

Three-month comparative assessment of insect diversity in a monoculture and a mixed-crop fields in Bazpur, Uttarakhand

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Abstract

Insects play essential ecological roles in agricultural ecosystems, influencing productivity, pollination, pest regulation, and nutrient cycling. This study investigated the diversity and relative abundance of insect species across two contrasting agroecosystems in Bazpur, Udham Singh Nagar district, Uttarakhand, India: A Poplar tree monoculture field (Site A) and a mixed crop and vegetable field (Site B). Field sampling was conducted from 1 of May 2025 to 31 of July 2025, using sweep netting and hand collection methods during both morning and evening hours. Insect specimens were identified using standard taxonomic keys and biodiversity indices such as Shannon-Wiener Index (H'), Evenness Index (E), and Margalef's Richness Index (d) were applied to assess diversity. Site A recorded 10 species from 4 orders and 7 families, with Orthoptera dominating (50.88% relative abundance). The Shannon-Wiener Index ($H'=2.835$), Evenness ($E=0.851$), and Margalef's Richness Index ($d=3.64$) reflected moderate diversity. In contrast, Site B showed higher diversity with 14 species from 5 orders and 9 families, led by Coleoptera (34.6% relative abundance). Its diversity indices ($H'=2.48$, $E=0.91$, $d=2.38$) suggest a more balanced and complex insect community. The findings highlight that crop diversity and vegetation structure significantly influence insect community composition. Site B's diverse cropping system supported a richer and more ecologically functional insect population compared to the monoculture in Site A. This study emphasizes the importance of diversified agroecosystems for sustaining insect biodiversity and promoting ecosystem services essential to sustainable agriculture.

Keywords: Insect diversity, Agroecosystem, Species richness, Shannon-Wiener Index, Crop diversity, Biodiversity indices, Sustainable agriculture

Introduction

Insects represent the most diverse and ecologically dominant group of organisms on Earth, accounting for over 75% of all known animal species [26]. They play foundational roles in terrestrial ecosystems by contributing to essential functions such as pollination, nutrient recycling, decomposition of organic material, and natural pest regulation [3, 22, 1, 18]. Their diversity and functional versatility make them indispensable to both natural ecosystems and agroecosystems. In the context of agriculture, insect biodiversity directly influences crop productivity and sustainability by supporting pollination services, pest suppression, and soil health. Farmlands are dynamic and often disturbed environments, and the capacity of these landscapes to support insect populations is largely determined by management practices, including crop diversity, use of agrochemicals, and habitat structure [2]. Landscapes managed with traditional, organic, or diversified cropping systems tend to host higher insect richness and abundance compared to monocultures that rely heavily on synthetic inputs. However, intensification of agriculture, habitat fragmentation, and widespread pesticide use have severely impacted insect populations worldwide, leading to notable declines in both beneficial and native species [28]. India, which harbors approximately 63,760 insect species belonging to 29 orders—accounting for around 7% of global insect diversity—offers a vast and varied landscape for studying insect ecology [10]. Yet, insect diversity in cultivated ecosystems, particularly in hilly or sub-humid regions such as Uttarakhand, remains underreported. Understanding insect community structure in such regions is

essential not only for ecological monitoring but also for ensuring sustainable agricultural development through integrated pest management (IPM) and biodiversity conservation [9]. Bazpur, located in the Udham Singh Nagar district of Uttarakhand, lies in the agriculturally rich Terai belt. It is a significant producer of crops such as rice, wheat, sugarcane, and vegetables. This patchwork of cultivated fields and remnant natural vegetation forms a mosaic of habitats capable of supporting a wide variety of insect life. However, with increasing dependence on chemical fertilizers and pesticides, coupled with the degradation of native flora, concerns have arisen over the long-term viability of insect biodiversity in the region. Several studies have highlighted the importance of assessing insect diversity and abundance in agricultural areas to better understand ecological functions and inform management practices [9, 12, 5, 4, 19]. Previous research in Uttarakhand and similar agroecological zones has documented a rich diversity of insect orders including Lepidoptera, Hymenoptera, Coleoptera, and Diptera, often with species acting as key pollinators and ecological indicators [15, 24, 16, 20, 29]. Studies by Maramis *et al.* [13] and Wasnia Al Houty [25] in other regions have similarly emphasized the impact of environmental conditions and agricultural practices on insect community dynamics. The current study is designed to document and analyze the diversity and relative abundance of insect fauna in some cultivated areas of Bazpur using field-based sampling and established biodiversity indices such as the Shannon-Wiener Index [21, 11], Evenness Index [8], and Margalef's Richness Index [14]. The research further explores seasonal variations and

species distribution across different crop types, aiming to generate baseline data that can support entomological research and sustainable agriculture policy in the region.

