Domestication and Propagation of the Leafcutting Bees, *Megachile Minutissima* in Different Locations at Ismailia Governorate

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Received: 31/12/2011

Abstract: Different models of artificial foam nests in their wooden shelters were prepared as attractive traps for re-nesting of *Megachile minutissima* Radoszkowski (Megachilidae: Hymenoptera), in different locations of natural nesting sites in El-Tel El-Kebir at Ismailia Governorate. These locations were El-Marzoukia, El-Zaheria and Tel-El-Hattab Bridge. The obtained results revealed that the model type of artificial nests, the position and the direction of these nests play an important role in the nesting activity of *M. minutissima*. Generally, the females prefer the artificial foam nests model No. 1 and attracted to the lower position and the right sides of these nests. Also, the average of cells per each straw reached the maximum of 4.73 cells in 2006 season, while the minimum was 3.44 cells in 2008 season.El-Marzoukia region was the best location for the nesting efficiency of *M. minutissima* at 43.77% completed straws, followed by 36.09% in El-Zaheria and 25.29% in Tel El-Hattab Bridge. The highest percentage of completed straws was observed at the left side and decreased gradually to the center then increased toward the right side of nest shelter. Meanwhile, the greatest number of live prepuae was found in El-Zaheria region, while the highest number of transformed pupae and adults was recorded in El-Marzoukia region.

Keywords: Artificial nests, polystyrene foam, leafcutting bee, nesting sites, nesting activity, *Megachile minutissima*

INTRODUCTION

Solitary bees are important pollinators in natural ecosystems and drastically outnumber the social bees including honeybees. Leafcutting bees, *Megachile* spp. (Megachilidae, Hymenoptera), are solitary but nests gregariously in pre-existing cavities, and have great potential as commercial pollinators of many seed crops, especially alfalfa, *Medicago sativa* L. (Hobs, 1965; Rashed and Ewies,1985 ,and Kemp and Bosch, 2000).

In Egypt, several attempts were conducted to establish and propagate these species of insect pollinators in new reclaimed lands where alfalfa are cultivated (Shebl *et al.*, 2008). These attempts had achieved greatest success in re-nesting of *Megachile minutissima* Radoszkowski, in artificial foam nests, which are easy to service, store and move to other alfalfa field places (Richards, 1978; Petrowski, 1991; Peterson *et al.*, 1994; Shoukry *et al.*, 2004; Kamel *et al.*, 2007). Several nesting materials were better suited for propagation of leaf cutting bees than others such as pine and fir polywood, polymers, styrofoam and polystyrene that produced a greater percentage of viable cells (Richards, 1978).

Various polystyrene and paper nests are commonly used from season 2000 until now in Egypt and developed year by year. Filled polystyrene and rolled paper nests are relatively inexpensive and easy to handle and better heat insulators (Petrowski, 1991). Under the artificial nesting, the bees have two generations per year; the first is the major one starting from late March until late of May and the second (minor one) starts from August until end of September (Kamel *et al.*, 2007, Richards 1984).

The present study was conducted to evaluate the nesting efficiency of *M. minutissima* using different models of artificial foam nests in order to adopt the most suitable type for propagation at different localities in El-Tel El-Kebir (El-Marzoukia, El-Zaheria and Tel-El-Hattab Bridge) at Ismailia Governorate.

