantha crenulata (D. Don.) M. Roem. An Important Food Source For Flower Visiting Insects

Aarti Badoni[1*] and Manoj Kumar Arya[1]

ABSTRACT

Insects are cosmopolitan as well as most dominant creatures on the Earth. Entomophilous flora depends on them for pollination and shows mutualistic relationship with them. *Pyracantha crenulata* is a very important medicinal plant, belong to family Rosaceae and endemic to temperate Himalaya. The present study was done in Nainital, Western Himalaya for aiming to investigate the quantitative spectrum of flower visiting insects on *P. crenulata* during blooming months (April-May, 2019). The selected plant species were visited by 17 species of insects belonging to 12 genera, three orders i.e. Diptera, Hymenoptera, and Lepidoptera. Species wise, the number of individuals of *Episyrphus balteatus* showed maximum abundance, whereas showed *Musca pattoni, Passeromyia* sp., *Heliophorus sena* and *Apis dorsata* minimum abundance. The Shannon diversity of flower visiting insects were recorded maximum in study site SS-A i.e., Manora peak.

Keywords: Flower visiting insects, Family, Diversity, Species richness, *Pyracantha crenulata*

INTRODUCTION

Insects are principal creatures on Earth. They are cosmopolitan and are found in frozen Antarctica to the scorching sun of the tropics, in water, land, air, deserts, and high mountains. It is believed that insects appeared on this planet in the Devonian period (Alfred, 1998). Insects play different roles in stabilizing ecosystems, maintaining nutrient cycling, decomposition of organic matter, regeneration, and protecting of soil, pollination, and natural regulation of pests (Foottit and Adler, 2009; Kumar *et al.*, 2016). Entomophilous flora depends on insects for pollination. The pollination

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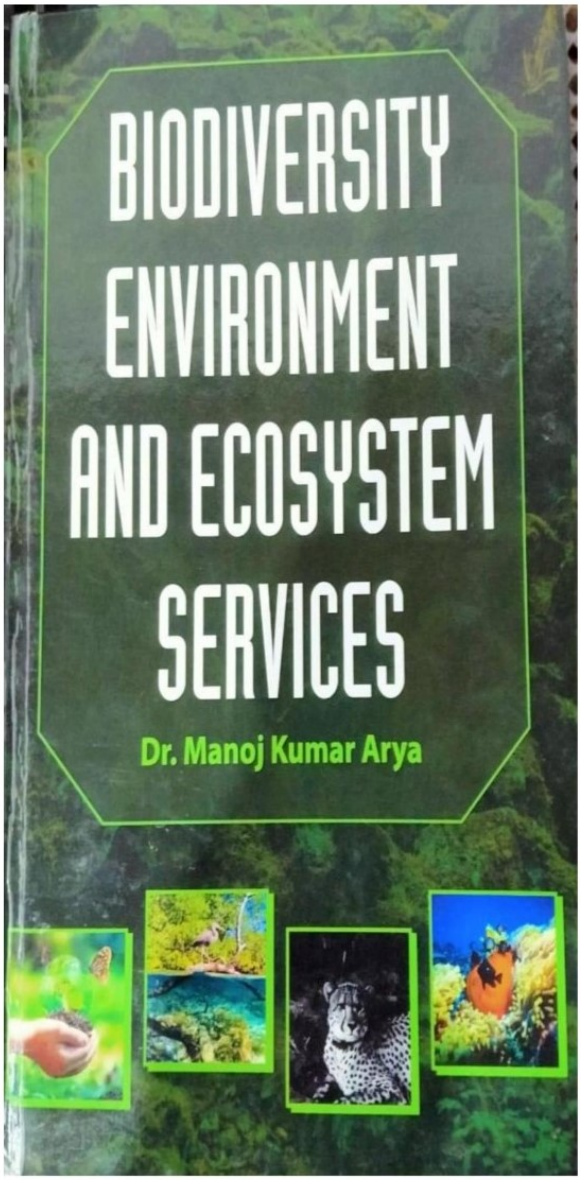

