



Abundance and Diversity of Floral Visitors on Jamun (*Syzygium cumini* L. Skeels)

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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 reproductive output in the form of seeds is dependent on pollinating species and the rate of effective pollination. In view of this fact the study on "Abundance and diversity of floral visitors on Jamun (*Syzygium cumini* L. Skeels) was carried out at Regional Horticultural Research and Extension Centre, College of Horticulture (RHREC); UHS sub campus, GKVK, Bengaluru-560 065. Totally thirty-one species of floral visitors were recorded on the wild and cultivated varieties of *S. cumini*, among them twelve were Hymenopterans (39%), six were Dipterans (19%), five were Lepidopterans (16%), seven were Coleopterans (23%) and one species belonged to Hemiptera (3%). Among the honey bees that visited the flowers, the per cent abundance of *A. dorsata* was highest followed by *A. florea*, *A. cerana* and *T. iridipennis* and they constituted 69.00 to 72.39 per cent of floral visitors. The per cent composition of ants that visited the flowers was highest, followed by Dipterans, Lepidopterans and Coleopterans and they together constituted 27.00 to 31.00 per cent. The diversity (H) of floral visitors varied throughout the day during 100 per cent flowering

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stage on all the wild and cultivated varieties of *S. cumini*. The peak activity of honeybees, including other floral visitors was observed during morning hours on all wild and cultivated varieties of *S. cumini*. Among the floral visitors, the dominance (d) and diversity of honey bees was comparatively highest.

Keywords: *Syzygium cumini*; abundance; diversity; dominance; floral visitors.

1. INTRODUCTION

Syzygium cumini L. Skeels belonging to family Myrtaceae is an important evergreen tropical fruit bearing plant. Jamun is native to Asia especially India. It is considered as medicinally important fruit tree but it's still an under explored indigenous fruit crop of India. The species range across India, Bangladesh, Pakistan, Nepal, Sri Lanka, Malaysia, the Philippines and Indonesia. In India, it is present in both moist and dry situations, seen in the tropical wet evergreen forests, tropical semi evergreen forests, tropical moist deciduous forests, littoral and swamp, tropical dry deciduous, tropical dry evergreen, subtropical broad-leaved hills and subtropical pine forests. It is also found growing in the lower ranges of the Himalayas up to an altitude of 1300 meters (Wrigley and Fagg, 2003).

The estimated world production of jamun is around 13.5 million tonnes, of which 15.4 per cent is contributed by India (Singh et al., 2011). India is the second largest producer of jamun in the world. It is being grown in Punjab, Haryana, Uttar Pradesh, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Chhattisgarh, Jharkhand, Karnataka, Kerala, Tamil Nadu and Andhra Pradesh of which, the Maharashtra is the largest producer of jamun followed by Uttar Pradesh, Tamil Nadu, Gujarat and Assam. The jamun trees are found in the gardens as avenue plantations in all the districts of Karnataka and it is also grown as shade tree for coffee in a few districts.

S. cumini has gained worldwide attention for its medicinal properties. Its leaves are used as fodder, green manure and food for tasar silkworms in India. The leaf distillates yield an essential oil which is used as fragrance in soaps and is blended with other chemicals to make inexpensive perfumes (Patel et al., 2010).

S. ternerianum is visited by 45 species of nectar feeding animals in which honey eaters and hawk moths are most important pollinators despite the honey bees being the prolific visitors. Blossom bats and honey eaters contributed half of pollination rate and the rest were by butterflies,

flies, thrips and wasps in *S. sayeri*. The mass-flowers of *S. floribundam* were pollinated by a guild of insects but bats did not visit. The blossom bats and hawk moths constituted a greatest percentage of successful pollination (Crome and Irvine 1986; Williams and Adam 2010). *S. paniculatum* was visited by a variety of insects (Payne, 1991, 1997).

Nine species of insects were recorded as visitors on *Syzygium myhendrae* (Bedd. Ex Brandis). Honey bees (*Apis cerana*, *A. dorsata* and *T. iridipennis*), butterflies (*Hypolimnas misippus* and *Pachilocta pandiana*), wasp species, beetle species, fly species were exclusively visiting the flowers of the candidate species. Among the honey bees, *A. dorsata* showed high visitation frequency (0.40 ± 0.01) followed by *A. cerana* (0.31 ± 0.02) and *T. iridipennis* (0.52 ± 0.02). As per the visitation frequency, it can be concluded that *A. dorsata* was the most frequent and effective pollinator at Southern Western Ghats, India (Divya & Sreekala, 2023). In India, the information on floral visitors, abundance and diversity is essential in revealing the fundamental causes for low fruit set and yield of jamun and also for conservation and management of efficient insect pollinators. Hence the systematic study aiming to document the abundance and diversity of floral visitors on wild and cultivated varieties of Jamun has been conducted.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out at Regional Horticultural Research and Extension Centre, College of Horticulture (RHREC); UHS sub campus, GKVK, Bengaluru-560 065 during the flowering period of 2018-19.

2.2 Wild and Cultivated Varieties of *S. cumini*

The observations on floral visitors, abundance, diversity and collection of floral rewards were made on four cultivated varieties of *S. cumini* viz., GKVK-1, GKVK-2, K-45, N-20 in jamun

orchard which were six years old planted at the spacing of 5m x 5m and also on naturally grown wild *S. cumini* trees of more than six-year-old at experimental site, RHREC, College of Horticulture; UHS sub-campus, GKVK, Bengaluru.

2.3 Methodology

The observations on different species of floral visitors their abundance, composition and diversity were recorded to recognize the most efficient pollinator species of wild and cultivated varieties of *S. cumini*.

2.4 Floral Visitors

All floral visitors of wild and cultivated varieties of *S. cumini* during flowering period of 2018-19 were collected through visual scanning and sweep net collection as per the methodology suggested by Belavadi and Ganeshiah (2013).

