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Relative abundance and foraging activity of hymenopteran pollinators in cucurbitaceous vegetables

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ABSTRACT: A study was conducted to investigate the diurnal activity patterns of hymenopteran pollinators in culinary melon and the dynamics of hymenopteran pollinators of five selected cucurbitaceous vegetables *viz.,*culinary melon, bitter gourd, pumpkin and ridge gourd in 34 locations of Kerala from 06:00 h to 18:00 h with a cone type hand net. The study revealed that *Apis cerana indica* was dominant in culinary melon, pumpkin and ridgegourd and *Tetragonula travancorica* was dominant in bitter gourd and ash gourd, *A. cerana indica, T. travancorica* and *Halictus* sp. recorded highest foraging speed during 10:00 h to 11:00 h; *Ceratina hieroglyphica* and *Lasioglossum* sp. recorded highest foraging speed during 09:00-10:00 h; *T. travancorica*, *C. hieroglyphica* and *Lasioglossum* sp. recorded maximum foraging rate during 10:00 h to 11:00 h; *A. cerana indica* and *Halictus* sp. recorded highest foraging rate during 11:00-12:00 h and 09:00-10:00 h.
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KEY WORDS: Pollinators, composition, relative abundance, diurnal activity, cucurbitaceous, foraging speed, foraging rate

INTRODUCTION

Insect pollinators play an important role in effecting optimum pollination of several crops and contribute to the raise of their productivity and quality. Their essentiality is more significant in crops like cucurbitaceous vegetables. Among the vegetable crops, cucurbits are cultivated extensively in India. The cucurbitaceous family comprises of cucumber, pumpkin, chow-chow, bitter gourd, bottle gourd, ridge gourd, ash gourd, watermelon, muskmelon, etc. Globally, the family cucurbitaceae comprises of 118 genera and 825 species. At present in India, cucurbits are cultivated in an area of 555,000 ha with a productivity of 9,912,000 MT and in Kerala cucurbits are cultivated in an area of 2,970 ha with a productivity of 41,610 MT (NHB, 2018). FAO estimates show that, in India about 6% of the total vegetables produced are from eight species of cucurbitaceous vegetables. In India, studies have been conducted on some of the important cucurbit crops to record the insect visitors and to understand the pollinators diurnal activity.

Cucurbits being monoecious, bearing male and female flowers separately on the same plant, depends mainly on insects for pollination and also, their pollen grains being large and sticky, cannot be blown away by the wind. Hence, pollination by insects is essential to bear improved quality of fruits

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and seeds (Free, 1970; Mc Gregor, 1976). In cucurbitaceous vegetables, among all the pollinating insects, the honeybees are known to be the most efficient. For maximizing the yield of cross pollinated crops, utilization of pollinators especially honeybees are considered as one of the cheapest and eco-friendly approach (Free, 1970).

Grewal and Sidhu (1978) recorded that in Punjab, the most frequent visitors of bittergourd flowers were *Apis florea* F. and various species of Anthophoridae and Halictidae with 28, 10 and 5.2 per-cent, respectively. In Vellayani, Kerala, on sponge gourd the most abundant pollinator was *Tetragonula iridipennis* Smith (Mohan, 2000). Pateel and Sattagi (2007) observed that in Karnataka, *A. florea, Apis cerana* F. and *Apis dorsata* F. were the most abundant insect pollinators visiting cucumber in Rabi season.

In Kannur, Kerala on ash gourd flowers, *T. iridipennis* was the most frequent pollinator followed by *Halictus timidus* Smith, *A. cerana* F., *Ceratina hieroglyphica* Smith, and *Halictus taprobanae* Cameron (Leena and Nasser, 2015). Lalita and Yogesh (2015) observed that in Hisar (Haryana), on pumpkin flowers, *A. dorsata* was the most efficient pollinator followed by *Apis mellifera* F., *A. cerana* and *A. florea*.

