



Diversity and abundance of insect visitors visiting rapeseed-mustard (*Brassica rapa* var. *toria*) crop during the blooming period in Manipur

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Summary

During the field survey, eight insect visitors visiting rapeseed mustard (*Brassica rapa* var. *toria*) were recorded, belonging to three major insect orders: Hymenoptera, Lepidoptera, and Diptera. Hymenoptera was the dominant order, comprising *Apis cerana himalaya*, *A. dorsata*, *A. florea* and *Sceliphron caementarium*. Lepidoptera included *Pieris canidia* and *Pontia daplidice*, while Diptera consisted of *Sphaerophoria scripta* and *Helophilus pendulus*. Among all visitors, *Apis cerana himalaya* was the most abundant species, accounting for 58.7% of total insect visitors, followed by *Sphaerophoria scripta* (9.65%), *Helophilus pendulus* (8.61%), *Apis florea* (7.62%), *Pieris canidia* (5.83%), *Pontia daplidice* (5.14%), and *Apis dorsata* (4.21%). *Sceliphron caementarium* showed the lowest abundance (0.95%). The predominance of Hymenopteran species, particularly *A. cerana*, highlights their important role in mustard pollination and seed set, while hoverflies and butterflies also contributed to effective cross-pollination.

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Introduction

Pollination is a fundamental ecological process that sustains biodiversity and ensures the reproductive success of flowering plants. Insects constitute one of the most important groups of pollinating agents, and their association with flowers has evolved through intricate mutualistic relationships. Insect-mediated pollination plays a vital role in the reproduction and persistence of numerous wild and cultivated plant species (Ollerton et al. 2011; Nidhi & Haldhar 2026). Among pollinators, bees are widely recognized as the most efficient and economically valuable taxon, contributing significantly to global food production (Atmowidi et al. 2008). Pollination facilitates the propagation of sexually reproducing plants by transferring pollen grains from the male reproductive organ (anther) to the female organ (stigma), enabling fertilization and subsequent seed formation (Buchmann & Nabhan 1996). Agricultural landscapes rely heavily on pollinator communities that are supported by nearby semi-natural habitats, which provide essential floral resources and nesting sites. The availability and heterogeneity of these habitats have been shown to enhance pollinator richness and abundance, thereby contributing to the maintenance of pollination services in crop ecosystems (Martínez-Núñez et al., 2022; Nidhi et al. 2025; Haldhar et al. 2025).

Globally, bees contribute extensively to the pollination of food crops, with their activity directly linked to enhanced fruit and seed set (Gallai et al. 2009). However, the

butterflies, hoverflies, and other insects that complement bee activity and ensure pollination continuity under varying environmental conditions. Understanding the composition and relative abundance of these pollinators is therefore crucial for developing sustainable crop management strategies. The present study was undertaken to identify and document the insect pollinators visiting rapeseed-mustard (*Brassica juncea*) flowers under field conditions (Haldhar et al. 2021a&b). Through systematic surveys, the research aimed to determine the major taxa responsible for effective pollination and their relative contribution to crop productivity. By characterizing the diversity and dominance of pollinator species, the study provides insights into the ecological interactions that sustain mustard cultivation and highlights the need for conserving pollinator habitats to secure long-term agricultural sustainability.

Materials and Methods

To investigate the effect of pollination on rapeseed-mustard yield, a field experiment was conducted during the Rabi seasons of 2022 and 2024 using the rapeseed variety "T-38." The experimental plot covered an area of 252 m², prepared meticulously to ensure uniform crop establishment. Land preparation involved the application of farmyard manure at 5 t/ha, which was thoroughly incorporated into the soil and levelled.

To assess pollinator activity, systematic surveys were conducted throughout the flowering period. The relative abundance of insect pollinators was measured as the number of flowers visited per unit time. Observations were carried out using sweep nets and direct visual counts at three distinct flowering stages: 10% bloom, peak bloom, and 10% remaining bloom. Sampling was performed at four-time intervals during the day 9:00 am, 11:00 am, 1:00 pm, and 3:00 pm—to capture diurnal

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diversity of pollinators extends beyond bees to include

variation in pollinator activity.