MATERIALS AND METHODS

Experimental Sites

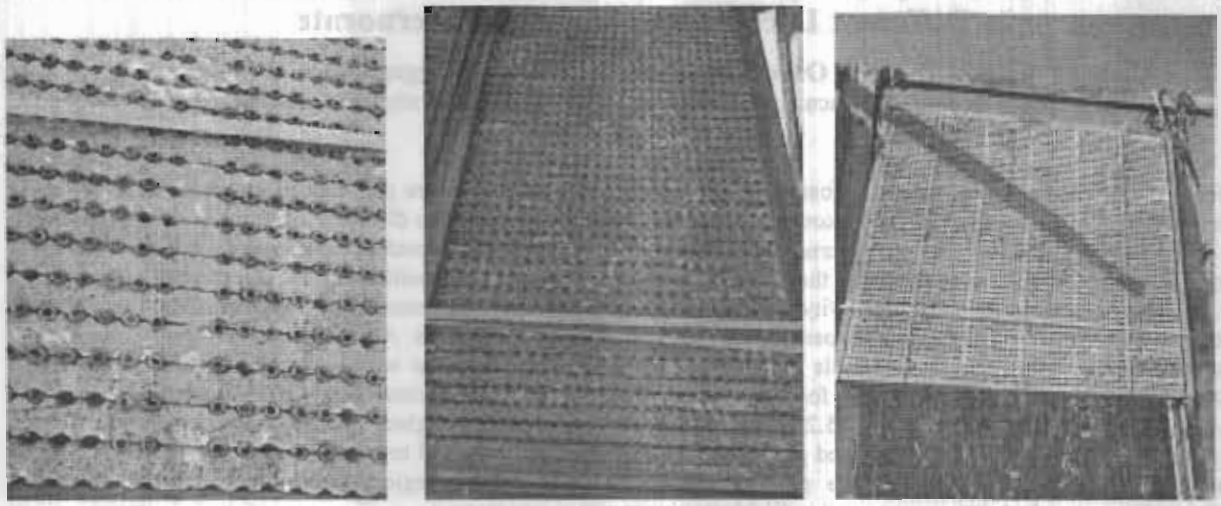
The field experiments were carried out on three different natural nesting sites of *M. minutissima* at three localities (El-Marzoukia, El-Zaheria and Tel-El-Hattab Bridge) of Tel El Kebir city (about 50 km west of Ismailia on the Delta of River Nile), during the period from 2006-2010.

Artificial Nests

Artificial nests were created and used for re-nesting of *M. minutissima* on their natural nesting sites. Shelters of wood boxes with grooved polystyrene wafers and inserted rolled paper straws were used as nesting materials to construct the artificial nests. Polystyrene foam wafers stacked one above the other. Each foam wafer was 50 cm in length, 12 cm in width and 2 cm thickness and contained 26 holes with 10 cm in depth and 6 mm in diameter. An appropriate number of paper straws (10 cm in length and 5.2 mm in internal diameter) by each straw were inserted in each hole. The outer surfaces of the artificial nests were painted with black or brown color to imitate the natural nests.

Three different models of artificial foam nests in their shelters were used in this experiment (Fig. 1). The first one (model No. 1) was 50 cm in width containing 30 holes arranged in two groups (15 holes in each) separated by equal distances of 2.5 cm, and 101 cm in length contained 46 holes without separating distances. The distance between holes was 1 cm in width and 1.5 cm in length. The model No. 2 was 49 cm in width containing 26 holes and 95 cm in length with a total of 40 holes. The distance between holes was 1 cm in width and 1.5 cm in length. Meanwhile, the model No. 3 (100 x 100 cm) had more number of holes about 60 and 48 holes in width and length, respectively. The distance between holes was 1 cm in both width and length.

The shelters of different models of artificial foam nests were distributed and hung on mud walls contain-



Model No. 1 Model No. 2 Model No. 3

Figure 1. Different tested models of artificial foam nests

-ing *M. minutissima* natural nests at the previous three different locations. In this study, 18 shelters (model No. 1) were used with a total number of 24840 holes, 14 shelters (model No. 2) with a total number of 14560 holes and 9 shelters (model No. 3) with a total number of 25920 holes.

Shelters of each foam nesting models were distributed to different locations as follows: shelters model No. 1 (13 shelters in El-Marzoukia, one in El-Zaheria and 4 in Tel El-Hattab Bridge), shelter model No. 2 (3 in El-Marzoukia, 9 in El-Zaheria and 2 in Tel El-Hattab Bridge) and shelter model No. 3 (4 in El-Marzoukia, 4 in El-Zaheria and one in Tel El- Hattab Bridge).

The nesting efficiency of *M. minutissima* in different models of artificial nests:

The nesting activity and efficiency of *M. minutissima* females in different models of artificial foam nests were studied during the period from 2006 to 2010. The successful completed straws in the different shelters of artificial nests were counted at the end of seasonal activity of *M. minutissima* to determine the followings:

- The best type of shelter models (model No. 1, model No. 2 and model No. 3).
- The suitable position for nesting on the surface of shelter (lower, upper, left and right directions).
- The mean number of failed straws in nests.
- The mean number of completed cells inside successful nested straws.

