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EFFECTS OF SOME DIETS AS POLLEN SUBSTITUTES ON CERTAIN BIOLOGICAL ACTIVITIES OF HONEYBEE COLONIES

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ABSTRACT

This study was carried out to elucidate the effect of some diets as pollen substitutes on some biological activities of honeybee colonies. The obtained results indicated that the liquid yeast diet (B) (*Candida tropicalis*) at 25%conc. had the highest value of mean amounts of sealed workers brood (in^2. /col.) at the different dates during the experimental period among the other tested diets. Clear significant differences between the monthly mean amounts of sealed workers brood (in^2. /col.) and the different months during spring and summer seasons represented the different tested pollen substitutes.

The colonies fed with liquid yeast diet (B) at 25% conc. recorded the highest mean values of the number of combs covered with bees/col. followed by sugar syrup (diet A) and dried brewer's yeast diet (C). While diets (D) and (E) indicated the lowest mean values. Clear significant differences between the monthly mean number of combs covered with bees/colony in the tested colonies fed with different pollen substitutes and the tested months during spring and summer seasons. These differences were clearly detected in May , June, July, and August months.

Colonies fed with dried brewer's yeast diet (C) followed by colonies fed with sugar syrup (diet A) as control and colonies fed with diet (D), recorded the highest mean number of queen cells /col. among the tested colonies particularly in the spring season.

Key words: *biological activities, honey bee colonies, pollen substitutes.*

1. INTRODUCTION

Beekeepers often feed their colonies with supplemental protein diets during periods of pollen and nectar dearth. When natural pollen is scarce, beekeepers can feed colonies of honeybees with supplemental protein diets. These proteins are either fed as "pollen supplements" or "pollen substitutes". A pollen substitute is any material that offers the pollen requirement of that colony for a short period of time. The same pollen substitute or any other proteins becomes a pollen supplement when pollen is added to the diet as an attractant or to increase its nutritive value (Graham 1992). Supplemental protein diets play an important role in the life of honey bee colony. Honey bees require protein (amino acids), carbohydrates (sugar), lipids (fatty acids, sterols), vitamins, minerals (salts), and water, where these nutrients must be in the diet in a definite qualitative and quantitative ratio for optimum nutrition. Adult bees obtain their dietary protein from the collected pollen or from nitrogenous food stuffs provided by the beekeeper. Colonies are normally fed on supplemental protein foods to produce strong colonies for package production, to develop colonies with optimum population for pollination of crops, to build up colony population for autumn and spring divisions and for queen rearing Shawer *et al.* (1985). Abdel-Latif *et al.* (1971) in Egypt found that colonies fed with the medicinal or fodder yeast reared significantly more brood than control colonies, whereas, colonies fed on active yeast reared less brood. Abd El-Wahab and Gomma (2005) indicated that, the application of 25% and 50% of yeast culture resulted in the highest significant amount of worker brood in comparison with other treatments. Nour (1992) recorded that, the number of combs covered with bees/ col. and the amount of drone brood (in. ^{2})/col. showed a positive correlation with queen cells production in the spring and early summer. El-Sherif *et al*. (1996) indicated that the highest number of accepted queen cells was found in colonies fed on a 50% sucrose syrup beside sucrose yeast cake or on honey syrup beside sucrose-pollen cake. Abd El-Aziem (1999) mentioned that the most suitable time for obtaining the highest number of the successful

queen cell cups was at late summer (August and September) and during spring (April). The second suitable time was during May-June-July and the least percentage occurred during March.

The aim of this work was to evaluate the effect of some diets as pollen substitutes on some biological activities of honeybee colonies.

