



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(3): 1157-1162

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Received: 18-03-2020

Accepted: 20-04-2020

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Surveying, record keeping and identifying the various insect pollinators visiting mango inflorescence under coastal Odisha conditions

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DOI: <https://doi.org/10.22271/chemi.2020.v8.i3o.9356>

Abstract

The present studies entitled “Studies on diversity of insect pollinators of mango (*Mangifera indica* L.) under coastal Odisha condition” have been undertaken during flowering season, 2018-2019 at OUAT orchard, Bhubaneswar, CHES, Bhubaneswar, Farmer’s field, Berhampur and Farmer’s field, Sakhigopal, so as to evince that the present status of various insect pollinators on mango inflorescence. Attempts were made to identify and document the pollinators visiting mango flower and experiments were conducted to study the foraging behaviour. The foraging activity of insect pollinators based on the mean of all the three flowering periods revealed that the Indian honey bee was maximum with 2.77 bees/m²/5 min. followed by Horse fly (2.76 flies/m²/5 min.), Blow fly (2.56 flies/m²/5 min.), House fly (2.35 flies/m²/5 min.), Little bee (2.26 bees/m²/5 min.), Flesh fly (1.98 flies/m²/5 min.), Stingless bee (1.65 bees/m²/5 min.) and Wasp (1.18 wasps/m²/5 min.)

Keywords: Surveying record keeping various insect pollinators visiting mango

Introduction

Mango (*Mangifera indica* L.) belong to family *Anacardiaceae*, the “King of fruits” (Purseglove, 1972) believed to be native to South Asia. Its wide distribution throughout the tropics and its wider adaptability makes it most important fruit crops throughout the tropical regions of the world. Botanically the fruit is known as drupe and considered as the “National fruit of India”. In 2016, worldwide production of mangoes (report incorporates mangosteens and guavas) was 46.5 million tons, driven by India with 40% (19 million tons) of the world aggregate. India accounts for 22,62,800 ha in area, 19,68,6900 MT in production and 8.7 MT/ha productivity in the year 2016-17. Odisha accounts 199300 ha in terms of area and 816200 MT in production (Horticultural Statistics at a glance 2017) [1]. Pollinator-subordinate products form a basic piece of human eating regimens (Eilers *et al.*, 2011) [6]. Albeit current cultivating practices have empowered overall higher yield efficiency (Aizen *et al.*, 2008) [2], decreases in pollinator dependent crop yields have been observed, frequently owing to isolation from natural habitat (Klein, Steffan-Dewenter and Tscharntke 2003). In perspective of the expanding interest for animal pollinated crops in human diet control plans, such efficiency misfortunes can quicken change of regular regions to cropland (Garibaldi *et al.*, 2009) [2]. Worldwide, a number of insects are considered effective cross-pollinators of numerous crops. Mango pollination has been claimed to occur naturally by insects coming under the Order Diptera, Coleoptera, Lepidoptera and Hymenoptera (Valmayor, 1961) [16]. So cross pollination is mediated by the arthropod population mostly by insects. In order to increase the fruit set there is necessity of pollinators. The thorough scrutiny of published information suggests that there is a relationship between the floral biology of the crop and pollinator activity.

Materials and methods

The present investigation on the insect pollinators of mango flower was carried out in the OUAT orchard, Bhubaneswar, CHES, Bhubaneswar, Farmer’s field, Berhampur and Farmer’s field, Sakhigopal during 2017-19. The soil type of the experimental area is lateritic and situated at 20.29° N and 85.82° E; 45m above MSL.