Hence, keeping in view of the pollination requirements of cucurbits, bee conservation requires rapid and effective tools for identification and delineation of species. For this purpose, composition, relative abundance and diurnal activity of hymenopteran pollinators is to be studied.

MATERIALS AND METHODS

The study was conducted during the year 2018 - 2019 on five selected cucurbitaceous vegetables *viz.,* culinary melon (*Cucumis melo var. acidulus*), bitter gourd (*Momordica charantia* L.), ash gourd (*Benincasa hispida* Thunb. and Cogn.), pumpkin (*Cucurbita moschata* L.) and ridge gourd (*Luffa acutangula* (Roxb.) L.). surveyed once in 34 locations in Thiruvananthapuram and four other districts of Kerala *viz.,* Kollam, Pathanamthitta, Alappuzha and Kasaragod in the months of September, October, November and December during the year 2018 and in January, February and March during the year 2019 from 06:00 h to 18:00 h of the day with a cone type hand net during the blooming period. The four southern districts were selected based on the mandate of the RARS whereas the Kasaragod district was included to represent north Kerala. The selected number of locations covered in each district is mentioned in the table 1.

Table 1. Localities of sample collection

District	Localities covered	Number of locations
Thiruvananthapuram	Vellayani, Karamana, Kulathoor, Karyavattom, Karode, Venkulam, Balaramapuram,Vellarada, Pangode, Parassala, Idinjar, Pallichal, Mukkola, Oorutukaala, Azhicode, Melvettoor, Kalliyoor, Muttakkad, Venganoor, Vizhinjam, Athiyanoor, Pothencode, Puliyancode, Vattiyoorkavu, Perumkadavila	25
Kollam	Edamon, Kottarakkara, Karunagappally	3
Kasaragod	Padannakkad, Nileshwar	2
Alappuzha	Moncompu, Kavalam	2
Pathanamthitta	Padam, Thiruvalla	2
	Total	34

The composition and relative abundance of the different hymenopteran pollinators visiting flowers of five selected cucurbitaceous vegetables from the randomly marked one square meter area were recorded from 06:00 h to 18:00 h of the day at an hourly interval for 5 minutes during flowering period and expressed as mean number of pollinators / m2/ 5 min. Diurnal activity observations were recorded from the flowers of one selected cucurbit viz., culinary melon in College of Agriculture, Vellayani during October to December. Foraging speed (time spent by the bee per flower) from landing till takeoff was recorded by using a stop watch and was expressed in seconds per flower, foraging rate (number of flowers visited by bee per minute) of bees were recorded. These observations were recorded from 06:00 h to 18:00 h at an hourly interval for 5 minutes during flowering period.

RESULTS AND DISCUSSION

A total of twenty-nine species of hymenopteran pollinators were recorded from five cucurbitaceous vegetables (Table 2).

The results on relative abundance (RA) and diurnal activity are presented in tables 3 to 7 and figures 1 to 4. The study on composition and relative abundance of hymenopteran pollinators from Thiruvananthapuram and four other districts of Kerala revealed that, *A. cerana indica* was the dominant pollinator in culinary melon (42.51%), pumpkin (38.76%) and ridgegourd (35.16%) whereas, *T. travancorica* was the dominant pollinator in bittergourd (31.86%) and ashgourd (33.50%). During two seasons, the foraging speed of *A. cerana indica, T. travancorica* and *Halictus* sp. was found to be highest during 10:00-11:00 h. The foraging speed of *Ceratina hieroglyphica* and *Lasioglossum* sp. was found to be highest during 09:00-10:00 h. The foraging rate of *T. travancorica*, *C. hieroglyphica* and *Lasioglossum* sp. was found to be highest during 10:00-11:00 h. The foraging rate of *A. cerana indica* and *Halictus* sp. was found to be highest during 11:00-12:00 h and 09:00-10:00 h respectively.