Materials and Methods:

Study Area

The study took place in Bazpur, a semi-urban agricultural town located in Udham Singh Nagar district, Uttarakhand, India. Nestled in the fertile Terai region at the foothills of the Himalayas, Bazpur sits between 29.15°N to 29.25°N latitude and 79.10°E to 79.25°E longitude, at an elevation of about 263 meters above sea level. The area experiences a humid subtropical climate, marked by hot summers, monsoon rains, and mild winters. Temperatures typically range from 12°C to 35°C throughout the year, with around 1400 millimeters of rainfall each year, mostly during the

monsoon season from June to September. The agricultural landscape here is diverse, featuring a mix of cropping systems and agroforestry practices, making Bazpur an excellent place to explore insect biodiversity in cultivated settings.

Study Duration

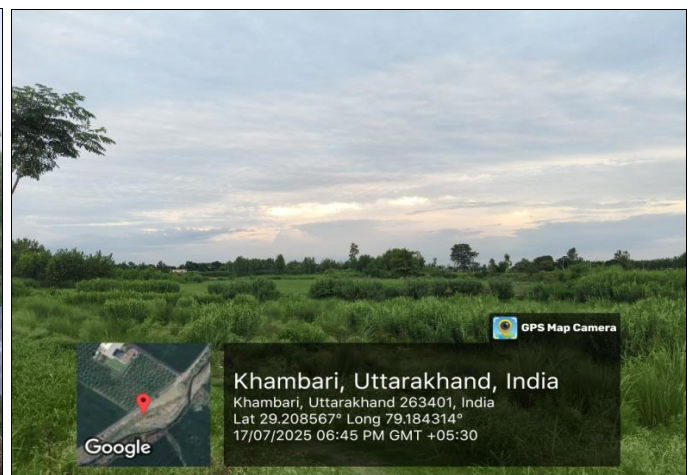
Fieldwork was carried out from 1 of May 2025 to 31 of July 2025—spanning both the pre-monsoon and early monsoon seasons. These months are notable for marked shifts in insect activity and numbers, primarily due to varying temperatures, rainfall, and crop growth stages.

Site Selection

Two distinctly different agricultural fields were chosen for the study



Site A



Site B

Fig 1: The study areas

Site A: Poplar Tree Field

This site was an agroforestry system dominated by *Populus deltoides*, with rich ground-level vegetation. Its dense tree canopy and soils enriched by decaying organic matter create favorable conditions for shade-loving insects and decomposers.

Site B: Mixed Crop and Vegetable Field: This field included a variety of crops such as okra, brinjal, various cucurbits, maize, and other quick-growing vegetables. Such crop diversity offers abundant resources for pollinators, plant-eating insects, and natural predators.

Collection and Data Analysis: Sampling took place three times every week at each site, from 1 of May 2025 to 31 of July 2025, resulting in close to 24 sampling sessions per site in total (over roughly eight weeks). Collecting insects was scheduled as Mornings: 8:00 AM to 11:00 AM (targeting mainly diurnal species) Evenings: 6:30 PM to 9:00 PM (focused on nocturnal insects). Sweep Netting was used for capturing flying insects and those dwelling on foliage while hand collection was used for insects found under leaves, soil, bark, or on flowers. Live insects were photographed with geo tagging. Collected insects were either stored in 70% ethanol or pinned, depending on preservation needs. Specimens were preliminarily sorted and labeled on-site. Identification was performed using widely accepted taxonomic keys (Gullan & Cranston, 2014; Triplehorn &

Johnson, 2005). In addition, the KnowYourInsects.org identification key and online database—developed by Eastern Michigan University students and curated with photographic examples and taxonomic guidance—were consulted to assist in order-level and family-level identification for a range of insect orders across regions beyond Michigan.

Data Analysis: Insect data from each collection session was compiled and analyzed using several biodiversity indices

Species Richness (S): it is the simplest measure of biodiversity, referring to the total number of distinct species recorded in a site during the study period without considering species abundance and higher value of S indicates.