The artificial nesting efficiency of *M. minutissima* at three different locations:

The efficiency of *M. minutissima* in artificial nesting was compared at three different locations of natural nesting sites (El-Marzoukia, El-Zaheria and Tel-El-Hattab Bridge). Three types of shelters of artificial nests were used in each location. The successful and completed straws were counted weekly at the different locations at the end of season during the period from 2006 to 2010 to determine the best location and the best type of these shelters for *M. minutissima* nesting.

Seasonal distribution of different stages in the artificial nests of *M. minutissima*:

Weekly dissections were made in the laboratory for particular numbers of the successful completed straws, which contained 3, 4, 5, 6 and 7 cells (Fig. 2). The averages of immature stages of *M. minutissima* and empty cells, which were found in all dissected straws, were recorded during the period from August 11th, 2006 to July 30th.

Occurrence of prepupae of *M. minutissima*:

The occurrence rate of *M. minutissima* prepupae in their artificial nests at the three different locations was recorded during the period from 2006 to 2010. Here, 100 completed straws of each location were taken and transferred to the laboratory. Dissections were conducted to record the alive and dead prepupae. Cocoons of *M. minutissima* were removed gently from their cells in the nested straws, and then the cocoons were opened with fine razor bladder to determine their status and order inside the straws.

RESULTS AND DISCUSSION

The nesting efficiency of *M. minutissima* in artificial nests

Results (Fig. 3) showed the percentage of completed straws in both upper and lower parts of three different models of artificial foam nests during 2006 and 2007 seasons. The results demonstrated that model No. 1 of artificial foam nests was the most suitable model, where the nesting efficiency of *M. minutissima* was highest in both seasons of 2006 and 2007 with percentages of completed straws at 47.76% and 41.66%, respectively. The percentages of completed straws in the model No. 2 showed the lowest rate at 18.42% and 12.32%, respectively. These percentages for model No. 3 were in-between with averages of 36.66% and 24.32% in

2006 and 2007 seasons, respectively. Also, the lower positions of all tested models of foam nests were the preferred position for nesting of *M. minutissima* compared to the upper position of the same model. On the other hand, there were no significant differences between the percentage of completed straws of *M. minutissima* in both right and left sides of the shelter nests.

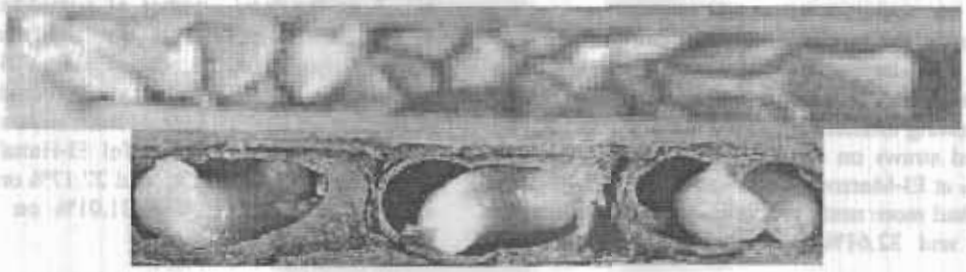


Figure 2. Dissection shows the immature stages of *M. minutissima* inside the successful nested straws.

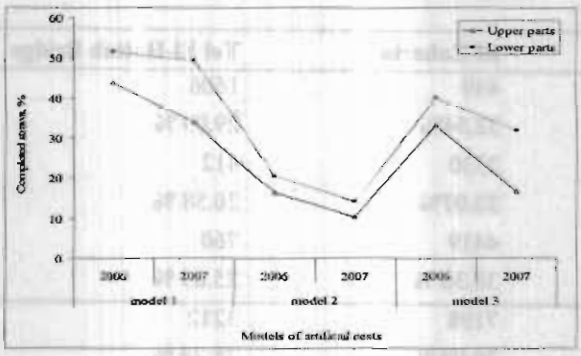


Figure 3. Percentage of completed straws of *M. minutissima* in both upper and lower positions of three different models of artificial foam nests during 2006 and 2007 seasons.

