Indian Journal of Entomology, 81(4): 000-000 (2019) DoI No.:

DIVERSITY OF FLORAL VISITORS IN BITTER GOURD IN MADURAI DISTRICT, TAMILNADU

YOGAPRIYA, A., B. USHARANI*, K. SURESH, **S. VELLAIKUMAR AND M. SHANTHI

Department of Agricultural Entomology; *ICAR-KVK; **Department of Biotechnology, Agricultural College and Research Institute, TNAU, Madurai 625104
*Email: ushateja@yahoo.com

ABSTRACT

Field experiments were conducted to evaluate the diversity of floral visitors/ pollinators in bitter gourd *Momordica charantia* L. at Kutladampatti Village, Vadipatti Block of Madurai district, Tamil Nadu. A total of 30 species were observed of which 14 species are of hymenopterans, 11 species of lepidopterans and 4 species of dipterans. Of Hymenoptera, *Tetragonula iridipennis* was the most abundant visitor followed by *Apis cerana indica* and *Apis florea. Syrphus* sp. was the dominant among dipterans, while *Danaus chrysippus* was the major one followed by *Pachliopta hector*, *Delias eucharis*, *Danaus genutia*, *Tirumala limniace*, *Pieris* sp., *Hasora chromus*, *Eurema* sp. *Paplio demoleus* and *Lampedes boeticus* among Lepidoptera. Species richness (S) was at its maximum (21 species) at 1000-1200 hr and minimum (4 species) at 1600- 1800 hr. Shannon's and Simpson's diversity indices were maximum at 1000- 1200 hr with 2.62 and 0.86, respectively. Shannon's evenness ranged from 0.44- 0.86, while Simpson's evenness ranged from 0.28- 0.54 with maximum evenness indices being at 1000- 1200 hr.

Key words: Bitter gourd, floral visitors, diversity indices, Lepidoptera, Diptera, Hymenoptera, visting hours

The cucurbitaceous vegetable bitter gourd *Momordica charantia* L., is also known as bitter melon, bitter cucumber, balsam pear and African cucumber (Heiser, 1979). It has many culinary uses and extensively as folk medicine (Heiser, 1979). Fruits, flowers and young shoots are also used as flavouring agents and leaves consumed as leafy vegetable (Behera et al., 2010). This has also a number of medicinal uses (Welihinda et al., 1986, Raman and Lau 1996; Gürbüz et al., 2000, Scartezzini and Speroni 2000, Beloin et al., 2005). Many species of bees, wasps, ants, butterflies, flies, and beetles provide pollination services to cucurbit flowers (Delaplane et al., 2000; Free 1995; McGregor 1976), and help in agriculture (Ollerton, 2017). The past two decades have seen unprecedented interest in pollinators and pollination ecology, stimulated in part by concerns about the decline of pollinator abundance and diversity (Ollerton, 2017).

The bitter gourd flowers start opening at 0300 hr of the day and open fully at 0530 to 1200 hr; with male: female flower ratio being 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. Pollination is a problem in cucurbits because of the monoecious flowering habit. The yield of the crop varies widely due to the pollination gap than fertilizer and pest related problems (Motzke et al., 2015). Bees are the most studied and utilized pollinators for cucurbit crops throughout the world and provide the greatest contribution to the pollination of cucurbits (Delaplane et al., 2000; Garibaldi et al., 2013). The present experiment evaluates the diversity of insects (floral visitors/ pollinators) visiting bitter gourd flowers.

MATERIALS AND METHODS

Periodical field survey was conducted at weekly intervals at Kutladampatti Village, Vadipatti Block of Madurai district during *kharif* 2018, with two replications. The experimental plots were 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 hr for five min with three replications. The data were later worked out for their means time-wise and group-wise to infer the pollinator fauna as well as the dominance of particular group. Insects foraging for 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. Insects were concluded as flower visitor/ pollinator based on their foraging approach as

observed by their foraging mode i.e. either side or top worker. 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).

