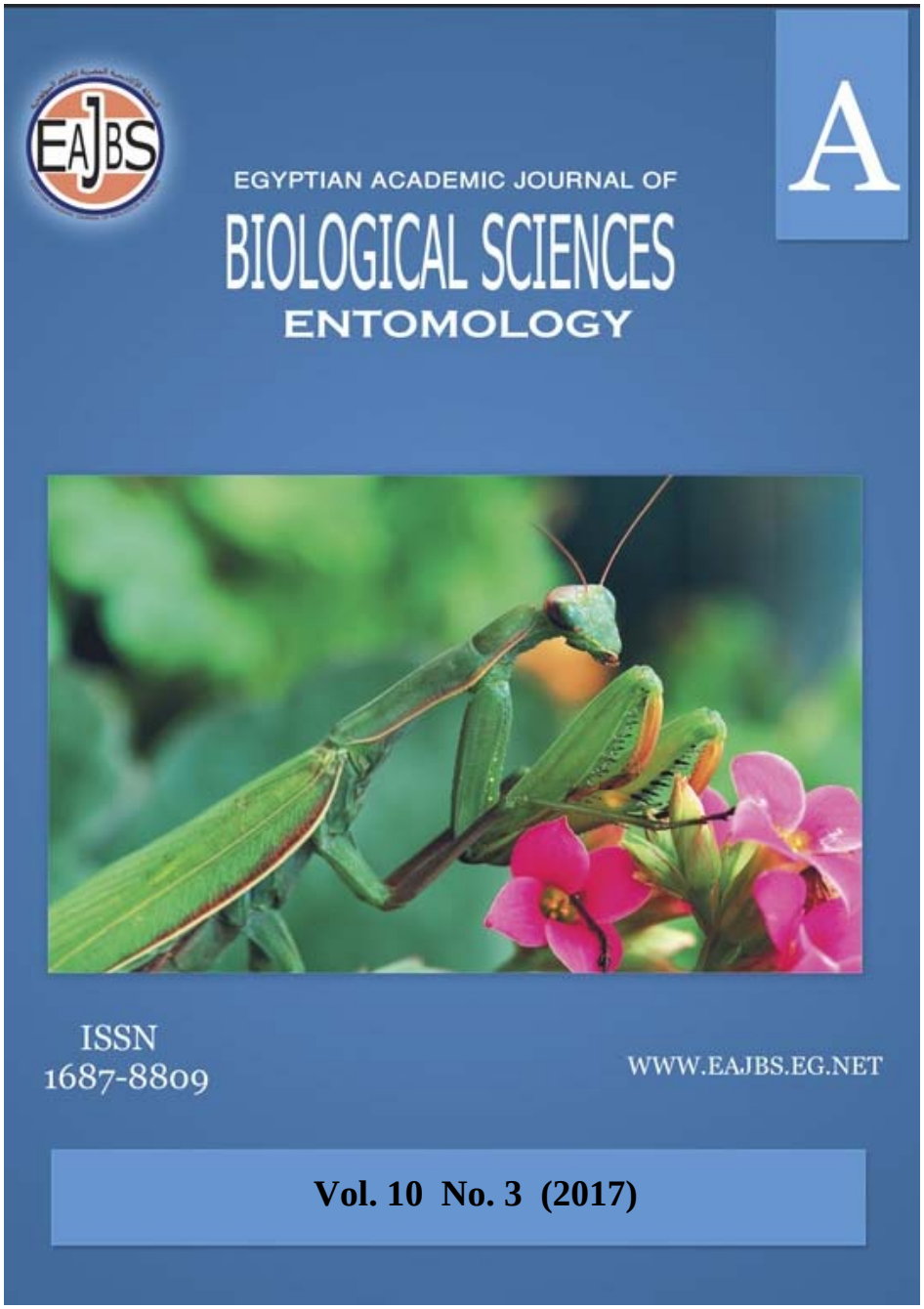

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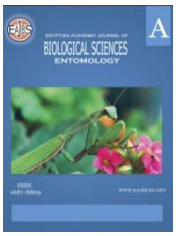

Evaluation of Nutritive Value of Some Medical Plants for Honey Bee Colonies (*Apis mellifera* L.).

