Original Research

Assessment of Honeybee (Hymenoptera: Apidae) Diversity and Abundance in Lakhimpur Kheri District, Uttar Pradesh, India

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Abstract

Pollinator diversity is crucial for maintaining crop productivity and ecological health in agro-ecosystems. This study assessed the composition, diversity and foraging activity of honeybee pollinators on *Brassica campestris* L. across five agricultural sites in Lakhimpur Kheri district, Uttar Pradesh, India, from January to March 2023. We recorded four species of honeybees: *Apis dorsata*, *Apis cerana indica*, *Apis florea* and *Apis mellifera*. A total of 1,000 individuals were observed. *A. dorsata* made up the highest relative abundance at 46.0%, followed by *A. cerana indica* at 27.5%, *A. florea* at 14.0% and *A. mellifera* at 12.5%. Species richness varied from 3 to 4 across the sites. Diversity metrics showed moderate variation, with Shannon-Wiener index values ranging from 0.99 to 1.28, Simpson's diversity (1–D) from 0.60 to 0.70, and consistently high Pielou's evenness at 0.90 to 0.92, indicating a relatively balanced pollinator group. The temporal analysis showed peak visits between 10:00 and 11:00 h, with 60 visits per 15 minutes, coinciding with the best floral resource availability. The dominance of native honeybee species highlights their important role in mustard pollination. These findings provide essential ecological data for pollinator conservation and management strategies aimed at improving sustainable crop production in northern Indian agro-ecosystems.

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Statement of Sustainability: This work contributes to the advancement of sustainable agriculture by documenting native honeybee pollinators associated with *Brassica campestris*. This illustrates the importance of native pollinators for crop productivity and ecosystem equilibrium. The authors successfully identify periods of peak foraging, which will inform practices to make agriculture more pollinator safe by helping guide the timing of agrochemicals. This contribution to conservation of biodiversity and reduced dependence on external pollination inputs assists the maturation of farm systems that are more resilient and ecofriendly.

1. Introduction

Pollinators are essential for supporting biodiversity and agricultural productivity by helping flowering plants reproduce (Reddy *et al.*, 2022; Dar *et al.*, 2016). Among insect pollinators, bees are key due to their effectiveness in transferring pollen. This transfer directly affects crop yield and quality (Priyadarshini *et al.*, 2025). Honeybees like *Apis cerana*, *A. mellifera*, *A. dorsata* and *A. florea* often visit a variety of crops, but their numbers and activity can change by season and location (Khan *et al.*, 2014; Khambhu *et al.*, 2023). Stingless bees forage year-round. In contrast, *Apis* species usually peak in activity during specific flowering times, especially in the Kharif season.

Hymenopterans tend to be the most common floral visitors, followed by Lepidoptera, Diptera and Coleoptera. This shows their important role in cross-pollination. Managed honeybee colonies significantly improve crop yield and quality in *Brassicaceae* crops, such as mustard (*Brassica juncea*) and watermelon (*Citrullus lanatus*). They fill in for natural pollinators (Michelson *et al.*, 2017; Jyoti *et al.*, 2022). The diversity of pollinators also impacts visitation patterns and the efficiency of cross-pollination. Interactions between species, such as bumblebees and honeybees, boost crop reproductive success (Eeraerts *et al.*, 2020).

The activity of pollinators changes with environmental conditions. Peak foraging usually happens around midday and during the middle of flowering (Roy *et al.*, 2014; Sarfaraz *et al.*, 2025). The structure of the landscape, floral traits and farming practices also affect species richness and abundance (Mattu and Nirala, 2016; Pudasaini *et al.*, 2015). To assess pollinator diversity and behavior accurately, it is important to use various sampling methods like pan traps, sweep nets, transect walks and scan sampling (Westphal *et al.*, 2008; Devi *et al.*, 2017).

Understanding the diversity, numbers and foraging behavior of insect pollinators is vital for improving pollination services and ensuring sustainable crop production. Research on mustard and other *Brassicaceae* crops has shown that both native and managed honeybees play a significant role in pollination. Species richness is a major factor in determining fruit and seed set (Das and Jha, 2018; Mallinger and Gratton, 2015). Therefore, conserving and managing pollinators is crucial for maintaining agricultural productivity and ecological balance.