Formula

$S = \text{Number of different species observed}$

Species richness was calculated separately for Site A and Site B for each week, month, and across the total study period.

Shannon-Wiener Diversity Index (H'): The Shannon-Wiener Index evaluates biodiversity by considering both the variety of species and their relative abundance, reflecting the likelihood of correctly guessing the species of a randomly sampled insects.

Formula

$$H' = -\sum (pi * \ln(pi))$$

Where:

- H represents the Shannon Diversity Index.
- \sum is the sum symbol, meaning the values for each species are summed.
- pi is the proportion of individuals of a particular species (species *i*) within the total community.

Simpson’s Index (D): It reflects the probability that any two randomly chosen individuals from a sample belong to an identical species and emphasizes species dominance.

Formula

$$D = 1 / \sum pi^2$$

All sampling activities adhered to ethical guidelines. To ensure authenticity of the data and minimize the collection of living insect geo tagged photographs were taken at the site. Only the minimum number of individuals necessary for proper scientific documentation was collected, in order to minimize disturbance to the local ecosystem.

Results and Discussion

Site A: Poplar Tree Field: The range and abundance of insect species recorded in Site A are displayed in Figures 1 and 3. Table 1 presents the list of insect species collected between 1 of May 2025 to 31 of July 2025. During this period, 10 different species were identified, spanning 4 orders and 7 families. Grasshoppers and their relatives (order Orthoptera) were most common, making up 5 species from 2 families. Both dragonflies (order Odonata) and butterflies/moths (order Lepidoptera) were represented by 2 species each, coming from 2 families per order. The order Hymenoptera was represented by just a single species from one family.

- Orthoptera was the most abundant group, comprising just over half (50.88%) of the observed insects, across families Acrididae and Pyrgomorphidae.
- Odonata and Lepidoptera were moderately represented, each spanning more than one family.
- Hymenoptera was the least common, suggesting a low diversity of pollinators in this monoculture field.

Table 1: Species richness and relative abundance (%) of insect fauna collected from the study area

S.No.	Species	Common Name	No. of individual	Relative Abundance (%)
Order – Orthoptera				
Family – Acrididae				
1.	Dichromorpha viridis	Green Grasshopper	25	10.96%
2.	Acrida cinerea	Chinese Grasshopper	30	13.16%
3.	Schistocera americana	American Bird Grasshopper	15	6.58%
4.	Valanga nigricornis	Javanese Bird Grasshopperv	28	12.28%
Family – Pyrgomorphinae				
5.	Tagasta marginella	Tagasta	18	7.89%
Order – Lepidoptera				
Family – Erebidae				
6.	Syntomoides imaon	Yellow belted burnet	12	5.26%
Family- Crambidae				
7.	Sitochroa palealis	Carrot Seed Moth	32	14.04%
Order – Odonata				
Family – Libellulidae				
8.	Pantala flavescen	Dragonfly	28	12.28%
Family – Coenagrionidae				
9.	Ischnura aurora	Golden Dartlet	26	11.40%
Order – Hymenoptera				
Family- Sphecidae				
10.	Sceliphron caementarium	Mud Dauber Wasp	14	6.14%
			228	100%

Order	Family	No. of Species	Total Individuals	Relative Abundance (%)
Orthoptera	Acrididae	4	98	42.98%
	Pyrgomorphidae	1	18	7.89%
Lepidoptera	Erebidae	1	12	5.26%
	Crambidae	1	32	14.04%
Odonata	Libellulidae	1	28	12.28%
	Coenagrionidae	1	26	11.40%
Hymenoptera	Sphecidae	1	14	6.14%
Total	7 Families	10 Species	228 Individuals	100.00%

Table 3: Species Diversity and Species Richness of Insect Fauna at Site A (Poplar Tree Field)

Parameter	Site A (Poplar Tree Field)
Shannon-Wiener Index (H')	2.835
Evenness (E)	0.851
Margalef’s Richness Index (d)	3.64
Total Number of Individuals	228
Total Number of Species	10

