



Foraging Behaviour Of Species Of Honey Bees In Safflower *Carthamus tinctorius* L.

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ABSTRACT

The peak foraging activity of all pollinators was found at 10.00 - 12.00 hrs and 7th day after 10 per cent flowering was observed. The maximum time spent for pollen foraging (8.70 hrs) was recorded by *A. indica* and minimum (6.45 hrs) by *Trigona* spp. The number of flowers visited per minute and time of pollen and nectar foraging were minimum in case of *A. mellifera*. It means that honey bees spent less time for foraging nectar than pollen. Number of honey bees in bee hive per minute was found to be highest in *A. indica* followed by *A. florea* *A. mellifera*.

Key words: Honey bee, *Apis* spp., foraging behavior and *Carthamus tinctorius* L.

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INTRODUCTION

Use of pollinators is considered as one of able, cost effective and eco-friendly methods to enhance the cross-pollination and increase productivity and quality of crop. Safflower (*Carthamus tinctorius* L.) an oilseed crop is a member of the family Compositae or Asteraceae. Safflower, a multipurpose crop, has been grown for centuries in India for the orange-red dye (carthamin) extracted from its brilliantly colored flowers and for its quality oil rich in polyunsaturated fatty acids (linoleic acid, 78%). Safflower flowers are known to have many medicinal properties for curing several chronic diseases and they are widely used in Chinese herbal preparations (Li and Mundel, 1996). In 2013-2014, India ranks second position in harvested area of safflower seed among the Asian Countries after Kazakhstan of 1,50,000 ha. Production of Safflower (*Rabi*) in India during 2014-2015 was 0.90 Lakh Tonns. (Anonymous, 2015-2016). In India, Productivity levels of Maharashtra and Karnataka states (2014-2015) accounts for 55 and 37% of total safflower area and production, respectively. The other safflower producing states are Andhra Pradesh, Orissa, Madhya Pradesh, Chhattisgarh and Bihar. Safflower production in India was mostly confined to rain-fed conditions during winter. Safflower production in India is mostly confined to rain-fed conditions during winter. In order to minimize the cost of production, several low cost technologies to be evolved, one among them is the use of pollinators.

Safflowers produce abundant quantity of nectar and pollen which attract large number of honey bees. Though pollination is performed by other pollinators, honey bees accounts for a major share among them. It was therefore, pertinent to undertake the present study.

MATERIALS AND METHODS

The present experiment was carried out in *Rabi* season of the year 2016-2017 at Department of Agricultural Entomology, College of Agriculture, VNMKV, Parbhani. The soil was uniform with heavy black cotton having good fertility and drainage. The safflower variety PBNS-12 was sown with spacing 45 x 10 cm dated on 25/10/2016. The study was made on the crop raised in 3.0 x 3.0 m plot in *Rabi* season of 2016-17. Insects other than honeybees that were visiting safflower were collected from 0600 hrs to 1800 hrs at one hour interval by using a standard insect collecting hand net. The pollinators so collected were pinned, labeled and later got identified from Dr. C. Viraktmath, PI, Biosystematics project, GKVK, Bangalore. Insecticides were not applied during flowering period of the crop. The role of honeybee

species on yield parameters had eight treatments with three replications laid out in randomized complete block design with following treatments: T 1: Spray with Imidacloprid 17.8 SL @ 2.24ml/10lit, T 2: Spray with Imidacloprid 17.8 SL @1.12ml/10lit, T 3: Spray with Acetamiprid 20 SP @2gm/10lit, T 4: Spray with Acetamiprid 20 SP @1.2 gm/10lit, T 5: Open pollination (OP), T 6: Pollination without insects (PWI), T 7: One *A. florea* Fab. Colony (1 AF), T 8: Six framed *A. mellifera* Linn. Colony (6 FAM), T 9: Sugar syrup spray 5% (SSS), T 10: Cinnamon spray 10% (CS). Nylon mosquito nets having 6 X 6 m³ size (mesh 20 micron) was erected over the plots by using the bamboo sticks for treatment no. T6, T7 and T8. One colony of *A. florea* and six framed colony of *A. mellifera* were kept in T7 and T8 respectively. When 10 per cent of flowering was observed, the bee colonies was kept in the cages supplemented with water and 50 per cent sugar solution, which was replaced as and when required. The colonies were retained in the cages till the cessation of flowering and all the cages were also removed at the same time. The 10 per cent cinnamon spray solution was prepared by using 100 g of cinnamon in 1 lit of water and sugar syrup was sprayed at 5% concentration was sprayed at 10 per cent flowering. In the plots under pollination without insect treatments, no pollinating insects were allowed to enter inside the net. Insecticides were not applied during flowering period of the crop.