Representative insect species collected were identified using standard taxonomic keys, and their abundance was quantified. The data generated provided insights into the diversity and dominance of pollinators in rapeseed-mustard fields. This methodology allowed for a comprehensive evaluation of pollinator contributions to crop yield, highlighting the importance of insect visitation patterns across different flowering stages. The experiment thus combined agronomic practices with ecological observations to establish a clear link between pollinator activity and rapeseed-mustard productivity. By documenting the diversity and abundance of floral visitors, the study contributes to understanding the ecological services provided by pollinators and underscores the need for their conservation in agricultural landscapes.

Statistical analysis

Table 1. Diversity of different insect pollinator visiting Rapeseed-mustard with order, family, scientific name, common name and relative abundance

S. No.	Common name	Scientific name	Order	Family	Relative abundance (%)		
					2022-23	2023-24	Pooled
1.	Indian honey bee	<i>A. cerana himalaya</i>	Hymenoptera	Apidae	57.90	59.50	58.70
2.	Rock bee	<i>A. dorsata</i>	Hymenoptera	Apidae	4.55	3.87	4.21
3.	Dwarf honey bee	<i>A. florea</i>	Hymenoptera	Apidae	7.95	7.29	7.62
4.	Mud dauber wasps	<i>Sceliphron caementarium</i>	Hymenoptera	Sphecidae	0.00	0.95	0.95
5.	Indian Cabbage white	<i>Pieris canidia</i>	Lepidoptera	Pieridae	5.86	5.79	5.83
6.	Bath white	<i>Pontia daplidice</i>	Lepidoptera	Pieridae	4.65	5.62	5.14
7.	Long hoverfly	<i>Sphaerophoria scripta</i>	Diptera	Syrphidae	10.64	8.67	9.65
8.	Marsh hoverfly	<i>Helophilus pendulus</i>	Diptera	Syrphidae	8.97	8.25	8.61

Which was closely followed by *Sphaerophoria scripta* constituting 10.64% in first year, 8.67% in second year and pooled mean of 9.65%, *Helophilus pendulus* 8.97% in first year, 8.25% in second year and pooled mean of 8.61%, *Apis florea* 7.95% in first year, 7.29% in second year and pooled mean of 7.62%, *Pieris canidia* 5.68% in first year, 5.79% in second year and pooled mean of 5.83%, *Pontia daplidice* 4.65% in first year, 5.62% in second year and pooled mean of 5.14% and *Apis dorsata* 4.21% whereas *Sceliphron caementarium* recorded the lowest abundance 0.95% by appearing in the second year only amongst the pollinators observed. Among bees, *A. cerana himalaya* showed the highest abundance, which could be due to its better adaptation to local agro-climatic conditions and active foraging throughout the flowering period. The consistent performance of other *Apis* species further highlights the importance of managed pollinators in enhancing pollination. Hoverflies (*Sphaerophoria scripta*) were the second most abundant group. In contrast, Lepidopteran pollinators such as *Pieris brassicae* and *Pontia daplidice* showed lower abundance. This may be due to their less frequent visitation, specific feeding behaviour, and dependency on environmental conditions. The pooled mean values provide a stable estimate. The findings reported that

The experimental data obtained from different pollinators were analysed using IBM SPSS Statistics. Data recorded was subjected to analysis of variance (ANOVA) to test the significance of treatment effects. Year-wise analysis was carried out separately for each season (2022–2023 and 2023–2024), followed by pooled analysis across years to determine the overall effect of treatment results.

Result and Discussion

Table 1 presents the diversity and abundance of insect pollinators visiting rapeseed-mustard during 2022–2024. A total of eight pollinator species belonging to three insect orders and four families were recorded. Hymenoptera was the dominant order with four species, followed by Lepidoptera and Diptera with two species each. Among all pollinators, *Apis cerana himalaya* was the predominant species, contributing 57.90% during 2022–23, 59.50% during 2023–24 and a pooled mean of 58.70%, indicating its major role in rapeseed-mustard pollination.

bees are the primary pollinators, followed by hoverflies and butterflies in crops. Overall, the order-wise trend of pollinator abundance followed: Hymenoptera > Diptera > Lepidoptera

Activity of insect visitors as observed in the experimental field

The data presented in Table. 2. reveals significant variation in pollinators activity across different hour of the day during 2022-23 and 2023-24. The pollinators abundance was highest during the late morning hours and gradually declined towards the afternoon. Among the pollinators, the most prominent and dominant pollinator insect was recorded on *A. cerana himalaya* with peak foraging hour between 11:00 am and 12:00 pm.

