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Foraging Behaviour of Major Pollinators in Bitter Gourd

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A B S T R A C T

Field experiments were conducted to record the diversity of floral visitors/pollinators in Bitter gourd *Kharif* season, 2018, with three replications. The experimental plot was kept free from chemical sprays during the flowering period. Insects belonging to various orders like Hymenoptera, Lepidoptera, Diptera, Hemiptera and Coleoptera were found visiting the bitter gourd flowers. Major pollinators of bitter gourd have been identified by their foraging activity. Foraging behaviour of major pollinators were recorded during different hours of the day *viz*. 0600 to 1800h based on No. of individuals/5min/m^2, Time spent by one individual (sec) on each flower, No. of flowers visited by one individual /5min and No. of individuals visited per flower/5min. Insects foraging on pollen and nectar from the flower were also recorded. From the above observations it was found that the bees forage on bitter gourd flowers very actively from 0600 to 1600 hours at a varying level.

Introduction

Momordica charantia is a tropical and subtropical vine of the family Cucurbitaceae, widely grown in Asia, Africa, and the Caribbean for its edible fruit. Its pods (fruits) are rich sources of phytonutrients like dietary fiber, minerals, vitamins, and anti-oxidants. Bitter melon notably contains phytonutrient, polypeptide-P and plant *insulin* known to lower blood sugar levels. Also, it composes hypoglycemic agent called Charantin. *Charantin* increases glucose uptake and glycogen synthesis inside the cells of the liver, muscle, and fatty (adipose) tissue. Together, these compounds may have been thought to be responsible for blood sugar levels reduction in the treatment of type-2 diabetes. Fresh pods are the excellent source of folates, carrying about 72 µg/100g (18% of RDA). Vitamin folate when taken by mothers during their early pregnancy time would help reduce the incidence of neural tube defects in the newborn babies.

Fresh fruit of bitter gourd is an excellent source of vitamin-C (100 grams of fresh pod provides 84 mg or about 140% of RDI). Vitamin-C is one of the powerful natural antioxidants which helps scavenge harmful free radicals from the human body. Further, it is an excellent source of health benefiting

flavonoids such as β-carotene, α-carotene, lutein, and zea-xanthin. It also contains a good amount of vitamin-A. Together, these compounds help act as protective scavengers against oxygen-derived free radicals and reactive oxygen species (ROS) that play a role in aging, cancers and various disease processes. Bitter melon stimulates smooth digestion and peristalsis of food through the bowel until it excreted from the body. Thus, it helps in relieving indigestion and constipation problems. Further, it has small amounts of B-complex vitamins such as niacin (vitamin B-3), pantothenic acid (vitamin B-5), pyridoxine (vitamin B-6) and minerals such as iron, zinc, potassium, manganese and magnesium (USDA National Nutrient data base).

Pollination is a problem in cucurbits because of the Monoecious flowering habit. The bitter gourd flowers starts opening at 0300 hours of the day and open fully at 0530 hours to 1200huors. The yield of the crop varies widely due to the pollination gap than fertilizer and pest related problems (Motzke *et al.,* 2015). Male: Female flower ratio will be 25:1 (Palada and Chang, 2003) and 19:1 (Deyto and Cervancia, 2009). Male flowers bloom two weeks earlier to female flowers during long days and vice versa during short days. Spraying flowering hormones to increase the number of flowers and therefore the fruits can increase the yield, but pollination of the flowers is challenging. Any material to increase the visit of pollinators can have greater impact on harnessing pollination (Viraktamath and Anagoudar, 2002). The present experiment was performed to study the pollinator activity in bitter gourd therefore to take-up necessary actions to improve pollination by increasing pollinator activity.

Materials and Methods

Periodical field survey was conducted at weekly intervals during *Kharif*, 2018, with three replications. The experimental plot was kept free from chemical sprays during the flowering period. The diversity of floral visitors/ pollinators of bitter gourd were recorded in five randomly selected one square meter area during flowering period at 0600 - 0800, 0800 - 1000, 1000 - 1200, 1200 - 1400, 1400 - 1600 and 1600 - 1800 h for five minutes. The data were later averaged time-wise and group-wise to infer the pollinator fauna as well as the dominance of particular group. Foraging behaviour of major pollinators of bitter gourd were recorded based on No. of individuals/5min/m^2, Time spent by one individual (sec) in each flower, No. of flowers visited by one individual /5min and No. of individuals visited per flower/5min. Insects foraging on pollen and nectar from the flower have also been recorded by observing the foraging activity of the insect visually to know the role of the flower visitors in pollination service. Honeybees with their activity of extending their proboscis into the flowers are considered as nectar collectors and bees carrying pollen on their hind legs were determined as pollen collectors (Balachandra *et al.,* 2014).

