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POLLINATOR DIVERSITY AND POLLINATION EFFICIENCY OF STINGLESS BEE *TETRAGONULA IRIDIPENNIS* SMITH IN BITTER GOURD

K Balaji[1]*, J Jayaraj[1], M Shanthi[2], S Vellaikumar[3], C Rajamanickam[4], N Chitra[5] and K Suresh[6]

[1]Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai, Tamil Nadu Agricultural University (TNAU), Coimbatore 641003, Tamil Nadu, India
[2]Centre for Plant Protection Studies, TNAU, Coimbatore 641003, Tamil Nadu, India
[3]Centre for Plant Molecular Biology and Biotechnology, TNAU, Coimbatore 641003, Tamil Nadu, India
[4]Horticulture College and Research Institute, Periyakulam, TNAU, Coimbatore 641003, Tamil Nadu, India
[5]Department of Agricultural Entomology, Centre for Plant Protection Studies, TNAU, Coimbatore 641003, Tamil Nadu, India
[6]Krishi Vigyan Kendra, Agricultural College and Research Institute, Madurai, TNAU, Coimbatore 641003, Tamil Nadu, India
*Email: balajikk111@gmail.com (corresponding author): ORCID ID 0009-0004-1656-0739

ABSTRACT

An experiment was conducted out to investigate the pollinator diversity and pollination efficiency of *Tetragonula iridipennis* Smith on bitter gourd (*Momordica charantia* L.). In this study, there were 16 floral visitor species were recorded. Among them, six species were the most frequent visitors. A highest mean of visits was recorded with *Halictus* sp. (7.80) during 1000-1200 hrs in relative abundance and the lowest was of *Megachile* sp. (2.90) at 1600-1800 hrs. The foraging rate of stingless bees was most active in morning 1000-1200 hrs. The maximum fruit set was observed in pollinator-imposed fields (80.23 %) compared to pollinator excluded fields (71.15 %). Prominent increase in fruit length and girth in the pollinator included plots were respectively observed to be 249.19 and 42.91 mm. Maximum number of fruit/ individual plant (24.10) was achieved with bee pollination as compared to control (21.20).

Key words: *Tetragonula iridipennis*, bitter gourd, pollinator imposed, floral visitor, relative abundance, foraging rate, pollination efficiency, frequency of visit, diurnal variations, fruit set, fruit length, girth, number of fruit

Stingless bees are a species of small sized bees with vestigial stings that live in tropical and many subtropical regions. They are important crop pollinators and can be domesticated. They are known to visit the flowers of nearly 90 crop species (Heard, 1999). Bitter gourd (*Momordica charantia* L.), fruits contain rich amount of vitamin C (Joseph and Jini, 2013). Bitter gourd flowers are monoecious in nature and they are easy to be pollinated due to their open position and flat structure. The male and female flower ratio approximately range from 19:1 to 25:1 (Deyto and Cervancia, 2009; Palada and Chang, 2003). Anthesis of bitter gourd occurs between 0330 and 0730 hr (Deshpande et al., 1979). The life period of bitter gourd flowers is very short, this period is critical for crop pollination. Pollinators must be present during this time period in order to get the fruits to be set. The quality of the fruits also depends on pollinator services (Abrol et al., 2019). Studies have consistently confirmed that proper pollinator utilization can increase yield levels up to 100 to 150% in cucurbitaceous crops (Kishan et al., 2017). Stingless bee colonies are easier to manage for pollination than other *Apis* bee colonies because they do not sting. Previous research on bitter gourd in India and abroad has focused on pollinators diversity (Balina et al., 2012; Dorjay et al., 2017; Subhakar et al., 2011), and medicinal properties (Rathi et al., 2002; Aeri and Raj, 2020; Shapiro and Gong, 2002). However, no research has been conducted on the diversity, abundance and pollination efficiency of stingless bee on bitter gourd. Hence, the current study aims to document the diversity and abundance of pollinators of bitter gourd and estimate the pollination efficiency of stingless bee.

