

Foraging Activity of Four Bee Species on Sesame Flowers During Two Successive Seasons in Ismailia Governorate, Egypt

Soliman M. Kamel¹, Hatem M. Mahfouz², Abd Elfatah H. Blal², Maysa Said Abd El-Wahed² and Mahmoud Farag Mahmoud^{1*}

¹Plant Protection Department, Faculty of Agriculture, Suez Canal University, 41522, Ismailia, Egypt (mfaragm@hotmail.com)

²Plant Production Department, Faculty of Environmental Agricultural Sciences, Suez Canal University El-Arish, Egypt

Received: January 8, 2013

Accepted: February 1, 2013

SUMMARY

Foraging activity of four bee species, *Apis mellifera* L., *Osmia* spp., *Ceratina tarsata* Morawitz and *Xylocopa pubescens* Spinola on sesame flowers was studied during two successive seasons of 2011 and 2012. Experimental observations were made during four periods of the day: 9:00-11:00 am, 11:00 am-1:00 pm, 1:00-3:00 pm and 3:00-5:00 pm, starting from initial flowering until the final session. Observation time was five minutes during each period and four bee species were observed visiting each square meter area. Five spots of 1 m² area were selected randomly, and the number of different species of bees visiting was counted for five minutes by using electronic stopwatch, voice recorder and digital video camera. The results of the study indicated that the four bee species were most abundant on sesame flowers between 11:00 am and 1:00 pm, and between 1:00 and 3:00 pm. Among the bees, *Apis mellifera* was the predominant species, followed by *Ceratina tarsata*, in the season of 2011, while a reverse order of the two was recorded in 2012. The average time spent per flower was highly significantly different among these four species.

Keywords: Sesame flowers; Bees; Foraging activity

INTRODUCTION

Co-evolution of flowering plants and their pollinators started about 225 million years ago (Price 1975; Maiti and Maiti 2011). Flowering sesame plants and bees have a special relationship in which both benefit from each other. Bees get food and in return facilitate the pollination process. Bees visit flowers to collect pollen or

nectar (Said 2012). Insufficient number of suitable pollinators causes a decline in fruit and seed production (Paratap 2001). Of total pollination activities, over 80% are performed by insects, and bees contribute with nearly 80% of total insect pollination, which makes them the best pollinators (Robinson & Morse 1989). Sesame blossom structure facilitates cross-pollination, even though the crop is usually viewed as self-pollinating. The rate of

cross-pollination lies between 0.5% and 65%, depending on insect activity, environmental conditions and availability of other vegetation (Rakesh Kumar & Lenin 2000). Ashri (2007) reported cross pollination rates of between 2.7 and 51.7% in Nigeria.

The objective of the present study was to record the foraging activities of four bee species on sesame flowers in Ismailia Governorate, Egypt, in order to identify the most important bees in different seasons and to include them in order to establish a balanced bee foraging system.

MATERIAL AND METHODS

The experiment was carried out at the experimental farm of the Faculty of Agriculture, Suez Canal University, Ismailia, Egypt, during the growing seasons of 2011-2012, randomly in all plots of a sesame crop that was raised for studies of pollinator fauna. Experimental observation was done during four periods of the day: 9:00-11:00 am, 11:00 am-1:00 pm, 1:00-3:00 pm and 3:00-5:00 pm starting with initial flowering until the final session 6-7 weeks later. The number of pollinators visiting each square meter area were counted for five minutes in each period. Five spots of 1 m² area were selected randomly, and the number of different species of visiting bees was counted for five minutes by using electronic stopwatch, voice recorder and digital video camera. The data were then averaged time-wise and species-wise to assess the most favourable period of the day for bee species to visit sesame flowers and the most dominant species in a day and at particular times of day.

Data obtained from the foraging activities were statistically analyzed using ANOVA (SAS Institute 2002). When F-test was significant, means were separated using Tukey's Honestly Significant Difference (HSD) Test at the 0.05 level of significance.

RESULTS

Foraging activity of *Apis mellifera* on sesame

The foraging activity of *Apis mellifera* on sesame flowers was observed from 9:00 am to 5:00 pm beginning on the third day after flowering throughout the forty-five days of flowering during the growing seasons of 2011 and 2012. Foraging activity during the first week after the appearance of mean 6 flowers started at 9:00-11:00 am with 2.4 bees/m²/5 min and the maximum was reached at 1:00-3:00 pm with 9.8 bees/m²/5 min (Table 1). As the day advanced, their activity declined to 7.8 bees/m²/5 min.