0900h (Morning)

At 0900 h, pollinator activity was found to be comparatively higher during the early morning hours, indicating active foraging behaviour of different insect pollinators on rapeseed-mustard flowers. Among the Lepidopteran pollinators, *Pieris canidia* and *Pontia daplidice* exhibited peak foraging activity during this period. *Pieris canidia* recorded mean populations of 13.64 and 12.82 pollinators during 2022–23 and 2023–24, respectively, with a pooled mean of 13.25 pollinators. Similarly, *Pontia daplidice* recorded 10.57 pollinators

during 2022–23 and 13.53 pollinators during 2023–24, with a pooled mean of 12.05 pollinators.

Among all pollinators, *Apis cerana himalaya* was the most dominant species during morning hours, recording mean populations of 69.83 and 66.73 pollinators during 2022–23 and 2023–24, respectively, with a pooled mean of 68.28 pollinators. The high abundance of *A. cerana himalaya* clearly indicates its major role in rapeseed-

mustard pollination during the early hours of the day. Other Hymenopteran pollinators also remained active during this period. *Apis florea* recorded mean populations of 9.19 and 10.57 pollinators during 2022–23 and 2023–24, respectively, with a pooled mean of 9.88 pollinators, whereas *Apis dorsata* recorded relatively lower populations of 6.23 and 5.47 pollinators, respectively, with a pooled mean of 5.85 pollinators.