Statistical analysis

The mean values were square root transformed and compared by Least Significant Difference (LSD) at 5 per cent probability with AGRES to assess the effective pollinator at different hours.

Results and Discussion

Insects belonging to various orders like Hymenoptera, Lepidoptera, Diptera, Hemiptera and Coleoptera (Table 1) were found visiting bitter gourd flowers during the study period where hymenopterans dominated other floral visitors. Foraging behaviour of major hymenopteran pollinators are discussed in this paper with a view of acquiring more

knowledge about the pollinator activity in bitter gourd ecosystem and to take-up pest control activities accordingly.

T. iridipennis was the major pollinator of bitter gourd with an abundance of 2.78 individuals/5min/m^2 followed by *A. florea* (1.46), *Halictus* sp (1.02) and *A. cerana indica* (0.90) (Fig1).

Time spent by every individual in each flower (average) varies as 48.12 seconds in *T. iridipennis*, while it was 25.42 seconds in *A. florea* and 18.25 seconds in *Halictus* sp. followed by 3.91 seconds in *A. cerana indica* (Fig1).

Also the average number of flowers visited by one individual was chief with 5.56 by *T. iridipennis*, followed by *A. florea, A. cerana indica* and *Halictus* sp. with 4.12, 3.95 and 3.17 respectively, which shows the swiftness of Indian bees (*A. cerana indica*) as a pollinator. No. of bees visiting one flower in 5min (mean) ranged from 0.86 in *Halictus* sp. to 2.99 in *T.iridipennis* and 1.70, 1.48 in *A. floraea* and *A. cerana indica* (Fig1).

The activity of *T. iridipennis* was maximum during 0600 – 1200h where the no. of individuals/5min/m^2, time spent by one individual (sec) in each flower and no. of flowers visited by one individual /5min were maximum with a peak activity during 0600 – 0800h. Abundance of *T. iridipennis* was in the order 5.29, 6.26 and 3.28 during 0600 – 0800, 0800 – 1000 and 1000 – 1200h respectively (Table 2). Average time spent by one individual per flower during the peak hours was in the range 118.64 (sec), 6364(sec) and 56.56(sec) respectively (Table 3). While the no. of flowers visited by one individual /5min was at the maximum at all hours with 4.67, 5.67, 16.67, 14.0, 6.0 and 3.0 flowers at 0600 – 0800, 0800 – 1000, 1000 – 1200, 1200 – 1400, 1400 – 1600 and 1600 - 1800h one by one (Table 4). No. of bees visiting one flower in 5min was 5.70 in 0600 – 0800h and 5.50 at 0800 – 1000h (both on par) followed by 3.27 and 2.23 from 1000 – 1200 and 1200 – 1400h respectively (on par). No. of bees visiting a single flower was minimum during 1400 – 1600 and 1600 – 1800 with 1.00 and 0.23 bees respectively (on par) (Table 5).

A. florea exhibited high pollinating (foraging) activity right from 0900 to 1600 hours with highest activity during 1000 – 1200h followed by 1200 – 1400h which extends up-to 1600 with a slight decrease after 1400h. During the peak foraging periods the abundance of *A. florea* was 5.02, 2.86 and 0.58 individually at 1000 – 1200, 1200 – 1400h and 1400 – 1600 hours (Table 2). While the average time spent by one individual per flower was 46.00(sec) at 1000 – 1200h, 52.00(sec) at 1200 – 1400h (on par) and 28.00 and 26.32(sec) during 0800 – 1000 (selectively after 0930h) and 1400 – 1600 hours (Table 3). Number of flowers visited on an average by one individual was 10.0 at 1000 – 1200h and 7.34 at 1200 – 1400 hours which represents the peak foraging periods of *A. florea.* Bitter gourd flowers attracted maximum no. of little bees during 1000 – 1200 and 1200 – 1400h (4.1 and 3.83) (Table 4). Whereas number of bees visiting bitter gourd flowers at 0800 – 1000 h was 1.17 and 1.07 during 1400 – 1600 hours (Table 5).