Study of hymenopteran pollinators composition and relative abundance in cucurbits

A. cerana indica was the most frequent pollinator followed by *T. travancorica.* Jangaiah (2007) reported that in Kerala, on culinary melon flowers, *A. cerana indica* was the most dominant and frequent floral visitor. *T. travancorica* (31.86 per cent) was recorded as the dominant pollinator on bitter gourd flowers followed by *A. cerana indica* (29.90 per cent) and *Ceratina* sp. (11.76 per cent). Subhakar *et al*. (2011) reported that, in Tirupathi on bitter gourd flowers, *T. iridipennis* (86.31 per cent) was the most frequent visitor. The abundance of bees depends on so many factors such as anthesis, weather parameters, competing flora, nectar concentration and its volume (Free, 1970). At peak flowering, the availability of flowers is more than commencement and cessation of flowering, and maximum number of insects would visit the crop during this period to increase the pollination process. Therefore, the flower number clearly influences the pollinator abundance, and in turn, the level of pollination.

A. cerana indica (38.76 per cent) was the frequent floral visitor followed by *T. travancorica* (24.03 per cent). Hemanthkumar (2006) and Mohapatra and Sontakke (2012) observed that on pumpkin flowers *A. cerana* was the most frequent and dominant pollinator followed by *A. dorsata. A. cerana indica* (35.16 per cent) was observed as the most frequent floral visitor on ridge gourd followed by *Xylocopa verticals* (18.68 per cent). Kuberappa *et al*. (2008) and Lakshmi (2013) also reported that on ridge gourd flowers *A. cerana* was the most frequent and dominant pollinator. *T. travancorica* (33.50 per cent) was the most dominant pollinator on ash gourd followed by *A. cerana indica* (26.73 per cent). Leena and Nasser (2015) reported that, on ash gourd flowers, *T. iridipennis* was the most frequent pollinator followed by *H. timidus*, *A. cerana*, *C. hieroglyphica* and *H. taprobanae* in Kannur (Kerala).

Table 2. List of hymenopteran pollinators in cucurbitaceous vegetables

Common name	Scientific name	Family	Vegetable
Indian bee	*Apis cerana indica* F.	Apidae	Culinary melon, Bitter gourd, Pumpkin, Ash gourd, Ridge gourd
Rock bee	*Apis dorsata* F.		Culinary melon, Bitter gourd, Pumpkin, Ash gourd, Ridge gourd
Little bee	*Apis florea* F.		Culinary melon
Stingless bee	*Tetragonula travancorica* Shanas and Faseeh		Culinary melon, Bitter gourd, Pumpkin, Ash gourd
	Tetragonula sp. nov.1		Pumpkin
Small carpenter bee	*Ceratina hieroglyphica* Smith, *Ceratina simillima* Smith, *Ceratina binghami* Cockerell, *Ceratina unimaculata javanica* van der Vecht		Culinary melon, Bitter gourd, Pumpkin, Ash gourd, Ridge gourd
Blue- banded bee	*Amegilla zonata* L.		Culinary melon, Ridge gourd
Carpenter bee	*Xylocopa verticals* Smith		Culinary melon, Ridge gourd
Sweat bee	*Lasioglossum* sp.	Halictidae	Culinary melon, Bitter gourd, Pumpkin, Ash gourd
	Halictus sp. 1, *Halictus* sp. 2, *Halictus* sp. 3		Culinary melon, Bitter gourd, Pumpkin, Ash gourd, Ridge gourd
Alkali bee	*Nomia eliotti* Smith, *Nomia westwoodi* Gribodo *Nomia curvipes* F., *Nomia* sp.		Culinary melon, Ashgourd
Leaf- cutter bee	*Megachile lanata* F., *Megachile disjuncta* F.	Megachilidae	Bitter gourd, Ash gourd
Paper wasp	*Ropalidia brevita* Das &Gupta	Vespidae	Culinary melon, Ridge gourd
Potter wasp	*Eumenes* sp.		Ridge gourd
	Anterhynchium abdominale abdominale Illiger		Culinary melon
Mud dauber	*Sceliphron madraspatanum* F.	Sphecidae	Culinary melon
Blue mud dauber	*Chalybion bengalense* Dahlbom		
Scoliid wasp	*Phalerimeris phalerata phalerata* de Saussure	Scoliidae	Ash gourd
	Campsomeriella annulata annulata F.		
Mole cricket hunters	*Larra maura* F.	Crabronidae	Culinary melon

