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Evaluation of Carniolan and Italian Honey Bee Colonies Fed on Artificial Diets in Dearth and Flowering Periods under Nasr City Conditions

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ABSTRACT

Impact of pollen substitutes feeding on the activity of honey bee was investigated using F_1 Carniolan and F_1 Italian honey bee colonies. During two periods, dearth period elapsed from July until October 2015, the flowering period from November 2015, to January, 2016, in the apiary of the Faculty of Agriculture in Al-Alzhar University at Nasr city, Egypt**.** Honey bee colonies have to struggle for their existence during dearth periods. Colonies must be fed with artificially formulated diets to maintain bee population.

Some food materials of high protein, sugar, vitamins and minerals content available locally were used to increase colony population, pollen collection as well as honey production. In the present study, efforts were made to develop highly palatable, nutritionally balanced and economically viable pollen substitute for *Apis mellifera*. The two new pollen substitute diets were; diet (B): crushed panicum, soybean, mixed from melon and orange shell juice, agwa and cinnamon oil and diet (F): crushed phalaris, soybean, mixed from melon and orange shell juice, agwa and cinnamon oil. Some honey bee activities, areas of sealed worker brood, consumption rates, honey production and pollen collection of tested colonies were evaluated. Proved to be best for honeybees in terms of net consumption, positive influence on colony parameters and input cost involved.

Key words: Honey bee, colonies, dearth period, Carniolan

Introduction

Honey bees utilize pollen and nectar of different flowers. According to Funari *et al.*, (2003), honey bees need protein, carbohydrates, minerals, lipids, Vitamins and water to complete their development and growth, which are obtained by collecting pollen, nectar and water. During the first five or six day of adulthood, the workers consume large quantities of pollen for protein and amino acids that will ensure their full growth and development. The insufficient level of protein in the diet of bees is problematic, since the development of hypopharyngeal glands, responsible for training of food for the larvae is not complete. Therefore the cycle of production and reproduction of the colony is affected (Perira *et al.,* 2006).

During certain periods of the year, weather conditions are unsuitable for bees and the availability of food (nectar and pollen) resources is very low (dearth period). In this case, the colony may be offered a pollen substitute, which is food intended to completely replace pollen. The most widely used substitute consists of a mixture of soybean flour, corn flour, and dried brewer's yeast (House, 1961; Jouanin, 2000; Feng, 2002 and Saffari *et al.,* 2004).

Nutrition is not only important for colony development and bee longevity but also plays a vital role against pathogens and in maintaining gut fitness (Ritz and Gardner, 2006). The factors influencing the nutrition and palatability of pollen substitutes include the amounts of protein and lipids that these substitutes contain (De Groot, 1953, Schmidt *et al*., 1987). There are several investigators formulated number of pollen substitutes as it helps much in maintaining colonies with sufficient brood area during the whole season, (i. e., Mohanna, 1977; Herbert, 1981; Imdrof *et al.*, 1988; Abd El-Aziz; 1992; Awad, 1998; Mladenovic *et al.*, 1999 and Mohammad, 2002).

Pollen trapping can have other effects on the honey bee colony. For example; Duff and Furgala (1986) reported that the foraging activity of pollen trapped colonies was reduced over time, although the percentage of returning foragers collecting pollen did not change. McLellan (1974) and Cook (1985) reported that pollen trapping did not affect brood production, while Nelson *et al.*, (1987) noticed a little effect on the area of sealed brood, and they compared the gross income of pollen trapped colonies with control colonies in Alberta, Canada, they concluded that trapping pollen reduced honey production by 11 to 31%, but gross income increased by 13 to 26%. The possibility of improving the efficiency of beekeeping by providing proteinaceous feed lies, in part, in the development of an effective pollen substitute to feed the colonies when pollen is scarce (Zahra and Talal, 2008), especially in preparation for early nectar flows (Skubida *et al.*, 2008). They mentioned that providing proteinaceous feed to stimulate colony strength would then help, in maximizing honey production and crop

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pollination, to overcome pesticide damage and resistance to parasites and diseases, and for package- bee production flows.

The purpose of this study was to assessment two new pollen substitute diets by measuring consumption rates, brood rearing, pollen yield and honey production. To help the beekeepers to solve the problem of short supply or low pollen availability during dearth periods.

