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Diversity and Abundance of Insect Pollinators in Sesame, *Sesamum indicum* Linnaeus

Alekhya G., Koteswara Rao S.R., Madhumathi T. and Ramesh D.

Acharya N.G. Ranga Agricultural University, Lam-522 034, India
E-mail: alekhyagorla@gmail.com

***Abstract*:** Field study was conducted during the *Rabi* 2023–24 at the Agricultural College, ANGRAU, Bapatla, to investigate the diversity and abundance of insect pollinators in sesame (*Sesamum indicum* L.). Thirty insect species belonging to four orders were recorded visiting sesame flowers. Among these, *Apis cerana indica* (Indian honey bee) was the most dominant pollinator. The family Megachilidae was dominating among the pollinator guild. Pollinator activity varied throughout the day, gradually increasing from 09:00 h and peaking between 09:30 and 11:05 h, before declining after 14:00 h. However, species *Megachile laticeps*, *Megachile lanata*, *Megachile cephalotes*, *Ceratina binghami*, and *Ceratina* sp. exhibited peak activity between 12:30 and 14:05 h. The Shannon–Wiener index (H) was lowest during the early morning hours but increased throughout the day, showing two peaks corresponding to morning and noon activity. Both the Berger-Parker dominance index (d) and Shannon's diversity index showed a positive correlation with floral abundance. These findings highlight the diversity, diurnal activity, and ecological significance of pollinators in sesame, emphasizing the need for their conservation and sustainable management.

Keywords: Sesame, Diversity, Pollinators, *Sesamum indicum*

Pollination is one of the most critical ecosystem services, directly and indirectly benefiting human societies through enhanced agricultural productivity and biodiversity conservation. Among various pollination mechanisms, insect-mediated pollination plays a pivotal role by facilitating the transfer of pollen within and between flowers (Fisher et al., 2009). Globally, about 35% of crop production depends on pollinators, particularly insects, which contribute to yield improvement in nearly 75% of major crop species (Klein et al., 2007). Among the insects, bees are considered the most efficient and dominant pollinators in both natural and agricultural ecosystems, providing sustainable pollination services.

Sesame (*Sesamum indicum* L.), a member of the family Pedaliaceae, is a valuable oilseed crop and ranks third globally after soybean and mustard. Sesame seeds contain approximately 50% oil and are widely used in the food, pharmaceutical, and chemical industries (Blal 2013, Elleuch et al., 2007, Namiki 2007). Although sesame is commonly regarded as a self-pollinating crop, its floral morphology favours cross-pollination. The rate of cross-pollination varies significantly from 0.5 to 65%, depending on insect activity, surrounding flora, and environmental conditions (Free 1993, Sharma and 2010). Despite the importance of pollinators in sesame, comprehensive studies on pollinator diversity and foraging behaviour in different agro-climatic regions, particularly in Andhra Pradesh, remain limited. Given the increasing interest in sustainable agriculture and pollinator-friendly practices, understanding the diversity and behaviour of native pollinators in sesame ecosystems is crucial. This study was therefore undertaken to document the diversity, abundance, and diurnal activity of insect pollinators visiting sesame flowers during *rabi* 2023–24. The findings aim to support conservation strategies and promote pollinator-friendly agricultural practices to enhance sesame productivity.

MATERIAL AND METHODS

Experimental site and crop details: The study was conducted during *Rabi* 2023–24 at the Agricultural College, Bapatla, ANGRAU. The experimental site is located at 15.900° N latitude, 80.460° E longitude, and an altitude of 8 meters above mean sea level, with an average annual rainfall of 914 mm. Sesame (*Sesamum indicum* L.) variety 'Sarada' (YLM-66) was sown under irrigated conditions in a 1400 m² field, with 1000 m² designated for observations. Land preparation involved two ploughings and levelling. Seeds were treated with carbendazim @ 3 g/kg and mixed with sand in a 1:1 ratio before sowing at a seed rate of 2.5 kg/ha. Manual sowing was done at a spacing of 30 × 10 cm. Thinning was carried out at 20 and 40 days after sowing to maintain proper plant spacing. Standard agronomic practices, except for plant protection measures, were followed throughout the crop season.