Table 3. Composition and relative abundance of different hymenopteran pollinators in culinary melon

Pollinator	Trivandrum	Kollam	Pathanam-thitta	Alappu-zha	Kasara-god	Total	% RA
Apis cerana indica	167	21	13	4	8	213	42.51
Tetragonula travancorica	77	5	6	-	5	93	18.56
Ceratina Sp.	46	6	5	-	-	57	11.38
Apis dorsata	44	2	4	-	1	51	10.18
Lasioglossum sp.	10	4	5	-	4	23	4.59
Nomia sp.	12	-	-	5	2	19	3.79
Halictus sp.	5	3	3	3	-	14	2.79
Apis florea	7	1	2	-	-	10	1.96
Xylocopa verticals	6	-	-	-	3	9	1.80
Amegilla zonata	5	-	-	2	-	7	1.40
Wasps	3	-	1	1	-	5	1.00
Total	382	42	39	15	23	501	42.51

No. of locations – 29
Total no. of pollinators collected - 501
% RA - mean number of pollinators/m^2/5 min

Table 4. Composition and relative abundance of different hymenopteran pollinators in bittergourd

Pollinator	Trivandrum	Kollam	Pathanam-thitta	Alappu-zha	Kasara-god	Total	% RA
Tetragonula travancorica	34	7	8	6	10	65	31.86
Apis cerana indica	39	6	7	4	5	61	29.90
Ceratina sp.	19	-	2	3	-	24	11.76
Megachile sp.	5	4	4	-	2	15	7.35
Lasioglossum sp.	8	2	-	1	3	14	6.86
Apis dorsata	7	2	-	3	1	13	6.37
Halictus sp.	6	3	1	2	-	12	5.88
Total	118	24	22	19	21	204	

No. of locations – 27
Total no. of pollinators collected - 204
% RA - mean number of pollinators/m^2/5 min

Foraging Behavior of Bees

On culinary melon flowers, *A. cerana indica, T. travancorica* and *Halictus* sp. recorded maximum foraging speed during 10:00 h to 11:00 h. *C. hieroglyphica* and *Lasioglossum* sp. recorded highest foraging speed during 09:00 to 10:00 h. *T. travancorica*, *C. hieroglyphica* and *Lasioglossum*

Table 5. Composition and relative abundance of different hymenopteran pollinators in Pumpkin

Pollinator	Trivandrum	Kollam	Pathanam-thitta	Alappu-zha	Kasara-god	Total	% RA
Apis cerana indica	28	7	6	5	4	50	38.76
Tetragonula travancorica	15	4	4	3	5	31	24.03
Ceratina sp.	8	3	-	-	3	14	10.85
Apis dorsata	7	-	1	3	2	13	10.08
Lasiog lossum sp.	2	5	2	1	1	11	8.53
Halictus sp.	5	1	2	2	-	10	7.75
Total	65	20	15	14	15	129	

No. of locations – 19
Total no. of pollinators collected – 129
% RA - mean number of pollinators/m^2/5 min

Table 6. Composition and relative abundance of different hymenopteran pollinators in ash gourd