Relative abundance, Species richness and Shannon's and Simpson's diversity indices were also computed. Insect specimen were collected from the field with aerial nets and preserved in 70% ethanol and photographed in stereozoom microscope (AXIOCAM) at the Centre of Innovation Agricultural College and Research Institute, Madurai. Diversity indices viz., Shannon's diversity index (H), Shanon's equality (EH), Simpson's diversity index (D) along with Dmax which equals S (Davila et al., 2012) were computed following standard methods. Relative abundance of a species or a group of species in the community (floral visitors/ pollinators) was calculated by dividing total number of species present by total number of individuals in a group/ community. The mean values were square root transformed and compared by Least Significant Difference (LSD) at p= 0.05 with AGRES to assess the foraging activity (abundance) of a flower visitor. Pollinator efficiency was calculated based on the relative abundance and foraging activity of an insect species at the peak pollinating hours.

RESULTS AND DISCUSSION

A total of 30 floral visitors/ pollinator species were found visiting bitter gourd flowers. Among the 30 species, maximum share by hymenopterans with 14 species followed by lepidopterans, dipterans and hemipteran. Among the floral visitors/ pollinators recorded *Apis* hymenopterans share 10%, non *Apis* hymenopterans share 36.67%, lepidopterans 36.67%, dipterans 13.33% and hemipterans 3.33%. Hymenoptera holds a maximum share of pollinators of 46.67% (*Apis* and non *Apis* hymenopterans together) (Table 1). In Hymenoptera, Apidae was the dominant family (5 species) followed by Halictidae (3 species), Formicidae (2 species), Xylocopidae (1 species), Megachillidae (1 species), Chrysididae (1 species) and Vespidae (1 species). Among Diptera, Syrphidae was dominating with (3 species) and among Lepidoptera 6 insects belongs to Nymphalidae, 2 insects belongs to Lycaenidae and Pieridae and 1 belong to Papilionidae and one unidentified Hemiptera (Table 1). While comparing the relative abundance of pollinators, non *Apis* Hymenoptera dominated in rank followed by *Apis* Hymenoptera, Lepidoptera and Diptera (Fig 1).

Foraging activity study revealed that among the hymenopterans, *Apis* genus included three insect species and non *Apis* genera included fourteen insect species. In *Apis* Hymenoptera, *A. cerana indica* was the most frequent visitor followed by *A. florea* and *A. dorsata*. The mean population of *A. cerana indica* F. was maximum at 0600 to 0800 hours (2.88/m^2/5 min) followed by 0800 to 1000 hours (2.63/m^2/5 min) and 1000 to 1200 hours (1.41/ m^2/5 min). *T. iridipennis* was the most abundant Non Apis visitor followed by *M. minimum*, *A. zonata, P. gallicus, Lasioglossum sp*., *Nomia sp., Halictus* sp., *Chrysis sp. and Megachile sp.* The mean population of *T. iridipennis* was found to be maximum (4.62/m^2/5min) at 0600 to 0800 hours and followed by (4.38/ m^2/ 5 min) at 0800 to 1000 hours.

Of Diptera, *Syrphus ribessi* was the major visitor followed by *Episyrphus* sp. and *Eristalis* sp. The population of dipterans visiting bitter gourd were

Fig. 1. Relative abundance % of different groups of pollinators visiting bitter gourd flowers at 0600 - 1800 hr of the day