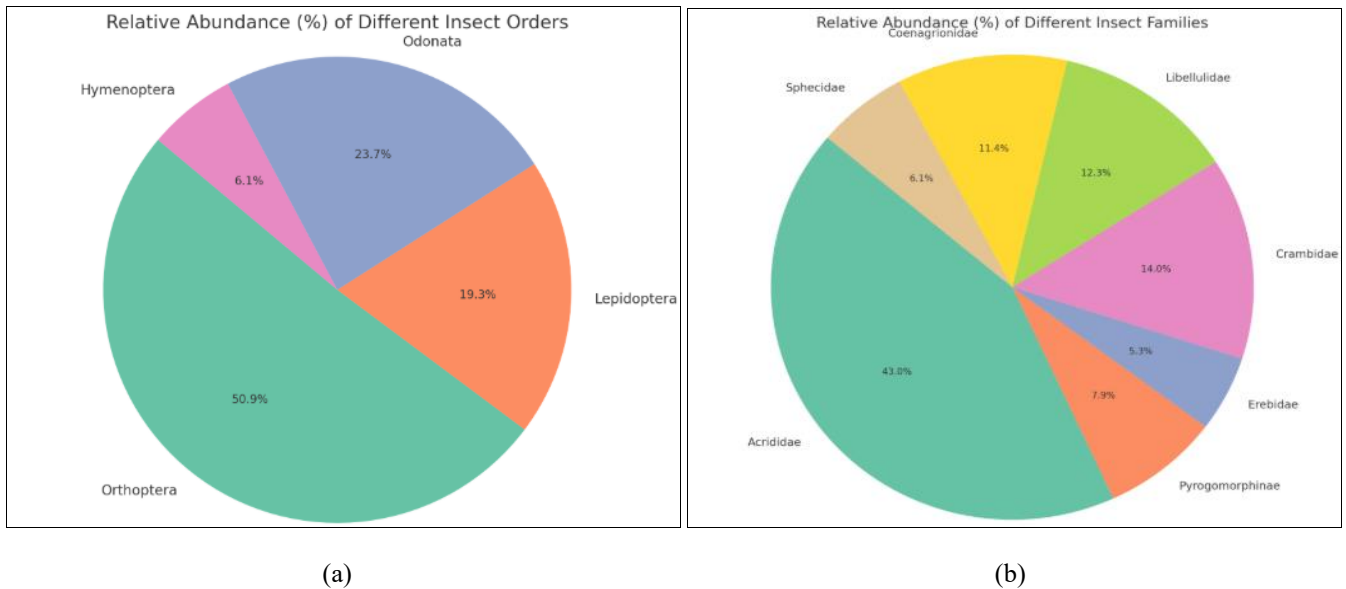
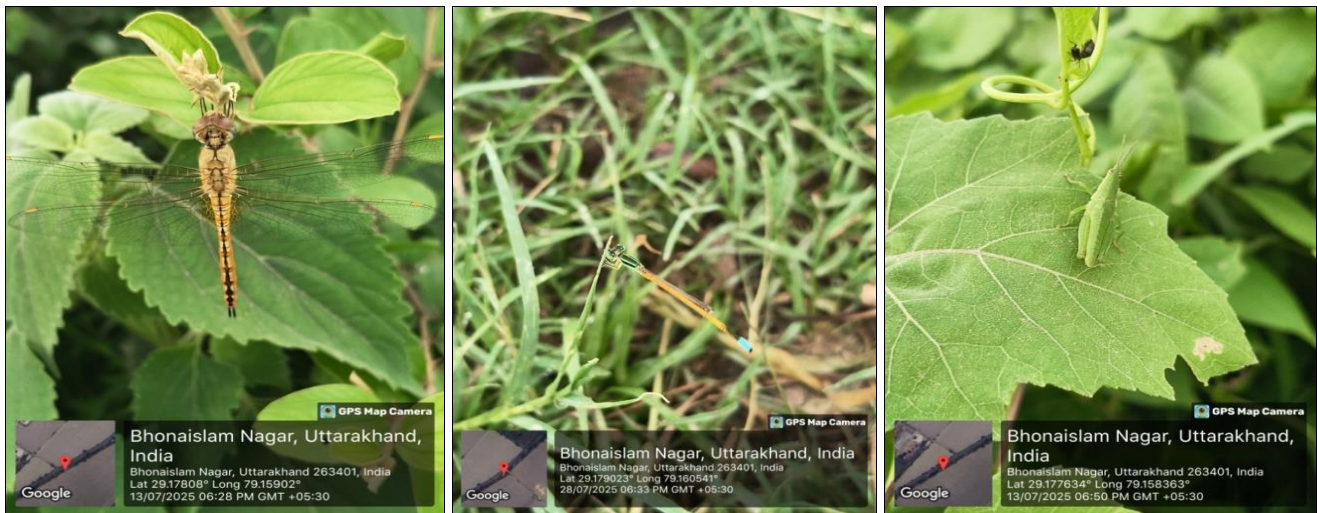


