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Abundance and Foraging Behaviour of Entomophilous Pollinators on Sesame, *Sesamum indicum* L.

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***Abstract*:** The present study focused on the community of insect pollinators, abundance and foraging behavior of different pollinators on sesame. During the study period 32 species of insect visitors were observed in sesame. The order Hymenoptera shared maximum abundance (81.25 %) followed by Diptera (12.50 %) and Coleoptera (6.25 %). Among them *Apis dorsata* acted as dominant forager contributing 24.72% followed by *Apis cerana indica* (22.44%) and *Apis florea* (11.29%). Most of the bees visited sesame flowers, but the density of *A. dorsata, A. c. indica* was maximum and peaked during 1000- 1200 hours with a mean population of 14.06 and 12.0 individuals / m^2/ 5 min whereas the activity of *A. florea* peaked (7.05 individuals/ m^2/ 5 min) at 0800-1000 hours and a steady decline in abundance of bees was observed during evening hours. The flower visitation frequency was found maximum (9.14 flowers/ min) in *A. c. indica* followed by *A. dorsata* (7.44 flowers/ min) during 1000- 1200 hours meanwhile the sequence of flower visitation reduces during evening 1600-1800 hours as 3.12 and 3.18 flowers/ min respectively. The time spent by different bees was in the order *A. florea* (18.05 sec/ flower) > *A. cerana* (15.04 sec/flower) >*A. dorsata* (11.14 sec/ flower) between 0600-0800 hours.

***Keywords*:** *Apis cerana indica,* Abundance, Foraging behaviour, Foraging rate, Pollinator, *Sesamum indicum*

The edible oil plays a crucial role in stabilization of human health. India shares an eminent place in global oilseeds production with 12-15 per cent of cultivation area and 9-10 per cent of the total edible oil consumption. Sesame *Sesamum idicum* L. belongs to the family Pedaliaceae is one of the oldest oil seed crop and indigenous to Africa due to the preponderance of wild species in that region (Azeez et al 2017). It ranks third among the world nine major edible oil seed crop after groundnut and mustard (Rakesh et al 2017) Next to Sudan, India cruises 14.31 percent of sesame production to global market. In Tamil Nadu, sesame is cultivated in an area of 0.446 lakh ha with a production of 0.244 lakh tones and productivity of 548 kg per ha (Anonymous 2020) The complimentary pollination carried out by honey bees in sesame improves seed germination, vigour of seeds and augments the crop yield to an extent of 22 to 33 percent. Insect pollinators serve as the effective source for enhancing the crop yield both qualitatively and quantitatively (Patidar et al 2017). It is estimated that global annual economic value of insect pollination is €153 billion (Das and Jha 2018). Being a self-pollinated crop the tubular floral structure of sesame facilitates cross pollination up to an extent of 65 percent (Kamel et al 2013). Hence this basic research was carried out to document the pollinator fauna and abundance of insect pollinators in sesamum.

MATERIAL AND METHODS

The experimental trial was laid out at Agricultural College and Research Institute (9.96 °N, 78.20 °E), Madurai during March - May 2021 to study the diversity of insect pollinators, foraging behavior, relative abundance, foraging rate and speed of insect pollinators on sesame. The experimental plot was laid out in randomized block design. The number of insect pollinators from each species visiting sesame flowers were recorded from 10 percent flowering stage of the crop to flowering cessation period and were collected using sweep net, subsequently killed and preserved in ethanol for identification. The foraging behavior of insect pollinators was observed for 5 minutes from 0600 - 1800 hours at two hours interval in five plants during alternate flowering days and expressed as mean No. of individuals/m^2/5 min (Das and Jha, 2019). The relative abundance of insect pollinators was calculated as

$$\text{Relative abundance (\%)} = \frac{\text{Population of particular species visiting flowers}}{\text{Total population of all species visiting flowers}} \times 100$$

Total population of all species visiting flowers

The foraging rate (mean no. of flowers visited / minute)

and foraging speed (time spent/ flower/minute) of insect pollinators were counted using electronic stop watch at two hours interval from 0600-1800 hours for five sunny days (Pashte and Shylesha, 2013). During the experimental period the cropping area was free from chemical applications to allow the frequency of natural pollinators. The data obtained were analysed using descriptive statistics and SPSS software package.