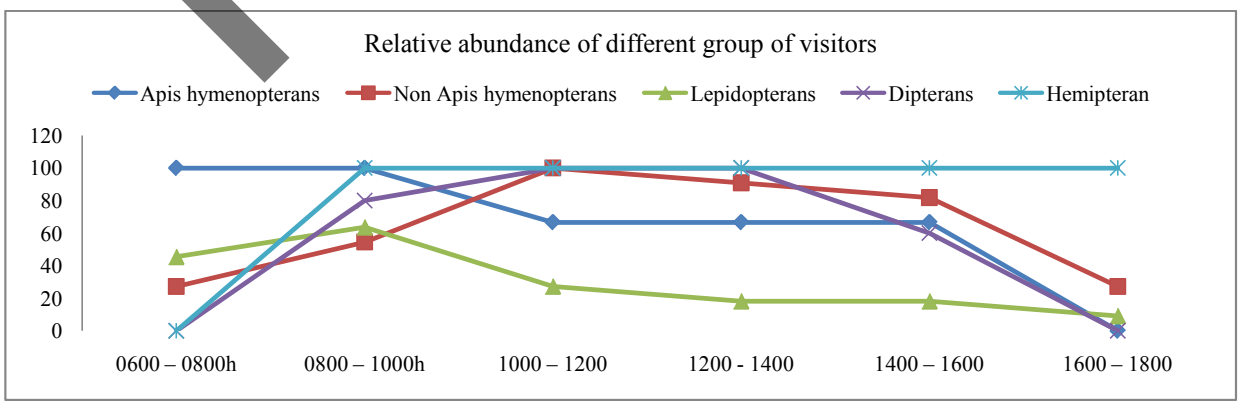

Table 1. Diversity of floral visitors in bitter gourd

S. No.	Pollinators	Family	Abundance (%)	Role*		Foraging mode**
				Pollen	Nectar	
Hymenoptera						
	Apis cerana indica F.	Apidae		+	+	T/S
	Apis dorsata F.	Apidae		+	+	T/S
	Apis florea F.	Apidae		+	+	T/S
	Tetragonula iridipennis Smith	Apidae		+	+	T/S
	Amegilla zonata L.	Apidae		+	+	T
	Xylocopa violacea L.	Xylocopidae		+	+	T
	Halictus sp.	Halicitidae	46.67	+	+	T/S
	Lasioglossum sp.	Halicitidae		+	+	T/S
	Nomia sp.	Halicitidae		+	+	T/S
	Megachile sp.	Megachellidae		+	+	T
	Chrysis spp.	Chrysididae		+	+	T/S
	Polistes gallicus L	Vespidae		-	+	S
	Camponotus pensylvanicus De Geer	Formicidae		-	+	T/S
	Monomorium minimum Buckley	Formicidae		-	+	T/S
Diptera						
	Syrphus ribesii L.	Syrphidae		-	+	T
	Episyrphus balteatus De Geer	Syrphidae		-	+	T
	Eristalis sp. Latreille	Syrphidae	13.33	-	+	T
	Unidentified	Muscidae		-	+	S
Lepidoptera						
	Danaius chrysippus L.	Nymphalidae		-	+	T
	Danaus genutia Cramer	Nymphalidae		-	+	T
	Eurema hecabe L.	Nymphalidae		-	+	T
	Eurema blanda Boisduval	Nymphalidae		-	+	T
	Tirumala limniace Cramer	Nymphalidae		-	+	T
	Delias euchrasis Drury	Nymphalidae	36.67	-	+	T
	Papilio demoleus L,	Pappilionidae		-	+	T
	Pachliopta hector L,	Pieridae		-	+	T
	Pieris sp.	Pieridae		-	+	T
	Lampedes boeticus L	Lycaenidae		-	+	T
	Hasora chromus **Cramer**	Lycaenidae				T
Hemiptera						
	Unidentified	Miridae	3.33	-	+	T/S

*+ collects, – does not collects; **T - Top worker; S - Side worker; T/S – Top and Side worker.

high at 1000-1200 hr with (0.80 visits/m^2/5 min). Lepidopterans were found to forage on botter gourd flowers throughout the day, *D. chrysippus* was the most abundant followed by *P.hector*, *D. euchrasis, D. genutia*, *T. limniace, H. chromus*, *E. hecabe*, *E.blanda*, *P. demoleus* and *L. boeticus*. Maximum visits of Lepidopterans on bitter gourd was observed at 1000-1200 h with 0.15/ m^2/ 5 min followed by 0600-800 and 0800-1000 hours with 0.14 / m^2/ 5min and minimum during 1400- 1600 and 1600-1800 hr with 0.03/m^2/5min (Table 2).