Fig 2: Relative abundance (%) of different (a) Order and (b) Families of Site A



Pantala flavescens

Ischnura aurora

Tagasta marginella

Fig 3: Insects collected from the Study Area Site A

Site B: Mixed Crop and Vegetable Field

The variety and relative numbers of insect species found in Site B are illustrated in Figures 1 and 5. Table 1 provides a checklist of all insect species collected during the study, which took place from 1 of May 2025 to 31 of July 2025. Over this period, a total of 14 species were identified, belonging to 5 different orders and 9 families. Among these,

beetles (order Coleoptera) were the most prevalent, with 6 species representing 3 families. The order Lepidoptera accounted for 3 species from 3 families. Both Hymenoptera and Hemiptera were represented by 2 species from 2 families each, while Orthoptera was represented by a single species from one family.

Table 4: Species richness and relative abundance (%) of insect fauna collected from the study area

S.No.	Species	Common Name	No. of individual	Relative Abundance (%)
Order – Coleoptera,				
Family - Chrysomelidae				
1.	<i>Gastrophysa viridula</i>	Green Dock Beetle	17	7.17%
2.	<i>Chrysolina fastuosa</i>	Dead-nettle Leaf Beetle	18	7.59%
3.	<i>Aulacophora foveicollis</i>	Red-pumpkin Beetle	28	11.81%
4.	<i>Chrysochus cobaltinus</i>	<i>Milkweed Beetle</i>	19	8.02%
Family - Meloidae				
5.	<i>Hycleus pustulatus</i>	Blister Beetle	26	10.97%
Family - Scarabaeidae				
6.	<i>Torynorrhina hyacinthina</i>	Scarab Beetle	16	6.75%
Order – Lepidoptera				
Family - Papilionidae				
7.	<i>Papilio polytes</i>	Mormon	18	7.59%

Family - Nymphalidae				
8.	Danaus chrysippus	Plain Tiger	22	9.28%
Family - Pieridae				
9.	Catopsilia florella	African Migrant	23	9.70%
Order – Hemiptera				
Family - Pyrrhocoridae				
10	Dysdercus cingulatus	Red Cotton Stainer	22	9.28%
Family - Alydidae				
11.	Leptocoris acuta	Paddy Earhead Bug	23	9.70%
Order – Hymenoptera				
Family - Vespidae				
12.	Ropalidia marginata	Paper Wasp	14	5.91%
Family - Apidae				
13.	Apis mellifera	Honey bee	11	4.63%
Order – Orthoptera				
Family - Acrididae				
14.	Oedaleus infernalis	Band-winged Grasshopper	28	11.81%
			237	100%

Table 5: Number of species, abundance and relative abundance (%) of different insect orders and their families

Order	Family	No. of Species	Total Individuals	Relative Abundance (%)
Coleoptera	Chrysomelidae	4	82	34.60%
	Meloidae	1	26	10.97%
	Scarabaeidae	1	16	6.75%
Lepidoptera	Papilionidae	1	18	7.59%
	Nymphalidae	1	22	9.28%
Hemiptera	Pieridae	1	23	9.70%
	Pyrrhocoridae	1	22	9.28%
Hymenoptera	Alydidae	1	23	9.70%
	Vespidae	1	14	5.91%
Orthoptera	Apidae	1	11	4.63%
	Acrididae	1	28	11.81%
Total	11	14	237	100%

Table 6: Species Diversity and Species Richness of Insect Fauna at Site A (Poplar Tree Field)

Parameter	Site A (mix of crops and vegetables)
Shannon-Wiener Index (H')	2.48
Evenness (E)	0.91
Margalef's Richness Index (d)	2.38
Total Number of Individuals	237
Total Number of Species	14