Regarding *A. cerana indica* abundance, average time spent per flower and number of flowers visited was maximum at 0600 – 0800h, while the time spent were on par for 0600 – 0800 and 0800 – 1000h. The abundance was at the maximum at 0600 – 0800h (2.48) (Table 2), while the time spent was on par between 0600 – 0800h and 0800 – 1000h (9.01 and 8.12 seconds), slightly decreasing during 1000 – 1200 (3.83 seconds) hours (Table 3). Number of flower visited was in the peak during 0600 – 0800h with

10.66 flowers and on par from 0800 to 1200 hours with 6.34 and 4.0 flowers for 0800 – 1000h and 1000 – 1200h (Table 4). Bitter gourd lured 3.67 and 3.17 bees from 0600 – 0800 and 0800 – 1000h respectively (Table 5). While number of bees visiting bitter gourd flowers was reduced to 1.17 in 1000 – 1200h, 0.5 in 1200 – 1400h and 0.34 during 1400 – 1600h (Table 5). Thus, the Indian bees (*A. cerana indica*) act as an effective pollinator of bitter gourd from 0600 – 1000 hours.

Abundance of *Halictus* sp. was maximum (2.73) at 1000 – 1200 hours followed by 1.41 during 0800 – 1000h (Table 2). Time spent per flower was higher from 0800h to 1200h with 42.42 and 38.32 seconds followed by 22.23 seconds during 1200 – 1400 hours (Table 3). However the number of flowers visited was on par from 0800 to 1400 hours (5.00, 6.00 and 4.67) (Table 4) and number of bees visiting bitter gourd flowers was higher 1.63 and 1.60 at 1000 – 1200 and 1200 – 1400h followed by 1.10 in 0800 – 1000h and 0.77 in 1400 – 1600 hours (Table 5).

The results of our experiment are in accordance with the findings of (Subhakar *et al.*, 2013) who reported that *Trigona iridipennnis*, *Halictus guttuorosus* and *Apis florae* as major pollinator of bitter gourd among the 14 species of pollinators recorded. Six hymenopterans, five Lepidopterans and three Dipterans were recorded pollinating bitter gourd flowers by (Subhakar *et al.*, 2013).

Further our findings are also in line with (Mann, 1953; Mcgregor *et al.*, 1950; Mcgregor and Todd, 1952; Mcgregor, 1965) who reported that bee activity in cantaloupe flowers reaches its peak during 1100 and 1200 hours while it opens shortly after 0700 - 0800 and becomes scanty in late afternoon.

Table.1 List of major pollinators in bitter gourd and their role as pollinators

S.no.	POLLINATORS	FAMILY	ROLE	
			Pollen	Nectar
Hymenoptera				
1.	*Apis cerana indica* Fab	Apidae	+	+
2.	*Apis dorsata* Fab	Apidae	+	+
3.	*Apis florea* Fab	Apidae	+	+
4.	*Tetragonula iridipennis* Smith	Apidae	+	+
5.	*Amegilla zonata* L	Apidae	+	+
6.	*Xylocopa violacea* L	Xylocopidae	+	+
7.	*Halictus* sp.	Halicitidae	+	+
Diptera				
8.	*Syrphus ribesii* L	Syrphidae	-	+
Lepidoptera				
9.	*Danaius chrysippus* L	Nymphalidae	-	+
10.	*Tirumala limniace* Cramer	Nymphalidae	-	+
Coleoptera				
11.	*Aulacophora* sp.	Chrysomelidae	-	+

*+ collects, – does not collects

Table.2 Abundance of major pollinators in bitter gourd flowers

Time (hours)	No. of individuals/5min/m^2			
	A. cerana indica	*A. florae*	*T.iridipennis*	*Halictus* sp.
0600 – 0800	2.48 (1.73)^{a}	0.00e (0.71)^{e}	5.29 (2.30)^{ab}	0.00 (0.71)^{e}
0800 – 1000	2.13 (1.62)^{b}	0.28 (0.88)^{d}	6.26 (2.50)^{ab}	1.41 (1.38)^{b}
1000– 1200	0.72 (1.10)^{c}	5.02 (2.34)^{a}	3.28 (1.81)^{a}	2.73 (1.80)^{a}
1200– 1400	0.02 (0.72)^{d}	2.86 (1.83)^{b}	1.46 (1.21)^{bc}	1.34 (1.35)^{c}
1400– 1600	0.02 (0.72)^{d}	0.58 (1.04)^{c}	0.24 (0.49)^{c}	0.62 (1.05)^{d}
1600– 1800	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.16 (0.40)^{c}	0.00 (0.71)^{e}
S.Ed	0.0563	0.0648	0.7637	0.0107
CD (0.05)	0.1255	0.1445	1.7016	0.0239