RESULTS AND DISCUSSION

Visitation of various pollinators at different day hours on safflower (bees/ m²/ 2 hrs). The visitation of various pollinators per meter square per minute at different day hours on safflower are presented in Table-5 and graphically depicted in Fig. 6 and Fig.7. The data from Table-5 revealed that the intensity of all the honey bee species gradually increases and reaches its peak from 10.00 to 14.00 hrs and then decline slowly.

Open pollination safflower plots

In the open pollinated safflower plots the foraging intensity of *Apis dorsata* was observed significantly maximum during 10 to 12 hrs (5.75 bees / m²) which were at par with intensity during 12 to 14 hrs (4.66 bees / m²), 08 to 10 hrs (3.33 bees / m²) and 14 to 16 hrs (2.58 bees / m²). In case of *Apis florea* maximum intensity recorded during 10 to 12 hrs (5.75 bees /m²) which was at par with 12 to 14hrs (4.66 bees /m²). The intensity of *A. indica* was observed significantly maximum during 12 to 14 hrs (5.08 bees / m²) which were at par with intensity during 10 to 12 hrs (4.50 bees / m²), 08 to 10 hrs (3.00 bees / m²) and 14 to 16 hrs (2.33 bees / m²).The maximum intensity of *Trigona* spp. recorded during 10 to 12 hrs (4.16 bees /m²) which were at par with intensity during 12 to 14 hrs (3.25 bees / m²), 08 to 10 hrs (2.33 bees / m²) and 14 to 16 hrs (2.08 bees m²). In case of *A. mellifera* maximum intensity recorded during 10 to 12 hrs (5.83 bees/m²) which was at par with 12 to 14 hrs (5.00 bees / m²). In other pollinators maximum intensity recorded during 10 to 12 hrs (3.41 pollinators /m²) which were at par with 08 to 10 hrs (2.16 pollinators /m²) and 12 to 14 hrs (2.08 pollinators /m²).

Caged safflower plots

In case of caged condition the foraging intensity of *A. florea* was maximum during 10 to 12 hrs (11.91 bees/m²) which was at par with 12 to 14 hrs (8.16 bees/m²). In six framed *A. mellifera* maximum intensity recorded during 10 to 12 hrs (15.66 bees /m²) which was at par with 12 to 14 hrs (12.66 bees /m²).

Sugar syrup sprayed safflower plots

The foraging intensity of pollinators in safflower plots sprayed with sugar syrup in general was increased in comparison with open pollinated plots. In case of intensity of *A. dorsata* it was maximum during 10 to 12 hrs (6.98 bees /m²) which was at par with 12 to 14hrs (5.16 bees /m²). The intensity of *A. florea* maximum during 10 to 12 hrs (6.70 bees/m²) but it was at par during 12 to 14 hrs (4.62 bees/m²). The intensity of *Trigona* spp. was maximum during 10 to 12 hrs (4.81 bees /m²) it was at par with 12 to 14 hrs (3.15 bees /m²). In case of *A. mellifera* highest foraging intensity recorded during 10 to 12 hrs (7.12 bees /m²) which was at par with 12 to 14 hrs (2.60 bees /m²). The *A. indica* recorded maximum foraging intensity insugar syrup sprayed safflower plots during 12 to 14 hrs (5.35 bees /m²) which were at par with 10 to 12hrs (5.23 bees /m²) and 08 to 10 hrs (2.70 bees /m²).The other pollinators observed maximum during 10 to 12 hrs (4.37 pollinators /m²).

Cinnamon sprayed plots

In cinnamon sprayed safflower plots the foraging intensity of *A. florea* was higher during 10 to 12 hrs (5.83 bees /m²) which was at par with intensity during 12 to 14 hrs (3.13 bees /m²).The intensity of *A. dorsata* and *A. indica* was maximum during 10 to 12 hrs (6.45 bees /m² and 4.45 bees /m², respectively). In *A. mellifera* the intensity was maximum during 10 to 12 hrs (6.95 bees/m²) which was at par with intensity during 12 to 14 hrs (4.30 bees /m²).The intensity of *Trigona* spp. was maximum during 10 to 12 hrs (4.45 bees /m²) it was at par with 12 to 14 hrs (2.95 bees /m²). In other pollinators it was maximum during 10 to 12 hrs (3.30 pollinators /m²) which were at par with intensity during 12 to 14 hrs (1.95

pollinators /m²), 08 to 10 hrs (2.05 pollinators /m²) and 14 to 16 hrs (1.30 pollinators /m²). In general intensity of all pollinators was low during 16 to 18 hrs.