Pollinator	Trivandrum	Kollam	Pathanam-thitta	Alappu-zha	Kasara-god	Total	% RA
Tetragonula travancorica	43	6	7	4	6	66	33.50
Apis cerana indica	39	4	5	2	4	54	27.41
Ceratina sp.	10	-	4	-	3	17	8.62
Halictus sp.	8	3	-	5	-	16	8.12
Nomia sp.	7	2	2	-	2	13	6.59
Wasps	-	5	2	4	-	11	5.58
Lasioglossum sp.	6	-	2	-	1	9	4.56
Apis dorsata	6	1	-	-	-	7	3.55
Megachile sp.	4	-	-	-	-	4	2.03
Total	123	21	22	15	16	197	

No. of locations – 24
Total no. of pollinators collected – 197
% RA - mean number of pollinators/m^2/5 min

sp. recorded the highest foraging rate during 10:00 h to 11:00 h. While *A. cerana indica* and *Halictus* sp. were observed to have maximum foraging rate during 11:00 to 12:00 h and 09:00 to 10:00 h. Rapp (1981) reported that, on cucumber flowers, honey bees started foraging at 06:00 h and their activity was maximum from 09:00 to 12:00 h and was found decreasing in the afternoon hours. The peak foraging activity during morning hours can be correlated with the abundant availability of pollen and nectar during this period.

In the present study the maximum time was spent by *T. travancorica* (11.23 sec and 11.46 sec) for pollen collection, followed by *Lasioglossum* sp. (11.06 sec and 11.30 sec), *A. cerana indica* (10.61

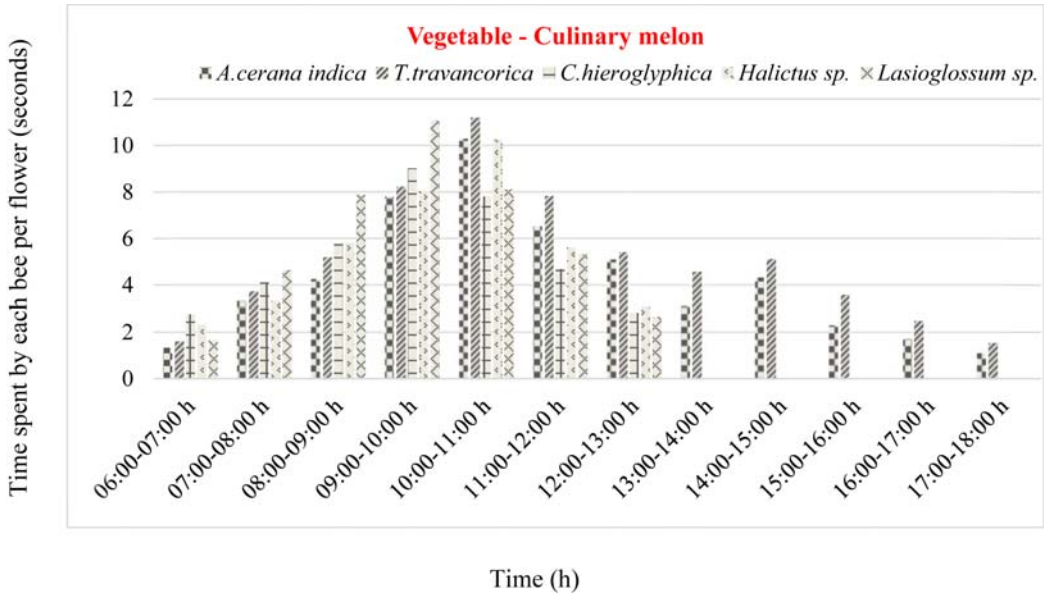

Fig. 1. Foraging speed (seconds) of hymenopteran pollinators during season I (October to November)