RESULTS AND DISCUSSION

Pollinator fauna: The sesame flowers attracted diverse group of insect visitors. A sum of 32 insect visitors belonging to four different orders such as Hymenoptera (16 species), Lepidoptera (8 species), Diptera (6 species) and Coleoptera (2 species) (Table 1, Fig. 1) In that 16 species of Hymenoptera 13 species was identified from seven different families such as Apidae, Megachilidae, Halictidae, Xylocopidae and Crabronidae, Formicidae and Chrysididae. In Hymenoptera the family Apidae was most abundant with six species namely *A. dorsata*, *A. cerana indica*, *A. florea, Ceratina* sp*., Braunsapis* sp. and *Amegilla zonata.* It was followed by the family Megachilidae, which shared three species *Megachile lanata, Megachile disjuncta* and *Anthidum* sp. However the family Xylocopidae and Halictidae contributes two species. Next to Hymenoptera the order of diversity was followed by Lepidoptera comprising eight species from four families namely, Nymphalidae, Pieridae, Papilionidae and Lycaenidae. Most of the insects visit sesame flowers for collecting pollen or nectar but those who carry considerable amount of pollen grains on their body were considered as pollinators and remaining insect visitors were considered as flower visitors, a visual observation was made to record foraging activity of insect foragers on pollen and nectar to substantiate the role of flower visitors in pollination service (Table 2).

Insect pollinators with their activity of extending their proboscis into the flowers were considered as nectar collectors and those carrying pollen on their hind legs were determined as pollen collectors. In the sesamum ecosystem only 16 species were confined as pollinators. Lepidoptera shares maximum species than Dipteran but did not have significant role in pollination service as they mainly gather only nectar by extending their proboscis. Due to the tubular floral structure of sesame flowers sometimes they probe over the corolla or by holding them to suck the nectar present inside the extra nectaral disc surrounding the ovary that does not aid in adhering of pollen grains as like sunflower, mustard, to their legs whereas Dipterans flight over the flowers to collect the floral rewards abundantly as like Hymenopterans. Mahfouz et al (2012) reported Hymenoptera, Diptera, Lepidoptera and Coleoptera where the order Hymenoptera pertains to maximum number of pollinators (Pashte et al 2013) witnessed 22 species of insect pollinators foraged on sesame flowers. Among them Hymenoptera shared 17 species associated by three species from Diptera and two species from Lepidoptera. Kamel et al (2013) recorded 29

Table 1. Flower visitors of sesame (*Sesamum indicum* L.) during 2020-21

Common name	Scientific name	Family
Hymenoptera		
Indian bee	*Apis cerana indica*	Apidae
Rock bee	*Apis dorsata*	Apidae
Little bee	*Apis florea*	Apidae
Small carpenter bee	*Ceratina* sp.	Apidae
Blue banded bee	*Amegilla zonata*	Apidae
Reed bee	*Braunsapis* sp.	Apidae
Large carpenter bee	*Xylocopa* sp. 1	Xylocopidae
Large carpenter bee	*Xylocopa* sp. 2	Xylocopidae
Wooly wall bee	*Megachile lanata*	Megachilidae
Resin bee	*Megachile disjuncta*	Megachilidae
Wool carder bee	*Anthidium* sp.	Megachilidae
Sweat bee	*Halictus* sp.	Halictidae
Sweat bee	*Nomia* sp.	Halictidae
Wasp	Unidentified	Crabronidae
Cuckoo wasp	*Stilbum cyanurum*	Chrysididae
Black ant	*Camponotus* sp.	Formicidae
Diptera		
Hoverfly	*Eristalinus* sp.	Syrphidae
Marmalade hover fly	*Episyrphus* sp.	Syrphidae
Green tailed fly	*Hedriodiscus* sp.	Stratiomyidae
Robber fly	Unidentified	Asilidae
House fly	*Musca* sp.	Muscidae
Blow fly	*Lucilia* sp.	Calliphoridae
Lepidoptera		
Monarch butterfly	*Danaus chryssipus*	Nymphalidae
Tawny coster	*Acraea terpsicore*	Nymphalidae
Blue pansy	*Junonia* sp.	Nymphalidae
Cabbage butterfly	*Pieris brassicae*	Pieridae
Orange tip butterfly	*Anthocharis cardamine*	Pieridae
Citrus butterfly	*Papilio demoleus*	Papilionidae
Swallow tail	*Papilio polytes*	Papilionidae
Pulse blue butterfly	*Lampides boeticus*	Lycaenidae
Coleoptera		
Chaffer beetle	*Oxycetonia versicolor*	Scarabaeidae
Pumpkin beetle	*Aulacophora foveocolis*	Chrysomelidae