In order to study the diversity of different insect pollinators visiting mango flowers, observations were taken during the flowering period of the crop. Collection of pollinators was done at 10 days interval during the early, mid and late flowering period in twenty sweeps each time at 08:00 a.m., 11:00 a.m., 01:00 p.m. and 04:00 p.m. covering all around the tree by using a sweeping net of 15 cm radius. After collection of pollinators, they were killed by using Ethyl acetate and dry preserved as per Borror *et al.* (1981) [3]. Identification of pollinators was done by matching with previously identified fauna of pollinators (Identified by AICRP on Honeybees & Pollinators, OUAT, Bhubaneswar and Division of Entomology, I.A.R.I., New Delhi). Diversity of pollinators was estimated by separating them based on their order and family, counting each and utilizing appropriate tools.

Observation on the foraging activity of Indian honey bee, Little bee, Horse fly, Blow fly, House fly, Flesh fly, Stingless bee and Wasp visiting on the flowers of mango in open pollination plot were made during the early flowering stage i.e. at 10-30% flowering followed by mid flowering stage i.e. at 31-70% flowering stage followed by late flowering stage i.e. at 71-100% flowering stage during different time period of a day i.e. 08:00 a.m.-09:00, 11:00 a.m.-12:00, 01:00 p.m.-02:00 p.m. and 04:00 p.m.-05:00 p.m. The observation were taken based on the number of insect pollinators visiting mango flowers per 1m² per 5 minute at randomly selected 10 spots within the field and the mean data was recorded for the final result. The data were computed for the study of activity

of pollinators during the cropping period and for estimation of activity of pollinators.

Results

The present studies entitled “Studies on diversity of insect pollinators of mango (*Mangifera indica* L.) under coastal Odisha condition” have been undertaken during flowering season, 2018-2019 at OUAT orchard, Bhubaneswar, CHES, Bhubaneswar, Farmer’s field, Berhampur and Farmer’s field, Sakhigopal, so as to evince that the present status of various insect pollinators on mango inflorescence. Attempts were made to identify and document the pollinators visiting mango flower and experiments were conducted to study the foraging behaviour.

Survey of insect pollinators on mango at costal condition of Odisha

Extensive survey was taken up at fortnight interval in mango field (Bhubaneswar, Berhampur and Sakhigopal) of coastal Odisha for collection of insect pollinators of mango inflorescence. After collection of insect pollinators, they were killed by using Ethyl acetate and dry preserved as per Borror *et al.* (1981) [3]. Total 19 number of species were collected from Bhubaneswar, 9 number of species from Berhampur and 9 number of species from Sakhigopal (4 number of species from Order Diptera and 5 number from order Hymenoptera) common being Indian honey bee, Little bee, Black ant, Horse fly, House fly and Flesh fly indicating their preference for the host. The survey report is indicated in Table 1.

Table 1: Survey of insect pollinators of mango at coastal Odisha during 2018-19

Sl. No.	Common Name	Scientific Name	Order	Place of collection		
				Bhubane-swar	Berham-pur	Sakhi- gopal
1.	Horse fly	<i>Tabanus</i> sp. Linnaeus	Diptera	✓	✓	✓
2.	House fly	<i>Musca</i> sp. Linnaeus	Diptera	✓	✓	✓
3.	Blow fly	<i>Chrysomya pingus</i> Rob.	Diptera	✓	✓	
4.	Blow fly	<i>Chrysomya megacephala</i> Rob.	Diptera	✓		✓
5.	Flesh fly	<i>Sarcophaga</i> sp. Meigen	Diptera	✓	✓	✓
6.	Hover fly	<i>Ischiodon scutellaris</i> Sack	Diptera	✓		
7.	Indian honey bee	<i>Apis cerana indica</i> Fabricius	Hymenoptera	✓	✓	✓
8.	Little bee	<i>Apis florea</i> Fabricius	Hymenoptera	✓	✓	✓
9.	Stingless bee	<i>Tetragonula iridipennis</i> Smith	Hymenoptera	✓		✓
10.	Allodapini bee	<i>Braunsapis hewitti</i> Michener	Hymenoptera	✓		
11.	Halictid bees	<i>Halictus scabiosae</i> Rossi	Hymenoptera	✓		
12.	Sweat bee	<i>Lasioglossum</i> sp. Curtis	Hymenoptera	✓		
13.	Paper wasp	<i>Polistes dominula</i> Christ	Hymenoptera	✓	✓	
14.	Small wasp	<i>Vespa</i> sp. Fabricius	Hymenoptera	✓	✓	
15.	Ichneumonid wasp		Hymenoptera	✓		✓
16.	Black ant	<i>Lasius niger</i> Linnaeus	Hymenoptera	✓	✓	✓
17.	Beetle		Coleoptera	✓		
18.	Green jewel bug	<i>Chrysocoris stollii</i> Hahn	Hemiptera	✓		
19.	Bug		Hemiptera	✓		