MATERIALS AND METHODS

The experiment was conducted at farmers field in Ayyur (10.056491°N, 78.087835°E) village of Madurai district, Tamil Nadu, India. All agronomical practices were carried out in accordance with good agricultural practices, with the crop being sown in the last week of January 2022. Two colonies of *T. iridipennis* were placed at 5% flowering for active pollination. In control

plot, the crop was not subjected to stingless bee for pollination. The relative abundance of stingless bee and most frequent flower visitors of other pollinators was measured in an open field when 50% of the plants bloomed from early morning (0600 hr) to late evening (1800 hr) at two hr intervals for ten days following Chauhan et al. (2019). The floral handling time of stingless bee on male and female bitter gourd flowers was recorded in randomly selected five plants separately at different foraging times (0600 to 1800 hrs) using a stopwatch and a hand tally counter (Free, 1993). Fruit set % was observed, for which ten female flowers/ vine were tagged randomly and observed. The data were subjected to ANOVA using SPSS 21.0 statistical package. The fruits were collected from twenty randomly selected plants and observed, viz. fruit length, fruit girth, fruit weight, number of fruit/ plant and yield/ plant were recorded using the scale, digital vernier caliper and weighing balance. The mean values were compared using t - test.

RESULTS AND DISCUSSION

A total of 16 flower visitors were observed in open field condition to visiting *M. charantia* flowers. Apidae (*Apis dorsata* F., *Apis cerana indica* F., *Apis florea* F., *Tetragonula iridipennis* Smith, *Amegilla zonata* L., and *Ceratina viridissima* Dalla Torre). Halictidae (*Halictus* sp, *Nomia* sp. and *Nomioides* sp.), Megachilidae (*Megachile* sp. and *Coelioxys apicata* Smith), and Xylocopidae (*Xylocopa violacea* L.). These were collecting both nectar and pollen from the male and female flowers, whereas Syrphidae (*Syrphus ribesii* L.) Nymphalidae (*Danaius chrysippus* L.) and Hesperidae (*Pelopidas mathias* F.) collected only nectar; and Chrysomelidae (*Raphidopalpa foveicollis* Lucas) were florivorous. Among them six (*A. dorsata*, *A. cerana indica*, *A. florea, T. iridipennis*, *Halictus* sp. and *Megachile* sp.) were more frequent species. A total of 22 insect species were observed by Bisui et al. (2020). The studies on relative abundance revealed that *A. dorsata, A. florea, A. cerana, Halictus* sp. and *Megachile* sp. on *M. charantia* visited flowers at different hours of the day (Table 1). Similar findings were reported by Balina et al. (2012) and Subhakar et al. (2011). who had recorded the relative abundance of bee species and other pollinators in bitter gourd. The highest and lowest mean population of most frequent flower visitors were recorded during 1000-1200, 1600-1800 hr, respectively with a maximum mean population of *Halictus* sp (7.80) followed by *A. florea* (6.80), *A. cerana* (6.10), *A. dorsata* (5.80) and *Megachile* sp (5.30) 1000-1200 hrs. The lowest mean

Table 1. Abundance and frequent flower visitors and foraging activity of *Tetragonula iridipennis* on *Momordica charantia* of (January-April, 2022)

Time (hr)	*Relative abundance					*T. iridipennis*			
	Apis dorsata	*Apis cerana*	*Apis florea*	*Halictus sp*	*Megachile sp*	*Relative abundance	*Foraging Rate	*Foraging speed	
								Male flower	Female flower
0600 - 0800	4.40 (2.07)^{bc}	4.80 (2.17)^{b}	3.40 (1.82)^{cd}	5.70 (2.37)^{bc}	3.70 (1.90)^{bc}	6.20 (2.48)^{abc}	7.20 (2.67)^{a}	3.45^{ab}	7.74^{a}
0800 - 1000	4.70 (2.14)^{ab}	4.50 (2.10)^{bc}	4.30 (2.05)^{bc}	6.10 (2.45)^{b}	3.20 (1.75)^{c}	6.80 (2.58)^{ab}	8.50 (2.90)^{a}	3.59^{a}	7.22^{c}
1000 - 1200	5.80 (2.38)^{a}	6.10 (2.45)^{a}	6.80 (2.59)^{a}	7.80 (2.78)^{a}	5.30 (2.28)^{a}	7.20 (2.67)^{a}	7.60 (2.74)^{a}	3.27^{bc}	7.40^{bc}
1200 - 1400	5.20 (2.26)^{ab}	5.10 (2.24)^{ab}	6.40 (2.50)^{a}	5.50 (2.33)^{bc}	3.40 (1.82)^{bc}	5.70 (2.38)^{bc}	5.60 (2.33)^{b}	3.52^{a}	7.51^{b}
1400 - 1600	4.60 (2.12)^{ab}	4.20 (2.02)^{bc}	4.60 (2.12)^{b}	4.90 (2.20)^{cd}	4.10 (2.01)^{b}	5.50 (2.33)^{c}	4.40 (2.07)^{b}	3.23^{c}	7.83^{a}
1600 - 1800	3.30 (1.79)^{c}	3.70 (1.91)^{c}	3.10 (1.74)^{d}	4.30 (2.05)^{d}	2.90 (1.67)^{c}	3.50 (1.85)^{d}	3.20 (1.74)^{c}	3.50^{a}	7.37^{bc}
Mean	4.67 (2.16)	4.73 (2.17)	4.77 (2.18)	5.72 (2.39)	3.77 (1.94)	5.82 (2.41)	6.08 (2.46)	3.43	7.51
CD (0.05)	0.28	0.22	0.24	0.21	0.24	0.21	0.30	0.21	0.22