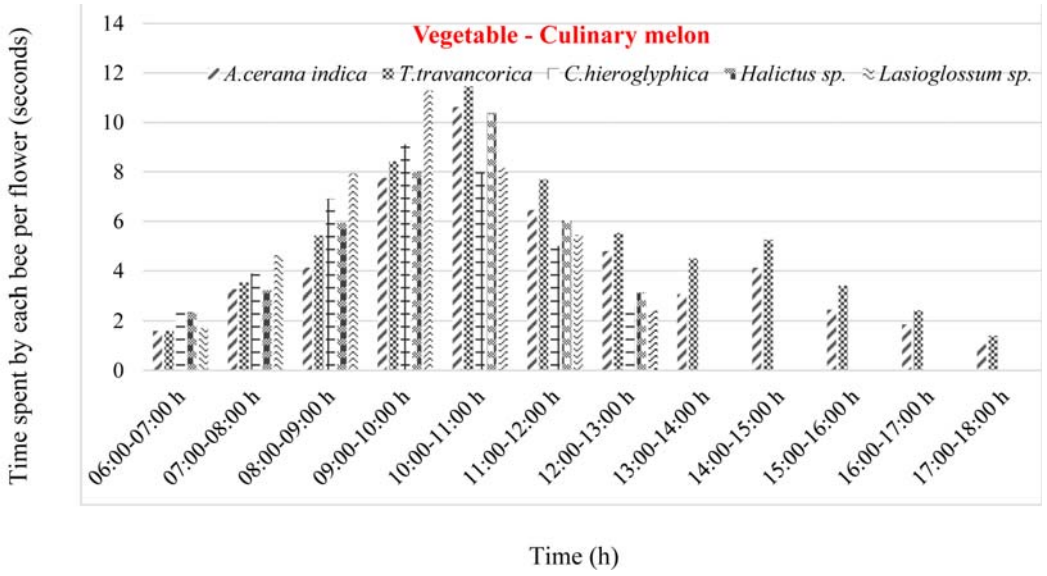

Fig. 2. Foraging speed (seconds) of hymenopteran pollinators during season II (November to December)

sec and 10.63 sec), *Halictus* sp. (10.26 sec and 10.40 sec) and *C. hieroglyphica* (9.02 sec and 9.11 sec) during two seasons. Prakash (2002) reported that in cucumber, among the honey bees, maximum time was spent for pollen collection, by *A. florea* (13.49 sec), followed by *T. iridipennis* (11.44 sec), *A. cerana* (9.65 sec), *A. mellifera* (8.74 sec) and the least in *A. dorsata* (7.22 sec). The difference in the foraging speed of bee species, may be due to different climatic conditions, type of

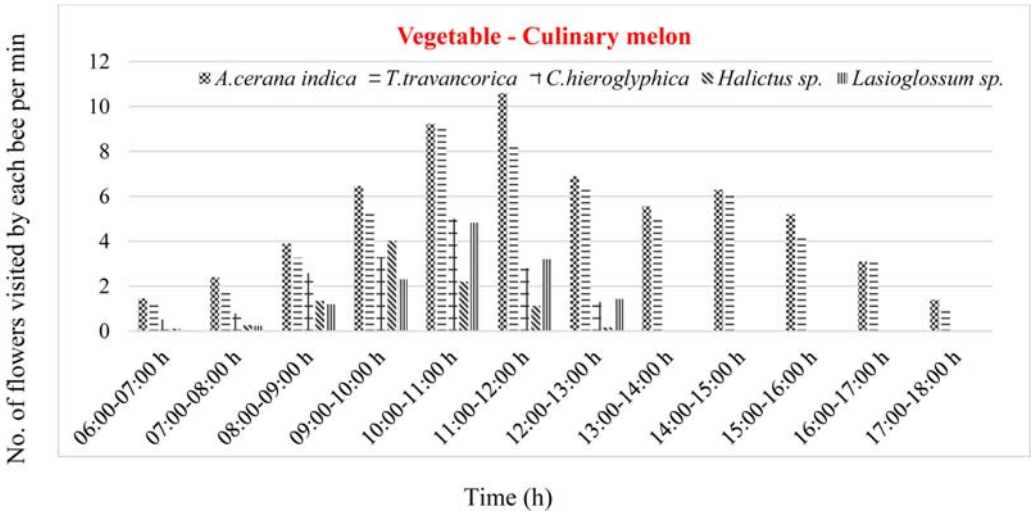

Fig. 3. Foraging rate of hymenopteran pollinators during season I (October to November)