species of insect pollinators in sesame flowers, in which the order Hymenoptera contributed 18 species, followed by seven species from the order Diptera, three species from Lepidoptera and one species from Coleoptera. Ngongolo et al 2015) reported 24 species of insect visitor aids in pollination service of sesame. Meanwhile, Das and Jha 2019) recorded minimum pollinators in sesame holding 10 insect visitors belonging to the order Hymenoptera comprising of five species *viz.*, *A. dorsata, A. mellifera, Megachile* sp.*, Vespa cincta* and *Camponotus sericius* followed by Diptera holding two species *viz., Sacrocophaga* sp. and *M. domestica* and Lepidoptera comprising three species *viz., D. chrycippus, Amata bicincta* and *Pieris* sp.

Foraging behaviour: Due to the presence of sufficient sunshine hours the foraging activity of *A. dorsata* and *A. c. indica* was maximum at 1000- 1200 hours and drastically reduced during evening 1600- 1800 hours. The activity of *A. florea* was peaked at 0800- 1000 hours with 7.05 individuals/m^2/ 5min. During 0800- 1000 hours, *Ceratina* sp. act as the most abundant pollinator with 2.74 individuals/m^2/ 5 min while its activity was nil between 1200-1400 hours. 1000-1200 hours was the predominant time for foraging on sesame flowers by *A. zonata* whereas very low activity was observed at 1400-1600 hours. The dominance of *Braunsapis* sp. was during 1000-1200 hours with 3.76 individuals/m^2/ 5 min. Both the *Xylocopa* sp. started their foraging on 0800-1000 hours and actively foraged on flowers at 1200- 1400 hours. The bounciness of Megachillid bees, *M. lanata* and *M. disjuncta* was soared at 1000-1200 hours. However a slow decline on individuals of *M. lanata* was recorded at 1200 - 1400 hours and complete cessation of *M. disjuncta* during 1200- 1800 hours. The activity of unidentified Hymenopteran, initiated at 0800- 1000 hours spired at 1000-1200 hours and terminated at 1200- 1400 hours. The foraging period of Halictid bees namely *Halictus* sp. and *Nomia* sp. on sesame flowers was maximum at 1000-1200 hours. Dipteran flies, *Eristalinus* sp. and *Episyrphus* sp. showed maximum abundance at 0800- 1000 hours and 1000-1200 hours respectively (Table 3). When the sesame flowers are exposed with adequate pollen and nectar source the difference in densities of pollinators on flowers occurs. The longer lower lip of sesame flowers is kept folded over the short upper lip until the flower opening which takes place usually around 0630 hours. As soon as opened, it provides running strip for bees and they blemishes over the foraging rewards in peak hours. Later, the tender flowers slowly closes their floral openings in late sunshine hours restricting the movement of bees thereby reporting low densities of individuals in evening hours. In the present study, the abundance of *A. dorsata* was maximum in the experimental site this was mainly due to the presence of adequate number of natural hives in nearby locations. Mahfouz et al (2012) recorded the maximum and minimum activity of honey bees at 0900- 1100 hours and 1500- 1600 hours respectively. They also observed that abundance of bee activity decreased with diminishing flowers per plant due to the increase in age of the crop. Bhagawati and Rahman (2016) observed the foraging behaviour of *A. cerana* on sesame and concluded that 0900-1000 hours was the peak period of visitation that is concurred with our present study results.

