

Diversity of insect pollinators in different agro-climatic zones of Haryana

Manoj Kumar Jat^{1#}, Sunita Yadav¹, Harish Kumar¹ and Lomash Kumar¹

Summary

The present study was undertaken to document the diversity of insect visitors on major crops across different agro-climatic zones of Haryana, India during 2023-24. Observations revealed a rich assemblage of pollinators, with 18 species recorded on mustard, 12 on seed spices, 12 on berseem, and 13 on sunflower. These visitors represented five major insect orders: Hymenoptera, Diptera, Lepidoptera, Coleoptera and Hemiptera. Among them, Hymenoptera emerged as the dominant group across all crops and regions, underscoring the central role of bees in pollination. In sunflower, Hymenopterans alone accounted for 69.23% of total visitors, highlighting their overwhelming contribution. Key pollinators included *Apis mellifera*, *A. dorsata*, *A. florea* and *A. cerana*, which were consistently observed across crops. Maximum diversity was recorded in agro-climatic zone II (Hisar region), suggesting that regional floral resources and climatic conditions strongly influence pollinator abundance. Diversity indices further indicated that berseem supported higher species richness and evenness compared to other crops, reflecting its suitability as a forage source for diverse insect groups. Interestingly, non-bee insects such as flies and butterflies also contributed to pollination, demonstrating the complementary role of different taxa in sustaining crop productivity. The variation in diversity patterns across crops and zones was largely shaped by the availability of floral resources and prevailing agro-climatic conditions. Overall, the findings emphasize the importance of conserving diverse insect pollinators, particularly Hymenoptera, to enhance pollination services and ensure sustainable agricultural productivity in Haryana's varied agro-ecosystems.

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Introduction

Insect pollinators play a vital role in sustaining agricultural productivity and maintaining ecosystem stability. Approximately 75 per cent of the world's leading food crops benefit from animal-mediated pollination, mainly by insects (Food and Agriculture Organization 2018; IPBES 2023). Among pollinators, bees (Hymenoptera) are considered the most efficient due to their foraging efficiency, floral constancy and wide distribution (Klein et al. 2007). In addition, other insect groups such as Diptera, Lepidoptera and Coleoptera also contribute significantly to pollination services in agricultural ecosystems (Rader et al. 2016; Dicks et al. 2021). Globally, pollinator diversity is declining due to habitat loss, climate change, pesticide use and agricultural intensification (Potts et al. 2010; Wagner et al. 2021, Nidhi et al. 2025). These declines pose a serious threat to crop production, biodiversity conservation and global food security (Garibaldi et al. 2013; Vanbergen AJ and Insect Pollinators Initiative, 2021). In India, several economically important crops such as mustard (*Brassica juncea*), sunflower (*Helianthus annuus*), berseem (*Trifolium alexandrinum*) and seed spices are highly dependent on insect pollinators for higher yield and quality. Studies have

reported that managed and wild bee species significantly enhance seed set, oil content and crop productivity in these crops (Aizen et al. 2009; Partap 2011; Haldhar et al. 2021a,b; Kumar et al. 2022). The diversity and abundance of pollinators are strongly influenced by agro-climatic conditions, cropping patterns and availability of floral resources (Winfree et al. 2009; Joshi & Joshi 2023). Variations in temperature, humidity and landscape heterogeneity across agro-climatic zones significantly affect pollinator composition, distribution and foraging behaviour (Kennedy et al. 2013; Orr et al. 2021; Singh et al. 2022; Haldhar et al. 2025). Recent studies in Indian agro ecosystems have also highlighted regional differences in pollinator diversity and seasonal abundance, emphasizing the importance of local ecological conditions in shaping pollinator communities (Indian Council of Agricultural Research 2015; Singh et al. 2024).

Haryana, one of the major agricultural states of India, comprises distinct agro-climatic zones supporting diverse cropping systems. However, increasing agricultural intensification, pesticide exposure and habitat fragmentation are major challenges affecting pollinator diversity in the region. Despite the importance of pollinators, comprehensive studies on insect visitor diversity across multiple crops and agro-climatic zones of Haryana remain limited.