The results obtained during present investigation are in conformity with Prakash (2002) who reported that, the activity of *A. indica* Fab. either in open plots or caged plots of cucumber was found to be maximum at 10.00 hr and lowest at 18.00 hr.

The results obtained during present investigation are in conformity with Prakash (2002) who reported that, the activity of *A. indica* Fab. either in open plots or caged plots of cucumber was found to be maximum at 10.00 hr and lowest at 18.00 hr. Patil and Sattigi (2007) reported the foraging activity of *A. florea* from 08.00 to 18.00 hr. of the day with significantly highest mean foraging bee activity at 12 hr. with 15.93 bees/m²/5min in watermelon. Baswana (1982) opined that *A. florea* and *A. dorsata* were main visitors of coriander and fennel ecosystem and their peak activity was found between 1100 to 1400 hr which was synchronized with peak of anthesis. Mc Gregor (1976) stated that mustard flowers are highly attractive to honey bees. Rakesh kumar *et al.* (1994) reported that honey bees were the most abundant pollinators constituting 97.00 per cent of all the insect visitors. *A. mellifera* was the most important pollinator (38.0 per cent) followed by *A. dorsata* (35.2 per cent). Bee foraging was observed from 06.00 to 18.00 hr with peak from 09.00 to 11.00 hr.

Visitation of various pollinators in safflower crop at different flowering periods (m²/min)

The data on visitation of various pollinators in safflower crop at different flowering periods are presented in Table 6 and graphically depicted in Fig.8 and fig.9. The data from Table 6 revealed that in general all the treatments the visitation of all the pollinators was maximum on 7th days after flowering.

Open pollinated safflower plots

The visitation of *A. mellifera* in open pollinated safflower was significantly highest at 7th days after flowering (4.72 bees/m²/min) which was found at par with 14th day after flowering (3.72 bees/m²/min). The visitation of *A. florea*, *A. indica* and *Trigona* spp. was also highest at 7th days after flowering (4.17, 4.22 and 3.39 bees/m²/min, respectively). In case of *A. Dorsata* the maximum visitation was at 7th days after flowering (4.61 bees/m²/min) but found at par with 14th day after flowering (3.66 bees/m²/min). The lowest visitation was at 1st days after flowering (2.22 bees/m²/min) which was at par with 21st days after flowering (2.55 bees/m²/min). The maximum visitation of other pollinators recorded at 7th days after flowering (2.61 pollinators /m²/min) which was at par with 14th (2.11 pollinators /m²/min).

Caged condition

The data regarding visitation of pollinators in caged condition revealed that maximum incidence of *A. mellifera* was observed during 7th day after flowering (12.61 bees/m²/min) but found at par with 14th day after flowering (9.94 bees/m²/min). In case of *A. Florea* visitation was significantly maximum during 7th day after flowering (8.61 bees/m²/min) but found at par with 14th day after flowering (6.83 bees/m²/min).

Sugar syrup sprayed safflower plots

The visitation of *A. dorsata* on safflower plots sprayed with sugar syrup was maximum on 7th day after flowering (4.81 bees/m²/min). The visitation of *A. indica* was significantly maximum during 7th day after flowering (4.26 bees/m²/min) which were at par with 14th day after flowering (3.10 bees/m²/min) and 1st day after flowering (2.76 bees/m²/min). In case of *A. florea* the maximum visitation was at 7th days after flowering (4.66 bees/m²/min) but found at par with 14th day after flowering (3.55 bees/m²/min). The visitation in case of *A. mellifera*, *Trigona* spp. and other pollinators were also maximum during 7th days after flowering (4.93, 3.15 and 3.05 bees/m²/min., respectively).

Cinnamon spray

The visitation of *A. dorsata* on cinnamon sprayed safflower plot was maximum on 7th day after flowering (4.65 bees/m²/min). The visitation in case of *A. florea*, *Trigona* spp., *A. mellifera* and *A. indica* were also maximum during 7th day after flowering (4.20, 3.05, 5.10 and 3.60 bees/m²/min., respectively). The maximum visitation of other pollinators recorded at 7th days after flowering (2.33 pollinators /m²/min) which was at par with 14th (1.81 pollinators /m²/min).

