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Study of insect diversity in two selected sites of Darjeeling Districts, West Bengal, India

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Abstract
To document insect diversity in two selected sites of the Darjeeling district, a field survey was conducted during late October. Insects were sampled using active searching, leaf-beating, and sweep-netting techniques. Observations were carried out during two time periods: morning (06:00–11:00 h) and evening (16:00–18:00 h). Specimens were documented through photography, and data were recorded systematically. A total of nine insect orders comprising 27 families were recorded during the survey. Hymenoptera emerged as the most dominant order, accounting for approximately 46.90% of the total insect abundance. This was followed by Coleoptera (39.30%), Hemiptera (16.94%), Diptera (11.81%), Lepidoptera (11.53%), Orthoptera (1.81%), Dermaptera (1.00%), and Phasmida (0.60%). Comparative analysis revealed that species richness and overall diversity were higher in Chatakpur than in Kurseong. This increased diversity in Chatakpur may be attributed to greater plant heterogeneity, enhanced resource availability, and more favourable habitat structure.

Keywords: Insect diversity, species richness, field survey, habitat structure, biodiversity assessment

Introduction
Insects constitute the largest and most diverse group within the phylum Arthropoda and are distributed across almost all terrestrial and freshwater ecosystems worldwide. Their remarkable adaptability has enabled them to colonise a wide range of habitats, from tropical forests and grasslands to deserts and agricultural landscapes. In addition to their ecological importance, insects are also known to function as pests, parasites, and vectors of several plant, animal, and human diseases. Due to their direct and indirect impacts on ecosystems, agriculture, and public health, insects have attracted the attention of researchers for several decades [1].
Biodiversity is broadly defined as the variety and variability of life forms present within a given ecosystem. In the context of agro-ecosystems, biodiversity is typically described as the composition and proportion of different organisms coexisting within cultivated landscapes [2]. The presence of diverse biological communities contributes significantly to the regulation and sustainability of ecosystems. Two critical aspects that determine ecosystem functioning are productivity and stability, both of which are closely linked to biological diversity [3]. High biodiversity often enhances ecosystem productivity by allowing for the efficient utilisation of available resources, while stability refers to the ability of ecosystems to resist environmental fluctuations and recover from disturbances, such as pest outbreaks, climatic extremes, or habitat modification [12].
In terrestrial ecosystems, insects play indispensable ecological roles. They are key agents in processes such as pollination, seed dispersal, decomposition of organic matter, and nutrient cycling. Insects also regulate population dynamics by serving as predators, parasitoids, and prey within complex food webs. Due to these functional roles, insects play a significant role in contributing to ecosystem resilience and sustainability. They are widely recognised as the most abundant and taxonomically diverse invertebrates on Earth [11]. Their immense diversity and ecological specialisation have made them model organisms for research in numerous scientific disciplines, including ecology, evolution, genetics, physiology, developmental biology, biomechanics, and studies related to climate change and environmental stress [7].
The wide range of morphological, physiological, and behavioural adaptations exhibited by insects has fascinated entomologists for centuries. However, this diversity also poses significant challenges for conservation and management, particularly in the face of rapid habitat loss, agricultural intensification, and climate change. The conservation of insect diversity has therefore emerged as a critical concern among scientists and policymakers (Jalali and Ojha, 2015). According to global estimates, the total number of insect species may be as high as 5.5 million, although only a small proportion of these have been scientifically described and documented.
India is recognised as one of the world's biodiversity-rich countries and supports a substantial proportion of global insect diversity. Approximately 63,760 insect species belonging to 29 orders have been reported from the country. Among these, eight major orders contribute nearly 94% of the total insect fauna, while the remaining 21 orders collectively account for only about 6% of the recorded species [9]. This uneven distribution highlights the dominance of certain insect groups and emphasises the need for further taxonomic and ecological studies of lesser-known orders.
On a global scale, nearly 800,000 insect species are currently recognised as extant species [10]. Fossil records further reveal the long evolutionary history of insects, with over 2,000 fossil species documented to date, indicating that insects have successfully survived multiple geological and climatic changes [4]. These findings also suggest that a considerable number of insect species remain undiscovered, particularly in tropical regions and underexplored habitats.
India alone harbours approximately 75,000 reported insect species, representing nearly 10% of the world's known insect fauna [15]. Globally, insects constitute the most diverse

group of animals on Earth, with more than one million species formally described so far [5]. Given their ecological significance, economic impact, and sensitivity to environmental change, insects serve as valuable indicators of ecosystem health. Therefore, comprehensive documentation and conservation of insect diversity are essential for maintaining ecological balance and ensuring the sustainability of natural and agricultural ecosystems.