2. MATERIALS AND METHODS

This study was carried out at the apiary yard of the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University, Giza, during the year 2006

2.1. Tested diets

Four diets were used as pollen substitutes Diet (A) Liquid yeast (*Candida tropicalis*) at 25% concentration. The diet was prepared from 1000 gm sugar + 250 ml. liquid yeast + 750 ml. water. Diet (B) Dried brewer's yeast (*Saccharomyces* sp.) at 25% concentration (1000 gm sugar + 250 gm. dried brewer's yeast + 750 ml. water) .Diets (A) and (B) were introduced to the bee colonies in the liquid form using plastic feeders. Diet (C) consisted of 400 ml. liquid yeast + 200 gm. soya bean (lipid free) + 300 gm. bran + 100 gm. corn flour + 1000 gm. sugar. Whereas diet (D) was prepared from 200 gm. dried brewer's yeast at 25% concentration + 400 gm. soya bean (lipid free) + 400 gm. barley (apical + roots) +1000 gm. sugar. Diets (C) and (D) were introduced to the bee colonies in the paste form, whereas sugar syrup (diet E) was used as the control ; 1000 gm. sugar + 1000 ml. water.

Thousand ml. from each sugar syrup (control, diet E) and diets (A) and (B) were introduced to the tested colonies every 14 day intervals during spring and summer seasons. While, 250 gm. from diets (C) and (D) were introduced to the tested colonies every 14 day intervals. The diets were placed between the top bars of the brood combs (brood nest) to prevent the dryness of these diets. Plastic cover with holes was used to cover these diets.

2.2. Honeybee colonies

Twenty honeybee colonies of local craniolian hybrid were assigned for this study. The tested colonies were headed by newly sisters mated queens and equal in strength. Four colonies for each tested diet as well as another four colonies for control were used.

2.3.Determination of the biological activities

The following biological activities were determined and recorded for each tested colony subjected to each tested diet at 14 day intervals during spring and summer seasons:

1. Mean amounts of sealed workers brood every 14 day intervals (in^2.)/colony.
2. Mean number of combs covered with bees (population density) every 14 day intervals /colony.
3. Mean number of queen cells production (the cells contained eggs, larvae or pupae of queen cells) every 7 day intervals/colony and calculated every 14 day intervals / colony.

3. RESULTS AND DISCUSSION

3.1. Amount of sealed workers brood (in^2./ col.)

As shown in Fig. (1) and Table (1), the liquid yeast diet (B) (*Candida tropicalis*) at 25%conc. indicated the highest value of mean amounts of sealed workers brood (in^2./colony) at the different dates during the experimental period followed by the dried brewer's yeast (C), diet (D) and sugar syrup as control (diet A) recorded the lowest values.

Table(1):The effect of some pollen substitutes on the biological activities of honey bee colonies during different dates in the spring and summer seasons.

Dates & Seasons		Biological activities		
		Mean amount of workers brood (in^2./col)	Mean no. of combs covered with bees/col	Mean no. of queen cells/col
Spring	25.3.06	211.15 de	7.05 f	3.70 a
	2.4.06	243.70 bc	8.20 d	1.38 cbd
	22.4.06	206.70 de	8.05 ed	1.03 cbd
	6.5.06	199.75 fe	8.40 d	1.38 cbd
	20.5.06	244.80 bc	8.53 d	1.53 cb
	3.6.06	268.70 a	10.10b	1.40 cbd
	7.6.06	259.85 ba	10.80 a	1.78 b
Summer	28.6.06	273.00 a	10.20b	0.85 cbd
	12.7.06	239.25 bc	10.33ba	0.80 cbd
	29.7.06	224.30 dc	10.60ba	0.80 cbd
	12.8.06	206.30 de	10.25ba	0.10 cd
	26.6.06	182.90 f	9.30 c	0.15 cd
	9.9.06	129.80 g	8.48 d	0.00 d
	21.9.06	103.70 h	7.50 ef	0.00 d

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability.

Statistical analysis of the obtained data revealed significant differences between the monthly mean amounts of sealed workers brood during spring and summer seasons represented the different tested pollen substitutes (Table 2).

Table(2):Monthly mean of some biological activities of honeybee colonies fed with some pollen substitutes during spring and summer seasons.