Table 2. Major floral pollinators of sesame in AC & RI, Madurai

Pollinators	Family	Collection of	
		Pollen*	Nectar*
A. c. indica	Apidae	+	+
A. dorsata	Apidae	+	+
A. florea	Apidae	+	+
Ceratina sp.	Apidae	+	+
A. zonata	Apidae	+	+
Braunsapis sp.	Apidae	+	+
Xylocopa sp. 1.	Xylocopidae	+	+
Xylocopa sp. 2.	Xylocopidae	+	+
M. lanata	Megachilidae	+	-
M. disjuncta	Megachilidae	+	-
Halictus sp.	Halictidae	+	+
N. crassipes	Halictidae	+	-
Unidentified	Crabronidae	-	+
Eristalinus sp.	Syrphidae	-	+
Episyrphus sp.	Syrphidae	-	+
O. versicolor	Scarabaeidae	+	-

*+ collected, - did not collect

Relative abundance of pollinators: The relative abundance of various insect pollinators was in the order Hymenoptera (81.25%) > Diptera (12.50%) > Coleoptera (6.25%) (Fig. 2).

The share of abundance contributed by *Apis* and Non *Apis* was 37.50 and 43.75 per cent respectively. *A. dorsata* was considered as dominant forager is representing an average population of 7.05 individuals/ m^2 constituting 24.72% of total insect pollinators. This was followed by *A. c. indica* composing 22.44 % of insect fauna whereas the *A. florea* showed less abundance of 11.29%. The *Ceratina* sp. exhibited 3.01% of abundance. Meanwhile *Braunsapis* sp. from the family Apidae shared 5.20 per cent abundance. The abundance of *Halictus* sp. and *Nomia* sp. was 6.80 and 3.26 percent followed by Megachillid bees, *M. lanata* and *M. disjuncta* shared 1.64 and 1.43 per cent of dominance among the pollinators respectively. Both the *Xylocopa* sp. occupied

1.71 and 1.64 % share of insect visitors. Among 12.50 % shared by the order Diptera, the *Eristalinus* sp. and *Episyrphus* sp. recorded 3.43 and 4.62 percent abundance. Coleoptera is the least abundant order where *Oxycetonia versicolor* contributed 1.50 percent (Table 4, Fig. 2). The population of pollinator increased in subsequent flowering period. On reaching the peak flowering period the abundance of pollinators gradually declined due to the cessation of flowers. It was stated that during the peak flowering period the abundance of pollinators were 43.55 insects/ m^2 but at the time of cessation of flowers the pollinator abundance was reduced to 18.63 insects/ m^2.

The abundance of *A. dorsata* was maximum (24.72%) during the course of study might be due to the natural nest congregation in the experimental area. The presence of suitable environmental condition and the availabilty of floral rewards like attractive colour, pollens from freshly opened flowers, copious flow of nectar throughout the foraging period strongly influence the dominance of pollinator species. Kamel et al (2013) observed abundance of order Hymenoptera was higher in two consecutive study seasons of sesame flowering period (90.94 and 89.59) followed by Diptera (3.93 and 5.38), Lepidoptera (3.58 and 3.62) whereas the least percent abundance was shared by order Coleoptera (1.53 and 1.39). Bhagwati and Rahman (2016) reported that *A. cerana* as dominant forager (32.66%) adhered by *A. dorsata* (26.54%) and *A. florea* (4.76%) during the entire blooming period of sesame. The present reports are in close relation with Das and Jha (2019) where they documented, the abundance of Hymenoptera was 89.87 % followed by Diptera (6.47 %).