Methods of methodology

Study site

The present study was conducted in October at two distinct sites in the Darjeeling district (26°52′N, 88°18′E), known for their rich floral diversity. Site 1, Chatakpur, is a small eco-village situated within the Senchal Wildlife Sanctuary, characterised by a diverse mix of herbs, trees, and vegetable patches. Site 2, Kurseong (popularly known as the Land of White Orchids), boasts a diverse array of flora, including orchids, tea plantations, rhododendrons, and various herbs, alongside a notable presence of fauna such as elephants, leopards, deer, and unique soil insects.

Photographic Documentation and Identification

Methodologies like Pitfall traps and hand picking were used for collection of most of the insects species during the present study. The butterflies were photographed in the field using a Canon EOS 700D DSLR camera fitted with a zoom lens. Images were captured without harming or capturing the specimens, ensuring ethical and non-invasive documentation. Species identification was based on key morphological features, including wing shape, size, colour, and pattern, with reference to established field guides [6,14]. Additionally, online resources such as the Butterflies of India database [8]. Were consulted to verify species identity and taxonomy.

Data analysis

Data analysis was done based on their abundance and habitat through Shannon diversity indices and Simpson's diversity indices for richness.

Results and Discussion

This study identified various insect orders from two sites, Chatakpur and Kurseong, both characterised by diverse vegetation, including herbs, shrubs, trees, and thick bushes, providing a suitable environment for insect survival and reproduction. Environmental conditions, temperature, and humidity at these sites support insect growth and development.

Chhatarpur comprised the following orders (Table1 1 & Fig. 1): Odonata, Lepidoptera, Diptera, Coleoptera, Hemiptera, Hymenoptera, and Dermaptera. A total of 505 insects were recorded from Chatakpur, distributed as follows: Odonata (37 insects; R.A.-7.33%), Lepidoptera (48 insects; R.A.-9.50%), Diptera (48 insects; R.A.-9.50%), Coleoptera (98 insects; R.A.-19.40%), Hemiptera (87; R.A.-17.23% insects), Hymenoptera (185 insects; R.A.-36.64%), and Dermaptera (2 insects; R.A.-.40%).

Kurseong harboured insects belonging to the orders Odonata, Lepidoptera, Diptera, Dermaptera, Coleoptera, Orthoptera, Phasmida, Hymenoptera, and Hemiptera (Table 2 & Fig. 2). Total 331 insects were found at Kurseong: Odonata (30 insects; R.A.-9.06%), Lepidoptera (24 insects; R.A.-7.26%), Diptera (37 insects; R.A.-11.18%), Dermaptera (2 insects; R.A.-0.60%), Coleoptera (130 insects; R.A.-39.27%), Orthoptera (6 insects; R.A.-1.81%), Phasmida (2 insects; R.A.-0.60%), Hymenoptera (34 insects; R.A.-10.28%), and Hemiptera (66 insects; R.A.-19.94%).

The Simpson diversity index for Chatakpur was 0.0589 and for Kurseong was 0.0763, indicating higher species richness and evenness in Chatakpur. The Shannon diversity index for Chatakpur was 2.726 and for Kurseong was 2.608, suggesting greater species richness in Chhatarpur (Table 3 & Fig. 3).

Comparative analysis of insect fauna revealed higher diversity in Chatakpur, attributed to its rich vegetation, presence of attractive migratory birds, wild grass species, thick bushes, herbs, and shrubs, which facilitate pollination. In contrast, Kurseong, though rich in vegetation such as trees, shrubs, and creepers, had fewer pollinating flowering plants compared to Chatakpur, resulting in lower insect diversity (Fig. 4).