Date	Biological activities		
	Mean amount of workers brood (in^2./col)	Mean no. of combs covered with bees/col	Mean no. of queen cells/col
March, 2006	**211.15 c**	**7.05 cd**	**3.69 a**
April, 2006	**225.20 b**	**8.13 bc**	**1.20 b**
May, 2006	**222.28 b**	**8.46 b**	**1.45 b**
June, 2006	**267.18 a**	**10.37 a**	**1.34 b**
July, 2006	**231.78 b**	**10.46 a**	**0.80 c**
August, 2006	**194.60 c**	**9.78 b**	**0.13 d**
Sept., 2006	**116.75 d**	**7.99 d**	**0.00 d**

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability.

Table(3): Seasonal mean of some biological activities of honeybee colonies fed with some pollen substitutes during spring and summer seasons.

Tested Diets	Biological activities			
	Season	Mean amount of workers brood (in^2./col)	Mean no. of combs covered with bees/col	Mean no. of queen cells/col
A	**Spring**	**212.54 a**	**8.45 b**	**1.50 a**
	Summer	**180.86 b**	**9.93 a**	**0.45 b**
B	**Spring**	**340.57 a**	**11.18 b**	**0.11 b**
	Summer	**286.93 b**	**11.93 a**	**0.25 a**
C	**Spring**	**217.75 a**	**8.86 b**	**4.93 a**
	Summer	**183.32 b**	**9.25 a**	**0.04 b**
D	**Spring**	**219.61 a**	**8.21 a**	**1.82 a**
	Summer	**151.21 b**	**8.27 a**	**0.48 b**
E	**Spring**	**177.14 a**	**6.96 b**	**0.33 b**
	Summer	**168.57 b**	**8.23 a**	**0.71 a**

A=1000 gm. sugar + 1000 ml. water.
B=1000 gm sugar + 250 ml. liquid yeast (*Candida tropicalis*) + 750 ml. water
C=1000 gm sugar + 250 gm. dried brewer's yeast + 750 ml. water
D=400 ml. liquid yeast (*Candida tropicalis*) + 200 gm. soya bean (lipid free) + 300 gm. bran + 100 gm. corn flour + 1000 gm. Sugar
E=200 gm. dried brewer's yeast *(Sccharomyces* sp.) + 400 gm. soya bean (lipid free) + 400 gm. barley (apical + roots) +1000 gm.Sugar
Means designated with the same letter in the same column are not significantly different at 0.05 level of probability.

The liquid yeast diet (B) recorded the highest seasonal mean of sealed worker brood in spring and summer seasons followed by brewer's dry yeast diet (C). Whereas diet (E) followed by diet (D) and the sugar syrup diet (A) as control recorded the lowest seasonal mean of sealed workers brood reared in the colonies in spring and summer seasons. There were clear significant differences in the seasonal mean amounts of sealed workers brood for each diet between spring and summer seasons (Table 3).

From the obtained results it could be suggested that feeding honeybee colonies at 14 day intervals/colony with liquid yeast diet (B) was very effective to induce the colonies to rear more amounts of sealed workers brood, particularly in the beginning of the active season (spring) in comparison with the other tested diets. This may be due to the stimulative effect of this diet for increasing the different activities (physiological and biological) of individuals of bee colonies, particularly the egg laying activity by the honeybee queens which was reflected by high amounts of sealed workers brood and high number of combs covered with bees during spring and summer seasons.

The obtained results are in agreement with those of Otto (1955), Francise (1961) and Rosenthal (1962). They indicated that the brewer's yeast was suitable as a pollen substitute for feeding bees in periods of dearth as it increased the brood rearing and the development of the pharyngeal glands of workers. Wahl (1963) compared the nutritive value of pollen, yeast, soybean flour, and dried milk. He found that natural pollen mixtures were able to initiate and maintain brood rearing in combined colonies of honey bees more effectively than the other tested proteins.

