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Diversity and Relative Abundance of Different Pollinators in Cucumber (*Cucumis sativus* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study on insect pollinator diversity and their abundance on cucumber flowers was conducted at the Vegetable Research Station, Agricultural Research Institute, Rajendranagar, Hyderabad during 2023 - 2024. A total of 25 species, including 13 species of Hymenoptera, five species of Diptera,

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five species of Lepidoptera and two species of Coleoptera were documented. Of which, Hymenoptera was found to be most abundant, accounting for 72.17% followed by Diptera at 16.49%. Among the families, Apidae was observed as most dominant, with a high abundance and species diversity at 49.48% followed by Syrphidae at 9.28%. The families Sphecidae, Hesperiidae, and Calliphoridae each had the least abundance at 1.03%. *Apis dorsata* Fabricius was reported as most abundant species at 12.37% followed by *Apis cerana indica*, *Ceratina binghami* Cockerell and *Camponotus compressus* Fab. each at 8.25%. The species *Acraea terpsicore* (0.82%) had the lowest abundance. In recent years due to urbanization and fragmentation a decreased trend in pollinator activity had been observed so this research provides the base line data about the existing pollinator species diversity in the study area which offer insights for taking appropriate management practices to conserve the pollinator species.

Keywords: Species diversity; pollinator; abundance; hymenoptera; apidae.

1. INTRODUCTION

Pollinators are vital for the pollination of numerous cross-pollinated crops, as these crops typically cannot depend on self-pollination. Insect pollinators are necessary for the fruit and seed production of many cross-pollinated crops. Over 90% of tropical plants are pollinated by various pollinating agents, majorly comprising two-thirds of insects as pollinators [1]. Insects are widely recognized as the most effective agents of pollination in the world's terrestrial ecosystems [2] and the interaction between flowering plants and pollinators are considered as mutualistic symbiosis.

Cucumber (Cucumis sativus L.) is one of the oldest vegetables that is cultivated world-wide in tropical and subtropical parts of the world [3]. Cucurbitaceae is one of the important family which includes many vegetables belonging to cucurbits [4]. It consists of 122 genera and 940 species which are distributed widely in tropical and subtropical regions of the world. Cucurbitaceae is an economically significant family, with many domesticated species, among which cucumber is one of the most common and widely cultivated worldwide. Cucumber flowers are monoecious and opens for one day [5] with maximum pollination during forenoon hours. Cucumber flowers have wrinkled petals and a yellow colour. A wide range of insect pollinators are drawn to the vast amounts of nectar produced by both the male and female [6]. It is grown over an area of 116000 hectares with a production of 1608000 MT in India [7]. Pollinators must be present during this time period in order to get the fruits to be set. The quality of the fruits also depends on pollinator services [8]. Studies have consistently confirmed that proper pollinator utilization can increase yield levels up to 100 to 150% in cucurbitaceous crops [9]. Hymenopterans, with their diverse pollinator taxa, are recognized as the most efficient and predominant pollinators compared to other pollinator groups. Honey bees from Hymenoptera are considered as major pollinators on cucumber. Honeybees pollinate 16% of total of 0.25 million of flowering plant species in the world and nearly 40,000 species of agricultural plants [10]. Honey bee pollination increases productivity and quality of the yield. The widespread application of agricultural chemicals, especially insecticides, has been identified as a major factor contributing to the decline of pollinators. These pesticides can be highly toxic to bees, causing immediate death or disrupting their foraging activities [11]. Unfortunately, pollinator diversity has been significantly declining in recent years due to urbanization and habitat fragmentation [12]. In many developed countries, efforts are being made to manage insect pollinators. However, in developing countries, there is limited knowledge about pollinating insects. Therefore, understanding their diversity and abundance is crucial for conserving pollinators. This study aims to document the diversity and abundance of various pollinators in cucumber fields.

2. MATERIALS AND METHODS

Present study was conducted during 2023-24 at Vegetable Research Station (VRS), Agricultural Research Institute, Rajendranagar, Hyderabad. The study area is located at 17’ 20’ N latitude and 78º 30’ E longitude with an altitude of 573 meters from mean level. The diversity studies were carried out in an experimental area of 500 square meters. A spacing of 0.5 cm was maintained between plant to plant. Diversity and abundance of different insect pollinators was studied using various trapping methods like water pan trap, sweep nets and aspirator.