T. iridipennis, A. cerana indica and *X. violacea* were the major pollinators during 0600-800 hr. *T. iridipennis, A. cerana indica* and *A. zonata* were the major pollinators during 0800-1000 hr. While stingless bees, *T. iridipennis* and Blue banded bees, *A. zonata* were dominating pollinators during 1000- 1200 hr and the population of extra floral nectar feeders starts increasing after 1000 hr thus diversity of species is high during 1000- 1200 hr. Little bee *A. florea* population starts increasing after 1100h and is the major dominating visitor/pollinator during 1200- 1400 hr. Solitary bees play major role as pollinators at 1400- 1600 hr. The population of ants were more after 1600 hr i.e. 1600-1800 hr. The order of dominating pollinators in bitter gourd ecosystem is *T. iridipennis* > *A. cerana indica* > *A. florea* > *A. zonata* > *Lasioglossum* sp. (Table 2).

Relative abundance

Relative abundance (RA) of *Apis* hymenopterans

Table 2. Foraging activity of floral visitors/ pollinators in bitter gourd at different hours of the day

Pollinators	*No. of individuals/ 5 min/ m^2						
	0600- 0800	0800 – 1000	1000 – 1200	1200 – 1400	1400 – 1600	1600 – 1800	Mean
Apis hymenopterans							
A. cerana indica	2.88 (1.83)^{b}	2.63 (1.76)^{b}	1.41 (1.38)^{h}	0.62 (1.05)^{l}	0.02 (0.72)^{fg}	0.00 (0.70)^{c}	1.26 (1.12)^{b}
A.florea	0.00 (0.70)^{g}	0.8 (1.14)^{d}	2.26 (1.66)^{e}	2.89 (1.84)^{b}	0.26 (0.84)^{d}	0.00 (0.70)^{c}	1.03 (1.01)^{bc}
A.dorsata	0.2 (0.83)^{ef}	0.4 (0.94)^{f}	0.00 (0.70)^{o}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.10 (0.31)^{ghf}
Non *Apis* hymenoperans							
T. iridipennis	4.62 (2.26)^{a}	4.38 (2.20)^{a}	3.00 (1.87)^{b}	1.28 (1.33)^{f}	0.2 (0.83)^{de}	0.00 (0.70)^{c}	2.24 (1.49)^{a}
Halictus sp.	0.00 (0.70)^{g}	0.62 (0.1.05)^{bc}	0.42 (0.95)^{l}	0.24 (0.86)^{n}	0.02 (0.72)^{fg}	0.00 (0.70)^{c}	0.21 (0.45)^{fgh}
A. zonata	0.00 (0.70)^{g}	0.82 (1.14)^{e}	2.67 (1.78)^{c}	1.51 (1.41)^{e}	0.72 (1.10)^{c}	0.00 (0.70)^{c}	0.95 (0.97)^{bc}
X.violacea	0.68 (1.08)^{c}	0.24 (0.86)^{d}	0.02 (0.72)^{no}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.15 (0.38)^{defgh}
Lasioglossum sp.	0.00 (0.70)^{g}	0.00 (0.70)^{g}	1.67 (1.47)^{g}	1.84 (1.52)^{c}	0.24 (0.86)^{d}	0.00 (0.70)^{c}	0.62 (0.78)^{cde}
P. gallicus	0.00 (0.70)^{g}	0.00 (0.70)^{i}	0.4 (0.94)^{l}	1.8 (1.51)^{d}	1.6 (1.44)^{b}	0.00 (0.70)^{c}	0.63 (0.79)^{cde}
Nomia sp.	0.00 (0.70)^{g}	0.2 (0.72)^{gh}	0.8 (1.14)^{i}	1.2 (1.30)^{g}	0.6 (1.04)^{c}	0.1 (0.77)^{b}	0.48 (0.69)^{fg}
Megachile sp.	0.00 (0.70)^{g}	0.00 (0.70)^{i}	0.2 (0.83)^{m}	0.4 (0.94)^{m}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.10 (0.31)^{h}
Chrysis sp.	0.00 (0.70)^{g}	0.00 (0.70)^{i}	0.48 (0.98)^{k}	0.72 (1.10)^{j}	0.04 (0.73)^{efg}	0.00 (0.70)^{c}	0.20 (0.44)^{fgh}
C. pensylvanicus	0.00 (0.70)^{g}	0.00 (0.70)^{i}	1.80 (1.51)^{f}	0.60 (1.04)^{l}	0.2 (0.83)^{d}	0.2 (0.83)^{b}	0.46 (0.67)^{defg}
M. minimum	0.4 (0.94)^{de}	0.6 (1.04)^{f}	3.6 (2.02)^{a}	6.28 (2.60)^{a}	3.06 (1.88)^{a}	2.6 (1.76)^{a}	2.75 (1.65)^{a}
Lepidopterans							
D. chrysippus	0.46 (0.97)^{d}	0.4 (0.94)^{f}	0.00 (0.70)^{o}	0.00 (0.70)^{p}	0.2 (0.83)^{d}	0.00 (0.70)^{c}	0.17 (0.41)^{fgh}
D. genutia	0.24 (0.86)^{ef}	0.00 (0.70)^{g}	0.00 (0.70)^{o}	0.2 (0.83)^{o}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.07 (0.26)^{h}
E. hecabe	0.00 (0.70)^{g}	0.26 (0.87)^{i}	0.00 (0)^{o}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.04 (0.2)^{h}
E. blanda	0.00 (0.70)^{dg}	0.24 (0.86)^{i}	0.00 (0.70)^{o}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.04 (0.2)^{h}
T. limniace	0.00 (0.70)^{g}	0.2 (0. 83)^{i}	0.00 (0.70)^{o}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.2 (0. 83)^{b}	0.06 (0.24)^{h}
D. euchrasis	0.22 (0.84)^{fg}	0.18 (0.82)^{gh}	0.04 (0.73)^{n}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.07 (0.26)^{h}
P. demoleus	0.00 (0.70)^{g}	0.00 (0.70)^{i}	0.2 (0. 83)^{m}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.03 (0.17)^{h}
P. hector	0.46 (0.97)^{d}	0.00 (0.70)^{ff}	0.2 (0. 83)^{m}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.11 (0.33)^{gh}
Pieris sp.	0.00 (0.70)^{g}	0.2 (0. 83)^{i}	0.00 (0.70)^{o}	0.00 (0.70)^{p}	0.2 (0.83)^{def}	0.00 (0.70)^{c}	0.06 (0.24)^{h}
L. boeticus	0.00 (0.70)^{g}	0.2 (0.83)^{i}	0.00 (0.70)^{o}	0.00 (0.70)^{p}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.03 (0.17)^{h}