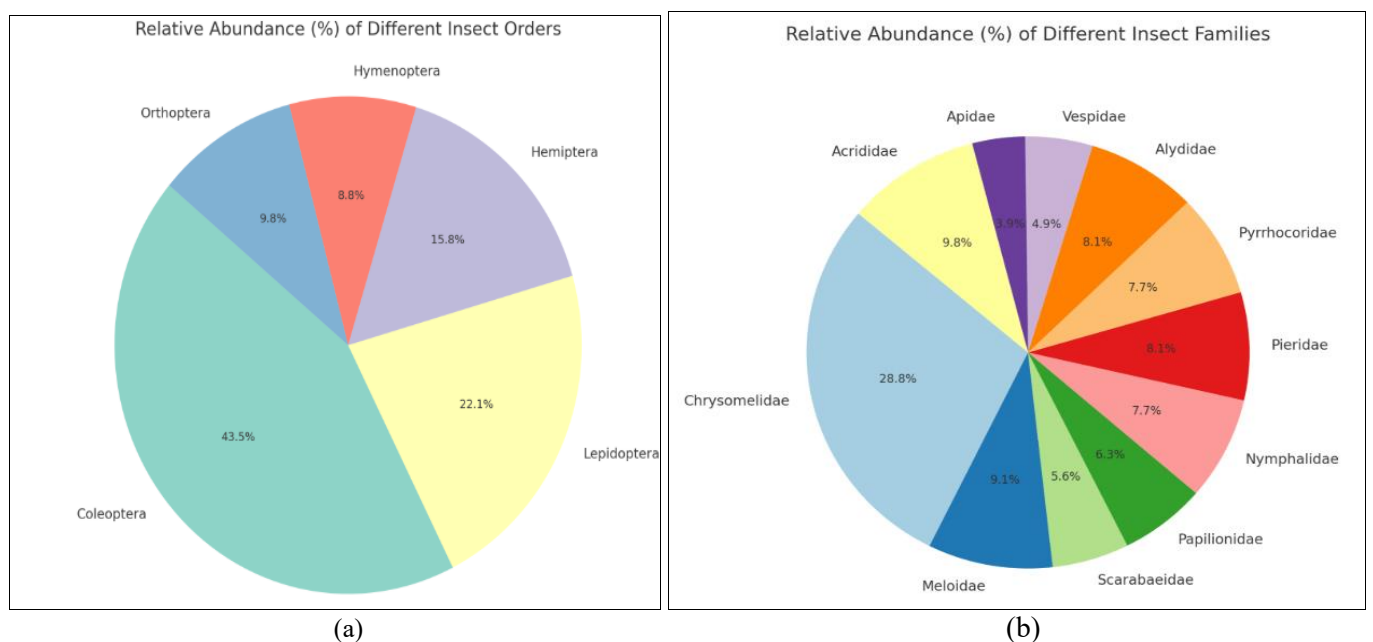
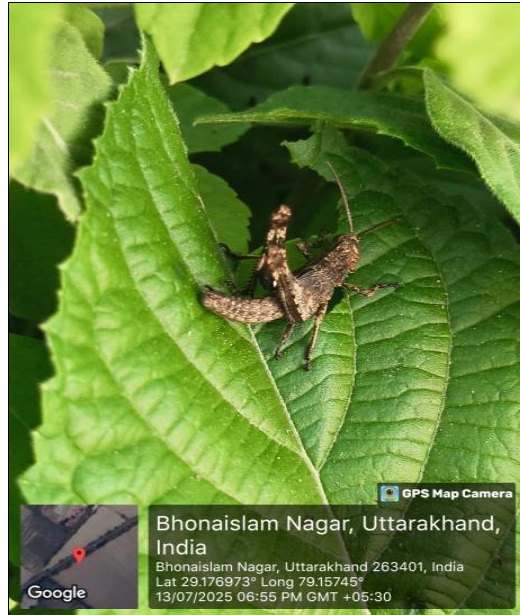