Flower visitors and pollinators: Insect visitation to sesame flowers was observed visually during the flowering period. Five random spots of 1 m² each were selected within the observation plot. Visual counts of flower-visiting insects were recorded for five minutes at each spot using a stopwatch. Observations were made at four time intervals: 06:30, 09:30,

12:30, and 15:30 h, at 25, 50, 75, and >90% flowering stages. Insects were collected using fine mesh sweep nets, preserved, and later identified by taxonomic experts at ICAR–National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru.

Pollinator diversity: Pollinator diversity and dominance were evaluated using standard ecological indices:

- Shannon-Wiener Diversity Index (H) (Shannon and Wiener, 1963):
- Simpson's Diversity Index: Measure of species richness and evenness.
- Berger-Parker Dominance Index (d) (Berger and Parker, 1970):
- Shannon Evenness Index

Abundance and diurnal activity of pollinators: To analyze the diurnal activity of pollinators, observations were made at 3-hour intervals between 06:30 h and 15:30 h during peak flowering. In each 1 m² spot, insect visitors were counted for five minutes per interval. The mean number of pollinators per square meter per five minutes was calculated and later standardized to hourly data for assessing relative abundance. This method was adapted with modifications from Revanasidda and Belavadi (2019), previously applied in studies on coriander and muskmelon

RESULTS AND DISCUSSION

Thirty species of insect pollinators were recorded of which seventeen belonged to Hymenoptera, nine to Diptera, three to Lepidoptera and one to Coleoptera (Table 1). Among these, the most effective and abundant pollinator was the Indian honey bee, *Apis cerana indica* L . Hymenoptera emerged as the most dominant group followed by Diptera. These findings are consistent with previous studies reporting Hymenoptera as the dominant order in sesame ecosystems (Pasthe and Shylesha 2013, Rao et al., 2022, Kamel et al., 2013).

Abundance of insect pollinators across flowering stages: At 25% flowering, *A. cerana indica* was most abundant (1.00–1.67 individuals/m²/5 min), followed by *Ceratina* sp., *M. lanata*, *M. laticeps*, and *C. binghami* (each with 0.00–1.00 individuals/m²). At 50% flowering, *A. cerana indica* (1.67–2.00), *C. binghami*, and *M. lanata* showed increased abundance, along with *Nomia* sp. and *Xylocopa* sp. At 75% flowering, a similar trend was observed, with *A. cerana indica*, *M. lanata*, *Sarcophaga* sp., and *M. cephalotes* being dominant. At 90% flowering, *A. cerana indica* peaked (up to 4.67 individuals/m²), with notable increases in *M. laticeps*, *Xylocopa* sp., *Eristalinus* sp., and *Ceratina* sp. These results confirm a positive correlation between floral density and pollinator abundance, consistent with previous

Table 1. Diversity of insect pollinator species of sesame at Agricultural College, Bapatla

Species	Family
Hymenoptera	
Apis cerana indica	Apidae
Xylocopa sp. (1)	
Xylocopa sp. (2)	
Ceratina binghami	
Ceratina sp.	
Amegilla confusa	
Amegilla cingulata	
Thyreus sp.	
Megachile laticeps	Megachilidae
Megachile lanata	
Megachile cephalotes	
Megachile sp.	
Coelioxys sp. (1)	
Coelioxys sp. (2)	
Halictus sp.	Halictidae
Nomia sp.	
Bembix priesneri	Crabronidae
Diptera	
Episyrphus sp.	
Eristalinus sp.	Syrphidae
Eristalinus obscuritarsis	
Sarcophaga sp.	Sarcophagidae
Musca sp.	Muscidae
Stomorhina sp.	Rhiniidae
Bombylius sp.	Bombyliidae
Physiphora sp.	Ulidiidae
Chrysomya sp.	Calliphoridae
Lepidoptera	
Catopsilia sp.	Pieridae
Papilio demoleus	Papilionidae
Danaus chyrsippus	Nymphalidae
Coleoptera	
Mylabris sp.	Meloidae

Table 2. Simpson's diversity and evenness index of insect visitors at different floral densities of sesame

Stage of the flowering	Simpson's diversity index	Evenness index
25% flowering	0.85	0.89
50% flowering	0.94	0.71
75% flowering	0.95	0.67
>90 % flowering	0.97	0.61

findings in muskmelon and other crops (Revanasidda and Belavadi 2019).