*Relative abundance= No. of foragers/ 5 min/ m^2; *Foraging rate= No. of flowers visited/ 5 min; *Foraging speed= time spent/ flower (in sec); Figures in parentheses square root transformed values. Different superscript letters in the same line denote significant differences ($p < 0.05$).

Table 2. Effect of applied stingless bee pollination in *Momordica charantia*

Parameters	Stingless bee pollinated field (Two colonies)	SEM	Control plot (Without stingless bee colony)	SEM	t value
Fruit set (%)	80.23± 1.18*	0.26	71.15± 1.44*	0.32	21.78
Fruit weight (g)	138.13± 6.99*	1.56	129.43± 5.33*	1.19	6.55
Fruit length (mm)	249.19± 4.75*	1.06	241.21± 3.43*	0.76	5.32
Fruit grith (mm)	42.91± 1.49*	0.33	34.21± 1.86*	0.41	16.16
No. of fruits/ plant	24.10± 2.12*	0.47	21.20± 1.43*	0.32	5.54
Fruit yield (kg/ plant)	3.31± 0.21*	0.04	2.76± 0.19*	0.04	8.95

The values are expressed as mean± standard deviation, *statistically significant at $p < 0.05$, SEM - Standard error mean.

population of *Halictus* sp (4.30) was recorded at 1600-1800 hr. followed by *A. cerana* (3.70), *A. dorsata* (3.30), *A. florea* (3.10) and *Megachile* sp (2.90). The Maximum number of stingless bees (7.20) was observed from 1000 to 1200 hr. The foraging rate revealed that stingless bees were the most active in the morning hours than in the afternoon hours. Floral handling time was longer in female flowers (7.51 seconds) as compared to male flowers (3.43). These observations on floral handling time are in agreement with those of Nicodemo et al. (2013) and Kishan et al. (2017).

Significant differences were also observed between stingless bee pollinated and control plots in yield parameters such as fruit set %, number of fruits/ plant, fruit length, fruit girth, fruit weight and yield/plant (Table 2). There was a significant increase in yield from *T. iridipennis* pollinated plots (80.23 %) as compared to open pollinated plots (71.15 %). Deyto and Cervancia (2009) reported increased fruit set of *M. charantia* (78%) was obtained by insect pollination. Chauhan and Singh (2022) recorded maximum fruit set in cucumber (81.66 %) in bee pollinated field. It was also found that the number of fruits on stingless bee pollinated plants was significantly more (24.10 fruits/plant) than in control (21.20 fruits/ plant). The plants pollinated with *T. iridipennis* had a higher fruit weight (138.13 g) and length (249.19 mm) when compared to control plots as (129.43 g) and (241.21 mm), respectively. Massive gains in fruit girth were also observed (42.91 mm) in pollinated plot while it was 34.21 mm in control plots. Individual plant fruit yield was higher (3.31 kg) in *T. iridipennis* pollinated plots. These results are found consistent with those of Bisui et al. (2020). This study gives an idea about a native pollinator abundance in bitter gourd ecosystem at Ayyur, Madurai. Stingless bees play a significant role in bitter gourd pollination and it has more impact in improving yield.

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AUTHOR CONTRIBUTION STATEMENT

The study was conceptualized and designed by J Jayaraj and M Shanthi. K Balaji carried out the experiments and prepared the manuscript. S Vellaikumar, C Rajamanickam, N Chitra and K Suresh assisted with the field experiment and data analysis. The article was read and approved by all the authors.

CONFLICT OF INTEREST

No conflict of interest.

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