During the course of investigation foraging activities of major insect pollinators were also observed periodically at Bhubaneswar and the results obtained are furnished below.

Foraging activity of insect pollinators

The foraging activity of insect pollinators in the three period i.e. Early flowering (10 to 30 per cent flower), mid flowering (31 to 70 per cent flower) and late flowering period (71 to 100 per cent flower) during 2018-2019 of mango inflorescence is presented in the Table 2, Table 3 and Table 4 respectively. During early flowering period seven number (Indian honey bee, Little bee, Horse fly, Blow fly, House fly, Flesh fly and Wasp) of insect pollinators visited mango inflorescence and

their population density varied from 0.72 to 4.46 number of insect pollinators per m² per 5 minute is presented in Table 3. Studies during early flowering period evince that the population of Horse fly was the maximum with 4.46 flies /m²/5 min followed by Blow fly (4.09 flies/m²/5 min.), House fly (3.82 flies/m²/5 min.), Flesh fly (2.62 flies/m²/5 min.), Indian honey bee (1.43 bees/m²/5 min.), Wasp (0.79 wasps/m²/5 min.) and Little bee (0.72 bees/m²/5 min.). Though the peak incidence of different insect pollinators varied with time of foraging but the mean peak incidence was highest at 11:00 a.m. (0.85) followed by 08:00 a.m. (0.65) and the least (0.46) being in the afternoon hour at early flowering period.

Table 2: Foraging activities of different insect pollinators during early flowering period of mango during 2018-19

S. No.	Name of the species	Number of insect pollinators/m ² /5min				
		8:00 a.m.	11:00 a.m.	1:00p.m.	4:00 p.m.	Total
1	Horse fly	1.03	1.70	0.93	0.8	4.46
2	Blow fly	0.93	1.87	0.86	0.43	4.09
3	House fly	1.00	0.86	0.93	1.03	3.82
4	Flesh fly	0.70	0.76	0.63	0.53	2.62
5	Indian honey bee	0.53	0.30	0.27	0.33	1.43
6	Little bee	0.16	0.06	0.40	0.10	0.72
7	Wasp	0.20	0.4	0.13	0.06	0.79
	Mean	0.65	0.85	0.59	0.46	

During mid flowering period eight number (Indian honey bee, Little bee, Horse fly, blow fly, House fly, Flesh fly, Stingless bee and Wasp) of insect pollinators visited mango inflorescence and their population density varied from 1.32 to 3.83 number of insect pollinators per m² per 5 minutes is presented in Table 3.

It was observed that the mid flowering period the population density was higher as compared to both early and late flowering period during the flowering periods of mango during 2018-2019. It was evinced that the Horse fly has

shown the peak activity with 3.83 flies/m²/5 min. followed by House fly (3.24 flies/m²/5 min.), Stingless bee (1.89 bees/m²/5 min) Flesh fly (1.88 flies/m²/5 min.), Indian honey bee (1.79 bees/m²/5 min.) and Little bee (1.70 bees/m²/5 min.). Though the peak incidence of different insect pollinators varied with time of foraging but the mean peak incidence was highest at 11:00 a.m. (0.68) followed by 08:00 a.m. (0.62) and the least (0.43) at being in the afternoon hour at mid flowering period.