The mean number of completed straws in the different nest models, as well as their average in both upper and lower positions was the highest in 2006 season compared to those in 2007 season. Similar results were obtained in the following seasons from 2008 till 2010, however the nesting efficiency of *M. minutissima* was gradually decreased year after year.

From the results, it was clear that the model type of artificial nests, the position and the direction of these nests play an important role in *M. minutissima* in nesting activity in such artificial nests. Generally, *M. minutissima* females preferred the artificial foam nests model No. 1 and attracted to the lower position in the right sides of these nests.

The percentage of empty cells inside the straw tubes was calculated through dissection of some samples of straws every year during the course of this study. Data in Fig. (4) indicated that the percentages of empty cells inside the examined straws were gradually increased year after year, but the mean average of cells per each straw reached the maximum of 4.73 cells in 2006 season, while the minimum was 3.44 cells in 2008 season.

Our results are in agreement with those obtained by Strickler *et al.* (1996), who found that the number of cells per completed nest ranged between 1-12 and 1-9 cells with an overall average of 4.2 and 4.9 cells for *M. relativa* and *M. inermis*, respectively. Analogously, Scott *et al.* (2000) found that the mean number of cells per completed nest were 3.59 and 4.54 for *M. inermis* and *M. relativa*, respectively. However, Medler and Koerber (1958) recorded 2-14 cells per one nest of *M. relativa* with a higher average of 7.7 cells.

The artificial Nesting Efficiency of *M. minutissima*

Results in Table (1) showed that the highest efficiency of *M. minutissima* nesting as completed straws was recorded in El-Marzoukia region using foam nests model No. 1 with a percentage of 54.66%, followed by El-Zaheria and El-Marzoukia regions using foam nests model No. 3 with 38.36% and 37.72%, respectively. However, El-Zaheria, El-Marzoukia and Tel El-Hattab Bridge regions had lowest nesting efficiency of *M. minutissima* using model No. 2 with completed straws percentages of 33.07, 20.58 and 8.27 %, respectively.

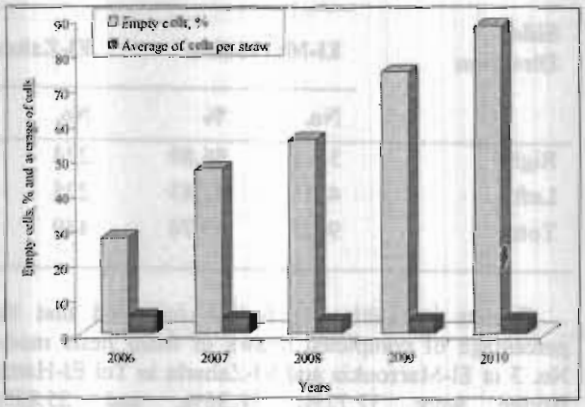


Figure 4. Percentage of empty cells in disseeted straws, and the average of cells per one straw during the period from January 6th, 2006 until July 30th, 2010.

Results also indicated that the highest percent of completed straws was recorded in the foam nests model No. 1 then in the model No. 3 at El-Marzoukia region. All the three foam nest models had moderately percentage of completed straws at El-Zaheria region. Generally, El-Marzoukia region was the best location for the nesting of *M. minutissima* with a percentage of 43.77% completed straws, followed by 36.09% in El-Zaheria and 25.29% in Tel El-Hattab Bridge. The

nesting efficiency of *M. minutissima* using model No. 1 as a percentage of completed straws was estimated at 54.66% in El-Marzoukia, 29.09% in Tel El-Hattab Bridge and 32.54% in El-Zaheria region in 2006 season (Table 1).

Furthermore, the rate of completed straws for each of right and left sides on these foam nests were recorded to determine the best side for nesting of *M. minutissima*. Results in nesting efficiency showed that the percentage of completed straws on right-side was 56.89% > left-side 52.43% at El-Marzoukia. However, the left-side of same nests had more nesting efficiency with percentage of 31.01% and 32.61% compared to the right-side 27.17% and 32.46% at Tel El-Hattab Bridge and El-Zaheria location, respectively.