Foraging rate: During 0800-1000 hours, *A. c. indica* visited more number of flowers (9.14 flowers / min) besides *A. dorsata* visited 7.44 flowers/ min as freshly opened flowers are maximum during morning hours however their activity drastically reduced in evening hours (3.12 and 3.18 flowers /

Table 3. Foraging behaviour of pollinators on sesame (AC&RI, Madurai)

Pollinators	*Mean No. of individuals/m^2/ 5 min						
	0600-0800	0800-1000	1000-1200	1200-1400	1400-1600	1600-1800	Mean
Apis bees							
Hymenopterans							
A. c. indica	5.06^{a}	8.13^{b}	12^{b}	7.04^{a}	4.13^{b}	2.06^{b}	6.40
A. dorsata	5.05^{b}	9.05^{a}	14.06^{a}	6.08^{b}	5.05^{a}	3.04^{a}	7.05
A. florea	2.17^{c}	7.05^{c}	5.04^{c}	3.25^{c}	1.01^{d}	0.8^{c}	3.22
Braunsapis sp.	0.00^{g}	2.66^{de}	3.76^{e}	1.94^{e}	0.65^{e}	0.00^{h}	1.50
A. zonata	1.26^{d}	2.42^{ef}	4.15^{d}	1.14^{h}	0.3^{f}	0.11^{g}	1.56
Ceratina sp.	0.00^{g}	2.74^{d}	1.51^{i}	0.00^{l}	0.61^{e}	0.30^{e}	0.86
Mean	2.25	5.34	6.75	3.24	1.95	1.05	3.43
Non- apis bees							
Halictus sp.	0.69^{f}	2.86^{d}	3.74^{g}	2.44^{d}	1.41^{c}	0.14^{f}	1.94
Nomia sp.	1.09^{e}	2.14^{g}	3.21^{h}	1.21^{h}	0.00^{f}	0.29^{e}	0.93
Xylocopa sp. 1	0.00^{g}	0.06^{m}	1.14^{l}	1.61^{f}	0.01^{f}	0.00^{h}	0.47
Xylocopa sp. 2	0.00^{g}	0.08^{m}	1.41^{j}	1.45^{g}	0.00^{f}	0.00^{h}	0.49
M. disjuncta	0.00^{g}	1.05^{i}	1.43^{ij}	0.00^{o}	0.00^{f}	0.00^{h}	0.41
M. lanata	0.00^{g}	0.77^{j}	1.26^{k}	0.92^{i}	0.00^{f}	0.00^{h}	0.49
Unidentified	0.00^{g}	0.49^{lk}	1.30^{k}	0.57^{k}	0.00^{f}	0.16^{f}	0.43
Mean	0.25	1.06	1.78	1.36	0.23	0.09	0.79
Dipterans							
Eristalinus sp.	1.08^{e}	2.06^{h}	0.90^{n}	1.17^{h}	0.68^{e}	0.00	0.98
Episyrphus sp.	0.45^{f}	2.04^{h}	3.06^{f}	1.53^{g}	0.84^{d}	0.00	1.32
Mean	0.76	2.05	1.98	1.35	0.76	0.00	1.15
Coleopteran							
O. versicolor	0.00	0.17	0.47	0.63	0.67	0.67	0.43

In a column means followed by same letter(s) are not significant with each other, DMRT ($P \leq 0.05$)
Mean ± Standard Error

min during 1600- 1800 hours respectively) (Table 5). *A. florea* visited 5.95 flowers/ min during 1000-1200 hours and their foraging activity was minimum during afternoon 1600-1800 hours (1.54 flowers/ min). Higher the foraging rate may enhance the efficiency of pollination.

Decline in foraging rate of honeybees in evening hours and maximum foraging rate of 12.6 florets/min at 1230-1330 hours in Niger was recorded by Gebremedhm et al (2014). Bhagwati and Rahman (2016) observed number of flowers visited by *A. cerana* was maximum) during 0500-0600 hours and minimum at 1600-1700 hours in sesame while our present study recorded maximum foraging by *A. c. indica* was at 1000-1200 hours and minimum at 1600-1800 hours. This may vary due to the difference in the observations in different time period and made evident as the increase in sunshine hours will decrease the visitation frequency. Vishwakarma and Chand. (2017) concluded that foraging rate of insect pollinators in forenoon hours was 1.5-1.7 times higher than in afternoon hours in mustard. Ahmad et al. (2018) documented the maximum visitation of sunflower heads was at 0900 hours by *A. mellifera* while the *Xylocopa* visited maximum at 1300-1700 hours .