2.5 Visual Scanning

Ad-libitum sampling of floral visitors for a sampling time of five minutes at an hourly interval was followed. All floral visitors of wild and cultivated varieties of *S. cumini* per sampling time were counted and recorded. Observations on species of floral visitors and numbers of each species per sample were recorded at different time intervals of the day. Sampling day was divided into three-time intervals of four hours each viz., from 0600-1000hr, 1000-1400hr and 1400-1800hr. This was done to record variation in species composition and their abundance, if any, at different time intervals of the day. Observations were repeated on different days during flowering season. Among the floral visitors, most frequent visiting species and type of floral resource (nectar/pollen) they collected were recognized during these observations for further studies on foraging behaviour (Belavadi and Ganeshiah., 2013). Those floral visitors collected and stored the pollen in their corbicula are considered as pollen gatherers and those collected only nectar by inserting their proboscis in to the nectaries of flowers are treated as nectar gatherers. Those insect species visited the flowers from beginning up to complete cessation of flowers in a season is treated as regular visitors whereas others were treated as occasional visitors. The inflorescences present in the branch of the tree at chest height were selected and labelled for recording all the observations.

2.6 Sweep Net Collection of Floral Visitors

Floral visitors of wild and cultivated varieties of *S. cumini* were collected at regular intervals starting from 0600-1900hr of a day using an insect sweep net. Sweep net samples were collected on different days with different flower densities. Floral visitors collected were transferred to a poison tube (Plastic tube containing cotton was immersed in ethyl acetate, 70%) and killed for future use. Floral visitors collected from sweep net samples were brought to the laboratory, mounted using insect pins, properly dried and preserved for future identification. Identification of species of floral visitors was done by using the available taxonomic keys and the expertise in the Biosystematics Lab, Niche Area of Excellence in Insect Taxonomy, Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bengaluru.

2.7 Abundance of Floral Visitors

The abundance of floral visitors was recorded during full bloom stage of crop. From the four directions of wild and cultivated varieties of *S. cumini*, four inflorescences were randomly selected and were tagged and labelled. The floral visitors were observed for five minutes at hourly intervals from 0600-1900 hr of the day and the species of floral visitors alighting were counted. The abundance of species of floral visitors was expressed as number of species per 5 minutes/four inflorescence.

2.8 Composition of Species of Floral Visitors

The mean abundance of individual floral visitors on wild and cultivated varieties of *S. cumini* from 0600-1900 hrs at hourly interval was calculated and expressed in per centage. The species composition is calculated by using the following formula,

Composition of species= Mean of individual floral visitors/all floral visitors of that order x 100

2.9 Diversity of Floral visitors

The frequency of visits by each species of floral visitors was recorded to identify the most abundant species effecting wild and cultivated varieties of *S. cumini* pollination. Floral visitor count data was used to compute Shannon-Weiner

index of diversity (H) by using the following formula

$$H = \sum p_i \ln p_i.$$

Where p_i is the proportion of the i^{th} species of floral visitor. The dominant species on any given sampling day was determined by the Berger-Parker Dominance index 'd', which gives the proportion of the total numbers of individuals in a sample that is due to the dominant species and was calculated by,

$$d = \frac{n_i}{NT}$$

Where n_i is the number of individuals of the i^{th} species on sampling date and NT is the total number of individuals in the sample (Southwood, 1988).

3. RESULTS AND DISCUSSION

The floral visitors of wild and cultivated varieties of *S. cumini* viz., GKVK-1, GKVK-2, K-45 and N-20 were recorded during flowering period commencing from 0600 upto 1900hrs at hourly intervals. Totally thirty-one species of floral visitors (Table 1 & Plate 1) were observed during the flowering period, they belonged to five insect orders viz., Hymenoptera (39%), Diptera (19%), Lepidoptera (16%), Coleoptera (23%) and Hemiptera (3%). These findings are supported by the works of Crome and Irvine, (1986) and Williams and Adam (2010) who recorded 45 species of nectar feeding animals on *S. tierneyanum* from South India, Reddi and Rangaiah, (1999-2000) recorded 24 species of flower visiting insects on *S. cumini*. Solomon Raju et al. (2014) recorded 33 species flower foragers on *S. alternifolium* and Hopper, (1980) recorded 45 species of floral visitors on *Syzygium tierneyanum* of which honeybees and hawk moths have been identified as effective pollinators.

Out of the thirty-one floral visitors of wild and cultivated varieties of *S. cumini*, twelve floral visitors comprising of five insect families were from Hymenoptera (Table 1). Among twelve floral visitors, three *Apis* species of honey bees (*A. dorsata* F., *A. cerana indica* F. and *A. florea* F.) and two non-*Apis* species (*Tetragonula iridipennis* S. and *Xylocopa fenestrata* F.) belonging to Apidae were regular visitors which foraged for both nectar and pollen and contributed primarily to cross pollination.

One species each from Ichneumonidae (*Xanthopimpla punctata* F.), Pompilidae (*Mygymia flava* F.) and three species from Formicidae (*Camponotus compressus* F., *Tapinoma melanocephalum* F. and *Tetraponera* sp.) were regular floral visitors which foraged only for nectar collection. The *Tapinoma* sp. from Formicidae present in the flowers was treated as a resident nectar forager whereas; the *Ropalidia marginata* L. from Vespidae foraged regularly for pollen collection., similarly, Solomon Raju et al., (2014) recorded nine flower foragers from Hymenoptera comprising three insect families (Apidae, Crabonidae and Vespidae), of which eight were: *Apis dorsata* F., *A. cerana* F., *A. florea* F., *Amegilla* sp., *Stizus* sp., *Eumenes* sp., *Vespa cincta* F. and *V. orientalis* L. which were all nectar foragers and *T. iridipennis* S. was the regular nectar and pollen forager from the flowers of *S. alternifolium*.