In Egypt many authors studied the effect of different artificial protein diets on brood rearing such as El- Banby and Gorgui (1970); Abdel- latif *et al.*(1971); Hussein (1981); Shawer *et al.*(1985); Abd Al-Fattah and El-Shemy (1988); Nour (1992); El-Shemy (1997) and Abd el- Wahab and Gomma (2005). Their data indicated that the protein feeding resulted in increasing the brood area.

3.2.Number of combs covered with bees (population density)/col.

The tested colonies fed with different diets as pollen substitutes and sugar syrup as control indicated high mean values of the number of combs covered with bees/colony in different dates during spring and summer seasons. The colonies fed with liquid yeast diet (B) at 25% conc. recorded the highest mean values followed by the sugar syrup diet (A) and dried brewer's yeast diet (C). While diets

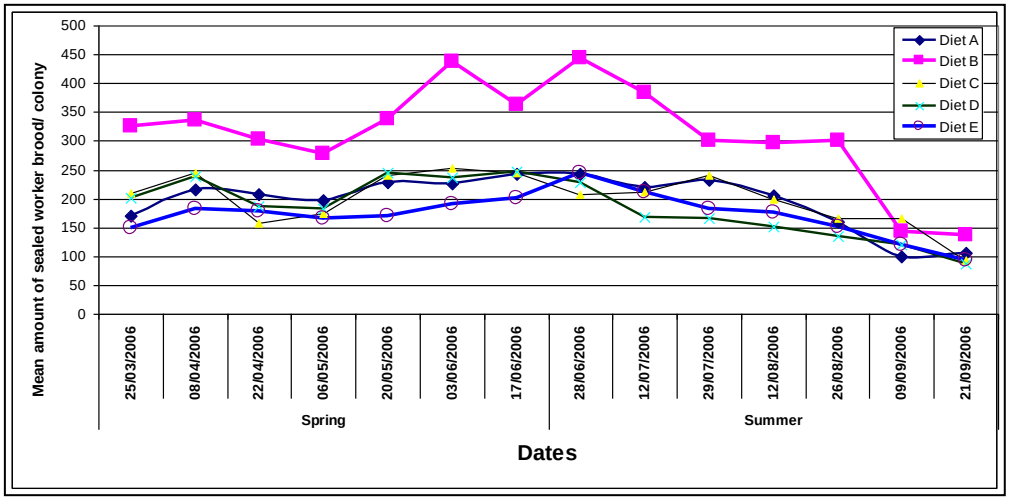

Fig.(1): The effect of some pollen substitutes on the mean amount of sealed worker brood in^2. /col. during spring and summer seasons.
Diet A=1000 gm. sugar + 1000 ml. water. Diet B=1000 gm sugar + 250 ml. liquid yeast + 750 ml. water
Diet C=1000 gm sugar + 250 gm. dried brewer's yeast + 750 ml. water. Diet D=400 ml. liquid yeast + 200 gm. soya bean (lipid free) + 300 gm. bran + 100 gm. corn flour + 1000 gm. Sugar. Diet E=200 gm. dried brewer's yeast + 400 gm. soya bean (lipid free) + 400 gm. barley (apical + roots) +1000 gm. Sugar.