Devi *et al.* (2009) revealed that irrespective of date of observation, the average bee activity on sunflower bloom was low during morning hours (0.4/m²/min) and highest during noon hours (3.8/m²/min). On any given day the foragers visited on an average 1.2 flowers per minute. The bees spent more time on the bloom during afternoon than during forenoon hours. However, bee foragers spent more time on each flower early in the season than during later dates.

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Table: 1 Visitation of various pollinators on safflower crop at different day hours (bees/m²).

Sr. No.	DAF	Open pollination (T5)						Caged condition	
		<i>A. mellifera</i>	<i>A. florea</i>	<i>A. indica</i>	<i>A. dorsata</i>	<i>Trigona</i> sp.	Others	<i>A. mellifera</i>	<i>A. florea</i>
1	06-08	1.58 (1.44)	1.47 (1.40)	1.33 (1.35)	2.00 (1.58)	1.00 (1.22)	0.83 (1.15)	5.41 (1.43)	3.33 (1.96)
2	08-10	3.33 (1.96)	2.91 (1.85)	3.00 (1.87)	3.33 (1.96)	2.33 (1.68)	2.16 (1.63)	8.91 (3.07)	5.25 (2.40)
3	10-12	5.83 (2.52)	5.50 (2.45)	4.50 (2.24)	5.75 (2.50)	4.16 (2.16)	3.41 (1.98)	15.66 (4.02)	11.91 (3.52)
4	12-14	5.00 (2.35)	4.83 (2.31)	5.08 (2.36)	4.66 (2.27)	3.25 (1.94)	2.08 (1.61)	12.66 (3.63)	8.16 (2.94)
5	14-16	2.83 (1.82)	2.66 (1.78)	2.33 (1.68)	2.58 (1.75)	2.08 (1.61)	1.58 (1.44)	9.00 (3.08)	5.33 (2.41)
6	16-18	1.25 (1.32)	1.00 (1.22)	0.75 (1.12)	1.25 (1.32)	0.83 (1.15)	0.75 (1.12)	4.75 (2.29)	3.50 (2.00)
SE (m)±		0.21	0.23	0.26	0.25	0.34	0.24	0.24	0.41
CD at 5 %		0.67	0.74	0.82	0.77	1.07	0.74	0.76	1.27

*Figures in parentheses are $\sqrt{X + 0.5}$ transformed values

Table: 1Contd...

Sr. No.	Hours	Sugar syrup spray (T9)						Cinnamon spray (T10)					
		<i>A. mellifera</i>	<i>A. florea</i>	<i>A. indica</i>	<i>A. dorsata</i>	<i>Trigona</i> sp.	Others	<i>A. mellifera</i>	<i>A. florea</i>	<i>A. indica</i>	<i>A. dorsata</i>	<i>Trigona</i> sp.	Others
1	06-08	1.88 (1.54)	1.62 (1.55)	1.56 (1.43)	1.88 (1.54)	1.05 (1.24)	1.05 (1.24)	1.62 (1.45)	1.70 (1.48)	1.13 (1.27)	1.80 (1.51)	1.05 (1.24)	0.87 (1.17)
2	08-10	3.72 (2.05)	3.15 (1.91)	2.70 (1.79)	3.12 (1.90)	2.14 (1.62)	2.20 (1.64)	3.12 (1.90)	2.80 (1.81)	2.07 (1.07)	2.87 (1.83)	2.06 (1.07)	2.05 (1.04)
3	10-12	7.12 (2.76)	6.70 (2.68)	5.23 (2.39)	6.98 (2.73)	4.81 (2.30)	4.37 (2.20)	6.95 (2.75)	5.83 (2.51)	4.89 (2.32)	6.45 (2.63)	4.45 (2.22)	3.30 (3.95)
4	12-14	2.60 (1.76)	4.62 (2.26)	5.35 (5.85)	5.16 (2.38)	3.15 (1.91)	2.80 (1.81)	4.30 (2.19)	3.75 (2.06)	3.13 (1.90)	4.30 (2.19)	2.95 (1.86)	1.95 (1.56)
5	14-16	2.80 (1.81)	2.95 (1.85)	2.54 (1.74)	2.49 (1.73)	1.80 (1.51)	1.63 (1.46)	2.80 (1.81)	1.75 (1.50)	1.87 (1.54)	2.21 (1.64)	1.39 (1.37)	1.30 (1.34)
6	16-18	1.36 (1.36)	1.49 (1.41)	1.61 (1.45)	1.34 (1.35)	0.77 (1.12)	0.70 (1.09)	1.45 (1.39)	0.83 (1.06)	0.81 (1.05)	1.31 (1.34)	0.62 (1.05)	0.62 (1.05)
SE±		0.15	0.20	0.20	0.18	0.17	0.12	0.26	0.22	0.15	0.18	0.21	0.17
CD at 5%		0.45	0.65	0.64	0.55	0.56	0.38	0.82	0.69	0.48	0.57	0.67	0.54