Table 3: Foraging activities of different insect pollinators during mid flowering period of mango during 2018-19

S. No.	Name of the species	Number of insect pollinators/m ² /5min				
		8:00 a.m.	11:00 a.m.	1:00 p.m.	4:00 p.m.	Total
1	Horse fly	0.93	1.30	0.90	0.70	3.83
2	Blow fly	0.56	0.93	0.66	0.56	2.71
3	House fly	0.86	0.96	0.76	0.66	3.24
4	Flesh fly	0.56	0.73	0.36	0.23	1.88
5	Indian honey bee	0.73	0.13	0.50	0.43	1.79
6	Little bee	0.56	0.50	0.37	0.27	1.70
7	Wasp	0.16	0.40	0.46	0.30	1.32
8	Stingless bee	0.63	0.53	0.43	0.30	1.89
	Mean	0.62	0.68	0.55	0.43	

During late flowering period six number (Indian honey bee, Little bee, Blow fly, Flesh fly, Stingless bee and Wasp) of insect pollinators visited mango inflorescence and their population density varied from 0.79 to 5.10 number of insect pollinators per m² per 5 minute presented in Table 4.

Studies during the late flowering period revealed that the population density decreased during the late flowering periods during 2018-2019 evince that the Indian honey bee shown the peak activity with 5.10 bees/m²/5 min. followed by Little bee (4.35 bees/m²/5 min.), Stingless bee (3.05 bees/m²/5 min.),

Flesh fly (1.45 flies/m²/5 min.), Wasp (1.42 wasps/m²/5 min.) and Blow fly (0.79 flies/m²/5 min.). Though the peak incidence of different insect pollinators varied with time of foraging but the mean peak incidence was highest at 11:00 a.m. (0.88) followed by 01:00 a.m. (0.66) and the least (0.51) at being in the afternoon hour at late flowering period.

Here it has shown that although the mean population Indian honey bee is lower in early and mid-flowering period but its population gradually increases and its population is maximum among all pollinators during late flowering period.

Table 4: Foraging activities of different insect pollinators during late flowering period of mango during 2018-19

Sl. No.	Name of the species	Number of insect pollinators/m ² /5min				
		8:00 a.m.	11:00 a.m.	1:00p.m.	4:00 p.m.	Total
1.	Blow fly	0.06	0.40	0.20	0.13	0.79
2.	Flesh fly	0.36	0.56	0.30	0.23	1.45
3.	Indian honey bee	1.10	1.90	1.10	1.00	5.10
4.	Little bee	1.13	1.36	1.06	0.80	4.35
5.	Wasp	0.20	0.26	0.53	0.43	1.42
6.	Stingless bee	0.96	0.83	0.80	0.46	3.05
	Mean	0.63	0.88	0.66	0.51	

The overall activity on taking mean of all the three periods revealed that the Indian honey bee shown the peak activity with 2.77 bees/m²/5 min. followed by Horse fly (2.76 flies/m²/5 min.), Blow fly (2.53 flies/m²/5 min.), House fly (2.35 flies/m²/5 min.), Little bee (2.26 bees/m²/5 min.), Flesh fly (1.98 flies/m²/5 min.), Stingless bee (1.65 bees/m²/5 min.) and Wasp (1.18 wasps/m²/5 min.) during flowering period of mango, 2018-2019 is presented in Table 5.

Attempts were made to document the foraging activity of insect pollinators in the four hours of a day which is calculated by taking data of ten locations for five minutes each, which is recorded in ten observations in ten days intervals which are shown in the Table 6. Results indicated that all the eight species were recorded at 08:00 a.m., 11:00 a.m., 01:00 p.m. and 04:00 p.m. Maximum species abundance is seen in 11:00 a.m. (2.09 insect pollinators/m²/5min.),

followed by 08:00 a.m.(1.67 insect pollinators/m²/5min.), (1.22 insect pollinators/m²/5min.) respectively, 01:00 p.m. (1.57 insect pollinators/m²/5min.) and 04:00 p.m.