2. Materials and methods

2.1. Study area

The study took place in five locations within the Lakhimpur Kheri district of Uttar Pradesh, India: Vanshi Nagar, Ram Nagar (Chandan Chauki), Najota, Gauriphanta and Bajahi. Sampling occurred during the mustard (*Brassica campestris* L.) flowering season, from January to March 2023. The sites represented different types of habitats, including agricultural fields, cropland near forests, rural areas and semi-urban edges (Devi *et al.*, 2014; Khan *et al.*, 2014).

2.2. Pollinator sampling

Pollinators were recorded using several methods:

a. Transect Walks and Scan Sampling: Observers recorded pollinator activity along 50 m transects at each site during peak flowering hours (08:00–14:00 h). They noted the species, number of visits, flower parts visited (nectar or pollen) and foraging behavior (Devi *et al.*, 2017).

b. Pan Traps: Yellow, blue and white pan traps filled with soapy water were placed randomly at each site for 24 h to capture a variety of bee species, including smaller or less active ones (Westphal *et al.*, 2008).

c. Sweep Netting: Active collection using sweep nets was done to confirm species identification and to help with observations of bees that were hard to identify in the field (Michelson *et al.*, 2017).

2.3. Identification and abundance

Honeybee species (*Apis dorsata, A. cerana indica, A. florea* and *A. mellifera*) were identified using standard morphological keys (Das and Jha, 2018). Relative abundance was calculated as the proportion of each species among the total number of honeybees.

2.4. Diversity and temporal activity

Species richness (S), Shannon-Wiener index (H′), Simpson's index (1–D) and Pielou's evenness (J′) were calculated to assess diversity and distribution. Hourly visitation rates (visits/15 min) were recorded and compared with environmental factors such as temperature, relative humidity, and wind speed (Roy *et al.*, 2014; Sarfaraz *et al.*, 2025).

3. Results and discussion

3.1. Honeybee species composition and abundance

Four honeybee species- *Apis dorsata*, *A. cerana indica*, *A. florea* and *A. mellifera*-were recorded on *Brassica campestris* flowers. *A. dorsata* was the most abundant (46%), followed by *A. cerana indica* (27.5%), *A. florea* (14%) and *A. mellifera* (12.5%) (Tables

2 and 3). The dominance of native species highlights their critical role in mustard pollination, while managed *A. mellifera* contributed supplementary pollination.

3.2. Diversity and evenness

We usually found between 3 and 4 different species at each location. The average diversity scores, like the Shannon-Wiener index (H′), were 1.21, and the Simpson's index (1–D) was 0.672 (Figure 1) Pielou's evenness was quite high, around 0.91. This means that even though *A. dorsata* was the most common species, all the other species still had a pretty equal presence (Priyadarshini *et al.*, 2025).

Figure 1. The study of diversity of honeybees: a. *Apis dorsata* b. *Apis cerana* indica

3.3. Temporal activity patterns

Most of the visitors showed up between 10 and 11 in the morning, and *Apis dorsata* was by far the busiest. Their activity slowed down after noon, probably because it got hotter and there wasn't as much nectar around. This lines up with what other studies have found.

3.4. Ecological and agricultural implications

When both local wild honeybees and farmed ones are present, it really helps the mustard plants get pollinated. Having a good variety and different kinds of species makes sure cross-pollination happens effectively. The surrounding habitat also affects which pollinators show up and how active they are. To keep our crops producing well, it's vital to protect wild pollinator's right alongside the managed bee colonies.

Table 1. Description of study sites in Lakhimpur Kheri district (U.P.), India.

Site	Location Name	Latitude (°N)	Longitude (°E)	Elevation (m)	Dominant Vegetation	Sampling Period	Habitat Type
1	Vanshi Nagar	27.95	80.77	147	Mustard, Wheat, Gram	Jan–Mar 2023	Agricultural field
2	Ram Nagar (Chandan Chauki)	28.53	80.58	147	Mustard, Forests	Jan–Mar 2023	Cropland near forest
3	Najota	27.95	80.77	147	Mustard, Vegetables	Jan–Mar 2023	Rural agricultural area
4	Gauriphanta	28.68	80.55	147	Mustard, Weeds	Jan–Mar 2023	Semi-urban edge
5	Bajahi	28.58	80.65	147	Mustard, Wheat	Jan–Mar 2023	Agricultural field

Table 2. Composition of honeybee pollinators visiting *Brassica campestris*.