A similar trend was observed throughout the six weeks after flowering. Bee activity started from 9:00-11:00 am with 9.6, 13.8, 17, 10.4, 6.2 and 2.6 bees/m²/5 min, respectively. The peak activity of bees was noticed at 1:00-3:00 pm with 20.8, 30.8, 41.2, 23.8, 12.6 and 7 bees/m²/5 min.

The total number of bees throughout the seven weeks of observations was 434.6 with an average of 62.08. Two peaks of the average number of bees/flower were noticed, the first one in the first week of observation, with 0.99 bees/flower, and the second one was in the sixth week after flowering with 0.88 bees/flower. The average number of bees per flower was 0.77.

The results of the second season showed the same trend as the previous one, table 1. A day after six mean flowers appeared, *A. mellifera* started foraging at 9:00-11:00 am with 0.4 bees/m²/5 min. Maximum activity was found at 1:00-3:00 pm with 3.2 bees/m²/5 min and it decreased to 0.2 bees/m²/5 min at 3:00-5:00 pm.

A similar trend was observed during the six weeks after flowering. Bee activity started from 9:00-11:00 am with 4.2, 6.2, 13, 11, 5.4 and 0.6 bees/m²/5 min, respectively. The peak activity of bees was noticed at 1:00-3:00 pm with 10.6, 12.5, 21, 19.4, 9.8 and 2.8 bees/m²/5 min. The least activity was found at 3:00-5:00 pm with

Table 1. Foraging activity of *Apis mellifera* L. on sesame flowers in the growing seasons of 2011 and 2012

Time of observation	Number of <i>Apis mellifera</i> L. /m ² /5 min														Total	Average		
	3 DAF *		10 DAF		17 DAF		24 DAF		31 DAF		38 DAF		45 DAF					
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012				
9:00-11:00 am	2.4 b	0.4 b	9.6 c	4.2 b	13.8 b	6.2 b	17.0 b	13.0 bc	10.4 b	11 bc	6.2 b	5.4 b	2.6 c	0.6 b	62.0	40.8	8.8	5.8
11:00 am-1:00 pm	3.6 b	1.6 b	15.6 b	7.6 a	35.0 a	10.8 a	47.8 a	16.8 ab	28.6 a	15.4 ab	9.4 ab	10.2 a	6.6 ab	2.4 a	146.6	64.8	20.9	9.2
1:00-3:00 pm	9.8 a	3.2 a	20.8 a	10.6 a	30.8 a	12.5 a	41.2 a	21.0 a	23.8	19.4 a	12.6 a	9.8 a	7.0 a	2.8 a	146.0	79.3	20.8	11.3
3:00-5:00 pm	7.8 a	0.2 b	12.2 bc	5.0 b	15.2 b	5.8 b	19.6 b	10.6 c	13.6	9.0 c	7.0 b	3.8 b	4.6 bc	0.4 b	80.0	34.8	11.4	4.9
Total	23.6	5.4	58.2	27.4	94.8	35.3	125.6	61.4	76.4	54.8	35.2	29.2	20.8	6.2	434.6	219.7	61.9	31.2
Average/day	5.90	1.35	14.50	6.85	23.70	8.82	31.40	15.35	19.10	13.70	8.80	7.30	5.20	1.55	108.60	54.92	15.50	7.80
Average/flower	0.99	0.22	0.58	0.27	0.67	0.25	0.78	0.38	0.76	0.54	0.88	0.73	0.74	0.22	5.40	2.61	0.77	0.37

* DAF= Days after flowering

**Means followed by the same letter in a column are not statistically different by Tukey's HSD (P=0.05)

0.2, 5.0, 5.8, 10.6, 9.0, 3.8 and 0.4, respectively. The highest average number of bees/flower was noticed after thirty-eight days of flowering with 0.73 bees/flower.

The results in Table 1 indicate that the foraging activity of *A. mellifera* recorded at different times of observation in the flowering season of 2012 was lower than it was in 2011.