Table 5: Foraging activities of different insect pollinators during all three-flowering period during different time period of days of mango during 2018-19

S. No.	Name of the species	Number of insect pollinators				Mean of three flowering period
		8:00 a.m.	11:00 a.m.	1:00 p.m.	4:00 p.m.	
1	Horse fly	1.96	3.0	1.83	1.50	2.76
2	Blow fly	1.55	3.2	1.72	1.12	2.53
3	House fly	1.86	1.82	1.69	1.69	2.35
4	Flesh fly	1.62	2.05	1.29	0.99	1.98
5	Indian honey bee	2.36	2.33	1.87	1.76	2.77
6	Little bee	1.85	1.92	1.83	1.17	2.26
7	Wasp	0.56	1.06	1.12	0.79	1.18
8	Stingless bee	1.59	1.36	1.23	0.76	1.65
	Mean	1.67	2.09	1.57	1.22	

Studies on the overall foraging activity expressed as per cent of pollinators to the total pollinators at different flowering period (Table 6) indicated that the major pollinators differed in their preference for visiting the mango inflorescence.

During early and mid-flowering period Horse fly, Blow fly and House fly are more prevalent compare to other pollinators while in late flowering period Indian honey bee was most prevalent followed by Little bee and Stingless bee.

Table 6: Foraging activities of different insect pollinators in different periods of flowering period on mango during 2018-19

Sl. No.	Name of the species	Number of pollinators (%)		
		Early flowering	Mid flowering	Late flowering
1	Horse fly	24.87	20.86	0.00
2	Blow fly	22.81	14.76	4.89
3	House fly	21.30	17.65	0.00
4	Flesh fly	14.61	10.24	8.97
5	Indian honey bee	7.97	9.75	31.56
6	Little bee	4.01	9.26	26.92
7	Wasp	4.40	7.19	8.79
8	Stingless bee	0.00	10.29	18.87

Foraging time on flower by insect pollinators

Data on foraging speed i.e. time spent by different insect pollinators on mango flower were recorded and presented in the Table 7. Results indicated that there is a marked variation in the time spent by different pollinators on each inflorescence. The mean time spent on each inflorescence varied between 6.0-9.0 sec with a mean of 7.33 sec in case of Indian honey bee, 8.0-12.0 sec with a mean of 10.33 sec in case of Little bee, 5.0-8.0 sec with a mean of 9.67 sec in case of Stingless bee, 11.0-15.0 sec with a mean of 13.33 sec in case of Horse fly, 12.0-15.0 sec with a mean of 13.33 sec in case of Blow fly, 12.0-15.0 sec with a mean of 13.67 sec in case of House fly, 9.0-12.0 sec with a mean of 10.67 sec in case of Flesh fly, 8.0-11.0 sec with a mean of 9.33 sec in case of Small house fly, 5.0-7.0 sec with a mean of 6.0 sec in case of Sweat bee and 2.0-4.0 sec with a mean of 3.0 sec in case of Halictid bee at 08:00 a.m.

The mean time spent on each inflorescence varied between at 10.0-13.0 sec with a mean of 11.67 sec in case of Indian honey bee, 10.0-14.0 sec with a mean of 12.0 sec in case of Little bee, 9.0-12.0 sec with a mean of 10.67 sec in case of Stingless bee, 12.0-17.0 sec with a mean of 14.67 sec in case of Horse fly, 13.0-17.0 sec with a mean of 14.0 sec in case of Blow fly, 14.0-16.0 sec with a mean of 15.0 sec in case of House fly, 10.0-12.0 sec with a mean of 11.0 sec in case of Flesh fly, 10.0-14.0 sec with a mean of 11.67 sec in case of Small house fly, 7.0-9.0 sec with a mean of 8.0 sec in case of Sweat bee and 4.0-6.0 sec with a mean of 5.0 sec in case of Halictid bee at 11:00 a.m.