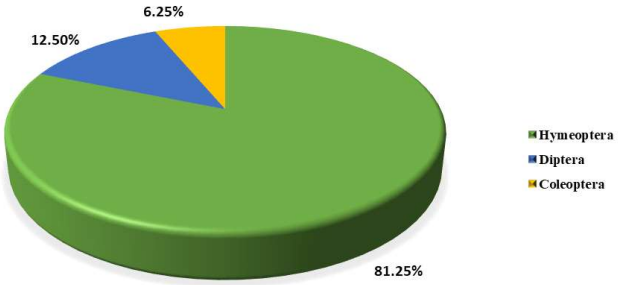

Fig. 2. Relative abundance of major pollinators of sesame at AC & RI, Madurai

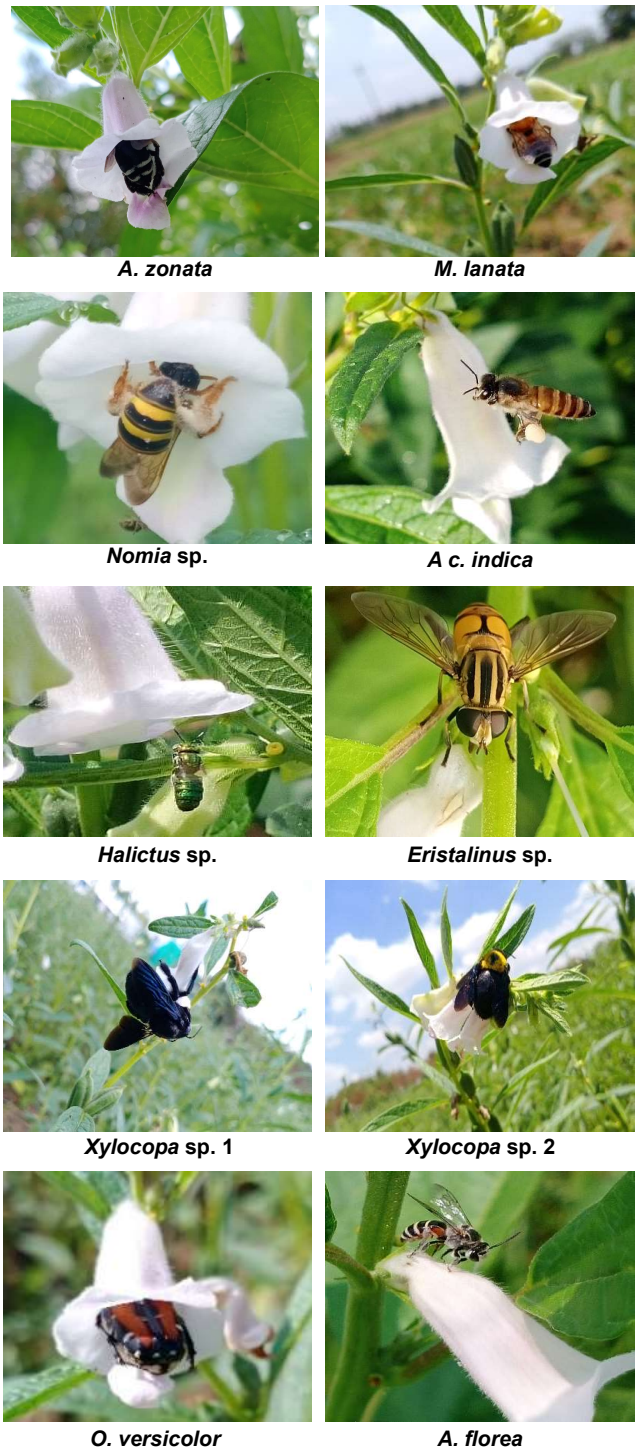

Fig. 1. Major pollinators in sesamum at AC & RI, Madurai

Foraging speed: *A. florea* spent maximum time of 18.05 sec/ flower on sesame. However, *A. c. indica* and *A. dorsata* spent 15.04 and 11.14 sec/ flower at 0600 -0800 hours for foraging on sesame flowers. This might be due to either low visitation of flowers, availability of maximum pollen and nectar source in the morning hours (Table 6). Even as they visited minimum flowers at 1400-1600 hours, the time spent by *A. dorsata* and *A. florea* tend to decline at 1600- 1800 hours (4.15 and 3.30 sec/ flower respectively) while the *A. c. indica* spared 3.31 sec/ flower. On observing the time spent by bees in evening hours, very low amount of pollens sticked on their bodily hairs. As soon as completion of peak anthesis period in the morning hours, the pollens started to dehisce and the sesame flowers ran out of floral rewards gradually from afternoon to evening hours. Bhagwati and Rahman (2016) quoted that maximum time spent per flower by *A. cerana* was 6.83 seconds during 0900- 1000 hours and minimum was 3.87 seconds during 1600-1700 hours of the day. Kaur et al. (2021) stated that the mean foraging speed of *A. mellifera* was 4.42 seconds compared to *A. cerana (*4.10 seconds) and *A. dorsata (*3.53 seconds) in mustard. In sunflower, *A. mellifera* spent 60.97, 74.46 and 62.12 seconds