Foraging activity of *Ceratina tarsata* on sesame

Small carpenter bee, *Ceratina tarsata*, started foraging activity in the 2011 season at 9:00-11:00 am of the first observation day (3 days after flowering) with 4 bees/m²/5 min, which was the lowest number of the day. Maximum activity was found at 1:00-3:00 pm with 9.6 bees/m²/5 min, and it decreased at 3:00-5:00 pm to 5 bees/m²/5 min.

Ten and 17 days after flowering, *C. tarsata* foraging was at its maximum during the 1:00-3:00 pm period with 14.5 and 20 bees/m²/5 min, followed by the period of 11:00 am-1:00 pm with 12 and 18.6 bees/m²/5 min, respectively. At 9:00-11:00 am, 7.2 and 11.4 bees/m²/5 min were found visiting sesame flowers, respectively, while 6.6 and 11.6 bees/m²/5 min were recorded at 3:00-5:00 pm.

In the last four observations, i.e. from the 24th to 45th day after flowering, *C. tarsata* foraging was at a maximum at 11:00 am-1:00 pm with 28.6, 22.6, 17.2 and 9.8 bees/m²/5 min, respectively. Total foraging activity of *C. tarsata* was 26 bees/m²/5 min in the 1st week and it increased to 40.6, 61.6 and 81.0, bees/m²/5 min in the 2nd, 3th and 4th weeks of observation. Then it decreased gradually over the last 3 weeks of observation with 67.2, 48.2 and 26.6 bees/m²/5 min as the sesame flowering period came to an end.

The total number of bees over the seven weeks of observation was 351.2, with an average of 50.17. Two peaks

of the average number of bees/flower were noticed, the first one in the first week of observation with 1.08 bees/flower, and the second one was in the sixth week after flowering with 1.2 bees/flower. The average number of bees per flower was 0.75.

In the second season of 2012, *C. tarsata* started their foraging activity from 9:00-11:00 am of the first observation week. Two peaks of foraging activity were identified at the observation time of 11:00 am-1:00 pm and 1:00-3:00 pm during the seven weeks of the flowering period. After this the activity slowly decreased at 3:00-5:00 pm.

The total number of bees over the seven weeks of observations was 329.8 with an average of 47.1. One peak of the average number of bees/flower was noticed in the first week of observation with 1.2 bees/flower. The average number of bees per flower was 0.67.

Foraging activity of *Osmia* spp. on sesame

Foraging activity of *Osmia* spp. on sesame flowers was observed from 9:00 am to 5:00 pm from the third to the forty-fifth day after flowering during the growing seasons of 2011 and 2012. Foraging activity in the first week after the appearance of mean 6 flowers started at 9:00-11:00 am with 1.6 bees/m²/5 min and the maximum was reached at 1:00-3:00 pm with 7.2 bees/m²/5 min (Table 3). As the day advanced, the bee activity declined to 3.6 bees/m²/5 min at 3:00-5:00 pm.

In the last four observations from the 24th to 45th day after flowering, *Osmia* spp. foraging was at a maximum at 11:00 am-1:00 pm with 21.2, 19, 11.8 and 4.8 bees/m²/5 min, respectively. Overall foraging activity of *Osmia* spp. was 19.2 bees/m²/5 min in the 1st week and it increased to 49.8, 51.8 and 56.8 bees/m²/5 min in the 3rd, 4th and 5th weeks of observation. Then it decreased gradually in the last 2 weeks with 32.6 and 10.4 bees/m²/5 min as the sesame flowering period came to an end.

Table 2. Foraging activity of *Ceratina tarsata* Morawitz on sesame flowers in the growing seasons of 2011 and 2012