Data in Table (2) indicated that the nesting efficiency of *M. minutissima* on the foam nests model No. 1 as the total number of completed straws was 48.94% and 46.58% on the right and left side, respectively. Therefore, the nesting efficiency of *M. minutissima* at different locations could be arranged depending on the part side of foam nests as follows; El-Marzoukia, El-Zaheria and Tel El-Hattab Bridge as a percentage of 56.89, 32.46 and 27.17% on the right side and 52.43%, 32.61% and 31.01% on the left side, respectively.

Table 1. Numbers and percentages of completed straws of *M. minutissima* in three types of artificial foam nests at three different locations in 2006 season.

Type of artificial foam nests		Locations		
		El-Marzoukia	**El-Zaheria**	**Tel El-Hattab Bridge**
Model No. 1	No. of completed straws	9823	449	1606
	%	54.66%	32.54%	29.09 %
Model No. 2	No. of completed straws	256	2330	412
	%	8.27 %	33.07%	20.58 %
Model No. 3	No. of completed straws	4323	4419	760
	%	37.72 %	38.36 %	25.85 %
Total		14236	7198	3212
		43.77 %	36.09 %	25.29 %

Table 2. Numbers and percentages of completed straws of *M. minutissima* in both right and left sides of the foam nests model No. 1 at three locations in 2006 season.

Side Direction	Locations							
	El-Marzoukia		**El-Zaheria**		**Tel El-Hattab Bridge**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Right	5112	56.89	224	32.46	750	27.17	6086	48.94
Left	4711	52.43	225	32.61	856	31.01	5792	46.58
Total	9823	53.74	449	32.54	1606	29.09	11879	47.76

Results in Table (1) further indicated that the percentage of completed straws of foam nests model No. 3 at El-Marzoukia and El-Zaheria in Tel El-Hattab Bridge were 37.72%, 38.36%, and 25.85%, respectively. It was clear that model No. 3 was the best model for nesting *M. minutissima*. Therefore, four shelters of this model type were selected and each one divided into six groups as columns beginning from the right side and ended to the left side of the shelter surface to determine the best position of these shelters for nesting efficiency of *M. minutissima*.

The highest percentage of completed straws was obtained at the left side and decreased gradually toward the center then increased toward the right side of nest shelter (Table 3). The percentages of completed straws were 52.67, 46.18, 39.27, 31.47, 29.06 and 27.7% for column 1, column 6, column 2, column 5, column 4 and column 3 at El-Marzoukia location, respectively. Also, the percentages of completed straws were 56.67, 55.57, 34.53, 34.11, 26.67, and 22.6% for the column 6, column 1, column 2, column 5, column 4 and column 3 at El-Zaheria location, respectively (Table 3).

Results indicated that highest percentage of completed straws was recorded in column No. 1 and column No. 6 at both locations of El-Marzoukia and El-Zaheria regions (Table 3). This indicates that the best direction for nesting of *M. minutissima* was observed at the far right-side (column No. 1) and far left-side (column No. 6) of nest shelters. Generally, the obtained results for the best part or column on the nest shelters for nesting of *M. minutissima* showed that, these column groups could be arranged as follows; 1st column (50.88%) > 6th (49.14%) > 2nd (35.19%) > 5th (32.41%) > 4th (27.78%) > 3rd (24.56%).

Data in Table (4) also indicated that the nesting activity were 47.76%, 36.66% and 18.42% for 2006 season and 41.66%, 24.32% and 12.31% for 2007 season in foam nests model No. 1, 3 and 2 respectively.

Table 3. Average numbers and percentages of completed straws of *M. minutissima* in column groups on foam nest shelters model No. 3 at three locations in 2006 season a Ismailia governorate.