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Therefore, the present investigation was undertaken to assess the diversity and composition of insect visitors on mustard, sunflower, berseem and seed spices across different agro-climatic zones of Haryana during 2023–24.

Materials and Methods

The study comprised four crops, namely mustard (*Brassica juncea*), sunflower (*Helianthus annuus*), berseem (*Trifolium alexandrinum*) and seed spices, grown across different agro-climatic zones of Haryana, India. Observations were recorded from selected locations representing zones I, II, and III.

Collection of Pollinators

Pollinating insects were collected from the target crops using insect collection nets by sweeping at randomly selected spots within the crop fields. Sampling was carried out throughout the flowering period, starting from the commencement of pollinator activity in the morning until cessation in the evening.

Preservation and Identification

The collected insect specimens were properly preserved and later identified up to species or genus level with the help of standard taxonomic keys and authentic literature sources. The identified insects were grouped into different orders for diversity assessment.

Observations Recorded

The number of insect visitors was recorded as the number of insects visiting per unit area (m²) per unit time (5 minutes). Observations were taken at regular intervals to assess the diversity and activity of pollinators on different crops.

Diversity Indices and Statistical Analysis

To quantify pollinator diversity, different ecological indices were calculated using standard formulae.

Species Richness (S):
S=Total number of species observed

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Species Richness (S):
S=Total number of species observed
Simpson's Index (D)
 $D = \sum (p_i^2)$

where,
 $p_i = \frac{N_i}{N}$
N_i = number of individuals of ith species
N = total number of individuals recorded.

Simpson's Diversity Index (1-D): 1-D
Simpson's Reciprocal Index (1/D): 1 / D
Shannon–Wiener Diversity Index (H') $H' = -\sum (p_i \ln p_i)$
Species Evenness (E) $E = H' / \ln(S)$

Where, p_i represents the proportion of individuals belonging to the ith species. These indices were used to evaluate species richness, dominance, diversity and evenness of insect pollinators visiting different crops across agro-climatic zones of Haryana



Source: Department of Meteorology, CCSHAU, Hisar, Haryana

Results and Discussion

Diversity of Insect Visitors in Mustard Ecosystem

The data presented in Table 1 revealed that a total of 18 insect species belonging to five orders were recorded on mustard across different agro-climatic zones of Haryana. Among these, Hymenoptera was the dominant order, contributing the highest proportion (44%), followed by Diptera (25%), Lepidoptera (19%), Coleoptera (6%) and Hemiptera. The major hymenopteran pollinators included *Apis mellifera*, *A. dorsata*, *A. florea*, and *A. cerana*, which were widely distributed across all locations. The dominance of Hymenoptera in the mustard ecosystem is in agreement with the findings of Klein A.M. et al. (2007) and Partap U. (2011), who reported that honey bees are the most efficient pollinators of oilseed crops. The presence of wild bees such as *Xylocopa fenestrata* and *Andrena* sp. further supports the role of native pollinators in enhancing pollination efficiency (Garibaldi et al. 2013). Agro-climatic zones-wise variation indicated higher diversity in zone II (Hisar and Fatehabad) compared to zone I, which may be attributed to favorable agro-climatic conditions and greater floral resource availability. Similar observations have been reported by Kennedy C.M. et al. (2013), who emphasized the influence of landscape and climate on pollinator diversity.

Table 1. Diversity of insect visitors in mustard ecosystem in different agro-climatic zones of Haryana

Insect visitors			Zones				
Order	Family	Scientific Name	I			II	
			Kaithal	Sonipat	Panipat	Hisar	Fatehabad
Hymenoptera	Apidae	<i>Apis mellifera</i>	√*	√	√	√	√
		<i>A. cerana</i>	√	×*	×	√	√
		<i>A. dorsata</i>	√	×	√	√	√
		<i>A. florea</i>	√	×	×	√	√
		<i>Tetragonula ruficornis</i>	×	×	×	√	×