The six species of floral visitors of wild and cultivated varieties of *S. cumini* represented four insect families were from Diptera (Table 1). Among these six floral visitors, one species each was from Calliphoridae (*Chrysomya* sp.), Stratiomyidae (*Odontomyia* sp.) and two species each were from Syrphidae (*Eristalinus obliquus* W. and *Syrphidae* L.) which were regular pollen and nectar foragers. The *Conopidae* sp. from Conopidae was occasional floral visitor which was both a nectar and pollen forager. *Sarcophaga carnaria* M. from Sarcophagidae was regular nectar forager. In accordance with these findings, Solomon Raju et al., (2014) recorded only two flower foragers from Diptera comprising two insect families. One species each was from Calliphoridae (*Chrysomya megacephala* F.) and Syrphidae (*Helophilus* sp.) which were occasional nectar foragers on the flowers of *S. alternifolium*.

Five floral visitors of wild and cultivated varieties of *S. cumini* comprising of two insect families were from Lepidoptera (Table 1). One species from Erebididae (*Amata* sp.), three species from Nymphalidae (*Melanitis leda leda* L., *Danaus chrysippus* L. and *Euploea core* C.) were regular exclusive nectar foragers whereas *Nyctemera* sp. from Erebididae was an occasional visitor feeding only on nectar. Earlier study made by Solomon Raju et al. (2014) also recorded nineteen flower foragers on *S. alternifolium* comprising six insect families (Nymphalidae, Papilionidae, Pieridae, Lycaenidae, Hesperidae and Sphingidae) from Lepidoptera.

Seven floral visitors of wild and cultivated varieties of *S. cumini* comprising of three insect families were from Coleoptera (Table 1). One species each from Cantheridae (Cantheridae sp.) and Cerambycidae (*Kunbir* sp.) were regular floral visitors, feeding only on pollen of the flowers. Three species from Scarabaeidae (*Protaetia albaguttata* V., *Clinteria* sp. and *Oxycetonia versicolor* F.) were occasional floral visitors feeding both on nectar and pollen of the flowers. Among the other two species of Cerambycidae, *Chlorophorus agnatus* C. was a regular floral visitor, feeding both on nectar and pollen of the flowers. An earlier study by Solomon Raju et al. (2014) also reported two flower foragers on *S. alternifolium* which belonged to family Scarabaeidae under order Coleoptera. The beetle, *Paillia impressipyga ohaus* is a resident forager feeding on flower parts and one unidentified beetle was an occasional nectar forager. The *Isyndus heros* F. (Reduviidae:Hemiptera) was found as a regular floral visitor feeding only on the nectar from the flowers of wild and cultivated varieties of *S. cumini* (Table 1).

3.1 Abundance of Floral Visitors on Wild *S. cumini* at GKVK

The abundance of floral visitors based on visual counts made during full bloom stage of wild *S. cumini* at GKVK at hourly intervals revealed that the composition of four species of honeybees was significantly higher in number and constituted 69.00 percent as compared to other floral visitors. Among honey bees, *A. dorsata* (22.20%) was the most abundant floral visitor, followed by *A. florea* (18.35%), *A. cerana* (14.84%) and *T. iridipennis* (13.82%). The abundance of other species of floral visitors constituted 31.00 percent, among which ants were the most abundant floral visitors (12.01%) followed by Dipterans (8.95%), Lepidopterans (4.87%), Coleopterans (1.13%) and *M. flava* (1.02%). However, the composition of other four species of floral visitors ranged from 0.45 (Hemiptera) to 0.91 (*X. fenestrata*) per cent. The peak activity of honeybees (*A. dorsata*, *A. florea* and *A. cerana*) was recorded during 1000 to 1200hrs whereas, for *T. iridipennis*, it was during 1100-1300hrs. The peak activity of ants and Dipterans was observed during 0800-1000hrs, whereas for Lepidopterans, it was during 1600-1800hrs.

The Shanon-Weiner index of diversity (H) was calculated for floral visitors on wild *S. cumini* at

GKVK during 100 per cent flowering stage across different hours of the day. The diversity was low during morning 0600 to 0700hrs (0.19) and evening 1800 to 1900hrs (0.44). The “H” value was highest during 1000 to 1100 hrs (1.04) indicating greater diversity of floral visitors and it was lowest during 0600 to 0700hrs with “H” value being 0.19 (Table 2).

3.2 Abundance of Floral Visitors on Cultivated Variety GKVK -1

The observations on the abundance of floral visitors on cultivated variety, GKVK-1 made during full bloom stage at hourly intervals revealed that the composition of four species of honeybees was significantly higher in number and constituted 70.43 per cent as compared to the other floral visitors. Among honey bees, *A. dorsata* (35.01%) was the most abundant floral visitor, followed by *A. florea* (15.34%), *T. iridipennis* (12.55%) and *A. cerana* (7.53%). The abundance of other species of floral visitors constituted 29.57 per cent, among these, ants were the most abundant floral visitors (15.06%) followed by Lepidopterans (7.11%), Dipterans (3.21%) and Coleopterans (1.39%), whereas, the composition of the other five species of floral visitors ranged from 0.28 (*R. marginata*) to 0.84 (*X. punctata*) per cent. The peak activity of honeybees, viz., *A. dorsata* was during (0800-1000hrs), for *T. iridipennis* (0900-1100hrs), for *A. florea* (0900 -1100hrs) and for *A. cerana*, it was during 1000-1200hrs. The peak activity of ants was recorded during 0600-8000hrs, for Dipterans during 0900-1100hrs, for Lepidopterans it was during 1100-1300hrs and for Coleopterans, it was during 1000-1200 hrs.

The Shanon-Weiner index of diversity (H) was calculated for floral visitors on cultivated variety GKVK -1 during 100 percent flowering stage across different hours of the day. The diversity was low during morning 0600 to 0700hrs (0.24) and evening 1800 to 1900hrs (0.15). The “H” value was highest during 1000 to 1100 hrs (0.80) indicating greater diversity of floral visitors and it was lowest during 1800 to 1900hrs with “H” value being 0.15 (Table 3).