3

Behavioral Thermoregulation by Butterflies Across Elevations in the Western Himalaya

Aman Verma[1*] and Manoj Kumar Arya[2]

ABSTRACT

Basking is the specialized mechanism of behavioral thermoregulation in which butterflies principally by orienting their body and wings in a particular position attain a relatively elevated temperature in their thoracic musculature, necessary for efficient and autonomous flight to occur. This process of body thermoregulation is achieved by different behavioral strategies such as selection of perching microhabitat and subtle changes in body orientation and wing posture relative to the sun. In the present study, behavioral thermoregulatory strategies of butterflies were explored across elevations ranging between 250 m to 2450 m in Champawat District of Uttarakhand, Western Himalaya. The highest number of species that performed basking were recorded from the Nymphalidae (48 species), followed by Hesperiidae (17 species), Lycaenidae (15 species), Pieridae (9 species), Papilionidae and Riodinidae (3 species each). Butterflies were observed perching on the foliage, rocks, pebbles, gunny bags, stick, log or trunk of the tress, metalled or unmetalled roads. The reflectance form of basking posture was the most frequently observed thermoregulatory position, followed by lateral basking, dorsal basking and appression form of basking.

Keywords: Basking, Behavior, Butterflies, Himalaya, Thermoregulation

INTRODUCTION

Basking is defined as the specialized mechanism of behavioral thermoregulation in which butterflies principally by orienting their body

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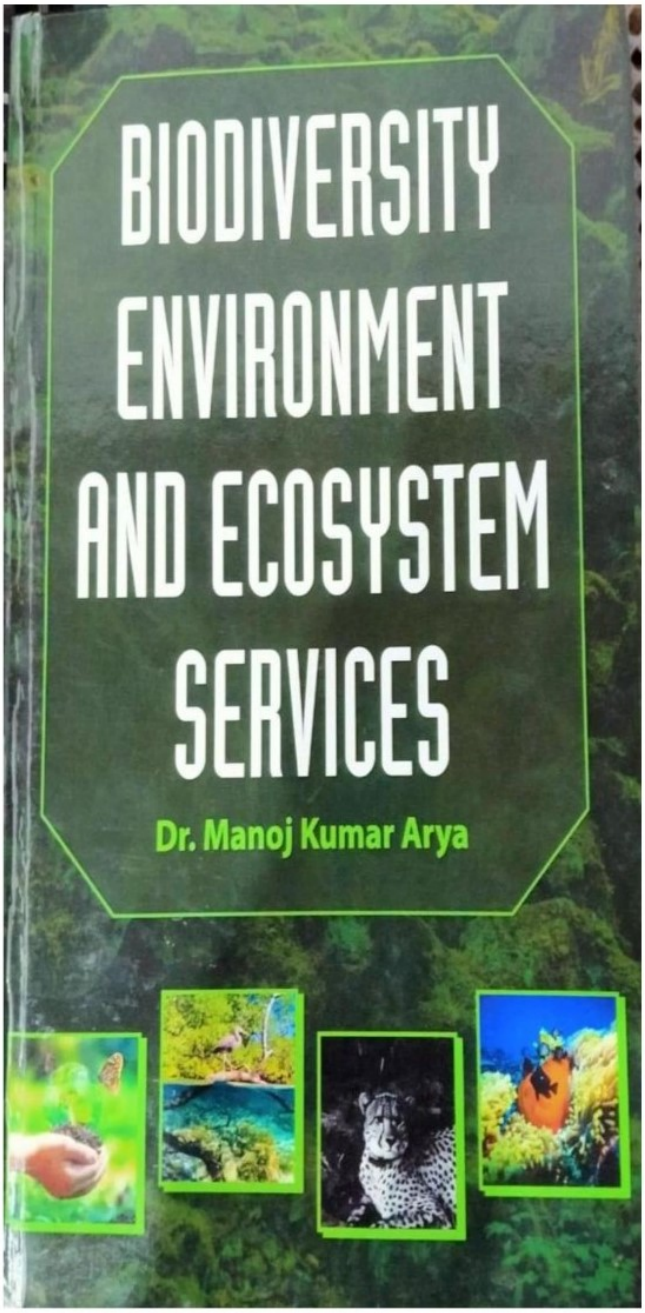