H. chromus	0.16 (0.81)^{g}	0.00 (0.70)^{h}	0.00 (0.70)^{o}	0.2 (0.83)^{o}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.06 (0.24)^{h}
Dipterans							
S. ribesii	0.00 (0.70)^{g}	0.46 (0.69)^{i}	1.82 (1.52)^{f}	0.6 (1.04)^{l}	0.18 (0.82)^{def}	0.00 (0.70)^{c}	0.51 (0.71)^{cd}
Episyrphus sp.	0.00 (0.70)^{g}	0.22 (0.84)^{i}	0.6 (1.04)^{j}	0.82 (1.14)^{l}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.27 (0.51)^{efg}
Eristalis sp.	0.00 (0.70)^{g}	0.01 (0.71)^{i}	0.6 (1.04)^{j}	0.68 (1.08)^{i}	0.02 (0.72)^{fg}	0.00 (0.70)^{c}	0.21 (0.45)^{fg}
Unidentified	0.00 (0.70)^{g}	0.00 (0.70)^{i}	0.2 (0.83)^{m}	0.2 (0.83)^{o}	0.00 (0.70)^{g}	0.00 (0.70)^{c}	0.07 (0.26)^{h}
Hemipteran							
Unidentified	0.00 (0.70)^{g}	0.08 (0.76)^{i}	2.34 (1.68)^{d}	1.02 (1.23)^{h}	0.24 (0.86)^{d}	0.02 (0.72)^{b}	0.61 (0.78)^{cde}
S.Ed	0.0409	0.0193	0.0131	0.0057	0.0602	0.0573	0.0971
CD(0.05)	0.0837	0.0394	0.0267	0.0117	0.1232	0.1171	0.1944
Mean	0.34 (0.91)^{c}	0.43 (0.96)^{b}	0.82 (1.15)^{a}	0.77 (1.12)^{a}	0.26 (0.87)^{d}	0.10 (0.77)^{e}	
	S.Ed = 0.0971				CD(0.05) = 0.1944		

