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Abundance and diversity of pollinator fauna of sunflower (*Helianthus annuus* L.) at honey bee research and training center, Pantnagar, Uttarakhand

Ritesh Kumar and Poonam Srivastava

Abstract
Insect pollinator abundance and diversity were assessed in sunflower (*Helianthus annuus* L.). Totally, 17 species of Apis and non Apis bees were recorded commencing from 0800 up to 1800 hrs at hourly intervals during different stages of flowering. The composition of different orders comprising of pollinator fauna were, Hymenoptera (11), Diptera (2) and Lepidoptera (4), were found to visit the sunflower field. Among the *Apis* species (*A. dorsata*, *A. mellifera* and *A. cerana indica*), followed by non *Apis* (*T. iridipennis*) were most abundant visitors in the variety Morden. In a day maximum time spent by *A. dorsata* at 1000-1200 am the 21.33±4.72 second (time spent/flower) and minimum time spent at 1600-1800 pm (15.67±4.07/flower/second) during different day hours of the day. While in case of time spent by *A. mellifera* 14.67 to 22.33 second/flower followed by *X. iridipennis* 14.67 to 21.33 second/flower, *M. disjuncta* 14.67 to 18.67 in different day hours and lowest time spent by *T. laeviceps* 9.67 to 14.67 second/flower. In case of open pollination, the intensity of *A. mellifera* was observed significantly more at 1000-1200 hr (13.67 bee/ 2 m^2 /2 min) and reached at its peaks at 1400-1600 hr (16.67 bee /2 m^2/2 min) and mean value of (11.08 bee/2m^2 /2 min). The intensity of *A. cerana indica*, *Trigona laeviceps*, *Trigona iridipenni*, *A. dorsata* mostly observed in 2000-4000 hr. The visitation of various pollinators was mostly active in during this period. The *Apis dorsta* reached at its peak at 2000-4000 hr (6.33 bee /2 m^2/2 min) after that decline trend was observed at 4000-6000 hr. The *A. cerana indica* reached at peak period of 2000-4000 (12.33 bee/2 m^2 /2 min) after that decline trend was observed at 4000-600 hr. Followed by different lepidopteran population reached at its peak at 2000-4000 and after that decline trend observed 4000-6000 hr during this period.

Keywords: Sunflower, diversity, abundance, *Apis mellifera* and pollinators

Introduction
In India, oilseeds share 14% of gross cropped area and account for nearly 3% of the gross domestic product and 5.98% of the value of all agricultural products. Despite being the largest cultivator of oilseeds in the world, India imports about 50% of the requirements, because of the life style changes in dietary pattern and increasing per capita income (Varaprasad, 2015) [17]. Sunflower (*Helianthus annuus* L.) popularly known as Surajmukhi or Suryakanti is a native of Southern USA and Mexico, belonging to family Asteraceae and is one among the four major oilseed crops cultivated globally *viz*., soyabean, sunflower, brassica and groundnut. Use of pollinators is considered as one of reliable, cost effective and ecofriendly methods to enhance the cross-pollination and increase productivity and quality of crop. Among different pollinators, bees are considered as the best pollinating agents due to their suitable body size, hairiness, thoroughness, steadfastness, floral consistency and manageable populations. Being polytrophic in nature and more flower- constant, they effectively pollinate a large number of crops. About one- third of the human diet comes from insect pollinated crop plants, and the honey bees account for 80 percent of pollination (FAO, 1995) [2]. The economic value of honey bees as pollinators of crop was estimated at about $14.6 billion in the USA and yield of fruits, seed, and nut crops would be Significantly reduced without the pollination services that bees provide (Morse and Calderone, 2000) [8]. The flowering phenology of sunflower ensures cross pollination, which is carried out by different species of insects especially the honey bees like *Apis dorsata* Fab., *A. indica* Fab., *A. florea* Fab., *Trigona iridipennis* Smith, solitary bees, flies, butterflies and beetles. Among these, honey bees play a major role in cross pollination of sunflower crop. The flowers produce abundant quantity of nectar and pollen which attract large number of pollinators.

