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INSECT POLLINATORS OF MUSTARD AND THEIR FORAGING BEHAVIOUR

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ABSTRACT

Mustard provides both nectar and pollen, so it is attractive to various insect visitors. To study the diversity and foraging behaviour, mustard crop was grown at the Research Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner. It was revealed that a total of 31 species belonging to 16 families of six orders visited flowers. *Apis florea* showed the peak activity at 13.00 hr (12.44 bees/ 10 plants/ 5 min) and foraging rate (14.49 flowers visited/ 5 min). *Eristalinus megacephalus* showed peak activity at 13.00 hr (9.06 insect visitors/ 10 plants/ 5 min) and foraging rate (12.37 flowers visited/ 5 min) and *Halictus* sp showed peak activity at 14.00 hr (8.69 insect visitors/ 10 plants/ 5 min) and foraging rate (6.30 flowers visited/ 5 min).

Key words: Mustard, insect visitors, diversity, foraging behaviour, pollinators, Hymenoptera, Lepidoptera, Diptera, entomophily, Brassica, honey bees, hover fly, house fly, carpenter bee, blow fly, sand bee, sweat bee

Pollination improves the quality of most crop species, making agricultural production one of the most important economic sectors (Choi and Jung, 2015). Out of 95% cross pollinated crops, 10% rely on wind pollination and 85% on animal pollination (Tewari and Singh, 1983), with insect pollination (entomophily) accounting for 90% of animal pollination (Buchmann and Nabhan, 1996). Pollinators play an important role in both natural and agroecological ecosystem services. Pollinating insects mainly belongs to three orders: Lepidoptera, Hymenoptera, and Diptera (Jadhav et al., 2018). Among the hymenopterans, honey bees are the predominent insect pollinators succeeded by wasps and flies (Bashir et al., 2018). Mustard (*Brassica juncea* L. Czern) is the most widely grown oilseed crop, accounting for approximately 28.6% of total oilseed production. Plants in the genus *Brassica*, like many others in the crucifer family, are known to be very attractive to insect pollinators, serving primarily as a source of nectar and pollen (Kunjwal et al., 2014). So far, honey bees have been regarded the most important pollinators on Brassica crops (Khan and Ghramh, 2021). Diversity is the basis for human survival. The composition and richness of species assemblages also strongly influences ecosystem functioning and stability. The degree of pollination mainly depends on foraging speed, foraging rate, strength and diversity of pollinators. Foraging ecology is one of important parameter in successful pollination and is variable from one pollinator species to other, even within the species. The present investigations were undertaken to study insect pollinator diversity and its foraging activity in mustard.

MATERIALS AND METHODS

The diversity of insect visitors/ pollinators on mustard was observed daily on ten randomly selected plants for five min at hourly interval from 06.00 to 18.00 hr throughout the flowering period. The insects visiting flowers were collected with sweep nets, mounted and got identified and the diversity was measured using Shannon- Weiner diversity index. The temporal variations (foraging time) were recorded for 5 min from 06.00 hr to 18.00 hr for major pollinator species at hourly interval and their variations in foraging activities at different timings were expressed as mean number of pollinators/ ten plants/ five min. The foraging rate (number of flowers visited by foraging species/ five min) was recorded at peak foraging hour of respective forager species during entire flowering period and average number of flowers visited by pollinator species was expressed as number of flowers visited by a pollinator/ five min. The foraging speed (time spent by each visitor on flower) were recorded with the help of a stopwatch during the peak foraging hour. The time spent to insert the proboscis and suck up the nectar or brushing/collecting pollen were considered as the time spent/ flower, which were

recorded with a stopwatch. The data were subjected to oneway ANOVA using the SPSS computer program (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.).