Table 1: Checklist of the Insects Orders recorded at the survey sites of Chatakpur

Sl.No.	Order	Family	No. of individuals	Relative abundance (%)
1.	Odonata	Libellulidae	20	3.96
		Coenagrionidae	17	3.37
2.	Lepidoptera	Geometridae	16	3.17
		Noctuidae	11	2.18
		Erebidae	21	4.16
3.	Diptera	Phoridae	15	2.97
		Chironomidae	20	3.96
		Psychodidae	13	2.57
4.	Coleoptera	Tenebrionidae	10	1.98
		Hydrophilidae	12	2.38
		Staphylinidae	12	2.38
		Carabidae	11	2.18
		Chrysomelidae	17	3.37
		Scarabaeidae	19	3.76
		Scutelleridae	17	3.37
5.	Hemiptera	Delphacidae	18	3.56
		Notonectidae	14	2.77
		Lygaeidae	23	4.55
		Cicadellidae	18	3.56

		Scutelleridae	14	2.77
6.	Hymenoptera	Formicidae	185	36.63
7.	Dermaptera	Forficulidae	2	0.40
TOTAL			505	100.00

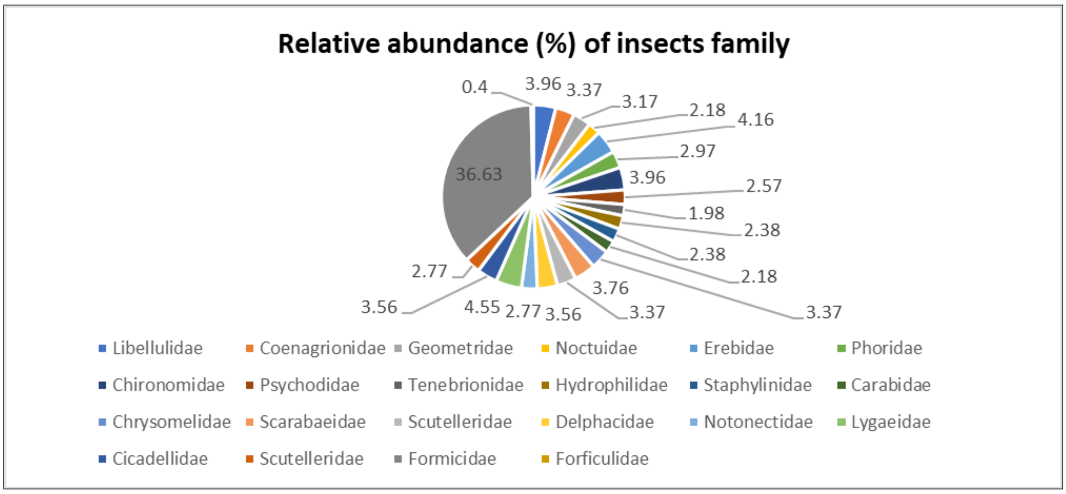

Fig 1: Relative abundance of insect families of Site 1

Table 2: Checklist of the Insects Orders recorded at the survey sites of Kurseong

SL.NO.	Order	Family	No. of individuals observed	Relative abundance (%)
1.	Odonata	Libellulidae	17	5.14
		Coenagrionidae	13	3.93
2.	Lepidoptera	Noctuidae	14	4.23
		Erebidae	10	3.03
3.	Diptera	Phoridae	9	2.72
		Chironomidae	17	5.14
		Chloropidae	11	3.32
4.	Dermaptera	Forficulidae	2	0.6
5.	Coleoptera	Tenebrionidae	63	19.03
		Scarabaeidae	67	20.24
6.	Orthoptera	Acrididae	6	1.81
7.	Phasmida	Phasmatodea	2	0.6
8.	Hymenoptera	Formicidae	34	10.27
9.	Hemiptera	Scutelleridae	12	3.63
		Lygaeidae	20	6.04
		Cicadellidae	15	4.53
		Delphacidae	9	2.72
		Anthocoridae	10	3.02
TOTAL			331	100.00