Though pollination is performed by other pollinators, honey bees accounts for a major share among them. Unfavorable weather conditions, poor flower resources (nectar and pollen) and other competitive forage sources around the field may act as major factors in failure of bee pollination in the target crop. Attracting bees to the target crop overlooking the other competitive forage sources is a challenging task in bee management for cross pollination. Hence, bee attractants play a very crucial role in this context. Bee attractant is any material which is used to enhance the bee pollinators to attract the target crop ensuring optimum pollination and crop productivity. It can save a crop threatened by poor weather conditions or having less resource in tenia of nectar and pollen. In many cases the initial attractant will establish foraging patterns that continue the pollination process. Therefore, this study was carried out at Honey Bee Research and Training Centre, Pantnagar, Uttarakhand in summer season of 2019-20 to "Abundance and diversity of pollinator fauna of sunflower (*Helianthus annuus* L.) at HBRTC Pantnagar".

Material and Methods

On onset of about 40% flowering (from May 7 to July 22, 2020), insect pollinators were collected with hand net and were killed in insect killing jar (having choloform). Pinning of those insect pollinators was done and brought to the Taxonomy Laboratory, Department of Entomology, G. B. Pant University of Agriculture and Technology, Pantnagar for their identification up to genus and species level. Foraging behavior of different pollinators was recorded by observing visitation rate (number of the flower visited by different insect pollinators per two minute/2 m^2 area) and stay time on ten randomly selected flower heads by using stop watch. Time was counted when insect landed on flower excluding the time, it circled on flower. Data of foraging behavior was recorded four times (0800, 1000, 1400 and 1600 hours) in a day on weekly basis throughout the flowering season. Pollinator's abundance was determined during the flowering season on ten randomly selected flower heads. Visitation frequency (no. of visits per flower per two minute) of different insect pollinators was observed for 60 seconds on each flower with the help of stop watch. Observations were made at 0800, 1000, 1400, and 1600 hours on weekly basis during the flowering season. Diversity of insect pollinators was determined by counting various insects while walking in rows for five minutes.

Statistical Analysis

Statistical analysis: Randomized Block Design (RBD) was used to compute the variance. After the determination of significance of difference between the treatments means at 0.05% probability, critical difference was calculated in order to compare the treatment means (Snedecor and Cochran, 1968).

Results and Discussion

Diversity of pollinators: A total of 17 insect visitors belonging to order Hymenoptera (11), Diptera (2) and Lepidoptera (4), were found to visit the sunflower crop (Table 1). Hymenopteran visitors belonged to five families namely Apidae (5), Xylocopidae (1), Anthophoridae (2), Halictidae (2), and Magachilidae (1), Lepidopteran (4) visitors belonged to families Pieridae (2), Nymphalidae (1) and Papilionidae (1). Besides this some Dipteran visitor belonged to families Syrphidae (2) were observed on sunflower. From the family Apidae, honeybees (*A. mellifera*, *A. dorsata* and *A. cerana indica*), and stingless bee (*Trigona laeviceps*) were the five species that were recorded on the field. Carpanter bee (*Xylocopa iridipennis*) of Xylocopidae, the Alkali Bees (*Nomia* sp.) and *Halictus* sp. of Halictidae, Leaf cutter bee (*Megachile disjuncta*) of Megachilidae, the digger bee (*Anthophora* sp.) of Anthophoridae and Sphex sp. of Sphecidae visited the sunflower. From Diptera family Syrphidae (*Syrphus corollae*) were seen in the field. Lepidopterans namely Cabbage butterfly (*Pieris brassicae*), Three spot grass yellow butterfly (*Eurema blanda*) of family Pieridae, Swallowtail butterfly (*Papilio demolus*) of family (papilionidae) and Blue moon butterfly (*Hypolimnas bolina*) of family (nymphalidae) was observed.