RESULTS AND DISCUSSION

Insect visitors documented from mustard revealed a total of 31 species belonging to 16 families of six orders (Table 1). The hymenopterans were the major floral visitors comprising of 11 species viz., *Apis florea* F., *Trigona* sp., *Apis dorsata* F., *Xylocopa auripennis, Xylocopa aestuans* L., *Xylocopa sp*. (Apidae), *Andrena* sp. (Andrenidae), *Halictus* sp. (Halictidae) *Camponotus compressus* F. (Formicidae), *Polistes olivaceus, Vespa orientalis* L. (Vespidae). They were followed by Lepidoptera which comprised of six species from three families viz., *Pieris brassicae* L., *Anaphaeis aurota, Cepora nerissa* (Pieridae), *Danaus chrysippus L.*(Nymphalidae), *Helicoverpa armigera* (Noctuidae), *Uthesia pulcella* L. (Erebidae). Hemiptera included four species from two families *viz*., *Halyomorpha halys*, *Nezara viridula* L, *Bagrada cruciferarum* (Pentatomidae), *Dysdercus cingulatus* (Pyrrhocoridae). Coleoptera included three species from a family viz., *Coccinella septumpunctata* L., *Coccinella transversalis, Cheilomenes sexmaculata* F. (Coccinellidae). Diptera included six species from three families viz., *Eristalinus megacephalus*, *Eupeodes corolla*, *Eristalis* sp. (Syrphidae), *Calliphora* sp., *Lucilia sericata* (Calliphoridae), *Musca domestica* (Muscidae). Neuroptera included only one species viz., *Chrysoperla carnea* (Chrysopidae).

Table 1. Diversity of insect visitors/pollinators in mustard

S.No.	Common name	Scientific name	Family	Order
1.	Indian little bee	*Apis florea* F	Apidae	Hymenoptera
2.	Stingless bee	*Trigona* sp.		
3.	Giant honey bee	*Apis dorsata* F		
4.	Carpenter bee	*Xylocopa auripennis*		
5.	Carpenter bee	*Xylocopa aestuans* L		
6.	Carpenter bee	*Xylocopa* sp.		
7.	Sand bee	*Andrena* sp.	Andrenidae	
8.	Sweat bee	*Halictus* sp.	Halictidae	
9.	Black ants	*Camponotus compressus* F	Formicidae	
10.	Common paper wasp	*Polistes olivaceus*	Vespidae	
11.	Oriental hornet	*Vespa orientalis* L		
12.	Shield bug	*Halyomorpha halys*	Pentatomidae	Hemiptera
13.	Green plant bug	*Nezara viridula* L		
14.	Painted bug	*Bagrada cruciferarum* (Kirkaldy)		
15.	Red cotton bug	*Dysdercus cingulatus* F	Pyrrhocoridae	
16.	Hover fly	*Eristalinus megacephalus* (Rossi)	Syrphidae	Diptera
17.	Hover fly	*Eupeodes corolla* F		
18.	Hover fly	*Eristalis* sp.		
19.	House fly	*Musca domestica* L	Muscidae	
20.	Blow fly	*Calliphora* sp.	Calliphoridae	
21.	Blow Fly	*Lucilia sericata* (Meigen)		
22.	Lady bird beetle	*Coccinella septumpunctata* L	Coccinellidae	Coleoptera
23.	Lady bird beetle	*Coccinella transversalis* F		
24.	Lady bird beetle	*Cheilomenes sexmaculata* F		
25.	Cabbage butterfly	*Pieris brassicae* L	Pieridae	Lepidoptera
26.	Ker butterfly	*Anaphaeis aurota* F		
27.	Common gull butterfly	*Cepora nerissa* F		
28.	African monarch butterfly	*Danaus Chrysippus* L	Nymphalidae	
29.	American bollworm	*Helicoverpa armigera* (Hübner)	Noctuidae	
30.	Sunn hemp moth	*Uthesia pulcella* L	Erebidae	
31.	Green lace wing	*Chrysoperla carnea* (Stephens)	Chrysopidae	Neuroptera