Diptera		<i>Xylocopa fenestrata</i>	✓	X	X	✓	✓
	Andrenidae	<i>Andrena</i> sp.	X	X	X	✓	✓
	Halictidae	<i>Lasioglossum</i> sp.	X	X	X	✓	X
	Scoliidae	<i>Campsomeriella</i> sp.	X	X	X	✓	X
	Syrphidae	<i>Episyrphus</i> sp.	✓	✓	X	✓	X
		<i>Eristalinus</i> sp.	X	✓	✓	✓	✓
	Calliphoridae	<i>Chrysomya rufifacies</i>	✓	✓	✓	✓	X
Lepidoptera	Muscidae	<i>Musca domestica</i>	✓	✓	✓	✓	✓
	Nymphalidae	<i>Danaus chrysippus</i>	X	✓	✓	✓	✓
		<i>Venes sacardui</i>	X	✓	X	✓	X
	Pieridae	<i>Pieris brassicae</i>	✓	X	✓	✓	✓
Hemiptera	Pentatomidae	<i>Bagrad ahilaris</i>	✓	✓	✓	✓	✓
Coleoptera	Coccinellidae	<i>Coccinella septumpunctata</i>	✓	X	✓	✓	X

✓-Present; X-absent

Diversity of Insect Visitors in Seed Spices Ecosystem

Table 2 indicated that a total of 12 insect species were recorded on seed spices across different districts. Hymenoptera was again the dominant group, comprising 7 species, followed by Diptera, Lepidoptera, Hemiptera, and Coleoptera. *Apis dorsata* and *A.s mellifera* were recorded in all locations, highlighting their wide distribution and adaptability. The highest number of insect visitors was recorded at Hisar (12 species) followed by Mahendragarh and Jhajjar. This variation in diversity may be due to differences in cropping systems and environmental conditions. The findings are in line with Winfree R. et al. (2009), who reported that pollinator diversity is strongly influenced by habitat quality and floral resource availability. The presence of non-bee pollinators such as *Polistes hebraeus* and *Camponotus* spp. suggests that diverse insect groups contribute to pollination. These results are supported by Rader R. et al. (2016), who highlighted

the Diversity of Insect Visitors in Seed Spices Ecosystem: The data in Table 3 showed that 12 insect species were recorded in berseem ecosystem across different locations. Hymenoptera dominated the insect visitor community, with *Apis dorsata*, *A. mellifera*, and *A. florea* present in all districts. Species such as *Megachile* spp. and *Campsomeriella collaris* were restricted to Hisar, indicating localized distribution. The higher diversity observed in zone II (Hisar) may be attributed to prolonged flowering duration and higher nectar availability in berseem crop. These findings are in agreement with Aizen et al. (2009), who reported that floral resource availability enhances pollinator diversity. Dipteran and lepidopteran insects were also observed, though in lower numbers, indicating their supplementary role in pollination. The presence of diverse insect groups contributes to stability and resilience of pollination services.

Table 2. Diversity of insect visitors on seed spices ecosystem in different agro-climatic zones of Haryana

Insect visitors			Zones				
Order	Family	Scientific Name	I		II		III
			Sonipat	Panipat	Hisar	Jhajjar	Mahendragarh
Hymenoptera	Apidae	<i>Apis florea</i>	X*	X	✓*	✓	✓
		<i>A. cerana</i>	X	X	✓	✓	✓
		<i>A. dorsata</i>	✓	✓	✓	✓	✓
		<i>A.mellifera</i>	✓	✓	✓	✓	✓
		<i>Tetragonula ruficornis</i>	X	X	✓	X	X
	Vespidae	<i>Polistes hebraeus</i> F.	✓	✓	✓	✓	✓
	Formicidae	<i>Camponotu</i> ssp.	✓	X	✓	X	✓
Diptera	Syrphidae	<i>Eristalinu</i> ssp.	✓	✓	✓	✓	✓
	Muscidae	<i>Musca domestica</i>	X	✓	✓	X	✓
Hemiptera	Pentatomidae	<i>Bagra dahilaris</i>	✓	✓	✓	✓	✓
Lepidoptera	Pieridae	<i>Pieris brassicae</i>	✓	✓	✓	✓	✓
Coleoptera	Coccinellidae	<i>Coccinella septumpunctata</i>	X	X	✓	X	✓

✓-Present; X-absent

Table 3. Diversity of insect visitors in berseem ecosystem in different agro-climatic zones of Haryana