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ABSTRACT

This study was conducted to evaluate the effect of different feeding treatments of some medical plantson brood production, population development of honey bee colonies and storage honey. Seven feeding treatments were carried out during March 2016to July2016. The feeding treatments were (sugar bush leaves (*Stevia rebaudiana*), moringa leaves (*Moringa oleifera*) in honey syrup (67%), tomatillo/jamberry (*Physalis peruviara*) in honey syrup (67%), guava (*Psidium guava*) in honey syrup (67%), coriander (*Coriandrum sativum*) in honey syrup (60%), honey syrup (67%) and sugar syrup (1 sugar:1 water).Colonies were equalized in number of frames covered with bees and brood areas and had young fertilized queen bees of the same age. Feeding was conducted at 10-day intervals with 500 ml syrup/colony of each treatment. The brood production and population development were recorded at 30 day-intervals. It was shown that brood production was significant highest in the honeybee colonies which fed on coriander, tomatillo/jamberry, guava and sugar syrup without significant deterrence between them (7083.17, 5652.58, 5287.08 and 6321.67 brood areas (Cm^2)/colony), respectively. Population development and honey storage were significant highest in honeybee colonies which fed on coriander (9.17 frames bees/colony and 4.50 frames honey/colony). The group fed on sugar bush and moringa syrup significantly did not increase brood area and honey bee population as compared with other groups.

INTRODUCTION

Honey bees (*Apis mellifera* L.) play an important role in biological communities as pollinators and have immense economic and ecological impact on crops and wild plants (Morse and Calderone 2000 and Keller *et al*., 2005). Honey bee colony losses are greater now than any time in recent history (van Engelsdorp *et al*., 2007, 2009).

Several factors negatively impact the development and productivity of honey bee (*Apis mellifera*) colonies and colony health, including pathogens (Cox-Foster *et al*. 2007), parasitic mites (Amdam *et al*., 2004), parasites such as *Nosema microsporidia* (Higes *et al*. 2009), pesticide exposure (Sanchez-Bayo and Goka 2014), poor nutrition (Brodschneider and Crailsheim 2010), and the interactions of these factors (Potts *et al*., 2010). Reasons for other losses such as those dying from colony collapse disorder (CCD) have been elusive (van Engelsdorp *et al*., 2009). Nutrition deficiency and starvation are likely contributing reasons for colony losses around the world (van Engelsdorp *et al*., 2009 and De Grandi-Hoffman *et al*., 2010).

Angiosperm plant pollen and nectar are essential food sources for bees (Haydak, 1970). Nectar is a carbohydrate source, whereas pollen is the primary protein source. In addition, pollen is also composed of carbohydrates, lipids, and various vitamins and minerals (Roulston and Cane, 2000).Nectar is primarily a carbohydrate source, but can contain some amino acids and lipids (Percival, 1961; Baker and Baker, 1975). Some digestion of pollen occurs in the midgut, but the primary means by which the nutrients from pollen are made available to the colony is its conversion to worker jelly.

Pollen is the honey bees' main source of several important nutrients; it insures the growth of colonies because it provides protein to adult bees and stimulates brood rearing. Consequently, an adequate pollen supply is essential to ensure the long-term survival of a colony and to maintain its productivity and reduced brood rearing (Keller *et al*., 2005; Mattila and Otis, 2007; DeGrandi-Hoffman *et al*., 2008) and workers that transition from nest activities to foraging earlier in their adult life (Schultz *et al*., 1998; Toth *et al*., 2005; Toth and Robinson, 2005).The pollen protein content from different plant species and regions varies widely (2.5–61 %; Roulston *et al*., 2000), which yields different nutritive values for bees. The availability, quality, and diversity of the pollen diet translate into the nutrients available to the colony and reflect bee health. Pollen quality can affect bee longevity (Schmidt *et al*., 1987), ovarian activation (Hoover *et al*., 2006; Human *et al*., 2007; Pirk *et al*., 2010), larva body size (Tasei and Aupinel, 2008), and physiological metabolism (Alaux *et al*., 2011; Di Pasquale *et al*., 2013), whereas pollen diversity likely also plays an important role in immunity (Alaux *et al*., 2010; Di Pasquale *et al*., 2013). Frias *et al*., (2016) evaluated the survival and physiology of adult queen less bees fed different mixed pollen diets. The results showed that the pollen-type composition and nutrition quality of the diet influenced bee physiology and health and certain pollen types are more detrimental than others.