S. No.	Pollinator Species	Common Name	Family	Behaviour on Flowers (Nectar/Pollen/Visit Type)	Flower Parts Visited	Notes/Remarks
1	*Apis dorsata* Fabricius	Giant honeybee	Apidae	Diurnal forager, strong flyer	Corolla, anthers, stigma	Dominant native species
2	*Apis cerana indica* Fabricius	Indian honeybee	Apidae	Early morning to noon	Corolla, stigma	Managed in traditional hives
3	*Apis florea* Fabricius	Dwarf honeybee	Apidae	Small size, active during sunny hours	Corolla	Small wild species
4	*Apis mellifera* Linnaeus	Western honeybee	Apidae	Managed colonies, generalist forager	Corolla, stigma	Introduced, managed species

Table 3. Relative abundance of honeybee pollinators on *Brassica campestris*.

S. No.	Pollinator Species	Total Individuals Observed	Mean Individuals per Observation ± SE	Relative Abundance (%)	Rank Order
1	*Apis dorsata*	460	15.33 ± 0.72	46.0	I
2	*Apis cerana indica*	275	9.17 ± 0.55	27.5	II
3	*Apis florea*	140	4.67 ± 0.39	14.0	III
4	*Apis mellifera*	125	4.17 ± 0.37	12.5	IV
Total	—	**1000**	—	**100.0**	—

Table 4. Diversity indices of honeybee pollinators visiting *Brassica campestris*.

Site	Species Richness (S)	Shannon–Wiener Index (H′)	Simpson's Diversity (1–D)	Pielou's Evenness (J′)
Vanshi Nagar	4	1.26	0.69	0.91
Ram Nagar (Chandan Chauki)	3	0.99	0.60	0.90
Najota	4	1.28	0.70	0.92
Gauriphanta	4	1.26	0.68	0.91
Bajahi	4	1.28	0.69	0.92
Mean ± SD	**3.8 ± 0.45**	**1.21 ± 0.13**	**0.672 ± 0.041**	**0.912 ± 0.008**

Table 5. Hourly visitation rate (visits/15 min) of honeybee pollinators on *Brassica campestris* flowers.

Time Interval (hrs)	*A. dorsata*	*A. cerana indica*	*A. florea*	*A. mellifera*	Total Visits
08:00–09:00	14	9	7	6	36
09:00–10:00	16	13	9	8	46
10:00–11:00	23	16	11	10	60
11:00–12:00	19	15	8	9	51
12:00–13:00	15	10	6	5	36
13:00–14:00	13	7	5	4	29
Total	**100**	**70**	**46**	**42**	**258**

4. Conclusion

We found that mustard plants (*Brassica compestris*) are visited by many different types of honeybees. The giant honeybee, *Apis dorsata*, was the most common, followed by *A. cerana indica, A. florea* and *A. mellifera.* There was a fair variety of bee species and because they were all pretty evenly spread out, it meant each type contributed steadily to pollination. The bees were busiest in the mid-morning and things like temperature and humidity seemed to affect this. It's clear that both the bees naturally found here and the ones brought in play important, different roles in helping mustard get pollinated better. So, protecting our native bees and managing *A. mellifera* colonies well is crucial. This helps keep pollination going and makes sure crops grow better. Things like the surrounding land, the variety of flowers, and the time of year all affected which bees were around and how active they were. This means we need to manage natural areas and farms together.

Overall, this study really shows why having many different kinds of pollinators is key for good cross-pollination and growing mustard crops year after year. It gives us a good basis for planning how to protect pollinators and get the best possible crop yields in the future.