Average time spent by different insect visitors on sunflowers at different time hours of the day: The data of foraging speed *i.e.* time spent by different species on *Helianthus annus* flower at different day hours during May-July 2019-20 at Pantnagar have been present in Table no 2. and and graphically depicted in Fig.1. In a day maximum time spent by *A. dorsata* at 1000-1200 am the 21.33±4.72 second (time spent/flower) and minimum time spent at 1600-1800 pm(15.67±4.07/flower/second) during different day hours of the day. While in case of time spent by *A. mellifera* 14.67 to 22.33 second/flower followed by *X. iridipennis* 14.67 to 21.33 second/flower, *M. disjuncta* 14.67 to 18.67 second/flower in different day hours and lowest time spent by *T. laeviceps* 9.67 to 14.67 second/flower. The foraging speed of different type of honey beees and solitary bees on sunflower was studied by Kumar *et al*. (1994). In *X. iridipennis, Anthophora sp, Halictus spp, Nomia sp, S. corolla, P. brassicae, H. bolina, E. blanda, P. demoleus* and *T. iridipenni* it was 14.67 to 21.33, 11.67 to 16.33,11.33 to 15.33,10.67 to 14.33,13.33 to 17.67, 13.67 to 15.67, 11.67 to 15.67, 12.33 to 17.33,10.33 to 14.67,10.67 to 14.33/ flower/second. But they spent more time at morning 0800-1000 am. The maximum time (average 18.33 second) per flower was spent by *A. dorsata* followed by *A. mellifera* (17.42 second) and *X. irridipennis* (17.17 second) respectively. A some what different observation has been made by Abrol and Kapil (1996) and Panchabhavi and Rao (1978) [11] *A. florea* and *A. mellifera* was chief visitor on sunflower crop in Karnataka and Hisar respectively. Swaminathan and Bhardwaj (1982) [16] on the other hand reported *A. dorsata* as the chief pollinator constituting about 81.2% of the total insect visitors followed by *A. florea* (8.23%), *Lasioglosum* sp (3.75%), *Pithitis smaragdula* (2.37%), *Xylocopa* sp (0.14%) and *Chalicodoma lerma* (0.13%). Irrespective of different insect species, the mean time spent during different day hours were varied from 13.07 to 18.02 second. The mean time spent by these insect species was significantly higher (18.02 second/flower) at 0800-1000 h than the mean time spent by these insect species during 1000-1200 h (15.38second/flower), 1400-1600h (14.04second/flower) and 1600-1800h (13.07 second/flower). The aforesaid results are in conformity with the results obtained by Pandey and Kumari (2007) who reported that maximum time was spent by *A. mellifera* in one flower i.e. 0.25 to 2 min. Rakesh Kumar and Lenin (2000) [13] also noted that *A.dorsata* and *A.florea* spent 8.6 and 11.2 second per flower and visited 8.5 and 4 flowers per minute. These result are in line with results obtained in present investigation.