3.3 Abundance of Floral Visitors on Cultivated Variety GKVK -2

The abundance of floral visitors on cultivated variety, GKVK -2 during full bloom stage at hourly intervals revealed that the composition of four species of honeybees was significantly higher in number and they together constituted

72.39 percent as compared to the other floral visitors. Among honey bees, *A. dorsata* (36.46%) was the most abundant floral visitor, followed by *A. florea* (14.06%), *T. iridipennis* (13.41%) and *A. cerana* (8.46%). The abundance of other species of floral visitors constituted 27.61 percent, among these; ants were the most abundant floral visitors (13.80%), followed by Lepidopterans (5.60%), Dipterans (3.65%) and Coleopterans (1.82%), whereas the composition of the other five species of floral visitors ranged from 0.26 (Hemipterans) to 0.91 (*X. fenestrata*) per cent. The peak activity of honeybees, *A. dorsata* was recorded during 0800-1000hrs, *T. iridipennis* was during 0900-1100hrs, *A. florea* was during 0900-1100hrs and for *A. cerana*, it was during 1000-1200hrs. The peak activity of ants was recorded during 0700-9000 hrs, for Dipterans it was during 0900-1100 hrs, for Lepidopterans it was during 1100-1300hrs and for Coleopterans, it was during 1000-1200hrs.

The Shanon-Weiner index of diversity (H) was calculated for floral visitors on cultivated variety GKVK -2 during 100 percent flowering stage across different hours of the day. The diversity was low during morning 0600 to 0700hrs (0.22) and evening 1800 to 1900hrs (0.15). The "H" value was highest during 1000 to 1100 hrs (0.82) indicating greater diversity of floral visitors and it was lowest during 1800 to 1900hrs with "H" value being 0.15 (Table 4).

3.4 Abundance of Floral Visitors on Cultivated Variety K-45

The number of floral visitors on cultivated variety K-45 during full bloom stage at hourly intervals indicated that the composition of four species of honeybees was significantly higher in number and together they constituted 70.96 percent as compared to the other floral visitors. Among honey bees, *A. dorsata* (35.30%) was the most abundant floral visitor, followed by *A. florea* (16.94%), *T. iridipennis* (11.41%) and *A. cerana* (7.31%). The abundance of other species of floral visitors constituted 29.04 per cent, among these; ants were the most abundant floral visitors (16.40%), followed by Lepidopterans (4.28%), Dipterans (2.67%), Coleopterans (1.43%) and *M. flava* (1.04%), whereas, the composition of the other four species of floral visitors ranged from 0.36 (Hemipterans) to 0.89 (*R. marginata*) per cent. The peak activity of honeybees i.e., *A. dorsata* was recorded during 0800-1000hrs, *T. iridipennis* during 0900-1100hrs, *A. florea* during 0900-1100hrs and for *A. cerana*, it was during 1000-1200hrs. The peak activity of ants recorded

during 0700-9000hrs, Dipterans during 0900-1100hrs, Lepidopterans during 1100-1300hrs and for Coleopterans it was during 1600-1700hrs.

The Shanon-Weiner index of diversity (H) was calculated for floral visitors on cultivated variety K-45 during 100 percent flowering stage across different hours of the day. The diversity was low during morning 0600 to 0700hrs (0.15) and afternoon 1500 to 1600hrs (0.18). The "H" value was highest during 1000 to 1100 hrs (0.75) indicating greater diversity of floral visitors and it was lowest during 1500 to 1600 hrs with "H" value being 0.18 (Table 5).

3.5 Abundance of Floral Visitors on Cultivated Variety N-20

The abundance in terms of number of floral visitors on cultivated variety N-20 during full bloom stage recorded at hourly intervals indicated that the composition of four species of honeybees was significantly higher in number and constituted 72.17 per cent as compared to the other floral visitors.

Among honey bees, *A. dorsata* (36.24%) was the most abundant floral visitor, followed by *A. florea* (15.40%), *T. iridipennis* (12.91%) and *A. cerana* (7.62%). The abundance of other species of floral visitors constituted 27.83 per cent. Among them, ants were the most abundant floral visitors (15.09%), followed by Lepidopterans (5.75%), Dipterans (2.95%) and Coleopterans (1.09%), whereas, the composition of the other five species of floral visitors ranged from 0.16 (*X. punctata*) to 0.93 (*X. fenestrata*) per cent. The peak activity of honeybees viz., *A. dorsata* was recorded during 0800-1000hr, *T. iridipennis* during 0900-1100hrs, *A. florea* during 0900-1100hrs and for *A. cerana*, it was during 1000-1200hrs. The peak activity of ants was recorded during (0700-9000hrs), Dipterans (0900-1100hrs), Lepidopteron (1100-1300hrs) and for Coleopterans, it was during 0900-1100hrs.

The Shanon-Weiner index of diversity was computed for floral visitors on cultivated variety N-20 during 100 per cent flowering stage across different hours of the day. The diversity was low during morning 0600 to 0700hrs (0.25), afternoon 1400 to 1500hrs (0.20) and evening 1800 to 1900hrs (0.20). The "H" value was highest during 1000 to 1100 hrs (0.83) indicating greater diversity of floral visitors and it was lowest during afternoon 1400 to 1500hrs and evening 1800 to 1900hrs with "H" value being 0.2 (Table 6).