De Grandi-Hoffman *et al*., (2010) found that the virus concentrations increased as bees aged and were highest in those fed sugar syrup and lowest in bees fed pollen. Overall results suggest a connection between diet, protein levels and immune response and indicate that colony losses might be reduced by alleviating protein stress through supplemental feeding. Ali (2006) evaluated seven food regimes in honey bee colonies and found that brood production and population development were significant highest in the group fed on pollen grains cake plus sugar syrup (PS); pollen grains cake only (P) and soya bean flour and pollen grains cake plus sugar syrup (SPS).

MATERIALS AND METHODS

Experiment was carried out on honey bee colonies (*Apis mellifera carnica*), during the period extended from March to July, 2016 in the apiary located at Faculty of Agriculture, Ain Shams University, Shoubra El-Khema, Cairo, Egypt. This region is poor in nectar and pollen sources.

Preparation of honey bee colonies:

Twenty one honey bee colonies were prepared for this study. Colonies were approximately equalized in number of frames covered with bees and brood areas and had young fertilized queen bees of the same age, each colony had two frames of brood, one frame honey and pollen and one empty frame, the frames were covered with adult workers of honey bees. They were divided into seven different groups, each group had three colonies and each one received one of the following feeding

treatments as follows:

- The first group received syrup of sugar bush leaves (*Stevia rebaudiana*).
- The second group received extract of moringa leaves (*Moringa oleifera*) in honey syrup (67%).
- The third group received extract of tomatillo/jam berry (*Physalis peruviara*) in honey syrup (67%).
- The fourth group received extract of guava (*Psidium guava*) in honey syrup (60%).
- The fifth group received extract of coriander (*Coriandrum sativum*) in honey syrup (67%).
- The sixth group received honey syrup (67%).
- The seventh group received sugar syrup (1 sugar: 1 water).

Feeding was conducted at 10-day intervals Mladenovic *et al*., (2002) and500 grams of each feeding was added during the experiment period.

Preparation of different feeding treatments:

- **Sugar bush:** 60 g of sugar bush leaves was ground in a blender and macerated in 1500 ml of water for one hour.
- **Moringa:** 60 g of moringa leaves was ground in a blender and macerated in 500 ml of water and warmed in water bath at 40^0c for a few minutes and added to 1000 g honey (80%).
- **Tomatillo/jam berry**: 60 g of tomatillo/jam berry fruits was squeezed in a blender and dissolved in 1500 ml of honey syrup (67%).
- **Guava:**60 g of guava fruits was squeezed in a blender and dissolved in 1500 ml of honey syrup (67%).
- **Coriander**: 60 g of coriander seeds was grounded in a blender and dissolved in 1500 ml of honey syrup (67%).
- **Honey syrup (67%):** To make honey syrup (67%), 130 ml of warm water was added to 1000 g of honey (80%) and steered well**.**
- **Sugar syrup:** The syrup was made of pure can sugar which is composed of 1 part of sugar to 1 part of water.

After preparing the feeding treatments, 500 ml syrup of each feeding treatment introduced immediately for each experimental colony. It was added in an inner feeder and some trees sticks were added inside the feeder for bees to stand on them during their feed on the syrup.

Honeybee colonies strength:

The following parameters were studied: Brood area in cm^2, number of frames covered with adult bees and number of frames of honey. The brood areas were measured for both sides of each brood frame in all the experimental colonies by using a ruler. The number of frames covered with honey bees from both sides and frames of honey were recorded visually for each frame. The brood production, population development and honey areas were recorded monthly.

Experimental Design and Analysis: The experimental design was a completely randomized design. Results were analyzed using SAS (SAS Institute, 1985). The general linear modules procedure to test for differences (alpha= 0.05) and applied the least significant differences as a mean separation test were used.