The mean number of insect visitors/ pollinators foraging in 10 plants was recorded for 5 min. The studies on foraging ecology of frequent and dominant insect visitors i.e., *A. florea*, *E. megacephalus*, *Halictus* sp, on mustard flowers at different hours of the day showed variations in activity over time. The *A. florea* started foraging activity from 9.00 hr and maximum activity was observed at 12.00 to 14.00 hr (9.28 to 11.07 bees/10 plants/ 5 min) with peak activity at 13.00 hr (12.44 bees/ 10 plants/ 5 min). The lowest activity was observed at 17.00 hr (4.74 bees 10 plants/ 5 min). *Eristalinus megacephalus* started its foraging activity from 10.00 hr showing an increasing trend up to 14.00 hr with maximum activity at 13.00 hr (9.06 insect visitors/10 plants/ 5 min) and later the activity declined thereafter with minimum at 16.00 hr (4.41 insect visitors/ 10 plants/ 5 min) of the day. The foraging activity of *Halictus* sp, was initiated at 11.00 hr and maximum activity was observed at 13.00 to 15.00 hr (6.81 to 6.19 insect visitors/ 10 plants/ 5 min) with peak activity at 14.00 hr (8.69 insect visitors/10 plants/ 5 min). The lowest activity was observed at 11.00 hr (3.81 insect visitors/ 10 plants/ 5 min). No activity was observed during early morning and evening hours. The mean pollinator population over different day hours on mustard flowers ranged from 5.62 insect visitors/ ten plants/ five min (*A. florea*) to 2.38 bees/ ten plants/ five min (*Halictus* sp). The activity of *Apis florea* and *Halictus* sp was maximum at 13.00 hr which is in agreement with Giri et al. (2018) who stated that foraging activity of *A. dorsata* was found to be dominant among other pollinators, which foraging activity recorded as maximum in afternoon followed by *A. mellifera* in forenoon (9.00-10.00 hr). The present results agree with those of Akhtar et al. (2018) who reported that the peak activity of *Apis* spp. at noon. Dalio (2018) observed that highest foraging rate of *Apis* spp. was at 1200 hr on the parental lines of *B. napus* Mandal et al. (2018) reported a maximum abundance of pollinators at 11.00 hr of the day. Other related literature revealed maximum foraging activity at 12.00 hr followed by 14.00 and 10.00 hr on *B. napus* at weekly interval (Khan and Ghramh, 2021).

The maximum number of flowers were visited by *A. florea* (14.49 flowers visited/ 5 min) followed by *E. megacephalus* (12.37 flowers visited/ 5 min), *Halictus* sp. (6.30 flowers visited/ 5 min) (Table 2). In *Apis florea*, the peak foraging hour was at 13.00 hr with mean number of pollinators as 12.44/ ten plants/ five min for *E. megacephalus*, the peak foraging hour was recorded at 13.00 hr with 9.06 insect visitors/ ten plants/ five min, respectively. The peak foraging hour for *Halictus* sp. was at 14.00 hr. Studies revealed that *A. florea* visited maximum number of flowers. The present study corroborates with Kunjwal et al. (2014) that *A. florea* visited 4.2 to 8.5 flowers/ min. Yadav et al. (2022) reported that *A. cerana* foraged 18.20 flowers/ min followed by *A. dorsata* (17.57), *A. mellifera* (17.32) and *A. florea* (6.45).

Eristalinus megacephalus spent maximum time (53 sec) (Table 2). This was followed by *A. florea* and *Halictus* sp. The present findings are in agreement with Ahmad et al. (2017) who found that *A. cerana* spent 6.24± 0.12 sec/ apple flower and visited 10.50± 0.18 flowers/ min, whereas *A. mellifera* spent 8.44± 0.38 sec/ flower and visited 9.40± 0.12 flowers/ min. Yadav et al. (2022) reported that *A. florea* spent the maximum of 5.3 sec/ flower, which was followed by *A. dorsata* (1.7 sec), *A. mellifera* (1.6 sec) and *A. cerana* (1.3 sec).

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Table 2. Foraging rate and foraging speed of insect visitors/ pollinators in mustard

Insect visitor/ pollinator species	Foraging rate (flowers visited/ 5 min)	Peak foraging hr	Mean no. of pollinators/ 5 min	Time spent on each flower (Sec)		
				Max	Min	Avg
Apis florea	14.49	13.00	12.44	51	6	27.66
Eristalinus megacephalus	12.37	13.00	9.06	53	21	35.36
Halictus sp.	6.30	14.00	8.69	39	19	26.91

CONFLICT OF INTEREST

No conflict of interest.

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