Visitation of various pollinators per two meter square per two minute at different day hours during May- July 2019-20: Visitation of various pollinators per two meter square per two minute at different day hr are presented in Table 3. It was evident from Table 3 that in the all cases the intensity of all the species of bees started initiating at 0800-1000 hr, then gradually increase and reached at its peak at 1000-1200 hr and 1400-1600 hr and then gradually decline slowly from 1600-1800 hr. In case of open pollination, the intensity of *A. mellifera* was observed significantly more at 1000-1200 hr (13.67 bee/ 2 m^2 /2 min) and reached at its peaks at 1400-1600 hr (16.67 bee /2 m^2/2 min) and mean value of (11.08 bee/2m^2 /2 min). The intensity of *A. cerana indica, Trigona laeviceps, Trigona iridipenni, A. dorsata* mostly observed in 2000-4000 hr. The visitation of various pollinators was mostly active in during this period. The *Apis dorsta* reached at its peak at 2000-4000 hr (6.33 bee /2 m^2/2 min) after that decline trend was observed at 4000-6000 hr. The *A. cerana indica* reached at peak period of 2000-4000 (12.33 bee/2 m^2 /2 min) after that decline trend was observed at 4000-600 hr. Followed by different lepidopteran population reached at its peak at 2000-4000 and after that decline trend observed 4000-6000 hr during this period. The intensity of other hours of the day of *A. mellifera* was significantly lower at 8000-1000 and 4000-6000 hr. Followed by other bees was lower population observed at 8000-1000hr and 4000-6000hr. So intensity of non Apis bee and other pollinators was at its peak at 2000-4000hr and after that decline trend was observed. The *X. iridipennis* intensity was lowest at 8000-1000 (3.33 bee/2 m^2 /2 min) and reached at picks its 1400-1600 (6.33 bee/2 m^2 /2 min) was observed. Among the diverse flower visitors of sunflower at the research area, Insect pollinators comprise honeybees especially the commercial *A. mellifera* species was abundant and the most frequent pollinator of sunflower. It has been known to participate in its pollination with major share in flowers visitation and crop yield (Hoffman, 1994; Moretti *et al*., 1993) [4, 7]. Ahmed *et al*. (1989) found that among the insects visiting sunflower, Hymenopterous species were the most important pollinators and honeybees formed 75 per cent of Hymenoptera on sunflower. Other bees which visited the crop and directly affected yield were *Bombus* spp., *Nomia melanderi*, *M. rotundata* and *Halictus* sp (Moreti *et al*., 1996) [6]. Nderitu *et al*. (2008) [10] reported 14 species visiting sunflower with maximum contribution of *A. mellifera* (Hymenoptera) followed by the Lepidopteron species. Radford *et al*. (1979) [12] found non-*Apis* bees as inefficient pollinators but their presence enhanced honeybee pollination efficiency. Variable time spent by *A. mellifera* has been previously observed (Landrige and Goodman, 1974) [5]. Another indigenous honeybee species, *A. cerana* spent 52.98 seconds /sunflower head (Sing *et al*., 1999) [14] and an important pollinator of brassica rapeseed (*Brassica campestris* L. var. toria) (Murell and Nash, 1981) [9]. Variation may be due to amount of nectar present in flower heads.

Table 1: Diversity of pollinator fauna on sunflower crop at HBRTC (Pantnagar).

Sr. No	Insect visitor	Common name	Order	Family
1.	*Apis mellifera*	Italian honey bee	Hymenoptera	Apidae
2.	*A. dorsata*	Rock bee	Hymenoptera	Apidae
3.	*A. cerana indica*	Indian honeybee	Hymenoptera	Apidae
4.	*A.florea*	Little bee	Hymenoptera	Apidae
5.	*Trigona laeviceps*	Stingless bee	Hymenoptera	Apidae
6	*Megachile disjuncta*	Leaf cutter bee	Hymenoptera	Megachilidae
7.	*Xylocopa iridipennis*	Carpenter bee	Hymenoptera	Xylocopidae
8.	*Anthophora sp*	Digger bee	Hymenoptera	Anthophoridae
9.	*Halictus spp*	Sweat bee	Hymenoptera	Halictidae
10.	*Nomia sp.*	Alkali bee	Hymenoptera	Halictidae
11.	*Syrphus corollae*	Syrphid fly	Diptera	Syrphidae
12.	*Pieris brassicae*	Cabbage butterfly	Lepidoptera	Pieridae
13.	*Hypolimnas bolina*	Blue moon butterfly	Lepidoptera	Nymphalidae
14.	*Eurema blanda*	Three spot grass yellow butterfly	Lepidoptera	Pieridae
15.	*Papilio demoleus*	Swallowtail butterfly	Lepidoptera	Papilionidae
16.	*Trigona iridipenni*	Stingless bee	Hymenoptera	Apidae
17.	*Sphaerophoria philanthus*	Syrphid fly	Diptera	Syrphidae

Table 2: Average time spent by different insect visitors on sunflowers at different hours of the day