*Each value mean of twenty two observations; Figures in parenthesis square root transformed values; In a column, means followed by same letter(s) on par by LSD (p= 0.05)

were in the peak from 0600 to 1000 hr which decreased thereafter. While the RA % of non *Apis* hymenopterans were maximum during 0800- 1000 hr followed by 1200- 1400 hr, 1400- 1600 hr and 0800- 1000 hr, respectively. The least activity of these visitors was observed at 0600- 0800 and 1600- 1800 hr. Abundance of Lepidoptera was highest during 0800- 1000 hr. Maximum activity of Diptera was noticed at 1000- 1400 hr (Fig. 1).

Species richness, relative abundance and diversity indices

Species richness (S) was at its maximum with 21 species at 1000-1200 h and minimum at 1600-1800 hours with occurance of 04 species. Shannon's diversity [H] and Shannon's evenness [E] indices deals with diversity i.e. Shannon's H and E increases as diversity of species increases while, Simpson's diversity [D] and Simpson's evenness [E] increases in relation with the abundance of the species. Shannon's index will be at the maximum when the diversity is higher and Simpson's index will be higher when the abundance of the species is highest. The results of Shannon's and Simpson's diversity indices depicts that both diversity and abundance of floral visitors/ pollinator species was maximum at 1000- 1200 hr with 2.62 and 11.51, followed by 0800- 1000 hr with 2.28 and 5.92 and 0600- 0800 hr with 1.60 and 3.45, respectively. Shannon's evenness ranged from 0.44- 0.86 and Simpson's evenness was from 0.28- 0.54. Both evenness indices were not varied much during the day with high evenness in periods when the diversity and abundance were high i.e. 1000- 1200 hr with 0.86 and 0.54, respectively (Table 3).

From Table 2, 3 and Fig 1 (foraging activity and relative abundance) it is knowable that *T. iridipennis* and *A. cerana indica* are the effective pollinators of bitter gourd. In general, the activity *Apis* Hymenoptera were more during the forenoon while non-*Apis* Hymenoptera and Diptera were slightly higher

Table 3. Species richness, relative abundance and diversity indices

Parameters	TIME					
	0600 – 0800	0800 – 1000	1000 – 1200	1200 - 1400	1400 – 1600	1600 – 1800
Species Richness (S)	11	20	21	19	16	04
Relative Abundance (%)	36.67	66.67	70.00	63.33	53.33	13.33
Shannon's H index	1.60	2.28	2.62	2.50	1.97	0.61
Shannon's E index	0.67	0.76	0.86	0.84	0.71	0.44
Simpson's D index	3.45	5.92	11.51	8.34	4.61	1.40
Simpson's E index	0.31	0.29	0.54	0.43	0.28	0.35

during afternoon. It is cognizable that the activity and abundance of pollinators is high from 0600 to 1400 hr of the day. Lepidopterans were found at all times of the day with a maximum in morning hours.