7

Recent and Future Ecotourism Potential at Nandhour Landscape

Exploring Economic Relevancy in Relation to Insect Conservation

Hem Chandra[1*], Aman Verma[2] and Manoj Kumar Arya[1]

ABSTRACT

Protected areas are currently facing the conservation funding crisis, and ultimately the challenge of biodiversity loss and extinction. Nandhour, an eco-fragile region in Terai Arc Landscape of India is protected in form of a wildlife sanctuary and it provides crucial tropical to sub-tropical forest ecosystems for rich floral and faunal diversity. However, the role of recreational assets and people's perceptions regarding sustainable ecotourism development and nature conservation is unknown. Therefore, the present study evaluated the economic relevance and positive impacts of recreational services in view of tourism growth, especially for the promotion of entomo-tourism at the Nandhour Landscape. The results suggested that the sanctuary holds the immense potential for sustainable tourism growth, and several sites provide maximum essential conditions regarding recreation and for promotion of entomo-tourism in the region. Effective collaboration at local, regional, state and national levels is required for proper biodiversity conservation and socio-economic development of local inhabitants by promoting ecotourism in a more sustainable and scientific manner. Presently, the development of private infrastructure is must for the ecotourism regulation and revenue generation in the Nandhour Landscape.

Keywords: Conservation, Economic relevance, Ecotourism, Ecosystem services, Recreation.

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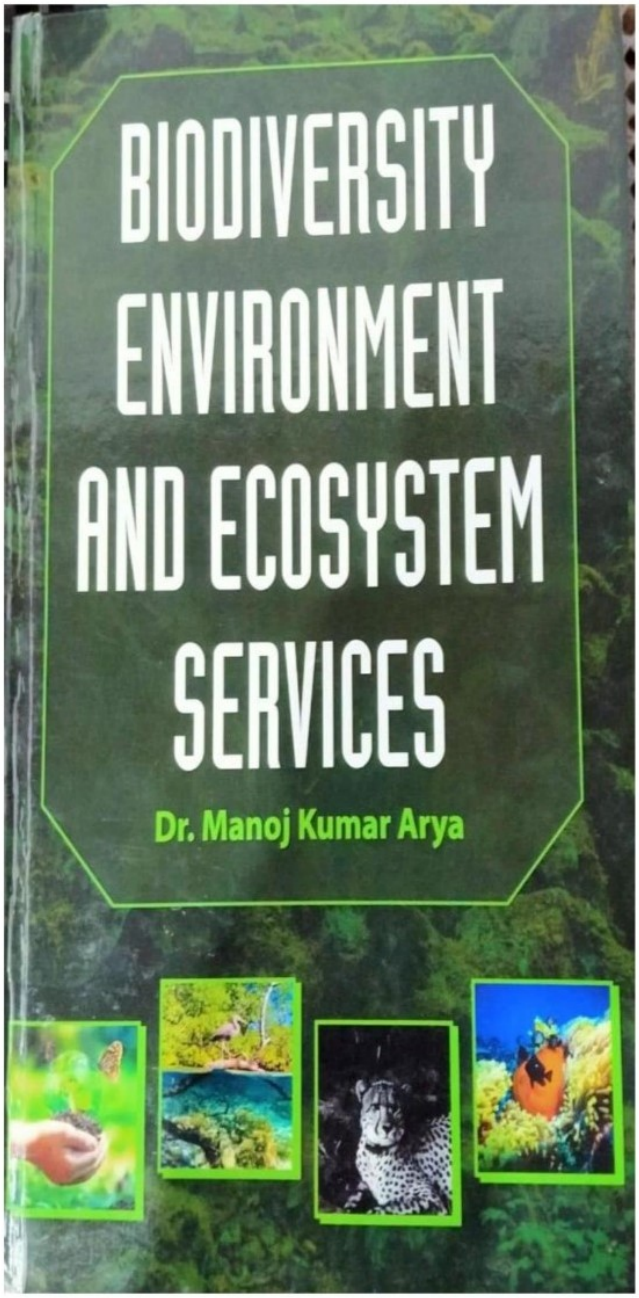