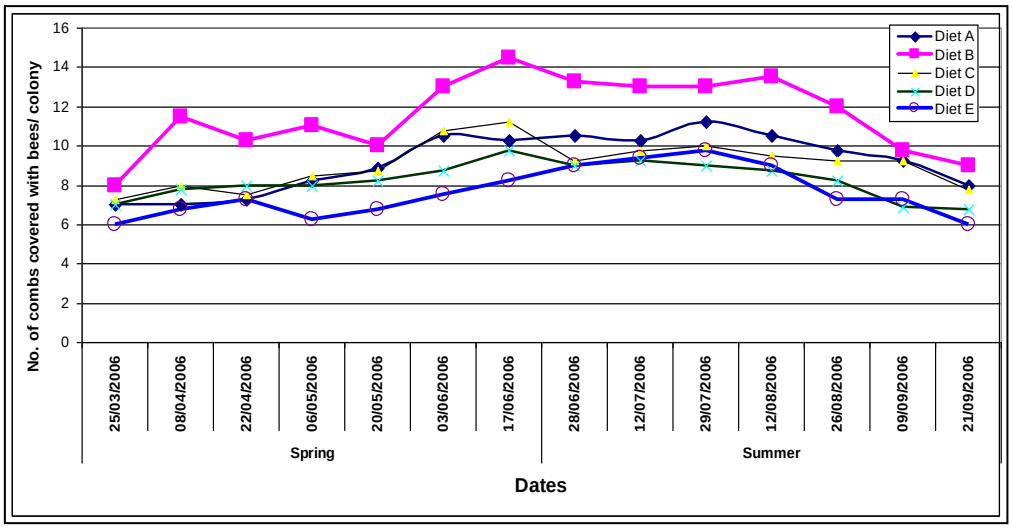

Fig. (2): The effect of some pollen substitutes on the mean no. of combs covered with bees/col. during spring and summer seasons
Diet A=1000 gm. sugar + 1000 ml. water. Diet B=1000 gm sugar + 250 ml. liquid yeast + 750 ml. water
Diet C=1000 gm sugar + 250 gm. dried brewer's yeast + 750 ml. water. Diet D=400 ml. liquid yeast + 200 gm. soya bean (lipid free) + 300 gm. bran + 100 gm. corn flour + 1000 gm. Sugar. Diet E=200 gm. dried brewer's yeast + 400 gm. soya bean (lipid free) + 400 gm. barley (apical + roots) +1000 gm. Sugar.

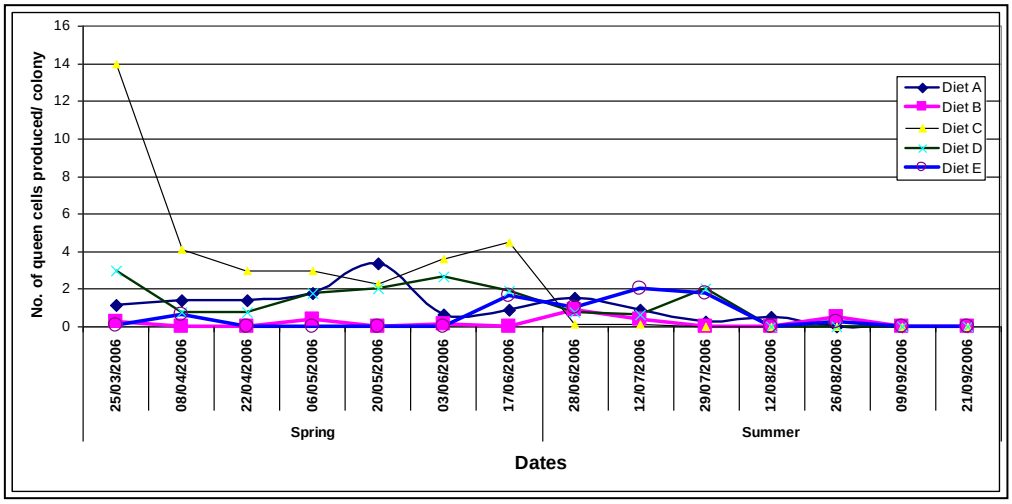

Fig. (3): The effect of some pollen substitutes on the mean no. of queen cells produced /col. during spring and summer seasons.
Diet A=1000 gm. sugar + 1000 ml. water. Diet B=1000 gm sugar + 250 ml. liquid yeast + 750 ml. water
Diet C=1000 gm sugar + 250 gm. dried brewer's yeast + 750 ml. water. Diet D=400 ml. liquid yeast (*Candida tropicalis*) + 200 gm. soya bean (lipid free) + 300 gm. bran + 100 gm. corn flour + 1000 gm. Sugar. Diet E=200 gm. dried brewer's yeast *(Sccharomyces* sp.) + 400 gm. soya bean (lipid free) + 400 gm. barley (apical + roots) +1000 gm. Sugar.