Materials and Methods

The present study was performed during the period of July, (2015) until February, (2016) in the apiary of the Faculty of Agriculture in Al-Alzhar University at Nasr city, Egypt. The duration of the experiment was divided into two periods, first period was from July to October, 2015 (dearth period), while, the second period was from November, 2015 to February, 2016 (blooming period). Frontal pollen traps were fitted to the entrances during flowering period. Two hybrids of honey bee (*Apis mellifera*) colonies were used. Carniolan and Italian hybrid bee colonies of about equal strength containing at least six combs covered with bees headed by new open mated Carniolan and Italian hybrid queens were used for this study. The colonies were divided into two equal groups. Each group contains nine colonies to evaluate the different feeding treatments (diets), three colonies were used for each substitute and three colonies were used as control fed on sugar syrup in the dearth period.

Preparation of pollen substitute:

Two pollen substitute B (crushed panicum) and F (crushed phalaris) were prepared as shown in Table 1.

Table 1: Composition of pollen substitutes:

Percentages %	Pollen substitutes	
	Diet B	Diet F
46%	Crushed panicum	Crushed phalaris
23%	Soybean	Soy bean
	Mixed from mellon	Mixed form mellon
23%	And orange shell juice (1:1)	And orange shell juice (1:1)
8%	Agwa	Agwa

Several food stuffs containing considerable amounts of protein and available in cheap price in the local market were chosen for this study. Flours of these stuffs were sifted using different sets of sifts with different mesh. Thereafter, they were mixed with sucrose solution (4:1 w/v) making cakes and spread on a plastic sheet. It was left for 24 hours to be little pit dried. All tested diets were fed in patties that directly placed over the brood nest of tested bee colonies and covered with plastic sheets to avoid drying (add to fed these colonies with sugar syrup). All tested diets were introduced to colonies at 7 days intervals and each colony was provided with 100g/tested diet. Before feeding the colonies, the unconsumed portions of the patty diets were removed from the colony and weighted to estimate consumption.

The biological activities were determined where areas of sealed worker brood measured at 12 days intervals by inch square according to Fresnay, (1962). At the end both the two periods (dearth period and blooming period), honey yield was determined by weighting the combs before and after the honey extraction process. The weight difference was considered as the amount of harvestable honey (Rashid *et al.,* 2012).

To estimate gathering pollen by honey bee a pollen trap rat the entrance of honey bee colony. The efficiency of the trap was 40% according to the equation reported by Eweis and Ali (1980) as the following.

Pollen trap efficiency = (number of pollen pellets in the box/200) x 100.

The trapped Pollen was collected from the pollen trays twice a week throughout the experimental period. The weight of fresh pollen was determined and recorded.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using "COSTA" computer using Duncan's multiple range test (Duncan, 1955).

Results and Discussion

The effect of the diets B and F on food consumption:

Data in table (2) showed that there were no significant differences between the tested diets in the amount means of consumption by Carniolan and Italian colonies during dearth and flowering periods; only a significant difference was recorded in the Carniolan colonies fed with diet (F) 91.06 g/week comparing with diet (B) 81.84 g/week/colony in the flowering period. Also, the highest mean of consumed amounts recorded during July for the diets (F& B) in the two tested periods (dearth and flowering periods) 99.06, 99.05, 93.38 and 98.82 g/week/colony resp. While the lowest amount means recorded in Dec. where the values for the two tested diets for the two hybrid, were 76.84, 79.75 and 86.54, 89.79 g/week/colony resp.

Table 2: Effect of different diets on weekly consumption rate by Carniolan and Italian hybrids of honey bee colonies during period from Jul. 2015 Until Feb. 2016 under Nasr city conditions.

Months	Carniolan hybrid		Italian hybrid		
	Mean amount of food consumption /g Diet B.	Mean amount of food consumption /g Diet F.	Mean amount of food consumption /g Diet B.	Mean amount of food consumption /g Diet F.	L. S. D. 5%
Jul. 2015	93.38	99.06	98.82	99.15	6.41
Aug.	91.15	93.08	95.66	94.12	
Sep.	91.13	89.03	95.68	90.29	
Oct.	87.47	84.64	91.85	90.38	
Mean	90.78a	92.70a	95.50a	93.49a	
Nov.2015	76.93	93.2	80.02	93.43	8.69
Dec.	76.84	86.54	79.75	85.62	
Jan. 2016	83.11	92.07	90.74	89.79	
Feb.	90.48	94.59	94.4	94.9	
Mean	81.84b	91.06a	86.23ab	90.94ab	
M. Mean	86.31a	91.53a	90.87a	92.21a	12.89

Different letters indicate significant difference between columns.