Time of observation	Number of <i>Ceratina tarsata</i> Morawitz/m ² /5 min																Total		Average	
	3 DAF *		10 DAF		17 DAF		24 DAF		31 DAF		38 DAF		45 DAF							
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012		
9:00-11:00 am	4.0 c	5.2 b	7.2 b	8.0 b	11.4 b	10.6 b	16 b	12.8 b	13 b	12.4 b	9.8 b	5.2 b	4.0 b	2.8 b	65.4	57.0	9.3	8.1		
11:00am-1.00 pm	7.4 ab	10.6 a	12.0 a	15.8 a	18.6 a	19.0 a	28.6 a	21.6 a	22.6 a	21.0 ab	17.2 a	10.6 a	9.8 a	7.0 a	116.2	105.6	16.6	15.08		
1:00-3:00 pm	9.6 a	9.2 a	14.8 a	14.8 a	20.0 a	17.6 a	23.0 a	24.6 a	21.2 a	24.4 a	15.0 a	9.2 a	8.8 a	8.6 a	112.4	108.4	16.05	15.4		
3:00-5:00 pm	5.0 bc	5.4 b	6.6 b	5.6 b	11.6 b	10.6 b	13.4 b	14.2 b	10.4 b	14.2 b	6.2 b	5.6 b	4.0 b	3.2 b	57.4	58.8	8.2	8.4		
Total	26.0	30.4	40.6	44.2	61.6	57.8	81.0	73.2	67.2	72.0	48.2	30.6	26.6	21.6	351.2	329.8	50.17	47.1		
Average/day	6.50	7.60	10.10	11.05	15.40	14.40	20.20	18.30	16.80	18.00	12.05	7.60	6.60	5.40	87.60	82.30	12.50	11.70		
Average/flower	1.08	1.20	0.40	0.44	0.44	0.41	0.57	0.45	0.67	0.72	1.20	0.76	0.94	0.77	5.30	4.75	0.75	0.67		

* DAF= Days after flowering

**Means followed by the same letter in a column are not statistically different by Tukey's HSD (P=0.05)

Table 3. Foraging activity of *Osmia* spp. on sesame flowers in the growing seasons of 2011 and 2012

Time of observation	Number of <i>Osmia</i> spp. /m ² /5 min														Total		Average	
	3 DAF *		10 DAF		17 DAF		24 DAF		31 DAF		38 DAF		45 DAF					
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
9:00-11:00 am	1.6 b	0.2 c	6.8 b	1.4 c	9.8 bc	5.0 b	7.6 b	8.0 b	9.2 b	4.8 b	5.0 b	3.0 a	1.8 b	1.4 a	41.8	23.8	5.9	3.4
11:00 am-1:00 pm	6.8 a	2.2 b	13 a	9.8 a	14.6 ab	11.8 a	19.2 a	14.6 a	19.0 a	8.4 a	11.8 a	4.8 a	4.8 a	3.4 a	89.2	55.0	12.7	7.8
1:00-3:00 pm	7.2 a	4.8 a	13 a	6.8 ab	16.6 a	10.6 a	15.4 a	13.8 a	18.2 a	6.6 ab	11.0 a	4.0 a	2.8 ab	3.2 a	81.6	49.8	11.6	7.1
3:00-5:00 pm	3.6 b	1.8 bc	6.4 b	4.2 bc	8.8 c	5.0 b	7.6 b	6.8 b	10.4 b	3.8 b	4.8 b	3.8 a	1.4 b	1.4 a	43.0	26.8	6.1	3.8
Total	19.2	9.0	39.2	22.2	49.8	32.4	51.8	43.2	56.8	23.6	32.6	15.6	10.4	9.4	259.8	155.4	36.3	22.2
Average/day	4.80	2.20	7.80	5.50	12.40	8.10	12.90	10.80	14.20	5.90	8.10	3.90	2.60	2.30	62.80	38.70	9.07	5.50
Average/flower	0.80	0.37	0.31	0.22	0.35	0.23	0.32	0.27	0.56	0.23	0.81	0.39	0.37	0.32	3.52	2.03	0.50	0.29

* DAF= Days after flowering

**Means followed by the same letter in a column are not statistically different by Tukey's HSD (P=0.05)

The total number of bees in the seven weeks of observation was 259.8 with an average of 37.1. Two peaks of the average number of bees/flower were noticed, the first one in the first week of observation with 0.80 bees/flower, and the second one was in the sixth week after flowering with 0.81 bees/flower. The average number of bees per flower was 0.50.

The results in Table 3 show the same trend as the previous Table (2). A day after the appearance of six mean flowers, *Osmia* spp. started foraging at 9:00-11:00 am with 0.2 bees/m²/5 min. Maximum activity was reached at 1:00-3:00 pm with 4.8 bees/m²/5 min and it decreased to 1.8 bees/m²/5 min at 3:00-5:00 pm.