The mean time spent on each inflorescence varied between 10.0-12.0 sec with a mean of 11.0 sec in case of Indian honey

bee, 8.0-11.0 sec with a mean of 9.33 sec in case of Little bee, 4.0-10.0 sec with a mean of 9.0 sec in case of Stingless bee, 27.0-32.0 sec with a mean of 29.33 sec in case of Horse fly, 17.0-19.0 sec with a mean of 17.67 sec in case of Blow fly, 14.0-18.0 sec with a mean of 15.67 sec in case of House fly, 10.0-14.0 sec with a mean of 12.0 sec in case of Flesh fly, 12.0-14.0 sec with a mean of 13.67 sec in case of Small house fly, 5.0-8.0 sec with a mean of 6.33 sec in case of Sweat bee and 3.0-5.0 sec with a mean of 4.0 sec in case of Halictid bee at 01:00 p.m.

The mean time spent on each inflorescence varied between 3.0-5.0 sec with a mean of 4.0 sec in case of Indian honey bee, 2.0-5.0 sec with a mean of 3.67 sec in case of Little bee, 2.0-3.0 sec with a mean of 2.33 sec in case of Stingless bee, 34.0-41.0 sec with a mean of 37.367 sec in case of Horse fly, 22.0-25.0 sec with a mean of 23.67 sec in case of Blow fly, 10.0-11.0 sec with a mean of 11.0 sec in case of House fly, 8.0-10.0 sec with a mean of 9.0 sec in case of Flesh fly, 8.0-10.0 sec with a mean of 9.0 sec in case of Small house fly, 3.0-5.0 sec with a mean of 4.0 sec in case of Sweat bee and 2.0-3.0 sec with a mean of 2.33 sec in case of Halictid bee at 04:00 p.m.

Time spent on mango inflorescence differed by different insect pollinators with different time period of the day during foraging. The mean maximum time spent was recorded to be highest in Horse fly with a mean of 37.67 sec at 04:00 p.m. and 29.33 sec at 01:00 p.m. followed by the Blow fly with a mean of 23.67 sec at 04:00 p.m. and 17.67 sec at 01:00 p.m., House fly with 15.67 sec at 01:00 p.m. and 15.0 sec at 11:00 a.m..Among Hymenoptera Little bee spent maximum time with 12.0 sec followed by Indian honey bee with 11.67 sec at

11:00 a.m. respectively, and Indian honey bee with 11.0 sec at 01:00 p.m. followed by Stingless bee 10.67 sec at 11:00 a.m.

It was found that Dipterans spent more time in comparison to Hymenopterans (Table 7).

Table 7: Time spent by different insect pollinators on mango inflorescence

Sl. No.	Name of species	Mean time spent on inflorescence (seconds)					Range of time spent inflorescence			
		08:00 a.m.	11:00 a.m.	01:00 p.m.	04:00 p.m.	Mean±SD	08:00 a.m.	11:00 a.m.	01:00 p.m.	04:00 p.m.
1.	Horse fly	13.33	14.67	29.33	37.67	23.75±10.20	11.0-15.0	12.0-17.0	27.0-32.0	34.0-41.0
2.	Blow fly	13.33	14.0	17.67	23.67	12.16±5.18	12.0-15.0	13.0-17.0	17.0-19.0	22.0-25.0
3.	House fly	13.67	15.0	15.67	11.0	13.83±1.79	12.0-15.0	14.0-16.0	14.0-18.0	10.0-11.0
4.	Flesh fly	10.67	11.0	12.0	9.0	10.66±1.08	9.0-12.0	10.0-12.0	10.0-14.0	8.0-10.0
5.	Small house fly	9.33	11.67	13.67	9.0	10.91±1.89	8.0-11.0	10.0-14.0	12.0-14.0	8.0-10.0
6.	Indian honey bee	7.33	11.67	11.0	4.0	8.5±3.08	6.0-9.0	10.0-13.0	10.0-12.0	3.0-5.0
7.	Little bee	10.33	12.0	9.33	3.67	8.83±3.13	8.0-12.0	10.0-14.0	8.0-11.0	2.0-5.0
8.	Stingless bee	9.67	10.67	9.0	2.33	7.91±3.28	5.0-8.0	9.0-12.0	4.0-10.0	2.0-3.0
9.	Sweat bee	6.0	8.0	6.33	4.0	6.08±1.42	5.0-7.0	7.0-9.0	5.0-8.0	3.0-5.0
10.	Halictid bee	3.0	5.0	4.0	2.33	3.58±1.01	2.0-4.0	4.0-6.0	3.0-5.0	2.0-3.0
	Mean	8.66	9.66	11.38	12.8					