Table 1. Floral visitors of wild and cultivated varieties of *S. cumini* at UAS, GKVK, Bengaluru during flowering period, 2018-19

Order	Family	Sl. No.	Scientific name	On wild <i>S. cumini</i>	On cultivated Varieties	Forage Collected	
Hymenoptera	Apidae	Visiting status of <i>Apis</i> bees					
		1	<i>Apis dorsata</i> F.	Regular	Regular	N+P	
		2	<i>Apis cerana indica</i> F.	Regular	Regular	N+P	
			3	<i>Apis florea</i> F.	Regular	Regular	N+P
			Visiting status of Non <i>Apis</i> bees				
			4	<i>Tetragonula iridipennis</i> S.	Regular	Regular	N+P
			5	<i>Xylocopa fenestrata</i> F.	Regular	Regular	N+P
		Vespidae	6	<i>Ropalidia marginata</i> L.	Regular	Regular	P
		Ichneumonidae	7	<i>Xanthopimpla punctata</i> F.	Regular	Regular	N
		Pompilidae	8	<i>Mygimnia flava</i> F.	Regular	Regular	N
		Formicidae	9	<i>Tapinoma</i> sp.	Resident	Resident	N
			10	<i>Camponotus compressus</i> F.	Regular	Regular	N
		11	<i>Tapinoma melanocephalum</i> F.	Regular	Regular	N	
		12	<i>Tetraponera</i> sp.	Regular	Regular	N	
Diptera	Calliphoridae	13	<i>Chrysomya</i> sp.	Regular	Regular	N+P	
	Stratiomyidae	14	<i>Odontomyia</i> sp.	Regular	Regular	N+P	
	Conopidae	15	Conopidae sp.	Occasional	Occasional	N+P	
	Syrphidae	16	<i>Eristalinus obliquus</i> W.	Regular	Regular	N+P	
		17	Syrphidae sp.	Regular	Regular	N+P	
	Sarcophagidae	18	<i>Sarcophaga carnaria</i> M.	Regular	Regular	N	
Lepidoptera	Erebidae	19	<i>Amata</i> sp.	Regular	Regular	N	
		20	<i>Nyctemera</i> sp.	Occasional	Occasional	N	
	Nymphalidae	21	<i>Melanitis leda leda</i> L.	Regular	Regular	N	
		22	<i>Danaus chrysippus</i> L.	Regular	Regular	N	
		23	<i>Euploea core</i> C.	Regular	Regular	N	
Coleoptera	Cantheridae	24	Cantheridae sp.	Regular	Regular	P	
	Scarabaeidae	25	<i>Protaetia albaguttata</i> V.	Occasional	Occasional	N+P	
		26	<i>Clinteria</i> sp.	Occasional	Occasional	N+P	
		27	<i>Oxycetonia versicolor</i> F.	Occasional	Occasional	N+P	
	Cerambycidae	28	<i>Chlorophorus agnatus</i> C.	Regular	Regular	N+P	
		29	<i>Chelidonium cinctum</i> G.	Occasional	Occasional	N+P	
			30	<i>Kunbir</i> sp.	Regular	Regular	P
Hemiptera	Reduviidae	31	<i>Isyndus heros</i> F.	Regular	Regular	N	

N: Nectar, P: Pollen

Table 2. Abundance and Shanon –Weiner index of diversity (H) for the floral visitors (no. /5min. /4 inflorescence) on wild *S. cumini* during (100% flowering) different hours of the day at GKVK, Bengaluru

Time (hr)	Abundance of floral visitors on wild <i>S. cumini</i> at GKVK														Total	“H” value
	<i>A. d</i>	<i>T. i</i>	<i>A. f</i>	<i>A. c</i>	<i>X. f</i>	<i>R. m</i>	<i>X. p</i>	<i>M. f</i>	Ants	Diptera	Lepi	Coleo	Hemi			
0600-0700	8	0	0	0	0	0	0	0	9	0	0	0	0	17	0.19	
0700-0800	13	2	0	0	0	0	0	0	16	0	0	0	2	33	0.32	
0800-0900	16	5	14	10	1	2	0	1	21	9	1	0	1	81	0.80	
0900.1000	19	11	16	14	2	1	2	2	23	18	4	0	0	112	0.99	
1000-1100	23	16	26	18	2	1	1	2	12	14	7	1	0	123	1.04	
1100-1200	28	19	31	24	0	0	0	0	0	5	2	3	0	112	0.76	
1200-1300	25	23	23	21	0	0	0	0	0	2	0	0	0	94	0.64	
1300-1400	13	12	16	13	0	0	0	0	0	0	0	0	0	54	0.49	
1400-1500	9	8	12	10	0	0	0	0	0	0	0	0	0	39	0.41	
1500-1600	7	6	8	8	0	0	0	0	0	0	0	0	0	29	0.35	
1600-1700	15	13	11	6	2	0	2	1	5	16	13	4	1	89	0.93	
1700-1800	12	5	5	4	1	2	2	2	12	9	11	2	0	67	0.80	
1800-1900	8	2	0	3	0	0	0	1	8	6	5	0	0	33	0.44	
Mean ± S D	15.08± 6.86	9.38± 7.03	12.46± 10.04	10.08± 7.70	0.62± 0.87	0.46± 0.78	0.54± 0.88	0.69± 0.85	8.15± 8.26	6.08± 6.60	3.31± 4.50	0.77± 1.36	0.31± 0.63			
% Composition	22.20	13.82	18.35	14.84	0.91	0.68	0.79	1.02	12.01	8.95	4.87	1.13	0.45			

Floral visitors: *A.d*-*A. dorsata*, *T.i* –*T. iridipennis*, *A.f* -*Apis florea*, *A.c* – *A. cerana*, *X.f* - *X. fenestrata*, *R.m*- *R. marginata*, *X.p* -*X.punctata*, *M.f*- *M. flava*, *Lepi*- *Lepidoptera*s, *Coleo*-*Coleoptera*s, *Hemi*-*Hemiptera*s

Table 3. Abundance and Shanon –Weiner index of diversity (H) for the floral visitors (no. /5min. /4 inflorescence) on cultivated variety of *S. cumini*, GKVK-1 during (100% flowering) different hours of the day at GKVK, Bengaluru