Table 4. Relative abundance of pollinators during different flowering period in sesamum

Pollinators	Abundance of pollinators during different flowering period of sesamum (No. of individuals/ m^2/ 5 min)					Abundance (%)
	15 % flowering	50 % flowering	100 % flowering	< 50% flowering	Mean	
A. c. indica	3.41	7.68	9.03	5.48	6.40	22.44
A. dorsata	5.03	7.89	8.82	6.47	7.05	24.72
A. florea	2.06	4.31	5.07	1.45	3.22	11.29
Ceratina sp.	0.61	1.09	1.41	0.35	0.86	3.01
A. zonata	0.52	2.09	2.73	0.92	1.56	5.47
Braunsapis sp.	0.68	2.16	2.59	0.57	1.50	5.26
Xylocopa sp. 1	0.23	0.85	0.91	0.0	0.49	1.71
Xylocopa sp. 2	0.17	0.81	0.92	0.0	0.47	1.64
M. lanata	0.21	0.71	0.85	0.13	0.47	1.64
M. disjuncta	0.23	0.56	0.78	0.08	0.41	1.43
Halictus sp.	1.19	2.15	2.85	1.57	1.94	6.80
Nomia sp.	0.44	1.17	1.65	0.46	0.93	3.26
Unidentified	0.14	0.67	0.82	0.11	0.43	1.50
Eristalinus sp.	0.45	1.28	1.82	0.37	0.98	3.43
Episyrphus sp.	0.38	2.14	2.25	0.53	1.32	4.62
O. versicolor	0.17	0.38	1.05	0.14	0.43	1.50
Mean	15.92	35.94	43.55	18.63	28.51	100

Table 5. Foraging rate of different *Apis* bees on sesame flowers during different hours of the day

Time/ pollinator	No. of flowers visited/min*						Mean
	0600-0800	0800-1000	1000-1200	1200-1400	1400-1600	1600-1800	
A. dorsata	5.30^{b}	7.44^{a}	6.18^{b}	4.74^{c}	2.46^{d}	3.18^{e}	4.88
A. c. indica	4.23^{b}	9.14^{a}	7.07^{b}	4.05^{d}	5.13^{c}	3.12^{e}	5.45
A. florea	3.21^{c}	4.02^{b}	5.95^{a}	3.07^{c}	2.32^{d}	1.54^{e}	3.35

In a row, means followed by same letter(s) are not significantly different from each other, DMRT ($P \leq 0.05$)