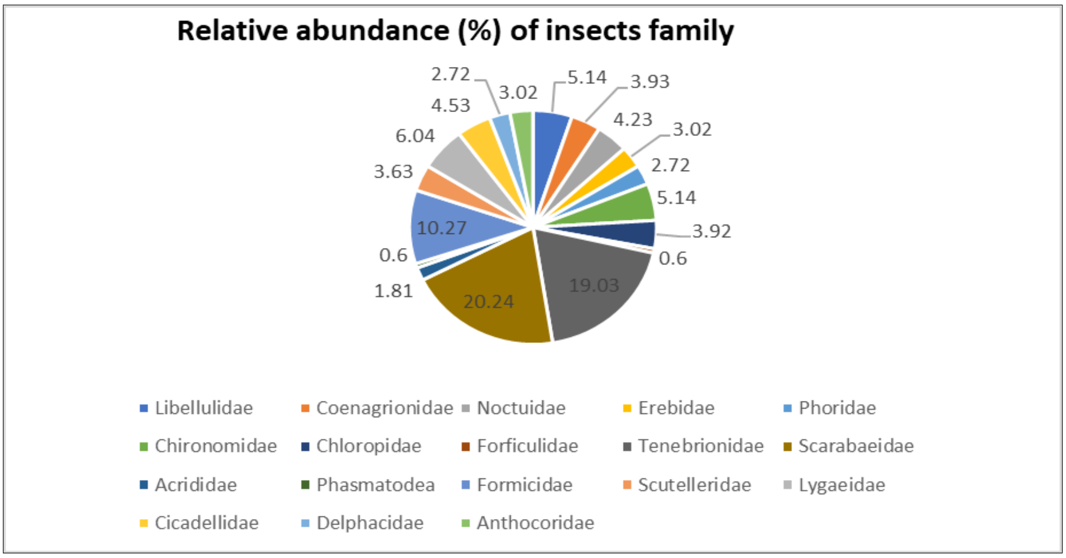

Fig 2: Relative abundance of insect families of Site 2

Table 3: Diversity indices for different habitats

INDEX	SITE 1	SITE 2
Simpsons	0.0589	0.0763
Gini-Simpson	0.9411	0.9237
Shannon-Weiner	2.726	2.608

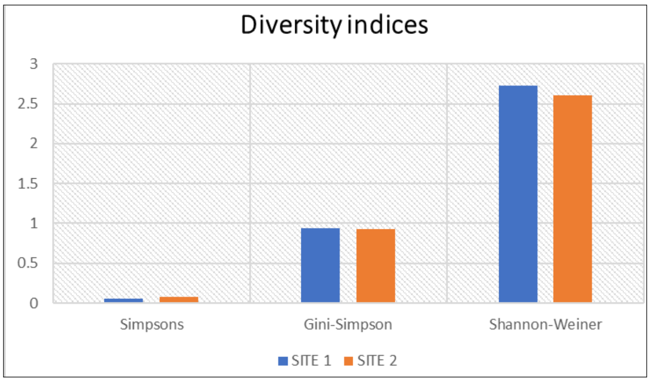

Fig 3: Diversity indices

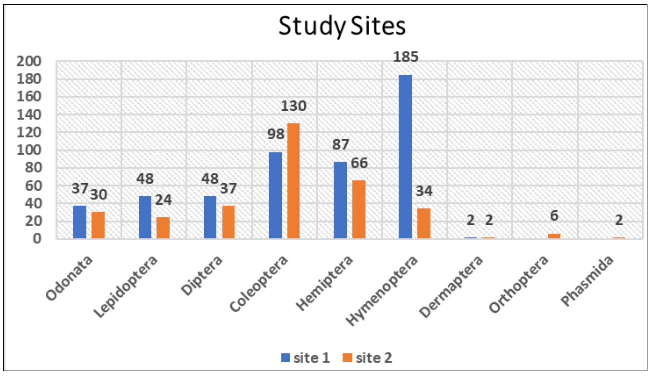

Fig 4: Number of individuals in two different sites

Conclusion

A study undertaken in the temperate montane forest ecosystem of two distinct sites in the Darjeeling district documented 836 individuals representing 27 families and 9 orders (Table: 1 to 3; Fig. 1 to 3). Hymenoptera emerged as the most diverse insect orders, followed by Hemiptera, which exhibited the highest number of crop visitors. While Diptera, Phasmida, and Dermaptera showed relatively lower diversity, their ecological roles remain significant. The observed insect abundance indicates marginal biological and ecological balance, suggesting an inadequately healthy ecosystem. Analysis of relative abundance reveals influences on natural processes and the local food chain, both directly and indirectly. Additionally, local pesticide and insecticide use impacts the environment and insect populations, with both immediate and long-term effects [13].

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