Sr. No	Bee Species	Time spent/flower(sec)				
		0800-1000	1000-1200	1400-1600	1600-1800	Mean
1.	*Apis mellifera*	22.33±4.82	17.33±4.27	15.33±4.03	14.67±3.95	17.42±4.26
2.	*A. dorsata*	19.67±4.54	21.33±4.72	16.67±4.19	15.67±4.07	18.33±4.38
3.	*A. cerana indica*	16.33±4.15	16.33±4.15	14.67±3.95	13.67±3.83	15.25±4.02
4.	*Trigona laeviceps*	14.67±3.94	12.33±3.65	10.33±3.35	9.67±3.26	11.75±3.55
5.	*Megachile disjuncta*	18.67±4.42	16.67±4.19	15.67±4.07	14.67±3.95	16.42±4.15
6.	*Xylocopa iridipennis*	21.33±4.71	17.33±4.27	15.33±4.03	14.67±3.95	17.17±4.24
7.	*Anthophora sp*	16.33±4.15	12.67±3.69	11.67±3.55	11.67±3.55	13.08±3.73
8.	*Halictus spp*	15.33±4.03	13.33±3.77	12.33±3.64	11.33±3.50	13.08±3.73
9.	*Nomia sp.*	10.67±3.41	14.33±3.90	13.33±3.77	12.67±3.67	12.75±3.68
10.	*Syrphus corollae*	17.67±4.31	13.67±3.82	14.33±3.91	13.33±3.77	14.75±3.95
11.	*Pieris brassicae*	15.67±4.08	15.33±4.03	14.67±3.94	13.67±3.81	14.83±3.96
12.	*Hypolimnas bolina*	11.67±3.55	15.67±4.08	14.67±3.95	12.67±3.69	13.67±3.81
13.	*Eurema blanda*	12.33±3.64	17.33±4.27	15.67±4.08	14.33±3.91	14.92±3.97
14.	*Papilio demoleus*	10.33±3.35	13.67±3.82	14.67±3.95	12.67±3.69	12.83±3.70
15.	*Trigona iridipenni*	14.33±3.91	13.33±3.77	11.33±3.50	10.67±3.41	12.41±3.64

	C.D. at 5%	0.32	0.38	0.40	0.40	
	SE(m)	0.11	0.13	0.13	0.13	
	SE(d)	0.15	0.18	0.19	0.19	
	C.V.	4.76	5.67	6.17	6.17	

Table 3: Relative abundance of different insect visitors on sunflowers of during different hours of the day.

Sr. No	Bee Species	Insect visitors/2m^2/2 min at different time interval				
		0800-1000	1000-1200	1400-1600	1600-1800	Mean
1.	*Apis mellifera*	4.33±2.29	13.67±3.82	16.67±4.20	9.67±3.26	11.08±3.39
2.	*A. dorsata*	5.33±2.49	5.33±2.48	6.33±2.68	6.33±2.69	5.83±2.58
3.	*A. cerana indica*	6.67±2.74	8.33±3.05	12.33±3.64	6.67±2.74	8.50±3.04
4.	*Trigona laeviceps*	6.33±2.66	8.67±3.09	10.67±3.41	5.33±2.50	7.75±2.91
5.	*Megachile disjuncta*	5.67±2.56	6.33±2.68	8.33±3.02	4.67±2.28	6.25±2.63
6.	*Xylocopa iridipennis*	3.33±2.06	3.67±2.13	5.33±2.49	3.33±2.06	3.92±2.18
7.	*Anthophora sp*	4.33±2.27	7.33±2.88	9.67±3.26	3.67±2.13	6.25±2.63
8.	*Halictus spp*	7.67±2.94	7.67±2.93	9.33±3.20	4.33±2.30	7.25±2.84
9.	*Nomia sp.*	6.33±2.66	5.67±2.57	7.33±2.87	3.67±2.08	5.75±2.54
10.	*Syrphus corollae*	6.67±2.74	8.33±3.00	10.33±3.35	3.33±2.06	7.17±2.78
11.	*Pieris brassicae*	7.67±2.92	12.33±3.64	13.67±3.82	2.67±1.88	9.08±3.06
12.	*Hypolimnas bolina*	4.67±2.35	6.67±2.76	8.67±3.10	2.67±1.88	5.67±2.52
13.	*Eurema blanda*	5.33±2.49	8.67±3.10	9.33±3.20	3.33±2.06	6.67±2.71
14.	*Papilio demoleus*	9.67±3.26	12.33±3.64	12.33±3.65	2.67±1.88	9.25±3.10
15.	*Trigona iridipenni*	2.67±1.88	13.33±3.78	14.67±3.95	3.33±2.06	8.50±2.91
	C.D. at 5%	0.66	0.40	0.34	.70	
	SE(m)	0.22	0.13	0.11	0.24	
	SE(d)	0.32	0.19	0.16	0.34	
	C.V.	15.36	7.82	6.22	18.52	