The two new diets were accepted in their consumption by bees. The factors that influence the nutrition and palatability of pollen substitutes include the amounts of protein and lipids that these substitutes contain (De Groot, 1953; Schmidt *et al.,* 1987; DeGrandi-Hoffman *et al.,* 2008) suggested that difference in the nutritional quality of the diets (i.e., amounts of protein and carbohydrate) and perhaps the digestibility and accessibility of their nutrients to worker bees influence the amount of broad that can be reared even when consumption rates are similar.

Impact of the diets (B) and (F) on brood rearing activity:

Data in table (3) there was significant difference between means of sealed brood areas resulted from carniolan hybrid fed on diet B and control colonies, also there was significant difference between means of sealed brood areas resulted from Italian hybrid fed on diet F and control colonies, during the dearth period from Jul. 2015 until Oct. 2015.

Table 3: Mean area of sealed brood (inch^2) in F_1 Carniolan and F_1 Italian honey bee colonies fed on diets(B)and (F) during the dearth period, under Nasr city conditions.

Months	Carniolan hybrid			Italian hybrid			L. S. D. 5%
	Diet B.	Diet F.	Control	Diets B.	Diet F.	Control	
Jul. 2015	204.33ab	201.00b	154.67c	222.33a	206.33ab	173.33c	19.03
Aug.	157.67ab	142.33abc	93.00c	166.50ab	174.83a	121.00bc	49.12
Sep.	184.66a	149.77abc	84.67d	138.44bc	161.55ab	113.33cd	42.54
Oct.	240.00a	200.67ab	152.67b	218.67ab	268.67a	152.00b	78.30
Mean	196.67ab	173.44abc	121.25c	186.49ab	202.85a	139.92bc	55.43

Different letters indicate significant difference between columns.

while, during the flowering period from Nov. 2015 until Feb. 2016, results indicated a significant difference between the mean brood areas in the Italian colonies fed on diet (F) and Carniolan colonies fed on same diet table (4) .Also, there was no significant difference between the mean brood areas in the carniolan and Italian colonies which fed on diet (B) and control colonies. (Wille and Schafer1970) showed an increase of brood production of 43 and 73% in colonies fed on substitutes comparing with unfed ones.

(Shehata and Nafea, 2006) who found that a significant difference in sealed brood area among the tested pollen substitutes and control hives treatment of El-Wady El-Jadeed colonies while there were no significant differences between them in brood rearing area of F_1 Italian colonies. (Abd El-Wahab *et al.,* 2016) reported that there were clearly significant difference between the all tested diets and control in the mean worker brood area during the experimental period of February and March. Also, (Serrag El-Dien 2004), was carried out that F_1 Italian hybrid reared more brood as compared with carniolan hybrid.

Table 4: Mean area of sealed brood (inch^2) in F1 Carniolan and F1 Italian honey bee colonies fed on diets (B)and (F) during the flowering period, under Nasr city conditions.

Months	Carniolan hybrid			Italian hybrid			L.S.D. 5%
	Diet B.	Diet F.	Control	Diet B.	Diet F.	Control	
Nov. 2015	237.00ab	225.83ab	191.67b	283.50ab	311.00a	208.00b	89.56
Dec. 2015	263.11a	218.55a	228.67a	285.00a	282.88a	254.00a	19.89
Jan. 2016	217.67a	204.33a	248.33a	264.17a	241.50a	282.00a	72.61
Feb. 2016	287.83a	270.00a	291.33a	321.00a	311.50a	308.33a	56.54
Mean	251.40ab	229.68b	240.00ab	288.42a	286.72a	263.08ab	50.57

Different letters indicate significant difference between columns.

The effect of pollen substitutes on honey production:

According to table (5), it could be noticed that, for the honey yield, the colonies which fed on artificial diet (B) and (F), during dearth period, revealed significant differences in the amount mean of honey yield between them and control colonies by carniolan and Italian honeybee colonies. While, total mean of honey yield in the colonies which feed on artificial diet (B) and (F), revealed no significant differences between them and control colonies during the flowering period (Eucalyptus trees)

Table 5: The effect of pollen substitutes (B) and (F) on honey production by Carniolan and Italian honey bee colonies during dearth and flowering period under Nasr city conditions.

Periods	Sort of hybrid	Diet B.	Diet F.	Control
Dearth period (Jul. – Oct. 2015)	Carniolan	6.0a	6.33a	2.57b
	Italian	6.2a	7.33a	3.07b
	L. S. D.	2.55		
Periods	Sort of hybrid	Diet B.	Diet F.	Control
Flowering period (Nov.2015 – Feb. 2016)	Carniolan	8.33a	8.50a	7.87a
	Italian	7.33a	8.67a	8.80a
	L. S. D.	3.05		

Different letters indicate significant difference between columns.