A similar trend was observed in all of the six weeks after flowering. Bee activity started from 9:00-11:00 am with 1.4, 5, 8, 4.8, 3 and 1.4 bees/m²/5 min, respectively. But maximum activity of bees was noticed from 11:00 am-1:00 pm in all six weeks of the flowering period from the 10th to 45th day after flowering, with 9.8, 11.8, 14.6, 8.4, 4.8 and 3.4 bees/m²/5 min, respectively. The highest average number of bees/flower was noticed after thirty-eight days of flowering with 0.39 bees/flower.

The results in table 3 indicate that the foraging activity of *Osmia* spp. recorded at different times of observation throughout the flowering season of 2012 was lower than it was in the flowering season of 2011.

Foraging activity of *Xylocopa pubescens* on sesame

Data in Table 4 show the foraging activity of *Xylocopa pubescens* at different times of observation in the day. Maximum activity was noticed at 11:00 am-1:00 pm with a total number of 69.2 bees, and 9.8 bees as the average number of bees/m²/5 min, followed by the period 1:00-3:00 pm with the a total number of 61.6 bees, and 8.8 bees as the average number of bees/m²/5 min.

The lowest foraging activity of *X. pubescens* was noticed at 9:00-11:00 am and 3:00-5:00 pm with the same number of bees (4.6) as the average number of bees/m²/5 min. Total foraging activity of *X. pubescens* was 195.4 bees and the average number/m²/5 min was 27.9 bees. The average number of bees/flower ranged from 0.26 to 0.6 bees/flower during the seven weeks

Table 4. Foraging activity of *Xylocopa pubescens* Spinola on sesame flowers in the growing seasons of 2011 and 2012

Time of observation	Number of <i>Xylocopa pubescens</i> Spinola /m ² /5 min														Total		Average	
	3 DAF *		10 DAF		17 DAF		24 DAF		31 DAF		38 DAF		45 DAF					
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
9:00-11:00 am	1.6 b	0.4 b	4.0 b	4.0 b	6.6 b	8.8 ab	8.2 b	9.6 b	6.6 b	8.2 bc	3.8 b	4.2 b	1.4 b	0.8 a	32.2	36.0	4.6	5.1
11:00 am-1:00 pm	5.2 a	2.6 a	7.4 a	8.4 a	12.8 a	12.0 a	15.2 a	15.4 a	14.8 a	15.0 a	7.8 a	7.8 a	6.0 a	2.0 a	69.2	63.2	9.8	9.02
1:00-3:00 pm	4.4 a	0.4 b	7.8 a	1.2 c	11.8 a	4.2 b	13.0 a	4.2 c	12.0 a	4.6 c	7.8 a	1.2 c	4.8 a	0.6 a	61.6	16.4	8.8	2.3
3:00-5:00 pm	1.2 b	1.0 ab	4.4 b	3.2 bc	6.2 b	9.4 ab	8.6 b	12.0 ab	6.0 b	11.8 ab	4.6 b	3.4 bc	1.4 b	1.8 a	32.4	42.6	4.6	6.08
Total	12.4	4.4	23.6	16.8	37.4	34.4	45.0	41.2	39.4	39.6	24.0	16.6	13.6	5.8	195.4	158.8	27.9	22.6
Average/day	3.10	1.10	4.70	4.20	9.30	8.60	11.20	10.30	9.80	9.90	6.00	4.10	3.40	1.40	47.50	39.60	6.90	5.60
Average/flower	0.51	0.18	0.47	0.16	0.26	0.24	0.28	0.25	0.39	0.39	0.60	0.41	0.48	0.20	2.99	1.83	0.42	0.26

* DAF= Days after flowering

**Means followed by the same letter in a column are not statistically different by Tukey's HSD (P=0.05)

of observation, and the average number of bees for 7 weeks was 0.58 bees/ flower.

Maximum activity was noticed at 11:00 am-1:00 pm with 2.6, 8.8, 12, 15.4, 15, 7.8 and 2 bees/m²/5 min (Table 4). The least activity was found at 1:00-3:00 pm with 0.4, 1.2, 4.2, 4.2, 4.6, 1.2 and 0.6 bees/m²/5 min. Also, the results in Table 4 revealed that the foraging activity of *X. pubescens* recorded at different times of observation throughout the flowering period of 2012 was lower (158.8 bees) than it was in 2011 (195.4 bees). The average number of bees per flower was 0.26.