*Each value is a mean of twenty one week observation.
Figures in parenthesis are square root transformed values
In a column, means followed by same letter(s) are on par by LSD (p= 0.05)

Table.3 Time spent by major pollinators of bitter gourd in each flower

Time (hours)	Time spent by an individual(sec) in each flower			
	A. cerana indica	*A. florae*	*T.iridipennis*	*Halictus* sp.
0600 – 0800	9.01 (3.08)^{a}	0.00 (0.71)^{c}	118.64 (10.92)^{a}	0.00 (0.71)^{e}
0800 – 1000	8.12 (3.07)^{a}	28.00 (5.34)^{b}	63.64 (8.01)^{b}	42.42 (6.55)^{a}
1000– 1200	3.83 (2.08)^{b}	46.00 (6.82)^{a}	56.56 (7.56)^{b}	38.32 (6.23)^{b}
1200– 1400	1.33 (1.35)^{c}	52.20 (7.23)^{a}	32.32 (5.73)^{c}	22.23 (4.77)^{c}
1400– 1600	1.17 (1.29)^{c}	26.32 (5.18)^{b}	14.28 (3.84)^{d}	06.52 (2.65)^{d}
1600– 1800	0.00 (0.71)^{d}	0.00 (0.71)^{c}	03.26 (1.93)^{e}	0.00 (0.71)^{e}
S.Ed	0.1693	0.2363	0.8086	0.0321
CD (0.05)	0.3773	0.5266	1.8017	0.0715

*Each value is a mean of twenty one week observation.
Figures in parenthesis are square root transformed values
In a column, means followed by same letter(s) are on par by LSD (p= 0.05)

Table.4 No. of flowers visited by one individual /5min in bitter gourd flowers

Time (hours)	No. of flowers visited by an individual /5min			
	A. cerana indica	*A. florae*	*T.iridipennis*	*Halictus* sp.
0600 – 0800	10.66 (3.27)[a]	0.00 (0.71)[d]	4.67 (2.27)[b]	0.00 (0.71)[c]
0800 – 1000	6.34 (2.62)[b]	04.34 (2.20)[c]	5.67 (2.48)[b]	5.0 (2.35)[a]
1000– 1200	4.0 (2.12)[b]	10.0 (3.24)[a]	16.67 (4.14)[a]	06.00 (2.55)[a]
1200– 1400	1.5 (1.41)c	7.34 (2.80)[b]	14.0 (3.81)[a]	4.67 (2.27)[a]
1400– 1600	1.17 (1.29)[c]	3.0 (1.87)[c]	6.0 (2.55)[b]	3.34 (1.96)[b]
1600– 1800	00.00 (0.71)[d]	0.00 (0.71)[d]	3.0 (1.87)[b]	0.00 (0.71)[c]
Mean	3.95	4.12	5.56	3.17
S.Ed	0.2262	0.1549	0.3448	0.1624
CD (0.05)	0.5040	0.3452	0.7683	0.3619