Reproduction index (RI): was calculated for each feeding treatment at each date of inspection according to the formula suggested by Udayagiri and Mason (1997) with slight modifications.

$$RI = \frac{\text{area of treated} - \text{area of control}}{\text{area of treated} + \text{area of control}}$$

The index takes a positive or negative value indicating feeding treatments that were preferred by honey bee workers to estimate queen for oviposition (positive value) and those that are not preferred (negative value).

RESULTS AND DISSCUSSION

Brood area in cm$^{2:}$ The data given in Table (1) show the square centimeters of brood. The square centimeters of broodafter a month of the beginning of the experiment in April17, 2016 were (4233.42, 4568.75, 5652.58, 5287.08, 7083.17, 5287.08 and 6321.67 cm^2/colony, for colonies fed on Sugar bush, moringa, tomatillo/jamberry, guava, coriander, honey syrup and sugar syrup, respectively. At end of the experiment in July 5, 2016 the square centimeters of brood were (3711.33, 4772.67, 4995.33, 4914.00, 8713.67, 6348.33 and 7379.67cm^2/colony) in colonies fed on Sugar bush, moringa, tomatillo/jamberry, guava, coriander, honey syrup and sugar syrup, respectively. The data summarized that honeybee colonies fed on Coriander, tomatillo/jamberry, guava and sugar syrup significantly produced more brood area (7083.17, 5652.58, 5287.08 and 6321.67 brood areas (cm^2)/colony), respectively without significant deterrence between them (Table 1), (F= 1.84, L.S.D= 2287.80).

Table 1: Brood areas (Cm^2) in the experimental honey bee colonies after feeding them on different medical plants (Mean ± S.E).

Dates of inspection	Treatments (Feeding Regimes)						
	Sugar bush	Moringa	Tomatillo/ Jamberry	Guava	Coriander	Honey syrup	Sugar syrup
April 17, 2016	3954.00 ± 1363.14bc (**0.171**)	2893.00 ± 1069.99bc (**0.017**)	4872.67 ± 1294.80abc (**0.271**)	4676.33 ± 2246.88abc (**0.252**)	3419.33 ± 1288.43bc (**0.100**)	3851.33 ± 258.38bc (**0.159**)	2796.67 ± 134.68c
May 15, 2016	5193.00 ± 1150.22abc (**-0.265**)	4474.67 ± 858.33abc (**-0.332**)	6890.33 ± 1352.41abc (**-0.129**)	6269.33 ± 1385.38abc (**-0.175**)	7256.00 ± 3020.87abc (**-0.103**)	4828.00 ± 269.05abc (**-0.298**)	8929.0 0 ± 891.88a
June 5, 2016	4075.33 ± 786.40bc (**-0.366**)	6134.67 ± 2462.39abc (**-0.178**)	5852.00 ± 1276.25abc (**-0.201**)	5288.67 ± 791.82abc (**-0.249**)	8943.67 ± 3848.68a (**0.009**)	6111.33 ± 1221.86abc (**-0.180**)	8788.67 ± 502.85a
July 5, 2016	3711.33 ± 436.23bc (**-0.331**)	4772.67 ± 2243.18abc (**-0.215**)	4995.33 ± 909.50abc (**-0.193**)	4914.00 ± 250.02abc (**-0.201**)	8713.67 ± 3359.11a (**0.083**)	6348.33 ± 1481.09abc (**-0.075**)	7379.67 ± 826.26ab
Mean ± S.E	4233.42 ± 239.90b (-0.198)	4568.75 ± 442.46b (-0.161)	5652.58 ± 359.29ab (-0.112)	5287.08 ± 245.96ab (-0.089)	7083.17 ± 915.96a (0.057)	5284.75 ± 472.54ab (-0.089)	6321.67 ± 1175.00a

Values between brackets represent reproduction indices (RI).
L.S.D.at 5%
Treatment 2287.80
Interaction 4575.50