Comparative foraging activity of four different bee species

Comparative foraging activity of four different bee species indicated that the foraging activity commenced at 9:00-11:00 am with 7.8 bees/m²/5 min in the 2011 season and decreased to 5.6 bees/m²/5 min in 2012. The activity of bees gradually increased and reached its peak at 1:00-3:00 pm with 14.3 bees/m²/5 min in 2011, and at 11:00 am-1:00 pm with 10.2 bees/m²/5 min in 2012. The least activity of bees in the two successive seasons (2011 and 2012) was recorded at 3:00-5:00 pm with 7.5 and 5.7 bees/m²/5 min, respectively.

Among the bees, *Apis mellifera* was the predominant species with 14.6 bees/m²/5 min, followed by *Ceratina tarsata* with 12.5 bees/m²/5 min in the season of 2011.

The results were reverse in the season of 2012, *Ceratina tarsata* was the predominant species with 11.7 bees/m²/5 min, followed by *Apis mellifera* with 7.8 bees/m²/5 min.

Average number of bees per flower and average time spent per flower

The average number of bees of the four species foraging per flower was significantly different in the two seasons of this study. Maximum foraging efficiency was observed in *Apis mellifera* with 0.77 average number per flower, followed by *Ceratina tarsata* with 0.75 average number per flower. These results reversed in the second season of 2012, when maximum foraging efficiency was observed in *C. tarsata* with 0.67 average number per flower. These results clearly indicate that sesame flowers were a preferable floral resource to both *A. mellifera* and *C. tarsata*, in addition to their higher relative abundance in both seasons, compared to *Osmia* spp. and *Xylocopa pubescens*. Highly significant differences were detected among these four species regarding their average time spent per flower. The results clearly indicate that the average time spent per flower was relatively longer for the small carpenter bee *C. tarsata*, with 32.10 and 35.35 seconds/flower in both seasons, compared to *Osmia* spp. and *A. mellifera*. The least average time spent per flower was observed in *X. pubescens* with 6.70 and 5.05 seconds/flower in both seasons, respectively.

Table 5. Comparative foraging activity of four bee species on sesame flowers during the growing season of 2011

Time of observation	Average number of bees/m ² /5 min					Average
	<i>Apis mellifera</i>	<i>Ceratina tarsata</i>	<i>Osmia</i> spp.	<i>Xylocopa pubescens</i>	Total	
9:00-11:00 am	11.3	9.3	5.9	4.6	31.1	7.7
11:00 am-1:00 pm	15.2	16.6	12.7	9.8	54.2	13.6
1:00-3:00 pm	20.8	16.05	11.6	8.8	57.2	14.3
3:00-5:00 pm	11.1	8.2	6.1	4.6	30.0	7.5
Total	58.4	50.1	36.3	27.8	172.5	-
Average	14.60	12.50	9.07	6.90	-	-

Table 6. Comparative foraging activity of four bee species on sesame flowers during the growing season of 2012

Time of observation	Average number of bees/m ² / 5min					Average
	<i>Apis mellifera</i>	<i>Ceratina tarsata</i>	<i>Osmia</i> spp.	<i>Xylocopa pubescens</i>	Total	
9:00-11:00 am	5.8	8.1	3.4	5.1	22.4	5.6
11:00 am-1:00 pm	9.2	15.08	7.8	9.02	41.1	10.2
1:00-3:00 pm	11.3	15.4	7.1	2.3	36.1	9.02
3:00-5:00 pm	4.9	8.4	3.8	6.08	23.1	5.7
Total	31.2	46.9	22.1	22.5	122.7	-
Average	7.8	11.7	5.5	5.6	-	-

Table 7. Average of bees per flower and average time spent per flower by four bee species during the growing season of 2011

Parameter	<i>Apis mellifera</i>	<i>Ceratina tarsata</i>	<i>Osmia</i> spp.	<i>Xylocopa pubescens</i>
Average number of bees per flower	0.77 a	0.75 a	0.50 ab	0.42 b
Average time spent per flower (seconds)	16.75 c	32.10 a	25.15 b	6.70 d

*Means followed by the same letter in rows are not statistically different by Tukey's HSD ($P=0.05$). The number of observations for average time spent per flower, $n=50$).