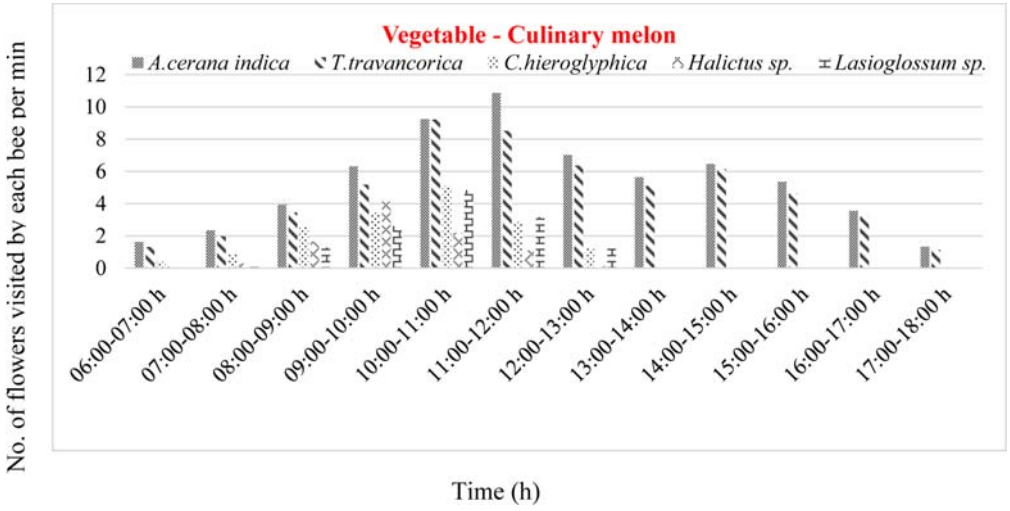

Fig. 4. Foraging rate of hymenopteran pollinators during season II (November to December)

crop, geographic location and species specific differences and variation in the availability of foraging source.

In culinary melon flowers, the mean foraging rate was found highest in *A. cerana indica* (10.60 & 10.88 flowers/min) followed by *T. travancorica* (9.16 and 9.23 flowers/min), *C. hieroglyphica* (5.01 and 5.10 flowers/min), *Lasioglossum* sp. (4.83 and 4.85 flowers/min) and *Halictus* sp. (4.03 and 4.13 flowers/min) during the two seasons. In Hisar, the data on the foraging activity of insect visitors in

Table 7. Composition and relative abundance of different hymenopteran pollinators in ridge gourd

Pollinator	Trivandrum	Kollam	Pathanam-thitta	Alappu-zha	Kasara-god	Total	% RA
Apis cerana indica	11	6	5	4	6	32	35.16
Xylocopa verticals	5	5	-	6	1	17	18.68
Wasps	5	-	4	3	2	14	15.38
Apis dorsata	3	4	1	-	4	12	13.19
Lasioglossum sp.	3	-	-	2	4	9	9.89
Amegilla zonata	1	3	3	-	-	7	7.69
Total	28	18	13	15	17	91	

No. of locations – 13
Total no. of pollinators collected – 91
% RA - mean number of pollinators/m^2/5 min

cucumber hybrids, *viz.*, Evergreen, NBH-Manu, Damini and Rani showed that the mean foraging rate irrespective of different day hours was highest in *A. dorsata* (8.63 flowers/min.) followed by *C. sexmaculata* (5.03 flowers/min.), and it was lowest in *Halictus* sp. (4.38 flowers/min.) (Hanh *et al*., 2014). Fluctuation in visits of insect pollinators on culinary melon flowers reveals that the visits were low at the time of commencement and cessation of flowering but these remained high during mid flowering period. This difference might be due to variation in the floral density during the span of blooming and changes in climatic conditions.

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