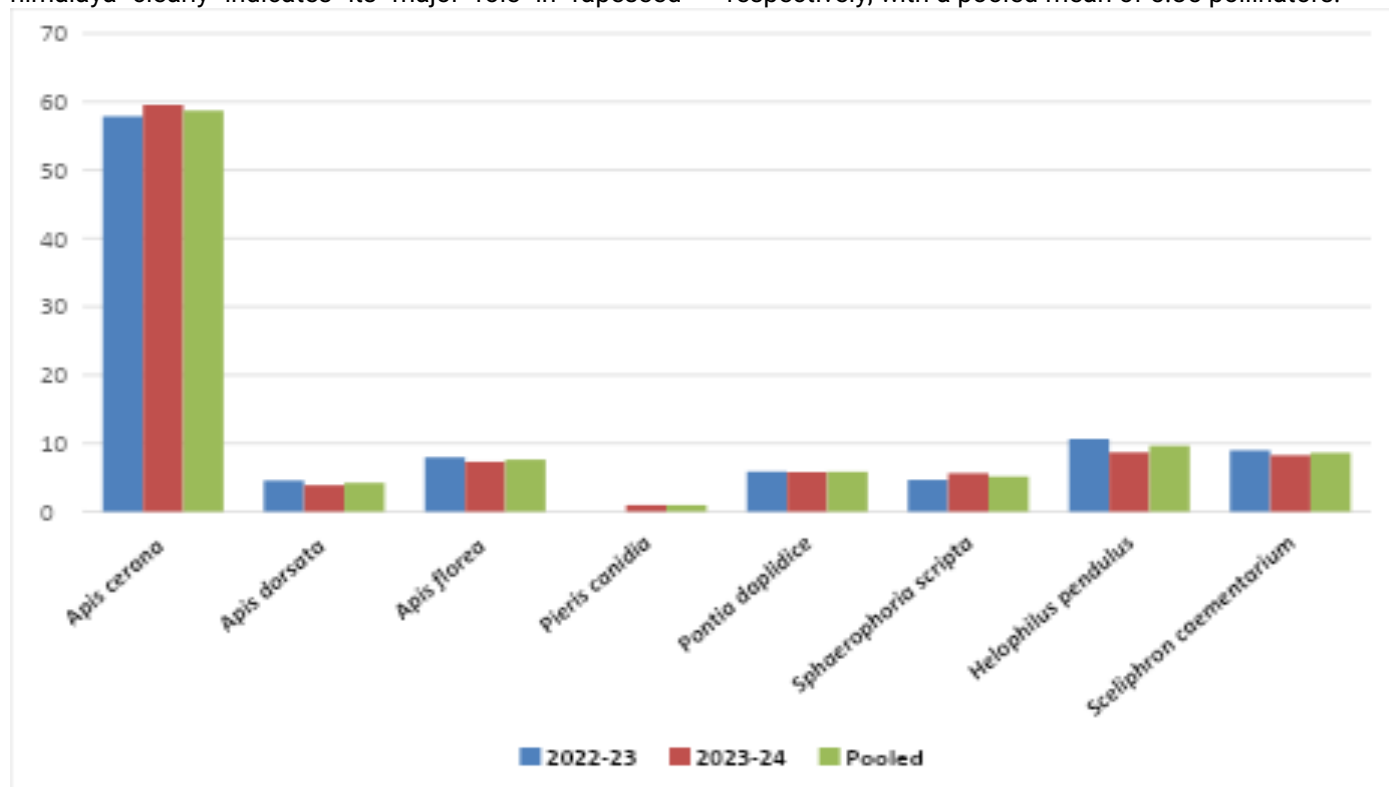


Figure 1. Relative abundance of different pollinators visiting the field during 2022-23 and 2023-24

Among Dipteran pollinators, *Sphaerophoria scripta* showed considerable abundance, recording 15.86 and 15.17 pollinators during 2022–23 and 2023–24, respectively, with a pooled mean of 15.52 pollinators. Similarly, *Helophilus pendulus* recorded mean populations of 14.16 and 11.93 pollinators during the respective years, with a pooled mean of 13.05 pollinators. In contrast, *Sceliphron caementarium* was observed only during 2023–24 with a very low abundance of 1.27 pollinators, indicating limited activity in the field.

1100h (Late morning/Peak activity)

At 11:00 hours, the peak pollinator activity was recorded across all species, excluding *Pieris canidia* and *Pontia daplidice* whose peak foraging hour was 0900h. During the 2022–23 and 2023–24 seasons, *Apis cerana himalaya* reached its highest peak with 108.41 and 106.54 pollinators, respectively, while under pooled conditions, it had 107.47 pollinators. A similar increase was observed in *Apis florea* with 16.45 and 13.59 pollinators during the 2022–23 and 2023–24 seasons, respectively, and under pooled conditions, it had 15.02 pollinators. *Apis dorsata* also showed an increase with 9.07 and 7.85 pollinators during the 2022–23 and 2023–24 seasons, respectively, and under pooled conditions, it had 8.46 pollinators. Diptera, specifically *Sphaerophoria scripta*, reached a peak abundance with 18.97 and 17.09 pollinators during the 2022–23 and 2023–24 seasons, respectively, and

under pooled conditions, it had 18.03 pollinators. Additionally, *Helophilus pendulus* had high pollinator counts with 17.42 and 15.73 pollinators during the 2022–23 and 2023–24 seasons, respectively, and under pooled conditions, it had 16.57 pollinators. Conversely, *Pieris canidia* and *Pontia daplidice* showed a decrease in pollinators with 8.00 and 6.67, and 8.64 and 7.17, respectively, during the 2022–23 and 2023–24 seasons, 3.41 and 3.03 under pooled mean respectively. *Sceliphron caementarium* had a significant presence with 2.31 pollinators during the 2023–24 season. This is considered the peak foraging period, attributed to optimal temperature, nectar secretion, and light intensity.

1300h (Midday)

Pollinator activity at 1300 h declined compared to the peak activity observed at 1100 h. However, *Apis cerana himalaya* remained the dominant pollinator, recording 71.53, 75.03, and a pooled mean of 73.28 pollinators during 2022–23, 2023–24 and pooled analysis, respectively. Among other bee species, *Apis florea* recorded a pooled mean of 6.55 pollinators, while *Apis dorsata* showed lower activity with a pooled mean of 2.98 pollinators. Among Dipteran pollinators, *Helophilus pendulus* and *Sphaerophoria scripta* recorded pooled means of 6.73 and 2.94 pollinators, respectively. Similarly, the Lepidopteran species *Pieris canidia* and *Pontia daplidice* showed reduced activity with pooled means of 3.41 and 3.03 pollinators, respectively.

Sceliphron caementarium exhibited very low activity and was recorded only during 2023–24. The decline in pollinator activity during midday may be attributed to high temperatures and reduced nectar availability.