*Mean of ten observations during each time of observation

Discussions

Survey of insect pollinators on mango

The survey report of present investigation of insect pollinators on mango during 2018-19 at costal condition of Odisha revealed that total 19 number of species were collected from Bhubaneswar, 9 number of species from Berhampur and 9 number of species from Sakhigopal belonging to Order Diptera, Hymenoptera, Hemiptera and Coleoptera common being Indian honey bee, Little bee, Black ant, Horse fly, House fly and Flesh fly. Kumar *et al.* (2016) [10] observed at Himachal Pradesh that mango was pollinated by numerous insects belonging to the orders Hymenoptera, Diptera, Lepidoptera and Coleoptera. Dag (2009) [5] in Israel documented 46 distinct species of pollinators in mango. Most of them belonged to three orders viz., Diptera (26), Hymenoptera (12), and Coleoptera (6). Sung *et al.* (2006) [15] reported that one hundred and twenty-six individual insects with thirty nine species belonging to twenty three families and five orders were observed as insect pollinators on mango blooms from February 13 to March 17, 2005 in Southern Taiwan and Dag and Gazit (2000) [4] reported that 46 distinct species or types were found to visit mango bloom in three consecutive years. They found that most insects belonged to the order Diptera (26), Hymenoptera (12) and Coleoptera (6). The present study corroborated with the report of earlier researchers.

Foraging activity of insect pollinators

Observation on foraging activity of insect pollinators in the four hours of a day which is calculated by taking data of ten locations for five minutes each, which is recorded in ten observations in ten days intervals revealed that all the eight species were recorded at 08:00 a.m., 11:00 a.m., 01:00 p.m. and 04:00 p.m. Maximum species abundance is seen in 11:00 a.m. (2.09 insect pollinators/m²/5min.), followed by 08:00 a.m. (1.67 insect pollinators/m²/5min.), 01:00 p.m. (1.57 insect pollinators/m²/5min.) and 04:00 p.m. (1.22 insect pollinators/m²/5min.) respectively. The investigation supported by Kumari *et al.* (2014) [11] surveyed in the mango orchard at Fruit Research Station, Sangareddy, Andhra Pradesh and pollinators were observed and recorded during peak flowering stage in fifty tagged inflorescences of five trees. Rummaging of pollinators were seen on mango blooms for 7 am to 9 am and 4 pm to 6 pm. The majority of these insect pollinators had a place with the Order Diptera and Hymenoptera. Fajardo *et al.* (2008) [7] reported that at Opina's

Mango Farm, in Barangay Sirang-Lupa, Calamba City, Laguna from 03 November 2006 to 10 April 2007 that the actively foraging timing was from 7:00–10:59 hr, with the peak period occurring at 8:00–8:59 hr. There was synchronization in foraging activity and flower anthesis. In present investigation Dipterans rummaging inflorescence at morning hour which is an agreement. However, Singh (1988) [14] observed that the most frequent insect visitor on mango flower were syrphid flies. On an average, in one minute, per panicle (untreated) 4 to 8 syrphid fly adults visited at 10 a.m. on a clear sunny day.