Table 6. Foraging speed of different *Apis* bees on sesame flowers during different hours of the day

Time/ pollinator	Time spent (sec/ flower)*						Mean
	0600-0800	0800-1000	1000-1200	1200-1400	1400-1600	1600-1800	
A. dorsata	11.14^{a}	10.21^{b}	9.24^{c}	5.90^{d}	5.23^{e}	4.15^{f}	7.64
A. c. indica	15.04^{a}	6.20^{c}	8.12^{b}	4.14^{d}	3.31^{e}	8.03^{b}	7.47
A. florea	18.05^{a}	14.18^{b}	11.14^{c}	10.49^{c}	4.85^{d}	3.30^{e}	10.33

Figures in the parenthesis are square root transformed values.
In a row, means followed by same letter(s) are not significantly different from each other, DMRT ($P \leq 0.05$)

per flower compared to *X. fenesterata* 66.65, 68.19 and 67.79 seconds during different sunshine hours *viz.,* 0900, 1300 and 1700.

CONCLUSION

The present study concludes that *A. dorsata* and *A. c. indica* were the efficient pollinators of sesamum ecosystem as they played vital role in pollination with maximum foraging activity. By conserving the natural pollinators in sesame growing areas will definitely enhance its productivity.

REFERENCES

Ahmad M 2018. Diversity of sunflower insect pollinators and their foraging behavior under field conditions. *Uludağ Arıcılık Dergisi* **18**(1): 14-27.

Azeez MA, Olowookere, Animasaun MB and Bello BO 2017. Utility of some floral characters in the assessment of genetic diversity in sesame (*Sesamum indicum L.*). *Acta Agriculturae Slovenica* **109**(1): 61-70.

Bhagawati S, Rahman A and Deka MK 2016. Diversity of insect foragers with reference to foraging behaviour of Asian honey bee, *Apis cerana* F. on sesamum, *Sesamum indicum* L. *Journal of Entomological Research* **40**(3): 213-216.

Das R and Jha S 2018. Record of insect pollinators and their

abundance on Indian mustard (*Brassica juncea L.)* in New Alluvial Zone of West Bengal. *International Journal of Pure and Applied Bioscience* **6**(5): 848-853.

Das R and Jha S 2019. Insect Pollinators of Sesame and the effect of entomophilous pollination on seed production in New Alluvial Zone of West Bengal. *International Journal of Current Microbiology and Applied Sciences* **8**(3): 1400-1409.

Gebremedhn H and Tadesse A 2014. Diversity of *Guizotia abyssinica* pollinators and their effect on seed quality in Mekelle, Northern Ethiopia. *Livestock Research for Rural Development* **26**(11).

Kamel SM, Blal, Mahfouz AH and Said M 2013. The most common insect pollinator species on sesame crop (*Sesamum indicum L.*) in Ismailia Governorate, Egypt. *Arthropods* **2**(2): 66.

Mahfouz AH, Kamel SM, Blal and Said M 2012. Pollinators visiting sesame (*Sesamum indicum L.)* seed crop with reference to foraging activity of some bee species. *Cercetari Agronomice in Moldova* **45**(2): 49-55.

Ngongolo K, Mtoka S and Rubanza CD 2015. Floral visitors and pollinators of sesame (*Sesamum indicum L.)* from Kichi forest to the adjacent local communities' farms. *Entomology and Applied Science Letters* **2**(2): 32-39.

Pashte VV and Shylesha AN 2013. Pollinator diversity and their abundance on sesamum. *Indian Journal of Entomology* **75**(3): 260-262.

Patidar BK, Ojha KN and Khan IU 2017. Role of honeybee (*Apis mellifera*) in enhancing yield of mustard in humid region of Rajasthan, India. *International Journal of Current Microbiology and Applied Science* **6**(7): 1879-1882.

Vishwakarma R and Chand P 2017. Foraging activity of insect pollinators and their impact on yield of rapeseed-mustard. *BIOINFOLET-A Quarterly Journal of Life Sciences* **14**(3): 222-227.

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