1500h (Afternoon)

At 1500 hours, pollinator activity reached an exceptionally low point. The count of *Apis cerana himalaya* plummeted to 11.56 in 2022-23, 14.63 in 2023-24, and a pooled count of 13.09 pollinators. Other bees, including *Apis florea* at 3.14 in 2022-23 and 2.36 in 2023-24, with a pooled of 2.75 pollinators, and *Apis dorsata* at 2.02 in 2022-23 and 1.23 in 2023-24, with a pooled of 1.62 pollinators, barely showed any activity. Diptera,

specifically *Sphaerophoria scripta* at 2.74 in 2022-23 and 1.64 in 2023-24, with a pooled of 2.19 pollinators, and *Helophilus pendulus* at 2.31 in 2022-23 and 2.24 in 2023-24, with a pooled of 2.27 pollinators, exhibited very low activity. Lepidoptera, namely *Pieris canidia* at 1.40 in 2022-23 and 0.94 in 2023-24, with a total of 1.17 pollinators, and *Pontia daplidice* at 0.81 in 2022-23 and 1.12 in 2023-24, with a pooled of 0.96 pollinators, were the least active. *Sceliphron caementarium* registered a mere 0.16 pollinators in 2023-24, indicating an almost complete absence. The afternoon decline can be attributed to heat stress, reduced floral rewards, and insect resting behaviour.

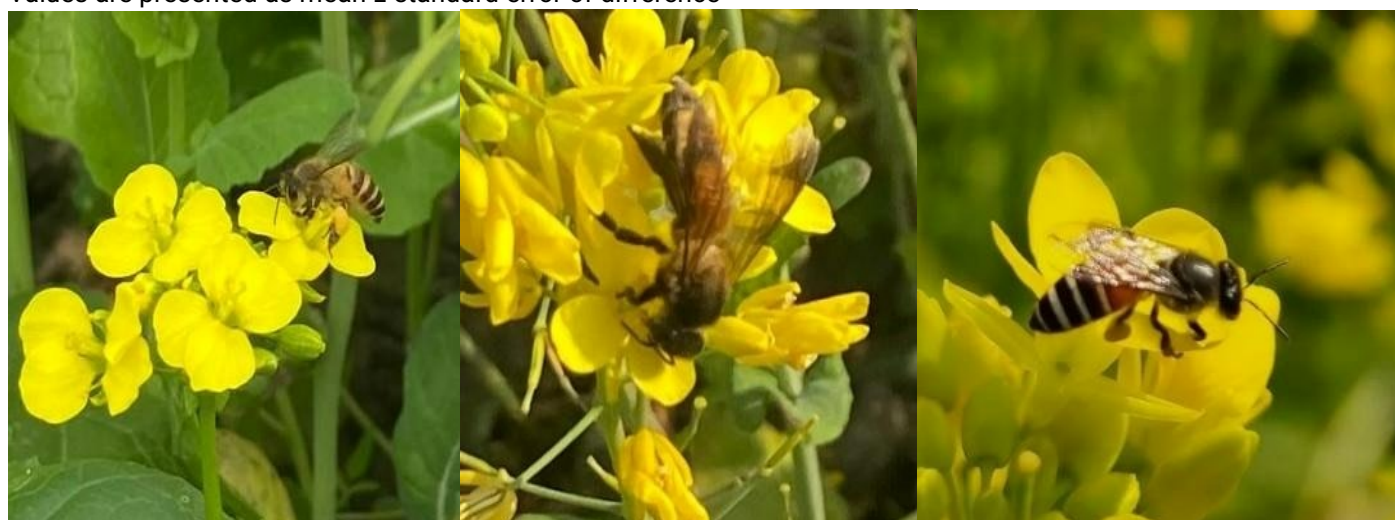
Table 2. Temporal abundance on insect visitors on Rapeseed mustard bloom during 2022-23