Frames covered with honeybees: The data presented in (Table 2) show the number of frames covered with adult honey bees. As shown, after a month of the beginning of the experiment in April 17, 2016, the mean number of frames covered with adult bees was (6.00, 5.33, 5.67, 6.67, 3.67, 6.00 and 4.00 frame/colony) in honeybee

colonies fed on Sugar bush, moringa, tomatillo/jamberry, guava, coriander, honey syrup and sugar syrup, respectively. The general mean obtained in Table (2) showed that, after four months feeding, colonies fed on coriander significantly produced more frames of adult bees (9.17 frames/colony), followed by colonies fed on moringa, tomatillo/jamberry, guava, honey syrup and sugar syrup, respectively without significant differences between them (6.25, 6.67, 7.25, 6.84 and 8.08frames/colony), respectively, (Table 2), (F= 1.46, L.S.D= 1.906).

Table 2: Mean number of combs covered from both sides with adult bees in the experimental honey bee colonies after feeding them on different medical plants (Mean ± S.E).

Dates of inspection	Treatments (Feeding Regimes)						
	Sugar bush	Moringa	Tomatillo Jamberry	Guava	Coriander	Honey syrup	Sugar syrup
April 17, 2016	6.00 ± 1.15def (**0.20**)	5.33 ± 0.33def (**0.143**)	5.67 ± 0.33def (**0.172**)	6.67 ± 1.20cdef (**0.250**)	3.67 ± 0.88f (**-0.043**)	6.00 ± 1.15def (**0.200**)	4.00 ± 0.00ef
May 15, 2016	6.67 ± 0.88cdef (**-0.11**)	6.00 ± 1.00def (**-0.163**)	7.33 ± 0.67cdef (**-0.064**)	8.00 ± 0.58cd (**-0.020**)	8.67 ± 2.96abcd (**0.020**)	7.67 ± 1.20cde (**-0.042**)	8.33 ± 0.33bcd
June 5, 2016	5.33 ± 0.33def (**-0.30**)	6.67 ± 1.33cdef (**-0.200**)	7.00 ± 1.00cdef (**-0.176**)	7.33 ± 0.33cdef (**-0.154**)	12.33 ± 4.26a (**0.104**)	6.67 ± 0.33cdef (**-0.200**)	10.00 ± 0.00abc
July 5, 2016	6.33 ± 0.33cdef (**-0.22**)	7.00 ± 1.53cdef (**-0.176**)	6.00 ± 0.00def (**-0.250**)	7.00 ± 0.00cdef (**-0.176**)	12.00 ± 3.00ab (**0.091**)	7.00 ± 0.00cdef (**-0.176**)	10.00 ± 0.00abc
Mean ± S.E	6.08 ± 0.21c (-0.141)	6.25 ± 0.29bc (-0.128)	6.67 ± 0.33bc (-0.158)	7.25 ± 0.21bc (-0.054)	9.17 ± 1.50a (0.063)	6.84 ± 0.25bc (-0.084)	8.08 ± 1.02ab

Values between brackets represent reproduction indices (RI).
L.S.D.at 5%

Treatment 1.906
Interaction 3.811

Frames of honey: Table (3) shows the mean number of stored honey. After a month of the beginning of the experiment in April 17, 2016 the mean number of stored frames of honey was (1.17, 1.17, 1.67, 0.83, 2.00, 3.00 and 1.83 frame/colony) in honeybee colonies fed on sugar bush, moringa, tomatillo/jamberry, guava, coriander, honey syrup and sugar syrup, respectively. The general mean obtained in Table (3) showed that, after four months feeding, colonies fed on coriander significantly stored more frames of honey (4.50 frame/colony), followed by colonies fed on honey syrup and tomatillo/jamberry (3.42and 2.96 frame/colony), respectively. Honeybee colonies fed on moringa and guava significantly stored less number of honey frames (1.71 and 1.67frame/colony), respectively (Table 3), (F= 9.05, L.S.D= 0.944).

This study was conducted to evaluate the effects of different feeding treatments of some medical plants on brood production, population development of honey bee colonies and storage honey during the period extended from March 2016 to the July 2016.It was shown that brood production was significant highest in the group fed on coriander, tomatillo/jamberry, guava and sugar syrup without significant deterrence between them (7083.17, 5652.58, 5287.08 and 6321.67 brood areas (cm^2)/colony), respectively. Population development and honey storage were significant highest in the group fed on coriander (9.17 frames bees/colony and 4.50 frames honey/colony).