10

Biodiversity Status and Seasonal Dynamics of Butterfly Fauna in and Around Askot Wildlife Sanctuary, Western Himalaya

Pradeep Pandey[1*], Manoj Kumar Arya[2]
Surabhi Bisht[2] and Aman Verma[3]

ABSTRACT

Askot Wildlife Sanctuary (AWLS) located in the north of Pithoragarh of Uttarakhand in Western Himalaya is an eco-sensitive and biodiversity rich zone, conserved primarily for the protection of endangered Himalayan musk deer (*Moschus chrysogaster*) and other wildlife. Despite of its national importance, there remains a large gap in the existing knowledge on insect diversity including butterflies which are crucial for long term conservation and planning in the sanctuary. Therefore, the species richness, status and diversity of butterflies was quantified and analyzed in and around the AWLS using Pollard walk method during 2022. A total of 58 species under six families of butterflies were documented and Nymphalidae with 28 species was the most dominant family. Species such as *Aglais caschmirensis*, *Pieris brassicae*, *Pieris canidia*, *Heliophorus sena*, *Eurema hecabe* and *Eurema brigitta* were the most abundant and common butterflies, while *Aulocera brahminus dokwana*, *Arhopala ganesa*, *Polygonia c-albium cognata*, *Tajuria diaeus*, *Carterocephalu avanti*, *Parnassius hardwickii* and *Lethe sidonis* were the least abundant and rare species. Six species namely, *Arhopala ganesa*, *Euploea core*, *Euploea midamus*, *Neptis sankara*, *Aporia agathon* and *Tajuria diaeus* were legally protected under the Indian Wildlife (Protection) Act, 1972. The species

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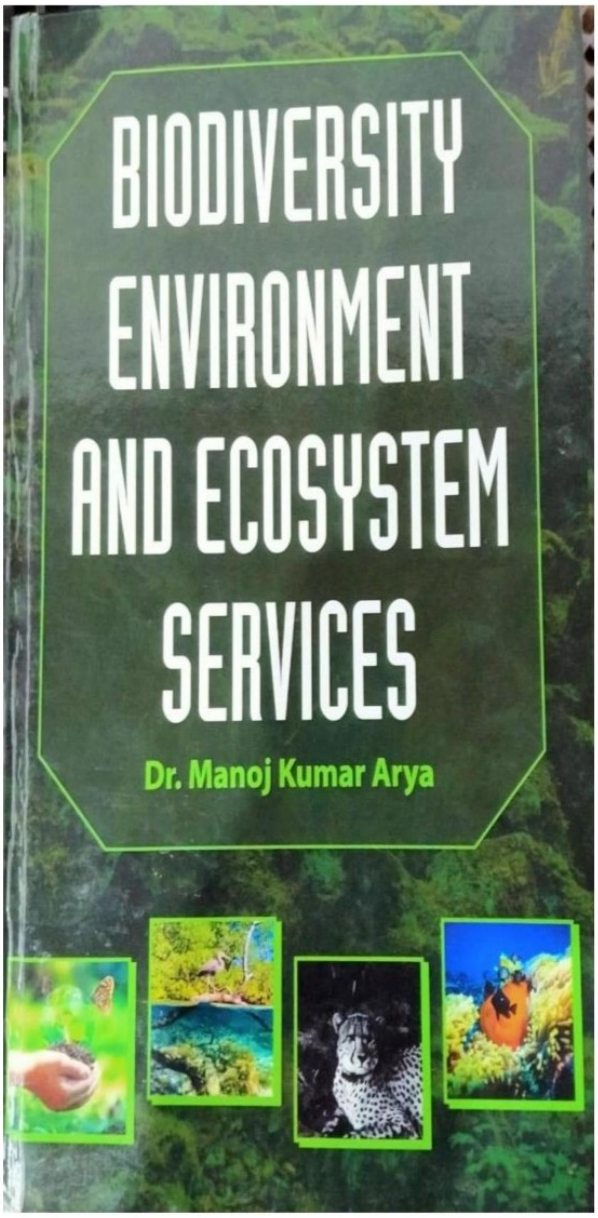