Insect visitors			Zones		
Order	Family	Scientific Name	I	II	
			Sonipat	Panipat	Hisar
Hymenoptera	Apidae	<i>Apis dorsata</i>	√*	√	√
		<i>A. mellifera</i>	√	√	√
		<i>A. florea</i>	√	√	√
		<i>A. cerana</i>	X*	X	√
	Megachilidae	<i>Megachile</i> spp.	X	X	√
	Vespididae	<i>Polistes olivaceus</i>	√	X	√
	Scoliidae	<i>Campsomeriella collaris collaris</i>	X	X	√
Diptera	Agromyzidae	<i>Melanagromyza obtuse</i>	X	X	√
	Syrphidae	<i>Eristalinus</i> spp.	X	√	√
	Muscidae	<i>Musca</i> spp.	√	X	√
Lepidoptera	Pieridae	<i>Pieris brassicae</i>	√	√	√
	Noctuidae	<i>Helicoverpa armigera</i> .	√	√	√

√-Present; X-absent

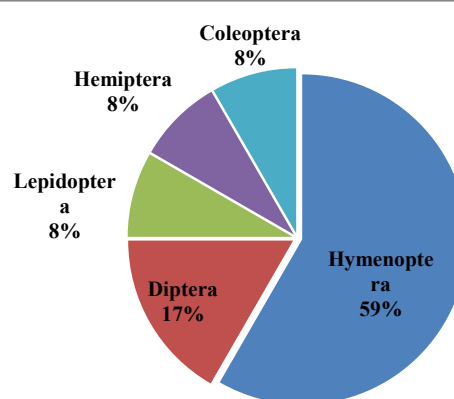
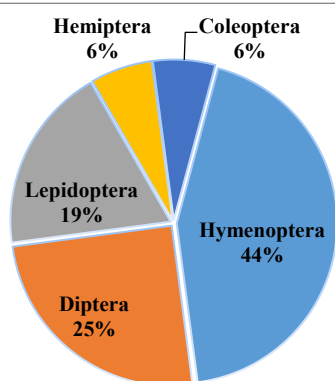
Diversity of Insect Visitors in Sunflower Ecosystem

Table 4 & Figure 1 revealed that sunflower crop supported 13 insect species belonging to four orders and eight families. Hymenoptera was the dominant group, contributing the highest proportion (69%), followed by Diptera, Lepidoptera, and Coleoptera. Major pollinators included *Apis* spp., *Megachile* spp., and

Anthophora sp. The dominance of hymenopteran pollinators in sunflower is consistent with the findings of Potts et al. (2010), who reported that bees are the most effective pollinators in oilseed crops. The presence of butterflies and flies further indicates the diversity of floral visitors, although their pollination efficiency may be comparatively lower.

Table 4. Diversity of insect visitors in the sunflower crop at Hisar

Order	Family	Scientific Name
Hymenoptera	Apidae	<i>A. dorsata</i> F.
		<i>A. florea</i> F.
		<i>A. mellifera</i> L.
		<i>Apis cerana indica</i> F.
		<i>Tetragonula ruficornis</i>
		<i>Xylocopa fenestrata</i> F.
	Megachilidae	<i>Megachile</i> spp.
Diptera	Anthophoridae	<i>Anthophora</i> sp.
	Halictidae	<i>Halictus</i> sp.
	Syrphidae	<i>Episyrphus</i> sp.
Lepidoptera	papilionidae	<i>Papilio demoleus</i> L.
	Pieridae	<i>Pieris brassicae</i> L.
Coleoptera	Coccinellidae	<i>Coccinella septumpunctata</i>