The group fed on sugar bush and moringa syrup significantly did not increase brood area and honey bee population as compared with other tested groups.

These findings were found in agreement with Schoreit and Hussein (1993) whom fed colonies of *A. mellifera* with sugar syrup mixed with a protein supplement

reared significantly more brood, and Wali and Chaudhry (1991) whom fed honey bee colonies with protein and sugar supplement during dearth period and found that supplement feeding with a mixture of sugar, pollen and soya bean flour increased brood development up to 81%.

Table 3: Mean number of honey combs in the experimental honey bee colonies after feeding them on different medical plants (Mean ± S.E).

Dates of inspection	Treatments (Feeding Regimes)						
	Sugar bush	Moringa	Tomatillo/ Jamberry	Guava	Coriander	Honey syrup	Sugar syrup
April 17, 2016	1.17 ± 0.17 hi (**-0.22**)	1.17 ± 0.44hi (**-0.222**)	1.67 ± 0.33 fghi (**-0.048**)	0.83 ± 0.17i (**-0.375**)	2.00 ± 0.58 efghi (**0.043**)	3.00 ± 0.58 defgh (**0.241**)	1.83 ± 0.17fghi
May 15, 2016	2.00 ± 0.00efghi (**0.00**)	1.67 ± 0.33 ghi (**-0.091**)	3.83 ± 0.60abcde (**0.314**)	0.83 ± 0.17i (**-0.412**)	5.33 ± 1.45ab (**0.455**)	3.67 ± 0.17bcdef (**0.294**)	2.00 ± 0.29efghi
June 5, 2016	3.33 ± 1.20 cdefg (**0.11**)	2.00 ± 1.00 efghi (**-0.143**)	4.33 ± 0.88abcd (**0.238**)	2.33 ± 0.33 efghi (**-0.067**)	5.67 ± 1.76a (**0.360**)	3.33 ± 0.67cdefg (**0.111**)	2.67 ± 0.33 defghi
July 5, 2016	3.00 ± 0.58 defgh (**-0.05**)	2.00 ± 0.00 efghi (**-0.250**)	2.00 ± 0.00 efghi (**-0.250**)	2.67 ± 0.33 defghi (**-0.111**)	5.00 ± 1.00abc (**0.200**)	3.67 ± 0.33bcdef (**0.048**)	3.33 ± 0.33cdefg
Mean ± S.E	2.38 ± 0.40cd (-0.017)	1.71 ± 0.15d (-0.179)	2.96 ± 0.56bc (-0.207)	1.67 ± 0.42d (-0.192)	4.50 ± 0.63a (0.294)	3.42 ± 0.13b (0.163)	2.46 ± 0.27cd

Values between brackets represent reproduction indices (RI).

L.S.D.at 5%

Treatment	0.944
Interaction	1.889

Hassan (1998) found that colonies fed on a diet with sugar solution resulted in moderate levels of brood area and frames of bees (701.00 and 7.75, respectively). However, they found that unfed colony showed weak results of these parameters (380.00 and 6.25, respectively). Dodologlu *et al*. (2004) examined the interacting effects of two feeding regimens (sucrose syrup or 'bee cake') on selected performance characters of honey bee (*Apis mellifera*) colonies in Turkey. They found that brood area was significantly increased in colonies that received supplementary feeding regardless of feeding method, feeding colonies with sugar syrup in autumn and with bee cake and syrup in early spring provided optimum colony build up for the production season. On the other hand, the results were found in disagreement with Mladenovic et al (2002) whom found that feeding with sucrose syrup (1:1 sucrose-water) did not increase the brood area and bee population.

Therefore, it concluded that feeding honey bee colonies with coriander, tomatillo/jamberry, and guava and sugar syrup is recommended for increasing the brood production in experiment area. It also summarized that, honey bee colonies fed on coriander stored more honey than other groups evaluated. Feeding honey bee colonies during this period with sugar syrup (1:1) is also recommended.

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