No. of insect visitors per 10 plants

Pollinator	0900h			1100h			1300h			1500h		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
<i>Apis cerana himalaya</i>	69.83 ±7.09	66.73 ±7.69	68.28 ±3.74	108.41 ±17.36	106.54 ±140.88	107.47 ±9.25	71.53 ±11.56	75.03 ±11.15	73.28 ±6.67	11.56 ±2.12	14.63 ±2.25	13.09 ±1.10
<i>Apis dorsata</i>	6.23 ±1.59	5.47 ±1.75	5.85 ±0.85	9.07 ±2.09	7.85 ±2.18	8.46 ±1.06	3.38 ±0.94	2.59 ±0.96	2.98 ±0.93	2.01 ±0.78	1.23 ±0.62	1.62 ±0.39
<i>Apis florea</i>	9.19 ±1.36	10.57 ±1.99	9.88 ±0.85	16.45 ±2.25	13.59 ±2.19	15.02 ±1.09	7.4 ±1.52	5.7 ±1.73	6.55 ±0.80	3.14 ±0.99	2.36 ±0.83	2.75 ±9.13
<i>Pieris canidia</i>	13.64 ±2.42	12.87 ±1.8	13.25 ±1.05	8 ±1.94	8.64 ±2.12	8.32 ±1.02	3.67 ±3.88	3.15 ±0.98	3.41 ±0.58	1.4 ±0.74	0.94 ±0.47	1.17 ±0.32
<i>Pontia daplidice</i>	10.57 ±1.96	13.53 ±2.13	12.05 ±1.12	6.67 ±1.68	7.17 ±2.28	6.92 ±1.02	3.09 ±1.18	2.97 ±0.95	3.03 ±0.54	0.81 ±0.44	1.12 ±0.58	0.96 ±0.29
<i>Sphaerophoria scripta</i>	15.86 ±2.16	15.17 ±1.77	15.52 ±1.02	18.97 ±2.37	17.09 ±2.06	18.03 ±1.13	1.44 ±1.95	4.44 ±1.38	2.94 ±0.85	2.74 ±0.97	1.64 ±0.66	2.19 ±0.42
<i>Helophilus pendulus</i>	14.16 ±1.95	11.93 ±2.24	13.05 ±1.05	17.42 ±2.12	15.73 ±1.93	16.57 ±1.04	6.96 ±1.59	6.51 ±1.27	6.73 ±0.77	2.31 ±0.99	2.24 ±0.79	2.27 ±0.45
<i>Sceliphron caementarium</i>	-	1.27 ±0.65	-	-	2.31 ±0.75	-	-	0.68 ±0.42	-	-	0.16 ±0.18	-

Means were compared using LSD at 5% level of significance ($p \leq 0.05$)

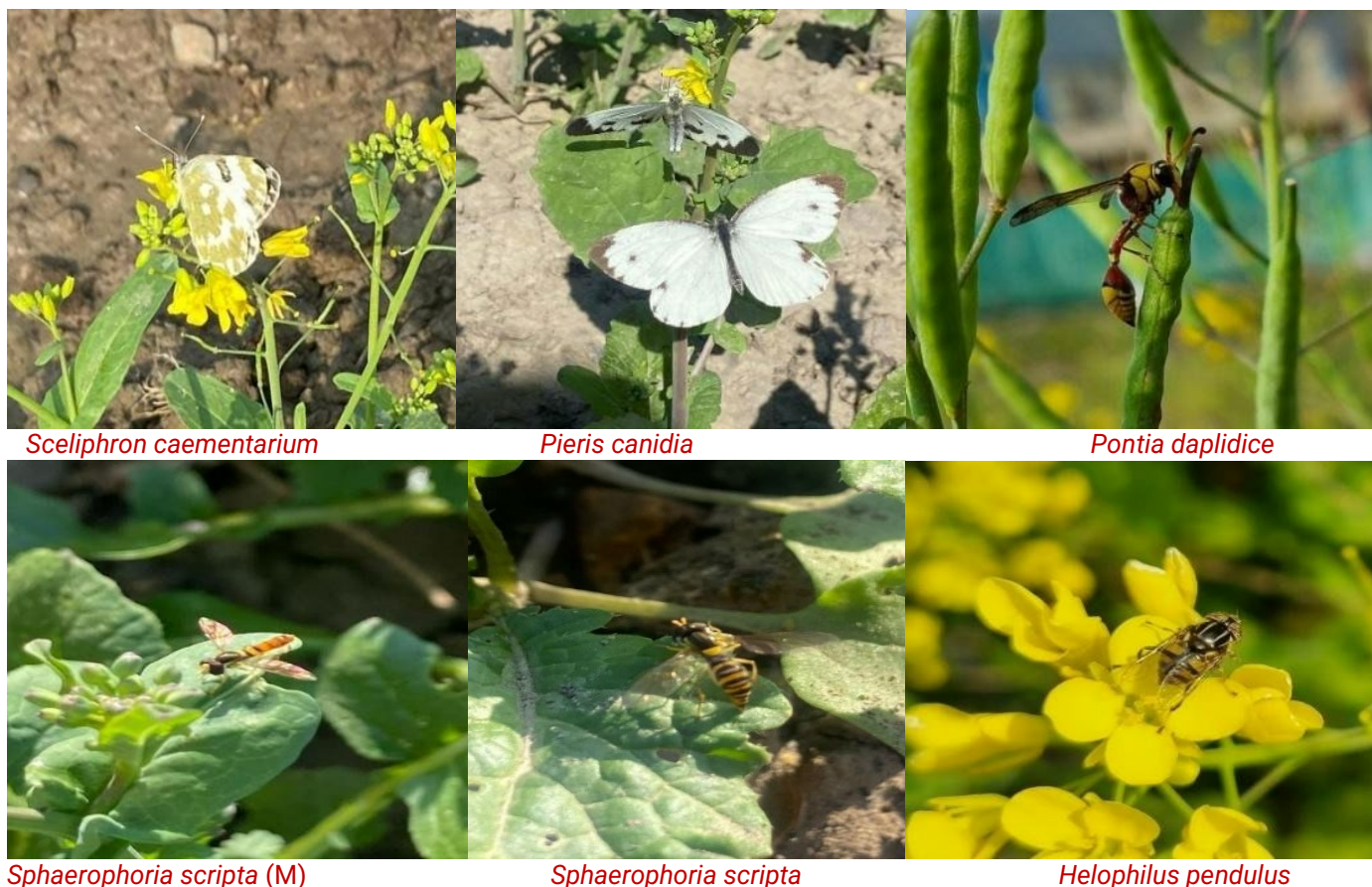
Values are presented as mean $\pm$ standard error of difference