(D) and (E) induced the lowest mean values as stated in Table (1).

It is also important to mention that the stimulative effect of the tested diets particularly the liquid yeast diet (B) which clearly stimulated the gradually increase in the number of combs covered with bees/colony at the beginning of the spring season and increased continuously during the summer season.

Statistical analysis of the obtained data revealed significant differences between the monthly mean number of combs covered with bees/colony in the tested colonies fed with different pollen substitutes and the tested months during the spring and summer seasons (Table 2).

From the obtained results it could be stated that feeding honeybee colonies with protein diets as pollen substitutes, particularly with liquid yeast caused marked increase in the mean number of combs covered with bees/colony during the experimental period. This may be due to the effect of this diet which stimulates high egg laying by the honeybee queens which resulted in higher amounts of sealed workers brood as well as high number of combs covered with bees during the spring and summer seasons.

The obtained results are in agreement with those of Haydak (1935) who stated that the annual pollen requirements for a colony of honey bees varied considerably depending upon colony location, strength, and the floral sources. Honey bee colonies require 44 to 66 Ibs. of pollen annually. Todd (1940) estimated the annual colony requirement to be 88 Ibs. On an individual bee basis each larva requires more than 100 mg of pollen to complete its development. Mahrous (1962) in Egypt studied the effect of some food materials of high protein content available locally on colony population and honey production.The materials used were broad beans, protulane moulu, Egyptian lupine, chickpea, casein and beans. He found that these diets increased colony population and consequently honey production, and they could be arranged in the following order broad bean, Egyptian lupine, protulane moulu and chickpea. Nour (1992), recorded that the number of combs covered with bees/ col. increased with the increase of queen cups production that took place in winter, summer and autumn, while in the spring a negative correlation was found. The number of combs covered with bees/ col. and the amount of drone brood (in.^{2})/col. showed a positive correlation with queen cells production in the spring and early summer. The number of combs covered with bees/ col. showed a positive correlation with the amount of drone brood (in.^{2}) in winter and summer, while a negative correlation was noticed in the spring. Abd El-Wahab and Gomma (2005), stated that colonies fed with 25% of the liquid yeast culture recorded significantly mean number of combs covered with bees higher than the control and the recommended traditional honey bee artificial diets.

3. 3. Number of queen cells produced /col.

As shown in Fig. (3) and Table (1), there are clear significant differences in the mean number of queen cells production in the tested colonies fed with the tested pollen substitutes and sugar syrup as control at the different dates during spring and summer seasons.

Statistical analysis of the obtained data revealed significant differences between the monthly mean number of queen cells production in the colonies fed with different pollen substitutes and the different months during spring and summer seasons. These differences were detected in March, May, June and April months which recorded the highest monthly mean production of queen cups Table (2).

Table (3) indicates that there were differences in the seasonal mean number of the production of queen cells in the tested colonies fed with different diets as pollen substitutes and sugar syrup as control. The liquid yeast diet (B) recorded the highest seasonal mean in the spring and summer seasons among the other diets and followed by diet (D). Whereas dried brewer's yeast diet (C) followed by diet (E) and sugar syrup (diet A) recorded the lowest seasonal mean number of queen cells produced in the colonies in the spring and summer seasons. There were significant differences for the seasonal mean number of production of queen cells for each diet between spring and summer seasons.

The obtained results in Table (1) show the total mean of queen cells production during the experimental period (spring and summer seasons together), and indicate clear differences among the different diets. Liquid yeast diet (B) recorded the highest total mean number and followed by diet (D) and dried brewer's yeast diet (C). While diet (E) followed by sugar syrup (diet A) as control indicated the lowest total mean number of queen cells production.

Referring to these results, it could be suggested that the production of queen cells in the spring and early summer may represent an index to the tendency of the colonies for swarming. The effect of pollen substitutes on the queen cells production in the colonies were clear in spring season particularly in colonies fed with dried yeast diet (C), diet (D) and sugar syrup (diet A) as control.