Observations from these traps were recorded at weekly intervals from 10 per cent to 90 per cent flowering. The collected species were preserved as both wet and dry specimens. The specimens were identified with assistance from experts at the National Centre for Biological Sciences (NCBS), GKVK in Bengaluru and the Indian Institute of Rice Research (IIRR) in Rajendranagar, Hyderabad.

The relative abundance of species was calculated using the formula given below.

$$\text{Relative abundance (\%)} = Ni \div NA \times 100 \quad [13]$$

Where,

Ni = Total number of individual pollinator species
NA = Total number of pollinator species

Shannon-Wiener Diversity index [14] It was used to measure community diversity. It takes the number of individuals as well as the number of taxa into account Shannon, [14]. The formula used for calculation-

$$H = -\Sigma Pi \ln Pi$$

Where,

Pi = S / N
S = number of species
N = total number of individuals
In = logarithm to base e

Simpson index : It considers the number of species as well as the abundance of each species. It is measured by subtracting the value of D from 1 Simpson Index [15]. The formula used for calculation -

$$D = \sum ni\,(ni - 1) / N(N-1)$$

where,

ni = Total number of individuals of a particular species
N = Total number of individuals of all species

3. RESULTS AND DISCUSSION

3.1 Diversity of Insect Pollinators on Cucumber

A total of 485 individuals were collected throughout the study from the cucumber flowers. These included 25 species from 13 families across four orders: Hymenoptera (350 individuals), Lepidoptera (27 individuals), Diptera (80 individuals) and Coleoptera (28 individuals). Among the collected species Hymenopterans were found to be major pollinators followed by Lepidoptera. Among the Hymenopterans13 species were recorded from four families. They were *Tetragonula* sp., *Apis florea* Fabricus, *A. cerana indica*, *A. dorsata* Fabricius, *C. binghami* Cockerell, *Ceratina heiroglyphica* Smith, *Ceratina smaragdula*, *Xylocopa* sp. and *Amegilla* sp. from family Apidae, *Nomia* sp. from Halictidae, *Camponotus compressus* Fab. and *Solenopsis* sp. from Formicidae and *Sceliphron madraspatanum* Fab. from Sphecidae. Among the Lepidopterans, species like *Danaus chrysippus* Linn. and *Acraea terpsicore* L. (Nymphalidae), *Eurema hecabe* and *Colotis danae* Fabricius (Pieridae) and *Baoris* sp. (Hesperiidae) were observed. The rest of the species belong to Diptera (five species from four families) and Coleoptera (two species from two families). These included *Musca* sp. (Muscidae), *Sarcophaga* sp. (Sarcophagidae), *Chrysoma* sp. (Calliphoridae), *Ischidon scutellaris* Fabricius and *Eristalinus quinquestriatus* Fabricius (Syrphidae) from Diptera, and *Cheilomenes sexmaculata* (Coccinellidae) and *Aulacophora foveicollis* (Chrysomelidae) from Coleoptera. Different species of pollinators recorded during the study were listed in Table 1.

The present findings align with some of the earlier works like Nishchith et al*.* [5] who recorded 19 species from 13 families across five orders (Hymenoptera, Lepidoptera, Diptera, Coleoptera, and Hemiptera) were recorded. *Solenopsis* sp., *Musca* sp., *Sarcophaga* sp., *Eristalis* sp., *C. sexmaculata*, *Coccinella septempunctata*, *Illeis cincta* and *Aulacophora* sp. were recorded during his study. Kurniawan et al*.* [16] documented 15 pollinator species from the orders Hymenoptera, Lepidoptera and Diptera, noting Hymenoptera as the most abundant group. Balachandran et al. [17] identified *A. dorsata*, A. cerana and Trigona sp. as pollinators of cucurbits in Karnataka. Similar findings were reported by Bano et al. [18], who documented insect pollinators belonging to the orders Hymenoptera and Diptera. Kannagi et al. [19] reported 36 species comprsing 9 sps (vespidae), 7 species (Apidae), 8 species (Formicidae), 5 species (sphecidae) 3 species (Meghachilidae). While halicidae, pompillidae, chrysilidae and mutilidae represented one species each.

Table 1. List of insect pollinators of cucumber (*Cucumis sativus* L.)