Diurnal activity of pollinators: Pollinator activity varied significantly throughout the day**.** Overall activity increased from 06:30 h, peaked between 09:30 and 11:05 h, and declined after 14:00 h. *A. cerana indica*, *Xylocopa* sp., *Nomia* sp., *Thyreus* sp., and *Halictus* sp. were most active during the mid-morning hours. *M. lanata*, *M. cephalotes*, *C. binghami*, and *Ceratina* sp. reached peak activity between 12:30 and 14:05 h. Sajjanar and Eswarappa (2015) and Mohapatra &

Table 3. Shannon-Weiner Diversity Index (H) of insect visitors at different floral densities of sesame during *Rabi*, 2023-24

Hour of the day	Floral density (%)			
	25	50	75	>90
6.30-08:05	1.37	1.97	2.03	2.15
09.30-11.05	2.54	2.56	2.77	2.86
12:30-14:05	2.36	2.48	2.55	2.85
15:30-17:05	0.00	0.95	1.03	1.07

Table 4. Dominance of insect species at different floral densities of sesame during *Rabi,* 2023-24

Species of visitor	Flowering density							
	25%		50%		75%		90%	
	Dominance Index							
	d	1/d*	d	1/d*	d	1/d*	d	1/d*
Apis cerana indica	0.12	8.63	0.14	7.06	0.12	8.19	0.12	8.09
Megachile laticeps	0.04	23.00	0.03	37.67	0.02	43.67	0.04	22.25
Megachile lanata	0.07	13.80	0.06	16.14	0.06	16.38	0.04	25.43
Megachile cephalotes	0.03	34.50	0.05	18.83	0.06	16.38	0.05	19.78
Megachile sp.	0.01	69.00	0.04	28.25	0.02	43.67	0.02	59.34
Ceratina binghami	0.04	23.00	0.09	11.30	0.05	21.84	0.03	29.67
Ceratina sp.	0.07	13.80	0.04	22.60	0.05	21.84	0.04	22.25
Xylocopa sp.(1)	0.04	23.00	0.04	28.25	0.03	32.76	0.04	22.25
Xylocopa sp.(2)	0.06	17.25	0.04	28.25	0.03	32.76	0.03	29.62
Amegilla confusa	0.01	69.00	0.02	56.50	0.05	21.84	0.04	22.25
Amegilla cingulata	0.01	69.00	0.03	37.67	0.02	43.67	0.04	25.39
Coelioxys sp.(1)	0.03	34.50	0.04	28.25	0.02	65.51	0.01	178.01
Coelioxys sp.(2)	0.01	69.00	0.02	56.50	0.01	131.02	0.01	89.01
Halictus sp.	0.03	34.50	0.04	22.60	0.04	26.20	0.03	29.67
Nomia sp.	0.01	69.00	0.04	22.60	0.02	43.67	0.03	35.67
Thyreus sp.	0.01	69.00	0.01	113.00	0.02	43.67	0.02	59.34
Bembix priesneri	0.04	23.00	0.03	37.67	0.02	43.67	0.03	35.60
Episyrphus sp.	0.03	34.50	0.03	37.67	0.05	21.84	0.04	25.47
Eristalinus sp.	0.04	23.00	0.03	37.67	0.05	21.84	0.04	25.43
Eristalinus obscuritarsis	0.00	0.00	0.03	37.67	0.03	32.59	0.04	25.47
Musca sp.	0.04	23.00	0.03	37.67	0.02	43.67	0.02	44.50
Stomorhina sp.	0.00	0.00	0.00	0.00	0.02	65.18	0.01	88.56
Sarcophaga sp.	0.04	23.00	0.02	56.50	0.04	26.20	0.03	29.67
Bombylius sp.	0.01	69.00	0.00	0.00	0.02	65.51	0.02	44.50
Physiphora sp.	0.00	0.00	0.01	114.14	0.02	65.51	0.03	35.53
Chrysomya sp.	0.03	34.50	0.02	56.22	0.02	43.67	0.02	59.34
Catopsilia sp.	0.03	34.50	0.03	37.67	0.03	32.76	0.03	35.60
Papilio demoleus	0.03	34.50	0.00	0.00	0.02	43.67	0.03	35.60
Danaus chyrsippus	0.04	23.00	0.05	18.83	0.03	32.76	0.02	44.50
Myalabris sp.	0.03	34.50	0.03	37.67	0.02	43.67	0.03	35.60

Sontakke (2012) also observed peak foraging activity of pollinators in sesame between 10:00 and 13:00 h.