Foraging time on flower by insect species

Observation on time spent on mango inflorescence during 2018-19 revealed that time spent differed by different insect pollinators with different time period of the day during foraging. The mean maximum time spent was recorded to be highest in Horse fly with a mean of 37.67 sec at 04:00 p.m. and 29.33 sec at 01:00 p.m. followed by the Blow fly with a mean of 23.67 sec at 04:00 p.m. and 17.67 sec at 01:00 p.m., House fly with 15.67 sec at 01:00 p.m. and 15.0 sec at 11:00 a.m.. Among Hymenoptera Little bee spent maximum time with 12.0 sec followed by Indian honey bee with 11.67 sec at 11:00 a.m. respectively, and Indian honey bee with 11.0 sec at 01:00 p.m. followed by Stingless bee 10.67 sec at 11:00 a.m. It was found that Dipterans spent more time in comparison to Hymenopterans. The present investigation was supported by Phoon *et al.* (1984) [12] concluded that *Lucilia* sp. spend 15 minutes per panicle and gnaw with its proboscis at the nectarines and traverse up and down several time before taking flight and Adegas *et al.* (1992) [1] observed that a bee spent an average of 3.2-3.5 second on a rapeseed flower. Stingless bees and honeybees spends 20 seconds on each flower from 0700-1100hr.

Conclusions

The research work entitled “Studies on diversity of insect pollinators of mango (*Mangifera indica* L.) under coastal Odisha condition” have been undertaken during 2018-2019 at OUAT orchard, Bhubaneswar, CHES, Bhubaneswar, Farmer's field, Berhampur and Farmer's field, Sakhigopal. Survey of insect pollinators on mango inflorescence at costal condition of Odisha revealed that occurrence of 19 number of species from Bhubaneswar, 8 number of species from Berhampur and 8 number of species from Sakhigopal belonging to four Orders viz. Diptera, Hymenoptera,

Hemiptera and Coleoptera. Indian honey bee, Little bee, Black ant, Horse fly, House fly and Flesh fly were recorded in all the locations.

During early flowering period, seven number of insect pollinators viz. Indian honey bee, Little bee, Horse fly, Blow fly, House fly, Flesh fly and Wasp foraged on mango inflorescence and their population density varied from 0.72 to 4.46 number of per m² per 5 minute with Horse fly being the most frequent visitors.

In mid flowering period eight number (Indian honey bee, Little bee, Horse fly, Blow fly, House fly, Flesh fly, Stingless bee and Wasp) of insect pollinators visited mango inflorescence and their population density varied from 1.32 to 3.83 number of insect pollinators per m² per 5 minute with Horse fly showing maximum occurrence (3.83 flies /m²/5 min)

In late flowering period six number (Indian honey bee, Little bee, Blow fly, Flesh fly, Stingless bee and Wasp) of insect pollinators visited mango inflorescence and their population density varied from 0.79 to 5.10 number of insect pollinators per m² per 5 minute with Indian honey bee showing the maximum density of 5.10 bees/m²/5 min.

The foraging activity of insect pollinators based on the mean of all the three flowering periods revealed that the Indian honey bee was maximum with 2.77 bees/m²/5 min. followed by Horse fly (2.76 flies/m²/5 min.), Blow fly (2.56 flies/m²/5 min.), House fly (2.35 flies/m²/5 min.), Little bee (2.26 bees/m²/5 min.), Flesh fly (1.98 flies/m²/5 min.), Stingless bee (1.65 bees/m²/5 min.) and Wasp (1.18 wasps/m²/5 min.)

The overall foraging activity indicated that during early and mid-flowering period Horse fly, blow fly and House fly are more prevalent compared to the other pollinators while in late flowering period Indian honey bee was most prevalent followed by Little bee and Stingless bee.

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