S.No	Common Name	Scientific Name	No. of Visitors	Family	Order
1.	Stingless bee	*Tetragonula* sp.	15		Hymenoptera
2.	Indian little bee	*Apis florea* Fabricus	20		
3.	Indian honey bee	*Apis cerana indica*	40		
4.	Rock bee	*Apis dorsata* Fabricius	60		
5.	Small carpenter bee	*Ceratina binghami* Cockerell	40	Apidae	
6.	Small carpenter bee	*Ceratina heiroglyphica* Smith	20		
7.	Emerald Small Carpenter	*Ceratina smaragdula*	10		
8.	Carpenter bee	*Xylocopa* sp.	5		
9.	Blue banded bee	*Amegilla* sp.	30		
10.	Alkali bee	*Nomia* sp.	35	Halictidae	
11.	Common black ant	*Camponotus compressus* Fab.	40	Formicidae	
12.	Tropical fire ants	*Solenopsis* sp.	30		
13.	Black mud-dauber wasps	*Sceliphron madraspatanum* Fab.	5	Sphecidae	
14.	Plain tiger	*Danaus chrysippus* Linn.	6	Nymphalidae	Lepidoptera
15.	Tawny coster	*Acraea terpsicore* L.	4		
16.	Common grass yellow	*Eurema hecabe*	8	Pieridae	
17.	Crimson tip	*Colotis danae* Fabricius	4		
18.	Paint brush swift	*Baoris* sp.	5	Hesperiidae	
19.	Housefly	*Musca* sp.	20	Muscidae	Diptera
20.	Flesh fly	*Sarcophaga* sp.	10	Sarcophagidae	
21.	Blow fly	*Chrysoma* sp.	5	Calliphoridae	
22.	Common hover fly	*Ischidon scutellaris* Fabricius	30	Syrphidae	
23.	Hover fly	*Eristalinus quinquestriatus* Fabricius	15		
24.	Six-spotted zigzag ladybird	*Cheilomenes sexmaculata*	8	Coccinellidae	Coleoptera
25.	Red pumpkin beetle	*Aulacophora foveicollis*	20	Chrysomelidae	

3.2 Relative Abundance of Insect Pollinators on Cucumber

Relative abundance of different pollinator species on cucumber flowers are listed in Table 2. Hymenopterans made up the majority of floral visitors at 72.17%, followed by Diptera at 16.49%, Coleoptera at 5.77%, and Lepidoptera at 5.57%. Among Hymenopterans, *A. dorsata* Fab. from the Apidae family was most prevalent at 12.37%, followed by *A. cerana indica*, *C. binghami* Cockerell and *C. compressus*, each accounting for 8.25% of the total abundance. In contrast, *Xylocopa* sp. and *S. madraspatanum* Fab. were the least abundant hymenopteran species, each representing 1.03% of the total. The Apidae family alone accounted for the majority of the abundance, contributing 49.48% (Fig. 1.). Dipterans were noted as the second most abundant group after Hymenopterans. The Syrphidae family had the highest abundance at 9.28%, while the Calliphoridae family was the least frequent at 1.03%. Among Diptera, *I. scutellaris* Fabricius was the most abundant pollinator, making up 6.19% of the total. Lepidopterans and Coleopterans were observed

to be less abundant, possibly influenced by weather conditions.

These findings are in conformity with Nishchith et al. [20] who reported that *A. cerana* had the highest prevalence among the Apidae family (Hymenoptera), accounting for 3.45%, followed by *A. florea* at 2.38% and *A. dorsata* Fabricius at 0.42%. Hymenopterans collectively represented 75% of the total abundance. Patel and Pastagia, [21] stated that honey bees belonging to Hymenoptera are the most abundant pollinators of cucumbers, accounting for 70.45%, followed by Coleopterans (9.34%), Hemipterans (9.09%), Lepidopterans (7.58%) and Dipterans (3.54%). Harisha and Shanas [22] observed that *A. cerana indica* was the predominant pollinator in various gourd crops in Kerala.

3.3 Shannon-Wiener Diversity index [14]

In the present study, Shannon-Wiener Diversity index from cucumber is (H=2.941) which reveals the community diversity for both the abundance and evenness of the species. The present findings are in accordance with Kannagi *et al*. [9] observed that the Shannon's diversity index (H) reached its highest value among Hymenopterans (H=1.95), which closely aligns with the findings of the present study. Yogapriya et al. [23] reported a maximum Shannon diversity index of 2.52 for insect pollinators, which is nearly similar to the present study, where we observed a value of 2.735 for bitter gourd.

3.4 Simpson Index [15]

In the present study, Simpson index from cucumber is (0.7571). it is the community diversity by assessing the probability of two individuals belonging to the same species, ranging from 0 to 1. The findings are similar to Nishchith et al. [14] who recorded Simpson index (D) for species richness of insect pollinators was 0.2162 in cucumber. Yogapriya et al. [23] reported that the highest value of the Simpson index as 0.22-0.40 in bitter gourd.