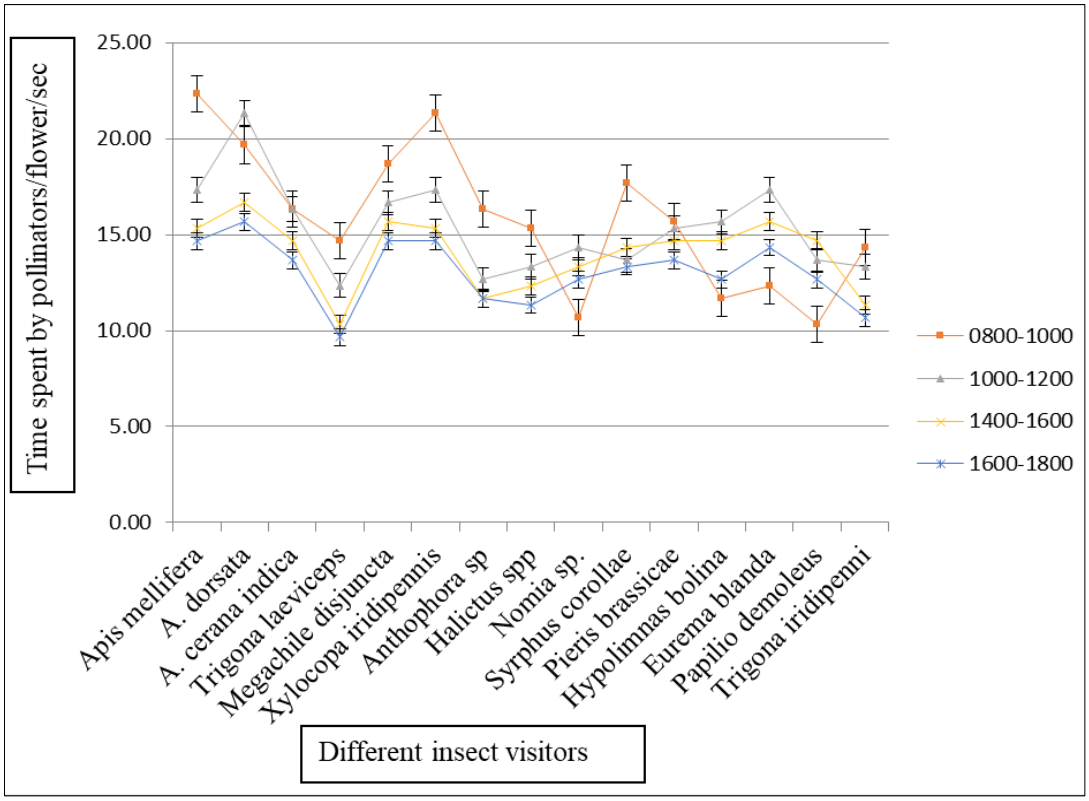

Fig 1: Average time spent by different insect visitors on sunflowers at different hours of the day during May- July2020 at MBRT (Pantnagar)

Conclusion

In conclusion, this study provides insights into the importance of pollinator insects to help plant pollination, included sun flower an importance crop in the tropic. The findings of the present investigation revealed that, totally 17 species belonging to different insect orders forage on sunflower inflorescence, the diversity was more during 1000 to 1200 hours and 2000-4000 hr both at 50 and 100 per cent flowering. It is clear from present finding that the sunflower capitulum in bloom is highly attractive to multitude of insect species, especially those belonging to Hymenoptera. Lepidoptera and Diptera. The results indicate a diversity and abundance of pollinator insects, especially bees, plays a significant role in seed set of sunflower. Hence, conservation of bee species by encouraging increased forage crops in the vicinity of cropped areas is recommended which enriches biodiversity along the line.

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