Table 8. Average of bees per flower and average time spent per flower by four bee species during the growing season of 2012

Parameter	<i>Apis mellifera</i>	<i>Ceratina tarsata</i>	<i>Osmia</i> spp.	<i>Xylocopa pubescens</i>
Average number of bees per flower	0.37 b	0.67 a	0.29 b	0.26 b
Average time spent per flower (seconds)	18.25 c	35.35 a	23.50 b	5.05 d

*Means followed by the same letter in rows are not statistically different by Tukey's HSD ($P=0.05$). The number of observations for average time spent per flower, $n=50$).

DISCUSSION

Four species of bees, *Apis mellifera*, *Ceratina tarsata*, *Osmia* spp. and *Xylocopa pubescens*, were observed during their foraging activity on sesame flowers in the growing seasons of 2011 and 2012. *Apis mellifera* visitation was noticed from 9:00 am to 5:00 pm with a peak activity at 1:00-3:00 pm. Bee activity declined in the afternoon, reaching the lowest activity at 3:00-5:00 pm. The foraging activity of *A. mellifera* was seen throughout the flowering period. However, bee activity was highest on the 17th, 24th and 31st day after initiation of flowering. On the 38th and 45th day, it decreased as the flowering period came to an end. The present results are consistent with a report by Mohanarao and Suryanarayana (1990) on *Apis dorsata* activity peaking at 9:00 and 16:00 h of the day. Peak activity of *A. dorsata* was observed at 12:00 and 16:00 h in a report by Guruprasad (2001). Peak activity of *A. dorsata* on sunflower was reported at 11:00-12:00 h by Ahmed and Rehman (2002).

The foraging activity of *Ceratina tarsata* was recorded throughout the day from 9:00 am to 5:00 pm during the seven weeks following the appearance of mean 6 flowers. In general, the peak daily foraging activity of small carpenter bee, *C. tarsata* was observed at 11:00 am-1:00 pm with 16.6 bees/m²/5 min in the first season and at 1:00-3:00 pm with 15.4 bees/m²/5 min in the second season. The next maximum activity was observed at 1:00-3:00 pm with 16.05 bees/m²/5 min in the first season and at 11:00 am-1:00 pm with 15.08 bees/m²/5 min in the second season.

The foraging activity of *Osmia* spp. on sesame flowers was observed from 9:00 am to 5:00 pm, starting three days after flowering until 45 days after flowering during the growing seasons of 2011 and 2012. The to-

tal number of bees during seven weeks of observation was 259.8, with 37.1 on the average, in 2011, and 155.4, with average 22.2, in 2012. The results shown in Table (3) indicate that the foraging activity of *Osmia* spp. recorded at different times of observation throughout the flowering season of 2012 was lower than it was in 2011.

Xylocopa pubescens reached its maximum foraging activity during the season of 2011 at 11:00 am-1:00 pm, with the total number of 69.2 bees and 9.8 bees as the average number of bees/m²/5 min, while foraging activity was lower at 1:00-3:00 pm, with the total number of 61.6 bees and 8.8 bees as the average number of bees/m²/5 min. Maximum activity was again noticed at 11:00 am-1:00 pm in the growing season of 2012, with 2.6, 8.8, 12, 15.4, 15, 7.8 and 2 bees/m²/5 min. These results are in agreement with Pando et al. (2011), who reported *Xylocopa calens* as the most frequent species, followed by *Chalicodoma cincta cincta* and *Apis mellifera*. *Xylocopa calens* mainly foraged for nectar resources.

The average number of bees of the four species foraging per flower was significantly different in the two seasons of this study. Also, the average time spent per flower was highly significantly different among the four species. The results clearly show that the average time spent per flower was relatively longer for the small carpenter bee, *C. tarsata*, with 23.10 and 35.35 seconds/flower in both seasons, compared to *Osmia* spp. and *A. mellifera*. The least average time spent per flower was observed in *X. pubescens* with 6.70 and 5.05 seconds/flower in both seasons. These results are consistent with a report by Kamel (1997).

Insect pollinators are most abundant on sesame flowers between 11:00 am and 1:00 pm and 1:00 and 3:00 pm. This is because nectar flow is especially copious in sesame crops at that mid-day period, while nectar concentration gradually decreases in later hours.