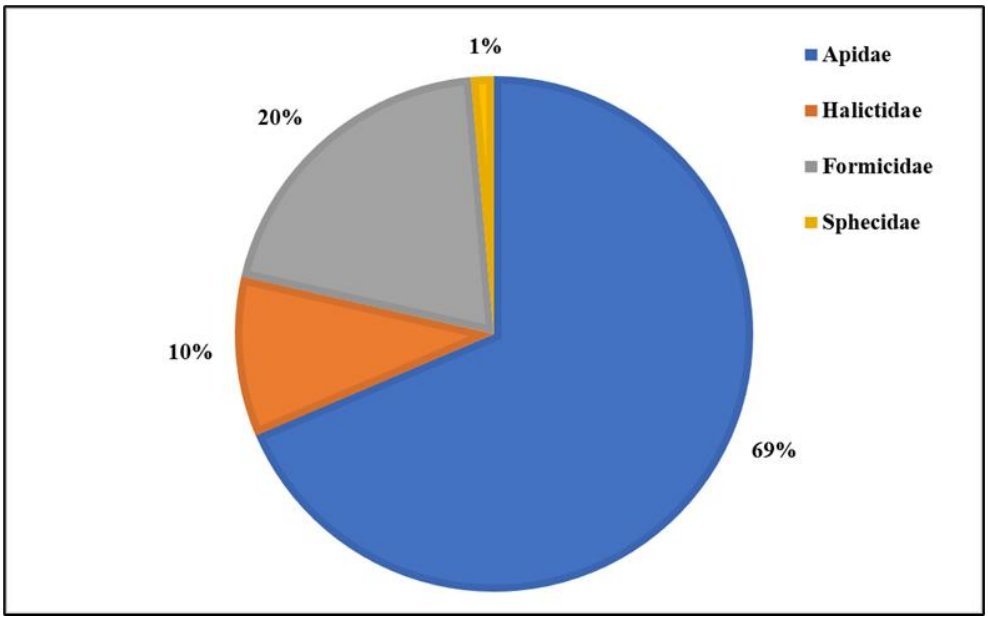

Fig. 1. Relative abundance (%) of pollinators from Hymenopteran families

Table 2. Relative abundance of insect pollinators on cucumber (*Cucumis sativus* L.)

Order	Family	Species	Abundance (%)	Total abundance (%)
Hymenoptera	Apidae	Tetragonula sp.	3.09	
		Apis florea Fabricus	4.12	
		Apis cerana indica	8.25	
		Apis dorsata Fabricius	12.37	
		Ceratina binghami	8.25	

Order	Family	Species	Abundance (%)	Total abundance (%)
		Cockerell		
		Ceratina heiroglyphica Smith	4.12	
		Ceratina smaragdula	2.06	
		Xylocopa sp.	1.03	
		Amegilla sp.	6.19	
	Halictidae	Nomia sp.	7.22	72.17
	Formicidae	Camponotus compressus Fab.	8.25	
		Solenopsis sp.	6.19	
	Sphecidae	Sceliphron madraspatanum Fab.	1.03	
Lepidoptera	Nymphalidae	Danaus chrysippus Linn.	1.24	
		Acraea terpsicore Linn.	0.82	
	Pieridae	Eurema hecabe	1.65	5.57
		Colotis danae Fabricius	0.83	
	Hesperiidae	Baoris sp.	1.03	
Diptera	Muscidae	Musca sp.	4.12	
	Sarcophagidae	Sarcophaga sp.	2.06	
	Calliphoridae	Chrysoma sp.	1.03	
	Syrphidae	Ischidon scutellaris Fabricius	6.19	16.49
		Eristalinus quinquestriatus Fabricius	3.09	
Coleoptera	Coccinellidae	Cheilomenes sexmaculata	1.65	5.77
	Chrysomelidae	Aulacophora foveicollis	4.12	

A. dorsta

A. cerana indica

C. binghami

C. compressus

Nomia sp.

Aulacophora foveicollis

Ischiodon scutellaris

Fig. 2. Pollinator fauna recorded on cucumber

4. CONCLUSION

Cucumber flowers with bright yellow coloured flowers attracts a diverse range of diurnal pollinators. Pollinator fauna of cucumbers belong to four insect orders. Among them, Hymenopterans showed the highest abundance and species diversity. Bees from the Apidae family were predominantly observed, but non-Apis bees also contributed significantly to pollination. This study provides valuable insights for conserving pollinator diversity and suggests measures for conservation efforts.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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