Results agree with those that reported by Peixin and Bao-Hua, (2010) who found that honey production generally decreased with decreasing pollen content in the diet. (Shoreit and Hussein, 1993) who found that colonies were fed with sugar syrup mixed with a protein supplement during March, produced more significantly honey than control colonies fed only on sugar syrup. (Abd El-Wahab *et al.,* 2016) reported that the colonies which feed on a new artificial diet (E) produced a highly amount of citrus honey in comparison with the other tested diets and control. While, (Abdellatif *et al.,* 1971) have reported the increased honey production from colonies feeding pollen substitute during dearth period. Also, (Chhuneja *et al.,* 1992) found that higher consumption of pollen substitute diet resulted in higher production of brood and more populous colonies produced significantly more honey.

Impact of diets (B) and (F) on pollen collection:

Data in table (6) demonstrates that there were no significant differences between the means of pollen quantities collected for Carniolan and Italian honeybee colonies which were fed with the diets (B) and (F) during the flowering period (Eucalyptus trees). The highest mean of pollen collected was recorded during February month for F_1 hybrid Carniolan and Italian honeybee colonies which were fed with the diet (B) (79.66 and 79.16 gm /colony) and diet (F) (92.90 and 72.99 gm/colony) respectively. While, the smallest mean of pollen collected was recorded in November month (39.84, 25.74 and 27.22,27.69 gm/colony) respectively , during the flowering period.

The above results are agreed with (Hussein, 1981) who stated that pollen collection was highest in March and September .The lowest activity was observed during Jun., Nov. and Dec. A positive and highly significant correlation was found between pollen gathering activity and brood rearing activity. (Fathy *et al.,* 1991) studied pollen gathering in winter. More activity was noticed in December and February 42.5%

and 34.3% respectively. (Taha *et al.,* 2009) reported that in Mansoura region, Egypt, no significant differences were noticed between total pollen collection by carniolan and Italian honeybee. While, in Giza region, Egypt, (Ibrahim, 1973) examined the effect of feeding on pollen Collection by honeybee colonies. Artificial feeding with different diets, generally increased pollen gathering activity of colonies. Also, in Nasr city, Cairo, Egypt, (El-Hefny *et al.,* 2012) found that activity of honeybee colonies in collecting pollen grains by two hybrid races Italian and cariolan increased gradually from Feb. until Jun..

Table 6: The effect of pollen substitutes B. and F. on gathering pollen produced by Carniolan and Italian honey bee colonies during flowering period under Nasr city conditions.

Months	Carniolan hybrid		Italian hybrid		L. S. D.
	Diet B.	Diet F.	Diet B.	Diet F.	
Nov. 2015	39.84a	25.74b	27.22b	27.69b	7.61
Dec. 2015	57.78a	48.65a	47.53a	42.38a	38.70
Jan. 2016	78.16a	74.62a	72.38a	52.18a	49.07
Feb. 2016	79.66a	79.16a	92.90a	72.99a	38.79
Mean	63.86a	57.04a	60.01a	48.81a	15.65

Different letters indicate significant difference between columns.

Conclusion

Colonies were usually fed substitute feeds for one or more of the following reasons:

- To ensure continued colony development in places and times of shortage of natural pollen and nectar.
- To build colonies to high populations for queen and package-bee production.
- To provide adequate food reserves for over wintering colonies.
- To develop colonies with optimum populations in time for nectar flows.

The possibility of improving the efficiency of beekeeping by maximizing honey production and crop pollination to overcome pesticide damage and produce strong colonies for package-bee production, lies in the development of an effective pollen substitute to feed the colonies when pollen is in scarce. (De Grandi-Hoffman *et al.,* 2008) suggested that differences in the nutritional quality of the diets (i.e. Amounts of protein and carbohydrate) and perhaps the digestibility and accessibility of their nutrients to worker bees influence the amount of brood that can be reared even when consumption rates are similar. A palatable diet containing proteins, carbohydrates, vitamins and minerals (diets (B) and (F)) were found to be highly useful in attaining an excellent bee strength and pollen and honey reserves. Therefore, these diets (B) and (F), seemed to be a suitable and economically viable pollen substitutes for the honeybee colonies during the floral dearth period. These diets helped maintaining the colony strength during the dearth period that resulted in excellent build up and honey production during nectar-pollen flow period. Through, some more investigations are required to make this formulation commercially promising, it can be recommended to be used by beekeepers during dearth period.

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