Time (hr)	Abundance of floral visitors on cultivated variety of <i>S. cumini</i> , GKVK-1														Total	“H” value
	<i>A. d</i>	<i>T. i</i>	<i>A. f</i>	<i>A. c</i>	<i>X. f</i>	<i>R. m</i>	<i>X. p</i>	<i>M. f</i>	Ants	Diptera	Lepi	Coleo	Hemi			
0600-0700	14	0	0	0	0	0	0	0	12	0	0	0	0	26	0.24	
0700-0800	20	6	0	0	0	0	0	0	19	0	0	0	0	45	0.36	
0800-0900	24	8	10	0	0	0	0	1	16	3	0	0	0	62	0.55	
0900-1000	28	10	12	6	1	0	0	1	13	4	0	1	1	77	0.72	
1000-1100	23	12	18	8	0	1	2	0	7	8	0	3	1	83	0.80	
1100-1200	20	10	16	12	1	1	0	0	0	0	8	4	0	72	0.69	
1200-1300	15	8	12	10	0	0	0	0	0	0	15	2	0	62	0.61	
1300-1400	12	6	10	0	0	0	1	0	0	0	10	0	0	39	0.42	
1400-1500	8	4	6	0	0	0	0	0	6	0	6	0	0	30	0.38	
1500-1600	18	12	8	4	0	0	2	0	8	5	5	0	0	62	0.67	
1600-1700	26	8	10	8	1	0	1	2	10	3	3	0	2	74	0.76	
1700-1800	22	6	8	6	0	0	0	1	17	0	4	0	0	64	0.61	
1800-1900	21	0	0	0	0	0	0	0	0	0	0	0	0	21	0.15	
Mean ± SD	19.31± 5.75	6.92± 3.88	8.46± 5.78	4.15± 4.43	0.23± 0.44	0.15± 0.38	0.46± 0.78	0.38± 0.65	8.31± 6.90	1.77± 2.62	3.92± 4.79	0.77± 1.36	0.31± 0.63			
% Composition	35.01	12.55	15.34	7.53	0.42	0.28	0.84	0.70	15.06	3.21	7.11	1.39	0.56			

Floral visitors: *A.d*-*A. dorsata*, *T.i* –*T. iridipennis*, *A.f* -*Apis florea*, *A.c* – *A. cerana*, *X.f*- *X. fenestrata*, *R.m*- *R. marginata*, *X.p*-*X.punctata*, *M.f*- *M. flava*, *Lepi*- *Lepidoptera*, *Coleo*-*Coleoptera*, *Hemi*-*Hemiptera*

Table 4. Abundance and Shanon –Weiner index of diversity (H) for the floral visitors (no. /5min. /4 inflorescence) on cultivated variety of *S. cumini*, GKVK-2 during (100% flowering) different hours of the day at GKVK, Bengaluru

Time (hr)	Abundance of floral visitors on cultivated variety of <i>S. cumini</i> , GKVK-2														Total	“H” value
	<i>A. d</i>	<i>T. i</i>	<i>A. f</i>	<i>A. c</i>	<i>X. f</i>	<i>R. m</i>	<i>X. p</i>	<i>M. f</i>	Ants	Diptera	Lepi	Coleo	Hemi			
0600-0700	16	0	0	0	0	0	0	0	8	0	0	0	0	24	0.22	
0700-0800	21	9	0	0	0	0	0	0	21	0	0	0	0	51	0.39	
0800-0900	26	11	8	0	0	0	0	0	18	4	0	0	0	67	0.56	
0900-1000	31	13	15	8	1	1	1	1	16	5	0	0	0	92	0.79	
1000-1100	26	16	18	12	0	2	0	1	10	6	0	2	0	93	0.82	
1100-1200	22	14	14	14	0	1	0	0	0	0	6	6	0	77	0.70	
1200-1300	18	10	10	8	0	0	0	0	0	0	12	4	0	62	0.61	
1300-1400	14	5	8	0	2	0	2	0	0	0	8	0	0	39	0.45	
1400-1500	9	4	6	2	1	0	0	0	5	0	4	0	0	31	0.42	
1500-1600	20	3	3	3	0	0	0	0	4	3	2	0	0	38	0.43	
1600-1700	28	10	14	10	2	0	1	1	10	6	6	1	1	90	0.87	
1700-1800	25	8	12	8	1	0	1	0	14	4	5	1	1	80	0.79	
1800-1900	24	0	0	0	0	0	0	0	0	0	0	0	0	24	0.15	
Mean ± SD	21.54±	7.92±	8.31±	5.00±	0.54±	0.31±	0.38±	0.23±	8.15±	2.15±	3.31±	1.08±	0.15±			
	6.12	5.17	6.20	5.16	0.78	0.63	0.65	0.44	7.40	2.54	3.90	1.89	0.38			
% Composition	36.46	13.41	14.06	8.46	0.91	0.52	0.65	0.39	13.80	3.65	5.60	1.82	0.26			

Floral visitors: *A.d*-*A. dorsata*, *T.i*–*T. iridipennis*, *A.f* -*Apis florea*, *A.c*– *A. cerana*, *X.f* - *X. fenestrata*, *R.m*- *R. marginata*, *X.p* -*X.punctata*, *M.f*- *M. flava*, Lepi- Lepidoptera, Coleo-Coleoptera, Hemi-Hemiptera

Table 5. Abundance and Shanon –Weiner index of diversity (H) for the floral visitors (no. /5min. /4 inflorescence) on cultivated variety of *S. cumini*, K-45 during (100% flowering) different hours of the day at GKVK, Bengaluru