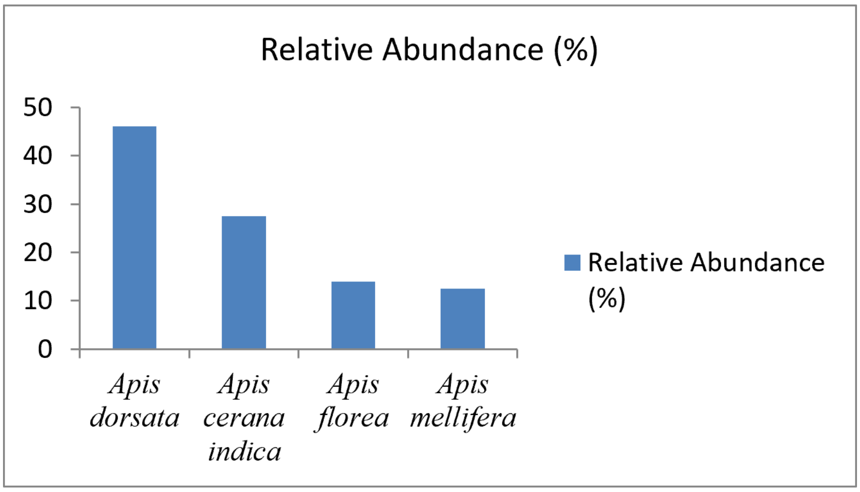

Figure 2. Relative abundance of honeybee pollinators on *Brassica campestris.*

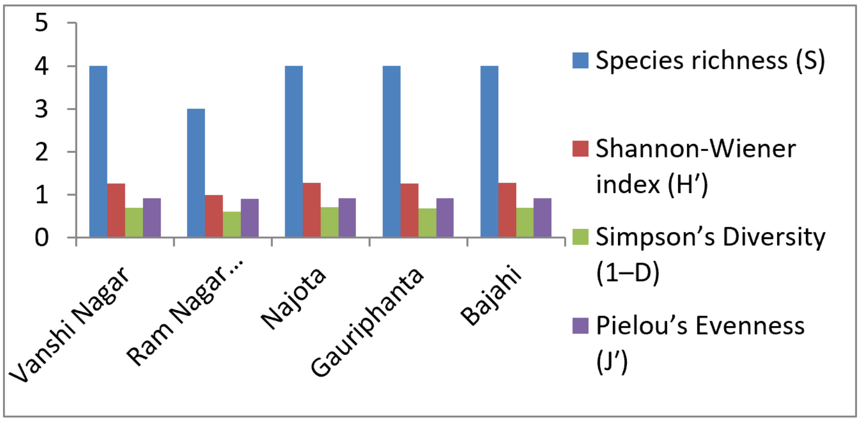

Figure 3. Diversity indices of honeybee pollinators visiting *Brassica campestris.*

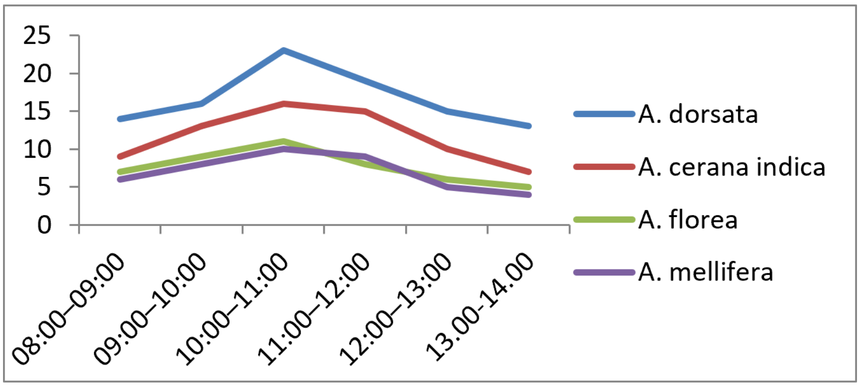

Figure 4. Hourly visitation rate (visits/15 min) of honeybee pollinators on *Brassica campestris* flowers.

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Author Contributions

Ram Pher: Performed and analyzed the study and wrote the original draft; Suresh Kumar: Review the data & editing; Dr. Sanjay Kumar: Conceptualized the study and critically reviewed the experiments during the entire study.

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Conflicts of Interest

The authors declare no competing interests.

Ethical Approval

Not Applicable.

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