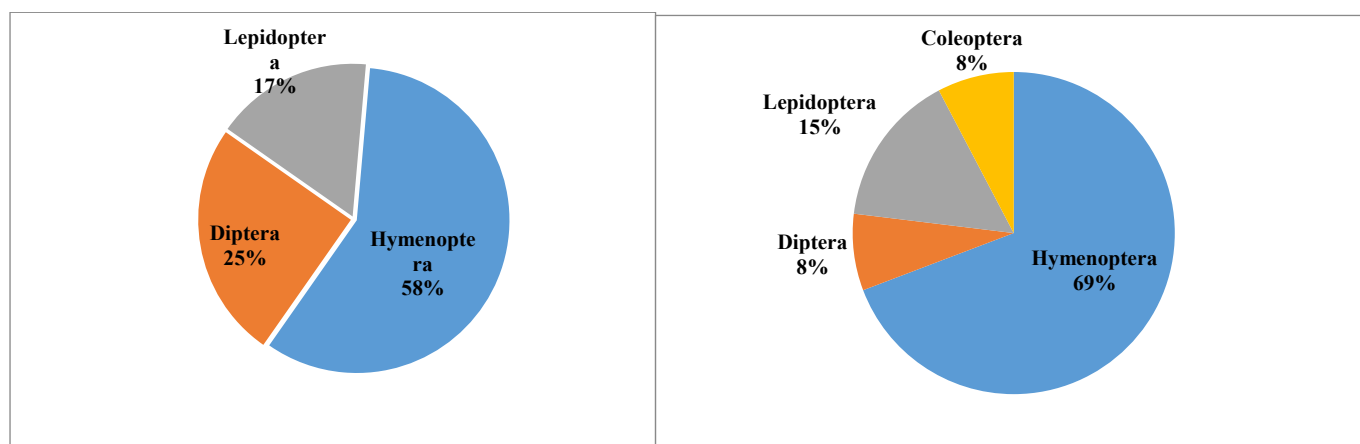


Figure 1. Diversity of insect visitors on mustard, seed spices, berseem and sunflower crop

Diversity Indices of Insect Visitors

The diversity indices presented in Table 5 indicated significant variation among different ecosystems. Berseem recorded the highest diversity, with Shannon-Wiener index ($H = 2.285$) and Simpson's index of diversity (0.889), followed by mustard ($H = 2.018$). Seed spices ($H = 1.744$) and sunflower ($H = 1.785$) showed comparatively lower diversity. Higher species evenness (0.818) in berseem indicates a more uniform distribution of insect species, reflecting a stable pollinator community. These findings are in agreement with Magurran (2004), who emphasized that diversity indices are important indicators of ecosystem stability and species distribution. The present study clearly demonstrated that Hymenoptera is the dominant and most ecologically important group of pollinators across

all crops and agro-climatic zones of Haryana. The widespread occurrence of *Apis* spp. highlights their key role in pollination and crop productivity. The presence of wild pollinators such as *Xylocopa*, *Megachile*, and *Andrena* further enhances pollination efficiency and ecosystem resilience. The variation in pollinator diversity across zones indicates the significant influence of agro-climatic factors and floral resource availability. Similar trends have been reported by Potts et al. (2010) and Garibaldi et al. (2013), who highlighted the impact of environmental factors on pollinator communities. From an applied perspective, the findings emphasize the need for pollinator conservation strategies, including habitat management, reduced pesticide use and promotion of floral diversity to sustain pollination services in agricultural ecosystems.

Table 5. Diversity indices of insect visitors in different crops

S. No	Name of the crop	Total number of insect visitors	Species Richness (S)	Simpson index (D)	Simpson index of diversity (1-D)	Simpson reciprocal index (1/D)	Shannon Wiener index (H)	Species evenness (E)
1	Mustard	1871	18	0.229	0.771	4.367	2.018	0.418
2	Seed spices	1493	12	0.281	0.719	3.564	1.744	0.477
3	Sunflower	1371	13	0.278	0.721	3.595	1.785	0.458
4	Berseem	1794	12	0.110	0.889	9.08	2.285	0.818

Conclusion

The present study revealed that Hymenoptera was the dominant group of insect pollinators across mustard, sunflower, berseem and seed spices in different agro-climatic zones of Haryana. Honey bees, particularly *Apis* spp., were the major pollinators, while wild pollinators such as *Xylocopa* and *Megachile* also contributed significantly to pollination services. Among the crops studied, berseem recorded the highest pollinator diversity and evenness. Variations in pollinator diversity among zones indicated the influence of agro-climatic conditions and floral resource availability. The findings emphasize the importance of pollinator conservation and adoption of

pollinator-friendly agricultural practices for sustaining crop productivity and ecosystem stability.

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Declarations of interests

All authors of this manuscript declare that they have no conflict of interest.

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