Apis cerana himalaya

Apis dorsata

Apis florea

*Sphaerophoria scripta* (M)*Sphaerophoria scripta**Helophilus pendulus***Plate 1.** Photographs of insect pollinators taken during the research study

The present investigation revealed that bee species (Hymenoptera) were the dominant pollinators of rapeseed-mustard, contributing the highest proportion of floral visits. Their dominance may be attributed to efficient foraging behaviour, floral constancy, and the ability to collect both nectar and pollen, making them effective pollinators. The study further showed that rapeseed-mustard attracted a diverse assemblage of insect pollinators belonging mainly to the order Hymenoptera, particularly the family Apidae comprising *Apis cerana himalaya*, *Apis florea*, and *Apis dorsata*. Similar findings have been reported by Bansal and Abrol (2023), Indora *et al.* (2023), Protim *et al.* (2023), Shakeel *et al.* (2019), Das & Jha (2018), Singh *et al.* (2022) and Haldhar *et al.* (2024). Among all pollinators, *Apis cerana himalaya* was the most abundant species, which is in agreement with the findings of Devi *et al.* (2017), Protim *et al.* (2023), and Chand *et al.* (1994). Its predominance may be due to the presence of nearby colonies and its adaptability to local conditions, as also reported by Mishra *et al.* (1988). Besides Hymenoptera, Dipteran and Lepidopteran pollinators were also observed visiting mustard flowers, supporting earlier reports by Bansal and Abrol (2023), Shakeel *et al.* (2019), Das and Jha (2018), and Neha and Yogesh (2014). Hymenopterans mainly visited flowers for nectar and pollen collection, whereas Dipterans and Lepidopterans primarily foraged for nectar. These observations are in accordance with the findings of Shakeel *et al.* (2019). Although reports on Orthopteran pollinators are limited, studies by Rácz *et al.* (2024) and Micheneau *et al.* (2010) suggested their possible role in pollination based on field

Conclusion

In conclusion, rapeseed-mustard flowers attracted a diverse group of insect pollinators, with eight species recorded during the study. Among them, Hymenopteran pollinators were the most dominant, particularly *Apis cerana himalaya*, which showed the highest abundance compared to Dipteran and Lepidopteran species. Although other insect groups contributed less to pollination, their role in enhancing cross-pollination cannot be ignored. The study further indicated that variations in foraging behaviour and pollinator abundance influence pollination efficiency and crop productivity. Therefore, both *Apis* and non-*Apis* pollinators play an important role in improving rapeseed-mustard yield and sustaining agricultural ecosystems.

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Declarations of interests

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

Data sharing

All relevant data are within the manuscript.

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