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Moths Diversity during the time of Covid-19 in Nainital of Kumaun Himalaya

Surabhi Bisht[1*] and Manoj Kumar Arya[1]

ABSTRACT

Among the insects, moths are a taxonomically well-known group that play an important role in the natural ecosystem. They may act as pollinators, herbivores in the food chain and prey for other organisms. Moths also have utility of being considered as indicators of consequences of habitat degradation and habitat fragmentation. The present investigation on species diversity and abundance of moth fauna was carried out in an urban habitat located in Kumaun division of Uttarakhand from March-October 2020 in order to monitor the effects of reduced human indulgence on nature imposed during the pandemic situation. The moths were assessed by the light trapping method. A total of 85 species of moths representing 79 genera belonging to nine families were recorded during the study period, including some species with new distributional records for the region. Among total species, species richness of family Erebidae was found to be the highest, followed by Crambidae, Geometridae, Noctuidae, Drepanidae, Eupterotidae, Lasiocampidae, Nolidae and Sphingidae. Maximum species richness was recorded during monsoon season. *Cnaphalocrocis medinalis* (Guenee) was recorded as the most abundant species during the study period followed by *Thalassodes veraria* (Guenee) and *Alcis variegata* (Moore), while *Baorisa hieroglyphica* (Moore) was recorded as the least abundant species followed by *Comostola laesaria* (Walker) and *Trabala vishnou* (Lefebvre). Shannon-Wiener Diversity index was employed to determine the species diversity and found to be 3.94 across the study period demonstrating considerable diversity in a period of few months as a result of COVID-19