Fig 4: Relative abundance (%) of different (a) Order and (b) Families of Site B



Oedaleus infernalis



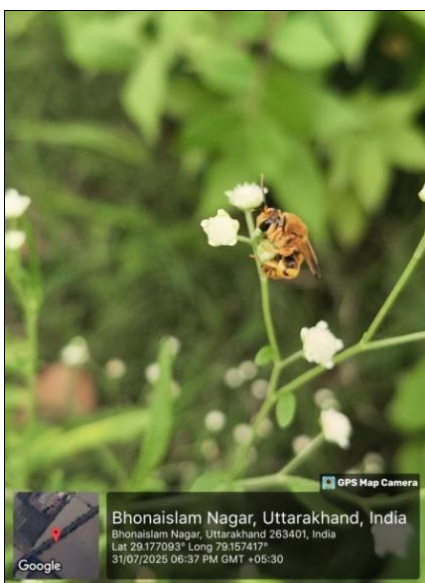
Torynorrhina hyacinthina



Gastrophysa viridula



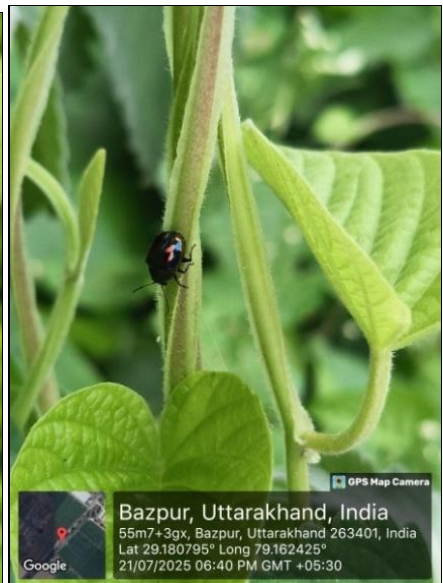
Dysdercus cingulatus



Apis mellifera



Leptocoris acuta



Fasta fastuosa

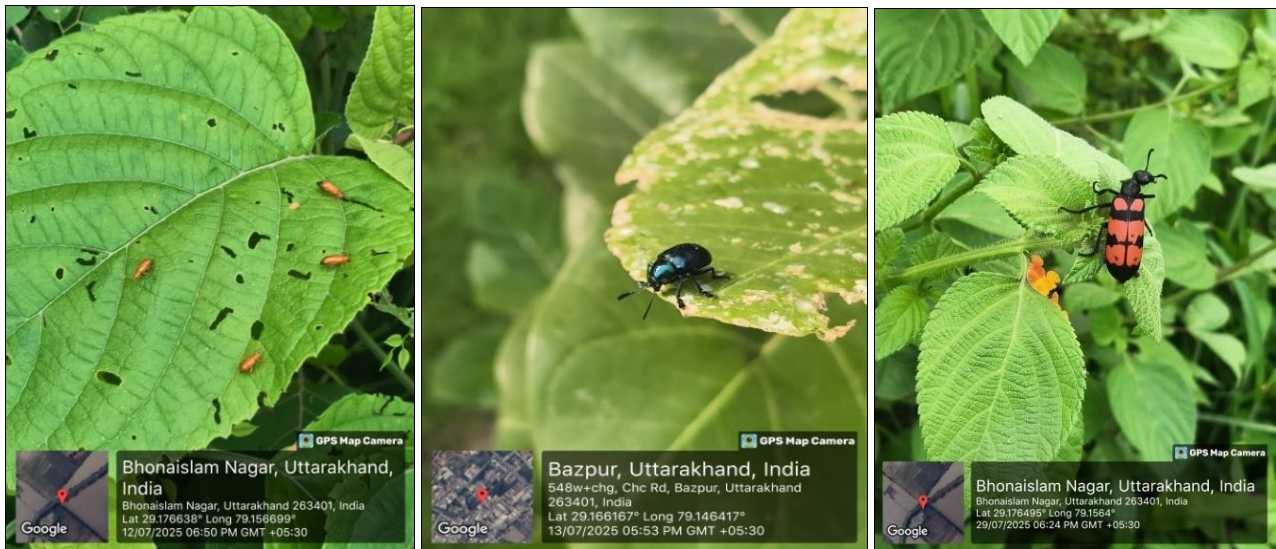
*Chrysochus cobaltinus**Aulacophora foveicollis**Hylecus pustulatus*

Fig 5: Insects collection from the Study Area Site B

Discussion

Site A: Poplar Tree Field

In Site A, the variety and numbers of insects observed are outlined in Figures 1 and 5, with species details listed in Table 1 for collections made between 1 of May 2025 to 31 of July 2025. Over this span, 10 insect species were noted, belonging to 4 different orders and 7 families. Most of the insects here were grasshoppers and their relatives (order Orthoptera), making up 5 species across two families (Acrididae and Pyrgomorphinae). Their high numbers point to a strong adaptation to the open, grassy environment beneath the poplar trees.