*Figures in parentheses are $\sqrt{X + 0.5}$ transformed values

Table: Visitation of various pollinators on safflower at different flowering periods (m²/min).

Sr. No.	DAF	Open pollination (T5)						Caged condition	
		<i>A. mellifera</i>	<i>A. florea</i>	<i>A. indica</i>	<i>A. dorsata</i>	<i>Trigona</i> sp.	Others	<i>Apis mellifera</i>	<i>Apis florea</i>
1	1 st	2.05 (1.60)	2.22 (1.65)	1.94 (1.56)	2.22 (1.65)	1.39 (1.37)	1.22 (1.31)	6.55 (2.66)	3.61 (2.03)
2	7 th	4.72 (2.28)	4.17 (2.16)	4.22 (2.17)	4.61 (2.26)	3.39 (1.97)	2.61 (1.76)	12.61 (3.62)	8.61 (3.02)

3	14 th	3.72 (2.05)	3.33 (1.96)	2.88 (1.84)	3.66 (2.04)	2.49 (1.73)	2.11 (1.61)	9.94 (3.23)	6.83 (2.71)
4	21 st	2.73 (1.80)	2.50 (1.73)	2.28 (1.67)	2.55 (1.75)	1.83 (1.53)	1.27 (1.33)	8.50 (3.00)	5.94 (2.54)
SE±		0.11	0.16	0.13	0.21	0.19	0.22	0.18	0.18
CD at 5%		0.36	0.55	0.43	0.69	0.63	0.73	0.59	0.59

*Figures in parentheses are $\sqrt{X + 0.5}$ transformed values.
flowering

DAF=Days after 10 per cent

Table: 2Contd.....

Sr. No.	DAF	Sugar syrup spray (T9)						Cinnamon spray (T10)					
		<i>A.mellifera</i>	<i>A. florea</i>	<i>A.indica</i>	<i>A.dorata</i>	<i>Trigoa sp.</i>	Others	<i>A. mellifera</i>	<i>A. florea</i>	<i>A.indica</i>	<i>A.dorsata</i>	<i>Trigona sp.</i>	Others
1	1 st	3.15 (1.91)	2.92 (1.85)	2.76 (1.80)	3.10 (1.90)	1.70 (1.48)	1.76 (1.50)	2.25 (1.66)	2.05 (1.59)	1.42 (1.38)	2.42 (1.70)	1.65 (1.70)	1.42 (1.38)
2	7 th	4.93 (2.33)	4.70 (2.28)	4.26 (2.18)	4.81 (2.30)	3.15 (1.91)	3.05 (1.88)	5.10 (1.36)	4.20 (2.16)	3.60 (2.03)	4.65 (2.27)	3.05 (1.88)	2.33 (1.68)
3	14 th	3.66 (2.04)	3.60 (2.02)	3.10 (1.90)	3.55 (2.01)	2.25 (1.66)	2.05 (1.59)	2.99 (1.57)	2.65 (1.77)	2.10 (1.61)	2.81 (1.81)	1.98 (1.57)	1.81 (1.52)
4	21 st	3.15 (1.91)	2.55 (1.74)	2.20 (1.64)	2.42 (1.71)	1.92 (1.55)	2.15 (1.62)	3.15 (1.91)	2.31 (1.67)	2.15 (1.62)	2.70 (1.79)	1.42 (1.38)	1.39 (1.37)
SE±		0.12	0.09	0.12	0.03	0.07	0.10	0.08	0.08	0.10	0.07	0.06	0.07
CD at 5%		0.44	0.34	0.43	0.12	0.26	0.35	0.28	0.29	0.36	0.26	0.21	0.27

*Figures in parentheses are $\sqrt{X + 0.5}$ transformed values.
flowering

DAF=Days after 10 per cent

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