Removing queen cells from the colonies at 14 day intervals, showed that colonies were able to replace them, and the replacement varied during the season; being higher in spring than early summer. Also, the kind of pollen substitutes fed by the colonies have an effect particularly in colonies fed with dried brewer's yeast (diet A), diet (D) and sugar syrup (diet A). The number of produced divisions (13 divisions) from colonies fed with liquid yeast diet (B) may be affected. The lowest number of queen cells was produced by those colonies during spring and early summer. The high mean number of queen cells produced by the tested colonies in the spring and early summer, can be utilized in replacing old queens in colonies with new ones.

The obtained results are in agreement with those of E1-Dakhakhni (1980) who observed queen cups in both colonies throughout the year, while queen cells appeared from February to October in strong colony and from May to September in the weak colonies. Kathy and Hultgren (1985) noticed that the Craniolian bees have a property to build numerous queen cells and will swarm as well as out of the season. They confirmed also that the highest number of successful queen cells occurred during summer. Also, the greatest number of successful queen cells was produced by queenless colonies. Omar (1989) mentioned that the maximum general mean number of constructed cells/colony was 8.5 cells, two days after queen removal, during clover honey flow and 9.88 cells, three days after queen removal during cotton honey flow. Nour (1992), found that, the production of queen cups and queen cells appear to be related to the amount of drone brood and population densities of colonies. Production of queen cells in the spring and early summer may represent an index to the tendency of the colonies to prepare for swarming. Graham (1992), found that bees build queen cells when a new queen is needed by the colony. Virgin queens are superseded, swarm queens are replaced with young ones, and queens lost by accident or disease are replaced. Successors to superseded and swarmed queens are reared from eggs that were laid in queen cell cups that open downward and which were made by bees at various places on the brood combs. Yakoub (1998) stated that both Craniolian and Egyptian bees produced large numbers of queen cells during the year, while the Italian race built only one cell cup during July. Al-Humyari *et al*. (1999) concluded that about 69.07 and 96.91% of the annual counts of periodical newly constructed queen cells (23.12 and 56.34 cells/colony) were in winter nectar flow in Yemeni and F_1 Craniolian colonies, respectively. Abd El-Aziem (1999) mentioned that the most suitable time for obtaining the highest number of the successful queen cells was on late summer (August and September) and during spring (April). The second suitable time was during May-June-July and the least percentage during March. Mohanny (1999) found that the highest number of successful queen cell cups was found during summer, spring, autumn and winter, respectively. Abd El-Wahab and Gomma (2005), stated that, producing the queen cups increased in fed colonies by 50% of liquid yeast culture overmatched either the control or the other tested treatments followed by 25% of yeast culture especially in April, May and June.

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تأثير بعض البيئات الغذائية كبدائل لحبوب اللقاح على بعض الأنشطة البيولوجية لطوائف نحل العسل

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ملخص

سجلت طوائف النحل المغذاه على الخميرة الحية السائلة (B) *Candida tropicalis* بتركيز 25% أعلى قيمة في متوسط كمية الحضنة المغلقة للشغالات المسجلة لكل طائفة بالبوصة المربعة وكذلك في متوسط عدد الأقراص المغطاة بالنحل لكل طائفة وذلك في موسمي الربيع والصيف ويليها طوائف النحل المغذاه على الخميرة الجافة C وكذلك البيئة D بينما سجلت الطوائف المغذاه على البيئة E وكذلك طوائف الكنترول A المغذاه على محلول سكري أقل قيمة.

سجلت طوائف نحل العسل المغذاه على الخميرة الجافة C متبوعة بطوائف النحل المغذاه على المحلول السكري ككنترول A وطوائف النحل المغذاه على البيئة D سجلت أعلى متوسط لعدد البيوت الملكية المنتجة خاصة في موسم الربيع بينما كان هذا العدد في موسم الصيف منخفضا.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (59) العدد الثاني (إبريل 2008): 96-102.