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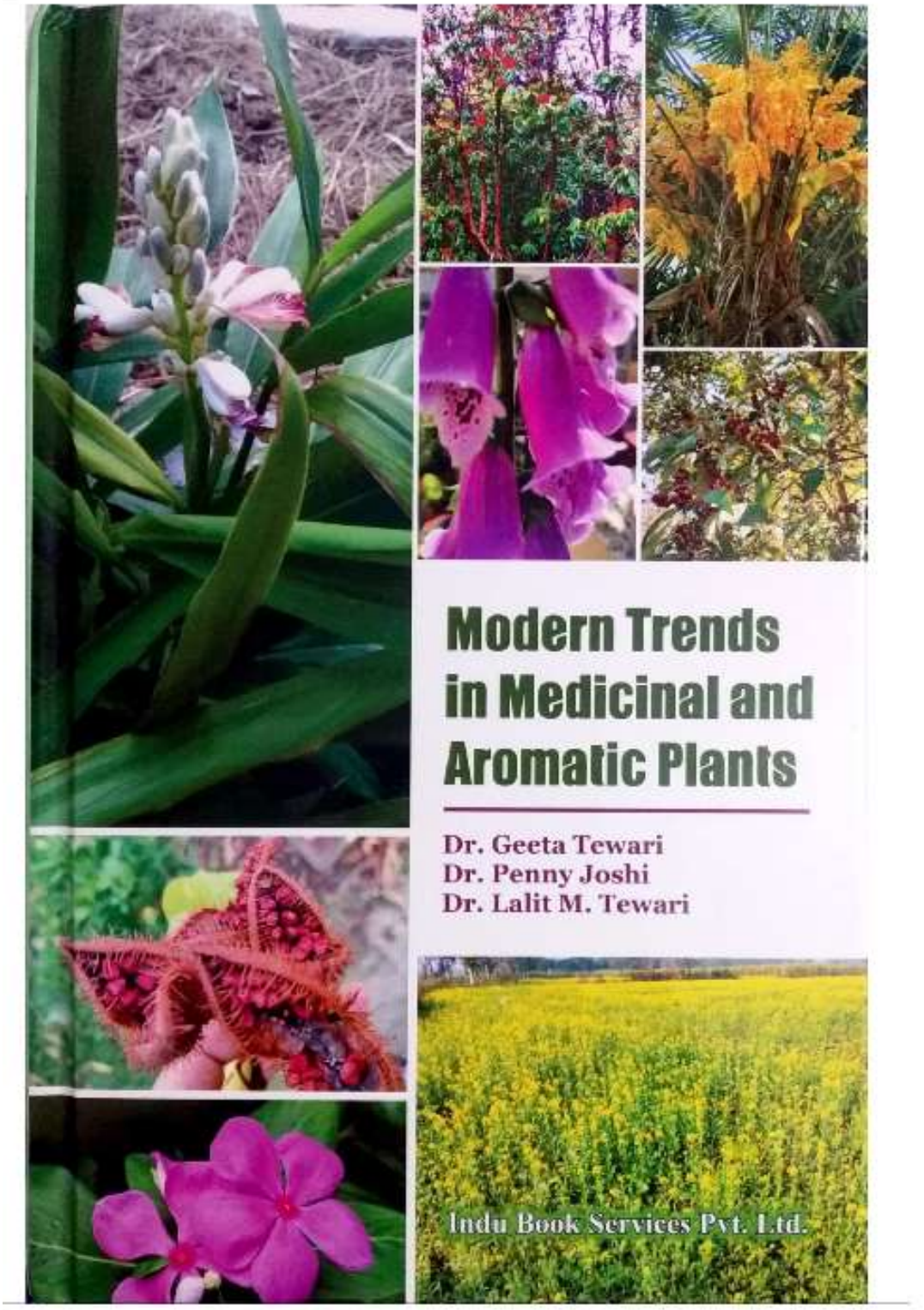
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Chapter 15

Biopesticidal Effects of Leaf Extracts of *Urtica parviflora* (Roxb.) on the Larvae of, *Helicoverpa armigera* (Hübner)

Niharika Bisht[1], Himanshu Pande[2], Divya Pangtey[2], Kanchan Bhandari[3], Raveesh Tripathi[4], Shankar Kumar[5], and Bodh R. Kaushal[2]

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ABSTRACT

Helicoverpa armigera Hubner (Lepidoptera: Noctuidae) is an important polyphagous pest that causes almost Rs. 2,000 crores annual loss in India has developed resistance against most of the recommended insecticides. In the present study, leaf extracts of *Urtica parviflora* were investigated to find out their potency as a larvicidal agent to the 4th, 5th and 6th instar larvae of this pest. The experiments were conducted to study knockdown (KD) toxicity. KD_0, KD_{50} ,and KD_{100} were evaluated for different instars. The minimum value for KD_0 amongst 4th, 5th ,and 6th instar larvae was 23 h for the extract in hexane solvent; the minimum value for KD_{50} amongst 4th, 5th ,and 6th instar larvae was 49 ± 2.73 h for the extract in hexane solvent, while the maximum value for KD_{100} amongst 4th, 5th and 6th instar larvae was164 ± 2.53 h which was observed for methanol extract. The extracts had lethal effects on larvae, disrupting normal physiological functions leading to mortality.

Keywords: *Helicoverpa armigera*, Knockdown toxicity, Larval mortality, *Urtica parviflora*