Time (hr)	Abundance of floral visitors on cultivated variety of <i>S. cumini</i> , K-45														Total	“H” value
	<i>A. d</i>	<i>T. i</i>	<i>A. f</i>	<i>A. c</i>	<i>X. f</i>	<i>R. m</i>	<i>X. p</i>	<i>M. f</i>	Ants	Diptera	Lepi	Coleo	Hemi			
0600-0700	6	0	0	0	0	0	0	0	5	0	0	0	0	11	0.15	
0700-0800	13	2	0	0	0	0	0	0	14	0	0	0	0	29	0.28	
0800-0900	18	4	7	0	0	0	0	0	17	2	0	0	0	48	0.45	
0900-1000	27	6	15	3	1	2	2	2	13	3	0	2	0	76	0.74	
1000-1100	22	15	24	5	0	0	0	0	6	5	3	2	1	83	0.75	
1100-1200	16	8	18	13	2	0	0	0	0	0	5	0	0	62	0.59	
1200-1300	14	5	9	6	0	0	0	0	0	0	7	0	0	41	0.45	
1300-1400	9	3	5	0	1	0	0	0	0	0	2	0	0	20	0.27	
1400-1500	3	2	4	0	1	0	0	0	0	0	1	0	0	11	0.19	
1500-1600	5	1	2	2	0	0	1	0	0	0	0	0	0	11	0.18	
1600-1700	21	6	1	5	1	0	1	1	15	3	0	3	0	57	0.60	
1700-1800	26	12	10	7	1	2	0	2	14	2	4	1	1	82	0.82	
1800-1900	18	0	0	0	0	1	0	1	8	0	2	0	0	30	0.31	
Mean ± SD	15.23± 7.82	4.92± 4.55	7.31± 7.67	3.15± 3.95	0.54± 0.66	0.38± 0.77	0.31± 0.63	0.46± 0.78	7.08± 6.76	1.15± 1.68	1.85± 2.30	0.62± 1.04	0.15± 0.38			
% Composition	35.30	11.41	16.94	7.31	1.25	0.89	0.71	1.07	16.40	2.67	4.28	1.43	0.36			

Floral visitors: *A.d*-*A. dorsata*, *T.i*–*T. iridipennis*, *A.f* -*Apis florea*, *A.c* – *A. cerana*, *X.f* - *X. fenestrata*, *R.m*- *R. marginata*, *X.p* -*X.punctata*, *M.f*- *M. flava*, *Lepi*- *Lepidoptera* , *Coleo*-*Coleoptera*, *Hemi*-*Hemiptera*

Table 6. Abundance and Shanon –Weiner index of diversity (H) for the floral visitors (no./5min. /4 inflorescence) on cultivated variety of *S. cumini*, N-20 during (100% flowering) different hours of the day at GKVK, Bengaluru

Time (hr)	Abundance of floral visitors on cultivated variety of <i>S. cumini</i> , N-20														Total	“H” value
	<i>A. d</i>	<i>T. i</i>	<i>A. f</i>	<i>A. c</i>	<i>X. f</i>	<i>R. m</i>	<i>X. p</i>	<i>M. f</i>	Ants	Diptera	Lepi	Coleo	Hemi			
0600-0700	14	0	0	0	0	0	0	0	14	0	0	0	0	28	0.25	
0700-0800	18	5	0	0	0	0	0	0	18	0	0	0	0	41	0.35	
0800-0900	25	6	10	0	0	0	0	2	21	2	0	0	0	66	0.55	
0900-1000	28	8	18	5	1	2	1	1	8	5	0	1	2	80	0.78	
1000-1100	25	14	20	8	0	1	0	1	4	7	5	2	1	88	0.83	
1100-1200	21	12	16	10	0	0	0	0	0	0	6	1	0	66	0.60	
1200-1300	16	10	12	8	0	0	0	0	0	0	10	0	0	56	0.55	
1300-1400	12	6	8	0	0	0	0	0	0	0	3	0	0	29	0.33	
1400-1500	3	4	4	0	0	0	0	0	0	0	2	0	0	13	0.20	
1500-1600	15	8	2	2	2	0	0	0	0	1	0	0	0	30	0.35	
1600-1700	23	6	1	10	2	0	0	1	15	3	0	2	0	63	0.62	
1700-1800	18	4	8	6	1	0	0	0	17	1	6	1	1	63	0.67	
1800-1900	15	0	0	0	0	0	0	0	0	0	5	0	0	20	0.20	
Mean ± SD	17.92±	6.38±	7.62±	3.77±	0.46±	0.23±	0.08±	0.38±	7.46±	1.46±	2.85±	0.54±	0.31±			
	6.65	4.11	7.18	4.17	0.78	0.60	0.28	0.65	8.32	2.26	3.29	0.78	0.63			
% Composition	36.24	12.91	15.40	7.62	0.93	0.47	0.16	0.78	15.09	2.95	5.75	1.09	0.62			

Floral visitors: *A.d*-*A. dorsata*, *T.i*-*T. iridipennis*, *A.f*-*Apis florea*, *A.c*-*A. cerana*, *X.f*-*X. fenestrata*, *R.m*-*R. marginata*, *X.p*-*X.punctata*, *M.f*-*M. flava*, *Lepi*-*Lepidoptera*, *Coleo*-*Coleoptera*, *Hemi*-*Hemiptera*

Table 7. Berger –Parker dominance index (d) for the floral visitors of wild and cultivated varieties of *S. cumini* during (100% flowering) different hours of the day at GKVK, Bengaluru

Floral visitors	Wild and cultivated varieties of <i>S. cumini</i>									
	Wild <i>S. cumini</i>		GKVK-1		GKVK-2		K-45		N-20	
	"d" value	1/d*	"d" value	1/d*	"d" value	1/d*	"d" value	1/d*	"d" value	1/d*
<i>A. dorsata</i>	0.222	4.505	0.350	2.857	0.365	2.743	0.353	2.833	0.362	2.760
<i>T. iridipennis</i>	0.138	7.238	0.126	7.967	0.134	7.456	0.114	8.766	0.129	7.747
<i>A. florea</i>	0.183	5.451	0.153	6.518	0.141	7.111	0.169	5.905	0.154	6.495
<i>A. cerana</i>	0.148	6.740	0.075	13.278	0.085	11.815	0.073	13.683	0.076	13.122
<i>X. fenestrata</i>	0.009	110.375	0.004	239.000	0.009	109.714	0.012	80.143	0.009	107.167
<i>R. marginata</i>	0.007	147.167	0.003	358.500	0.005	192.000	0.009	112.200	0.005	214.333
<i>X. punctata</i>	0.008	126.143	0.008	119.500	0.007	153.600	0.007	140.250	0.002	643.000
<i>M. flava</i>	0.010	98.111	0.007	143.400	0.004	256.000	0.011	93.500	0.008	128.600
Ants	0.120	8.330	0.151	6.639	0.138	7.245	0.164	6.098	0.151	6.629
Dipterans	0.089	11.177	0.032	31.174	0.036	27.429	0.027	37.400	0.030	33.842
Lepidopterans	0.049	20.535	0.071	14.059	0.056	17.860	0.043	23.375	0.058	17.378
Coleopterans	0.011	88.300	0.014	71.700	0.018	54.857	0.014	70.125	0.011	91.857
Hemipterans	0.005	220.750	0.006	179.250	0.003	384.000	0.004	280.500	0.006	160.750

NB;*1/d Reciprocal of Berger –Parker dominance index indicating increase in abundance and decrease in dominance with the increase in 1/d value



Apis dorsata F.