The presence of both dragonflies (Odonata) and butterflies/moths (Lepidoptera)—each with two species from two families—suggests a certain balance in the ecosystem, as these groups include both predators and pollinators. However, there was only one species from the order Hymenoptera, indicating a limited presence of bees or wasps. This scarcity may be due to fewer flowering plants or less suitable nesting options within this largely uniform, tree-dominated landscape.

Fewer insect species and families were recorded in Site A, likely because the vegetation here is more uniform with less variety in flowers and overall plant structure. With fewer types of plants and not much habitat variation, there are fewer opportunities for different insects to thrive. Yet, the dominance of grasshoppers signals that herbivores adapted to the poplar understory find good conditions for survival in this environment.

Site B: Mixed Crop and Vegetable Field

By comparison, Site B displayed much higher insect diversity. As shown in Figures 1 and 5 and detailed in Table 1, 14 insect species spanning 5 orders and 9 families were documented over the same period. Beetles (order Coleoptera) were most common—with 6 species from three families—suggesting that this site offers plenty of decomposing plant matter, a variety of flowers, and ample feeding and egg-laying sites.

Butterflies and moths (Lepidoptera) were also quite well represented, with three different families present, indicating richer nectar sources and host plants for caterpillars. There

were also two species each from both Hymenoptera and Hemiptera—signaling the presence of both beneficial species (like pollinators and natural enemies) and plant-feeding insects that might act as pests. Site B only had one grasshopper species, which may reflect the more controlled and cultivated conditions with less grassy groundcover.

The greater diversity recorded in Site B likely results from its mix of crops, flowering plants, multiple layers of vegetation, and overall habitat complexity. Such a patchwork of habitats supports a wider range of insect types—herbivores, pollinators, predators, and decomposers all finding niches that meet their needs.

Comparative Insights

- Site A shows lower overall diversity, with grasshoppers dominating because of open, grassy conditions under the poplars.
- Site B stands out for its greater diversity, both in terms of insect types and ecological roles, thanks to a wider variety of plants and more complex habitat structure.
- These findings clearly show how the type of vegetation, plant diversity, and management practices directly shape the insect communities present.
- Although Site A harbors a more uniform and stable insect population, Site B sustains a more diverse community that plays a crucial role in key ecosystem functions like pollination, biological pest regulation, and nutrient cycling.

Conclusion

This study explored the variety and abundance of insects in the Bazpur region of Udham Singh Nagar, Uttarakhand, focusing on two different types of farmlands: a poplar tree field (Site A) and a mixed crop and vegetable field (Site B). Conducted between May 15 and July 31, 2025, the research aimed to see how different farming practices and plant diversity influence insect communities.

The results revealed clear differences between the sites. Site A, with its poplar monoculture, supported 10 insect species across 4 orders and 7 families. In contrast, Site B, which included a blend of crops and vegetables, was home to 14 species from 5 orders and 9 families. This suggests that

fields with a mixture of crops and greater plant diversity can offer more habitats and food sources, leading to higher insect diversity and abundance.

Grasshoppers and other Orthoptera were especially common in Site A, reflecting their preference for less diverse, single-crop environments. While a few other insects, like dragonflies and butterflies, were found, overall diversity and ecological complexity in Site A remained modest.

On the other hand, Site B supported a more balanced and richer insect community, illustrated by higher diversity measurements (such as the Shannon-Wiener Index and others). Beetles (Coleoptera) were particularly prevalent, showing their adaptability to varied surroundings. Other important groups like butterflies, true bugs, and bees were also plentiful, indicating that Site B nurtures a diverse and dynamic ecosystem, including beneficial insects like pollinators and natural pest controllers.

Some of the key takeaways from this research are

- The mixed crop field (Site B) had greater species richness, highlighting the role of varied farming in supporting insect biodiversity.
- Site A was dominated by Orthoptera, reflecting the limited ecological opportunities in monoculture fields.
- Diversity and evenness indices indicated that insect populations in Site B were more balanced, pointing to a healthier and more resilient environment.
- The presence of pollinators and predators in Site B underlines the important ecosystem services they provide in diversified farmland.

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