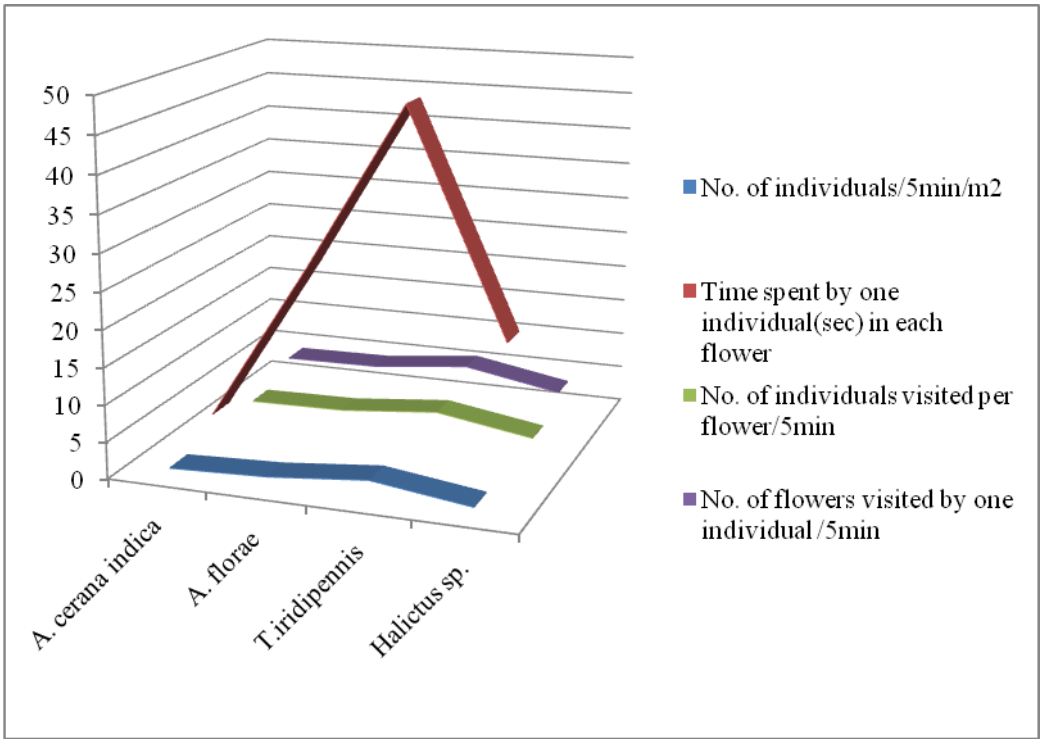
*Each value is a mean of twenty one week observation.
Figures in parenthesis are square root transformed values
In a column, means followed by same letter(s) are on par by LSD (p= 0.05)

Table.5 No. of individuals of major pollinators each flower received/5min

Time (hours)	No. of individuals visited per flower/5min			
	A. cerana indica	*A. florae*	*T.iridipennis*	*Halictus* sp.
0600 – 0800	3.67 (2.04)[a]	0.00 (0.71)[b]	5.70 (2.49)[a]	0.00 (0.71)[b]
0800 – 1000	3.17 (1.91)[a]	1.17 (1.29)[b]	5.50 (2.45)[a]	1.10 (1.26)[a]
1000– 1200	1.17 (1.29)[b]	4.1 (2.14)[a]	3.27 (1.94)[b]	1.63 (1.46)[a]
1200– 1400	0.5 (1.0)[c]	3.83 (2.08)[a]	2.23 (1.65)[b]	1.60 (1.45)[a]
1400– 1600	0.34 (0.91)[c]	1.07 (1.25)[b]	1.00 (1.224)[c]	0.77 (1.13)[ab]
1600– 1800	0.00 (0.71)[c]	0.001 (0.71)[b]	0.23 (0.85)[c]	0.00 (0.72)[b]
S.Ed	0.1917	0.2498	0.1820	0.2041
CD (0.05)	0.4271	0.5566	0.4055	0.4548

*Each value is a mean of twenty one week observation.
Figures in parenthesis are square root transformed values
In a column, means followed by same letter(s) are on par by LSD (p= 0.05)

Fig.1 Foraging behaviour of major pollinators in bitter gourd



Our results are in accordance with the reports of (Nidagundi and Sattagi, 2005) who observed the foraging activity of bees on bitter gourd was observed from 08:00 hours to 18:00 hours of the day, during 10 percent flowering. Foraging activity *A. dorsata* and *A. florea* were observed from 08:00 to 18:00 h of the day, with the highest foraging activity at 12:00 h with 6.68 and 15.44 bees/m^2/5min., respectively. But, *Apis cerana* and other pollinators foraging activity was maximum at 10:00 hours, with 12.51 bees/m^2/5min. and 6.39 pollinators /m^2/5min.

From our findings it is clear that the activity of major pollinators falls between 0600 hours and 1400 hours. Farmers should take care to increase the activities of pollinators and perform agronomic practices accordingly. Our suggestion from this experiment is that pest control measures should be taken after 1600 hours in order to safeguard the pollinating insect species from the adverse effect of insecticidal applications, since the number of bees visiting the flowers by major pollinators is maximum till 1600h. Moreover use of inorganic chemicals in bitter gourd pest control is not advisable. Use of phyto-insecticides prepared from plant leaves and organic formulations like NSKE, Neem Oil and Chilli-Garlic extract which are found to be safer to honey bees are advisable in bitter gourd pest control.

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