Diversity Indices

Shannon-Wiener diversity index (H): Pollinator diversity was lowest in early morning and late afternoon and increased significantly during peak hours. The Shannon-Wiener Index values were 00–1.37 at 25% and increased to 1.07–2.15 at 90%flowering (Table 2). Two activity peaks were observed one in the morning (09:30–11:05 h) and in the afternoon (12:30–14:05 h). This suggests a bimodal foraging pattern linked to floral resource availability and favourable microclimatic conditions.

Simpson's diversity index (D): Simpson's Index also indicated increasing diversity with flowering rising from 0.85 at 25% flowering to 0.97 at 90% flowering respectively. This confirms that both species richness and evenness improved during peak bloom periods. Similar patterns were also reported by Prakash & Bijoy (2021) in ash gourd (Table 3).

Shannon evenness index: Evenness decreased with increasing flowering, 0.89, 0.71, 0.67, and 0.61 across the four flowering stages. This decline indicates dominance by a few species primarily *A. cerana indica*, *Megachile* spp., and *Ceratina* sp.in later stages of flowering. Comparable results were also reported in bitter gourd by Yogapriya et al. (2019) (Table 2).

Dominance patterns: The Berger-Parker Dominance Index revealed that *A. cerana indica* was consistently dominant (d = 0.12–0.14), followed by *Ceratina* sp., *M. lanata*, *M. cephalotes*, and *C. binghami*. The dominance index decreased with increasing floral abundance, indicating greater pollinator diversity at later flowering stages. The inverse of dominance (1/d) ranged from 8.63 to 178.01, indicating a richer and more even distribution of pollinators during peak flowering (Table 4).

Pollination behaviour and floral traits: The significant plant-pollinator interaction was observed. The sesame flower's bell-shaped corolla and pinkish-white colour likely enhanced pollinator attraction through visual cues. Rich nectar and pollen resources further supported frequent visitation. While foraging, most insects contacted the pollen-laden anthers, resulting in sternotribic pollination (pollen transfer via the ventral body). This efficient pollination mechanism has also been reported in previous studies (Shankar and Mukhtar, 2022). Pasthe and Shylesha (2013) documented that honey bees formed 77.67% of sesame flower visitors. Rao et al. (2022) also observed Hymenoptera as the dominant order (62%) in sesame. Blal et al. (2013) and Gebremedhn and Tadesse (2014) reported peak foraging during mid-day due to high nectar availability which is in consistent with the present study. Selvakumari et al. (2022) found highest diversity index between 10:00–12:00 h, aligning with the current findings.

CONCLUSION

The study documented diverse assemblage of 30 insect pollinator species visiting sesame flowers with Hymenoptera, particularly *Apis cerana indica* and Megachilidae bees, being dominant. Pollinator abundance and diversity were positively correlated with floral density, showing two activity peaks in mid-morning and early afternoon. Diversity indices confirmed increased richness and dominance of key species during peak flowering. Sesame's floral traits, including bell-shaped corolla and abundant nectar, effectively attracted foragers, facilitating efficient sternotribic pollination. These findings highlight the ecological importance of native pollinators and emphasize the need for their conservation through pollinator-friendly practices, reduced pesticide use, and enhancement of local floral diversity.

AUTHOR'S CONTRIBUTION

G. Alekhya carried out the implementation, writing of original draft, review, editing and data curation. S.R. Koteswara Rao was responsible for conceptualization, investigation, project administration, and validation, T. Madhumathi provided supervision and validation and contributed to the manuscript through review and editing. D. Ramesh performed the formal analysis.

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