The results obtained from this study are in accordance with the findings of Subhakar et al. (2013) who reported that *Tetragonula iridipennnis, Halictus guttuorosus* and *Apis florea* were the major pollinators in bitter gourd ecosystem. Saeed et al. (2012) also recorded the maximum activity of *Apis dorsata, Tetragonula iridipennnis and Eristalinus laetus* species in bitter gourd flowers. *T. iridipennis* and *A. cerana indica* were the most abundant species that visit the bitter gourd flowers. Hence, they can be effectively used for supplementing pollination in bitter gourd to get higher yield in Bitter gourd. Since, the diversity and abundance of floral visitors/ pollinators is high during 0600 – 1200 hours in bitter gourd, spraying insecticides during the morning hours should be avoided to conserve the population and activity of pollinators in bitter gourd.

REFERENCES

Bhalchandra W, Baviskar R K, Nikam T B. 2014. Diversity of nectariferous and polleniferous bee flora at Anjaneri and Dugarwadi hills of Western Ghats of Nasik district (M. S.). Journal of Entomology and Zoology Studies 2 (4): 244-249.

Behera T K, Behera S, Bharathi L K, John K J, Simon P W, Staub J. 2010. Bitter gourd: Botany, Horticulture, Breeding (J. Janick ed.). Volume 37, Horticultural Review.

Beloin N, Gbeassor M, Akpagana K, Hudson J, De Soussa K, Koumaglo K, Arnason J T. 2005. Ethnomedicinal uses of Momordica charantia (Cucurbitaceae) in Togo and relation to its phyto-chemistry and biological activity. Journal of Ethnopharmacology 96(1-2): 49-55.

Davila Y C, Elizabeth E, Vamosi C, Hermanutz L, Kerr J T, Lortie C J, Westwood A R, Woodcock T S, Worley A C. 2012. Ecosystem services of pollinator diversity: a review of the relationship with pollen limitation of plant reproduction. Botany 90: 535-543.

Delaplane K S, Mayer D R, Mayer D F. 2000. Crop pollination by bees: CABI.

Free J. 1993. Insect pollination of crops. Academic Press, London, UK.

Garibaldi L A, Steffan-Dewenter I, Winfree R, Aizen M A., Bommarco R, Cunningham S A, Kremen C, Carvalheiro L G, Harder L D, Afik O. 2013. Wild pollinators enhance fruit set of crops regardless of honey bee abundance. Science 339 (6127): 1608-1611.

Gürbüz I, Akyüz Ç, Yeşilada E, Şener B. 2000. Anti-ulcerogenic effect of *Momordica charantia* L. fruits on various ulcer models in rats. Journal of Ethnopharmacology 71(1-2): 77-82.

Heiser C B. 1979. The Gourd Book Norman: University of Oklahoma Press.

Mcgregor S E. 1976. Insect pollination of cultivated crop plants (Vol. 496): Agricultural Research Service, US Department of Agriculture Washington, DC.

Ollerton J. 2017. Pollinator Diversity: Distribution, Ecological Function, and Conservation. Annual Review of Ecology, Evolution and Systematics 48(1): 353-376.

Raman A, Lau C. 1996. Anti-diabetic properties and phytochemistry of *Momordica charantia* L.(Cucurbitaceae). Phytomedicine 2(4): 349-362.

Saeed S, Malik S A, Dad K, Sajjad A, Ali M. 2012. In search of the best native pollinators for bitter gourd (*Momordica charantia* L.) pollination in Multan, Pakistan. Pakistan Journal of Zoology 44(6).

Scartezzini P, Speroni E. 2000. Review on some plants of Indian traditional medicine with antioxidant activity. Journal of ethnopharmacology 71(1-2): 23-43.

Subhakar G, Sreedevi K, Manjula K, Reddy N E. 2013. Pollinator diversity and abundance in bitter gourd, *Momordica charantia* Linn. Pest Management in Horticultural Ecosystems 17(1), 23-27.

Welihinda J, Karunanayake E, Sheriff M, Jayasinghe K. 1986. Effect of *Momordica charantia* on the glucose tolerance in maturity onset diabetes. Journal of Ethnopharmacology 17(3): 277-282.

(Manuscript Received: May, 2019; Revised: October, 2019;
Accepted: October, 2019; Online Published: November, 2019)