REFERENCES

- Ahmed, B., & Rehman, A. (2002). Population dynamics of insect foragers and their effect on seed yield of rapeseed (*Brassica campestris* L. var. *toria*). *Indian Bee Journal*, 64 (3-4), 1-5.
- Ashri, A. (2007). Sesame (*Sesamun indicum* L.). In Singh, R. J., ed.: *Genetic Resources, Chromosome Engineering, and Crop Improvement*. Vol 4: Oilseed crops. CRC Press, Boca Raton, FL, USA, pp. 231-289.
- Guruprasad, G.S. (2001). *Maximization of niger productivity through enhancement of bee pollination*. M. Sc (Agri.) Thesis, Uni. Agril. Sci. Dharwad, India.
- Kamel, S.M. (1997). Occurrence and activity of hymenopterous insects on sesame flowers with special reference to their effect on crop production. *Annals of Agric. Sc. Moshtohor*, 35(3): 1713-1725.
- Maiti, P.K., & Maiti, P. (2011). *Biodiversity: perception, peril and preservation*. Asoke K. Ghosh, New Delhi, India, 542 pp.
- Mohana Rao, G.M., & Suryanarayana, M.C. (1990). Studies on the foraging behavior of honeybees and its effect on seed yield in Niger. *Indian Bee Journal*, 52: 31-33.
- Pando, J.B., Fohoud, F.N.T., & Tamesse, J.L. (2011). Foraging and pollination behaviour of *Xylocopa calens* Lepeletier (Hymenoptera: Apidae) on *Phaseolus coccineus* L. (Fabaceae) flowers at Yaounde (Cameroon). *Entomological Research*, 41(5): 185-193.
- Partap, T. (2001). *Mountain agriculture, marginal land and sustainable livelihoods: Challenges and opportunities*. International Symposium on Mountain Agriculture in HKH Region (21-24 May 2001). ICIMOD, Kathmandu, Nepal.
- Price, P. (1975). *Insect Ecology*. John Wiley and Sons, New York, USA.
- Rakesh, K., & Lenin, J.K. (2000). Insect pollinators and effects of cross pollination on yield attributes of Sesame (*Sesamum indicum* L.). *Indian Bee Journal*, 62: 80-88.
- Robinson, W.E., & Morse, R.A. (1989). The value of honeybees as pollinators of US crops. *American Bee Journal*, 129 (1): 477-487.
- Said, M. (2012). *Ecological studies on yield of sesame crop in the reclaimed lands*. M.Sc. thesis. Faculty of Agricultural Environmental Sciences, Suez Canal University, Al-Arish, Egypt, 118 pp.
- SAS (2002). *SAS/STAT User's guide, version 9.1*. SAS Institute Inc. Cary, North Carolina, USA.

Ispaša četiri vrste pčela na cvetovima susama tokom dve uzastopne godine u oblasti Ismailija u Egiptu

REZIME

Ispaša četiri vrste pčela, *Apis mellifera* L., *Osmia* spp., *Ceratina tarsata* Morawitz i *Xylocopa pubescens* Spinola, proučavana je na cvetovima susama tokom dve uzastopne godine, 2011. i 2012. Eksperimentalna posmatranja obavljena su tokom četiri perioda u toku dana: 9:00-11:00, 11:00-13:00, 13:00-15:00 i 15:00-17:00, u vreme između početka cvetanja i poslednjeg pregleda. Tokom svakog perioda, posmatranje je obavljeno u vremenu od pet minuta, a četiri vrste pčela su zabeležene u svakom kvadratnom metru. Pet tačaka od po 1 m² izabrano je po principu slučajnog uzorka, a pčele različitih vrsta brojane su tokom pet minuta pomoću elektronske štoperice, diktafona i digitalne video-kamere. Rezultati pokazuju da je najveći broj pčela sve četiri vrste posetilo cveće susama između 11:00 i 13:00, i između 13:00 i 15:00. Među pčelama *Apis mellifera* je bila najzastupljenija vrsta, a potom *Ceratina tarsata* tokom 2011. godine, dok je naredne 2012. godine redosled ove dve vrste bio obrnut. Prosečno vreme zadržavanja na cvetu se vrlo značajno razlikovalo za ove četiri vrste.

Ključne reči: Cvetovi susama; pčele; ispaša