Locations		Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
El-Marzoukia	No. of completed straws	1006	750	529	555	601	882
	%	52.67%	39.27%	27.7%	29.06%	31.47%	46.18%
El-Zaheria	No. of completed straws	1067	663	434	512	655	1088
	%	55.57%	34.53%	22.6%	26.67%	34.11%	56.67%
Tel El-Hattab Bridge	No. of completed straws	125	107	98	133	144	153
	%	25.52%	21.84%	20.0%	27.14%	29.39%	31.22%
Total	No. of completed straws	2198	1520	1061	1200	1400	2123
	%	50.88%	35.19%	24.56%	27.78%	32.41%	49.14%

Number of a live prepupae of *M. minutissima* at different locations:

Data presented in Fig. (5) showed that the greatest number of alive prepupae was recorded in El-Zaheria region at 64.84%, followed by 56.54 and 51.24% in Tel El-Hattab Bridge and El-Marzoukia. On the contrary, the lowest percentage of dead prepupae of 4.25% was recorded in Tel El-Hattab Bridge region. The highest rate of empty cells 29.15% was observed in El-Marzoukia region, followed by 21.90% and 19.63% in Tel El-Hattab Bridge and El-Zaheria, respectively. The average percentages of alive and dead prepupae, as well as the empty cells inside the dissected completed straws were 56.01%, 7.30% and 24.70%, respectively.

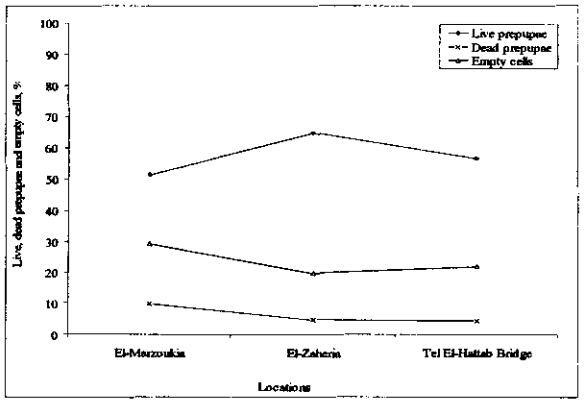


Figure 5. Percentage of alive, dead prepupae and empty cells in dissected straws at four locations during the periods from July 7th, 2006 to May 30th, 2007.

It was clear from the previous data that the El-Zaheria region was the best location for nesting of *M. minutissima* in terms of the highest percentage of living prepupae, while El-Marzoukia region was the least suitable location in this respect. The obtained results are in agreement with those obtained by Strickler *et al.* (2000) who demonstrated that the bees of *M. rotundata* in Canada usually have a much greater percentage of alive cells (about 75%) than do bees reared in the U.S (about 45%).

Regarding the second generation, results in Table (5) showed that the average of alive and dead prepupae inside dissected cells was 6.28% and 0.49% for the second generation compared to 56.01% and 7.3% for the first one, respectively. On the contrary, the percentage of empty cells in the second generation was greatly higher at 92.68% as compared with 24.70% in the first generation.

In general, it could be concluded that the obtained results of alive prepupae in the first generation was much better than results of the second generation, as well as the increase in the rate of empty cells in the second generation due to the lack of a sufficient number of females in this season.

CONCLUSIONS

In conclusion, the obtained results clearly demonstrated that the nesting efficiency of *M. minutissima* was affected by the model type of artificial nests and different localities of natural nest sites. The maximum occurrence of adult stage was recorded in May and September represented by two generations of *M. minutissima* per year. The influence of the different locations on the nesting activity of *M. Minutissima* may be due to variation in the natural ecosystems including vegetation cover and pollen sources, in addition to the differences in natural nest size and populations. Assuming that the variance of nesting efficiency depending directly or indirectly on the bees' preference for their nesting sites and localities. Sun radiation, winds, nesting height, vegetation and surrounding areas might have a great impact on bees choice for the nesting site.

Table 4. Numbers and percentages of completed straws of *M. minutissima* in three models of artificial nests in 2006 and 2007 seasons.

Season	Model No.1	Model No.2	Model No.3
2006	11878 (47.76%)	2998 (18.42%)	9502 (36.66%)
2007	6911 (41.66%)	1879 (12.31%)	6303 (24.32%)

Table 5. Number of alive and dead prepupae of second generation of *M. minutissima* and the numbers of empty cells at the three studied locations during the period from July 6th, 2007 to August 17th, 2007.

Location	Total No. of Straws	Total No. of Cells	Prepupae		Empty cells
			live	dead	
El-Marzoukia	20	87	10	1	76
El-Zaheria	15	70	3	0	67
Tel El-Hattab Bridge	15	48	1	0	47
Total	50	205	14 (6.28%)	1 (0.49%)	190 (92.68%)

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