Apis cerana indica F.



Apis florea F.



Tetragonula iridipennis S.



Xylocopa fenestrata F.



Ropalidia marginata L.

Plate 1. Contd.



Xanthopimpla punctata F.



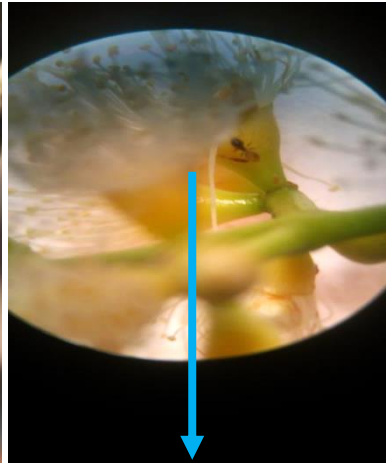
Mygnumia flava F.



Tapinoma sp.



Camponotus compressus F.



Tapinoma melanocephalum F.



Tetraponera sp.

Plate 1. Contd.



Chrysomya sp.



Odontomyia sp.



Conopidae sp.



Eristalinus obliquus W.



Syrphidae L.



Sarcophagidae M.

Plate 1. Floral visitors on wild and cultivated varieties of *S. cumini*

3.6 Berger-Parker Dominance Index (d) of Floral Visitors on Wild and Cultivated Variety *S. cumini*

The Berger-Parker dominance index ('d') values for floral visitors on wild *S. cumini* at GKVK ranged from 0.007 to 0.222. It was highest in case of *A. dorsata* (0.222), followed by *A. florea* (0.183), *A. cerana* (0.148), *T. iridipennis* (0.138), ants (0.120), Dipterans (0.089) and Lepidopterans (0.049). The 'd' value for the other six species of floral visitors ranged from 0.007 (*R. marginata*) to 0.011 (Coleopterans). The abundance (1/d) values ranged from 4.505 to 220.750 and the highest '1/d' value of 220.750 was recorded for Hemipterans during 100 per cent flowering (Table 7) stage of wild *S. cumini* at GKVK.

The Berger-Parker dominance index ('d') values for floral visitors on cultivated variety GKVK -1 ranged from 0.006 to 0.350. It was highest in case of *A. dorsata* (0.350), followed by *A. florea* (0.153), ants (0.151), *T. iridipennis* (0.126), *A. cerana* (0.075), Lepidopterans (0.071) and Dipterans (0.032). The 'd' value for the other six species of floral visitors ranged from 0.003 (*R. marginata*) to 0.014 (Coleopterans). The abundance (1/d) values ranged from 2.857 to 358.500 and the highest '1/d' value of 358.500 was recorded for *R. marginata* during 100 per cent flowering (Table 7) stage of cultivated variety, GKVK-1.

The Berger-Parker dominance index ('d') values for floral visitors on cultivated variety GKVK -2 ranged from 0.003 to 0.365. It was highest in case of *A. dorsata* (0.365), followed by *A. florea* (0.141), ants (0.138), *T. iridipennis* (0.134), *A. cerana* (0.085), Lepidopterans (0.056) and Dipterans (0.036). The 'd' value for the other six species of floral visitors ranged from 0.003 (Hemipterans) to 0.018 (Coleopterans). The abundance (1/d) values ranged from 2.743 to 384.000 and the highest '1/d' value of 384.000 was recorded for Hemipterans during 100 per cent flowering (Table 7) stage of cultivated variety, GKVK-2.

The Berger-Parker dominance index ('d') values for floral visitors on cultivated variety K-45 ranged from 0.004 to 0.353. It was highest in case of *A. dorsata* (0.353), followed by *A. florea* (0.169), ants (0.164), *T. iridipennis* (0.114), *A. cerana* (0.073), Lepidopterans (0.043) and Dipterans (0.027). The 'd' value for the other six species of floral visitors ranged from 0.004

(Hemipterans) to 0.014 (Coleopterans). The abundance (1/d) values ranged from 2.833 to 280.500 and the highest '1/d' value of 280.500 was recorded for Hemipterans during 100 per cent flowering (Table 7) stage of cultivated variety, K-45.

The Berger-Parker dominance index ('d') values for floral visitors on cultivated variety N-20 ranged from 0.002 to 0.362. It was highest in case of *A. dorsata* (0.362), followed by *A. florea* (0.154), ants (0.151), *T. iridipennis* (0.129), *A. cerana* (0.076), Lepidopterans (0.058) and Dipterans (0.030). The 'd' value for the other six species of floral visitors ranged from 0.002 (*X. punctata*) to 0.011 (Coleopterans). The abundance (1/d) values ranged from 2.7603 to 643.000 and the highest '1/d' value of 643.000 was recorded for *X. punctata* during 100 per cent flowering (Table 7) stage of cultivated variety, N-20.

4. CONCLUSION

The research on abundance and diversity of floral visitors on Jamun (*Syzygium cumini* L. Skeels) come across a diverse range of *Apis* and non-*Apis* floral visitors which included 31 insect species belong to sixteen insect families and five insect orders. Out of 31 insect species, six species were found occasional visitor and 25 were regular visitors. Among the honey bees that visited the flowers, the per cent abundance of *A. dorsata* was highest compared to other bee species. Dominance and diversity of honey bees was highest when compared to other floral visitors. This reflected that the wild and cultivated varieties of *Syzygium cumini* L. was attracted more of honey bees for its cross pollination.

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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