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SHORT NOTE

Effect of Feeding Different Pollen Substitutes on Brood Rearing and Colony Strength of Honeybees (Hymenoptera: Apidae)

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Abstract

A preliminary trial was conducted during May-September (a dearth period) 2014 in Khartoum State, Sudan, in order to test the effect of feeding different pollen substitutes on brood rearing and colony strength of Carniolan honeybees (*Apis mellifera carnica*). Ground seeds of *Acacia Senegal*, *Moringa oleifera* and *Prosopis chilensis*, each mixed with honey, powder sugar, and yeast, were used in form of pancakes as pollen substitutes. Sixteen colonies were studied in a Completely Randomized Design. Sealed worker brood area and strength of colonies were investigated. Consumed pancakes were also calculated. The results showed that the area of the worker brood reared was significantly highest in colonies fed *M. oleifera* (1008.50±68.63in^2), followed by *P. chilensis* (934.50±228.48) and then *A. Senegal* (834.50±214.14) pancakes, all were significantly higher than the control (321.00±35.36 in^2). Colonies fed pollen substitutes developed well and the bees covered between 6.25±0.25 and 4.50±0.65 of combs, while control colonies showed diminished strength (2.00±0.00). Hence, the studied pollen substitutes are useful and promising to be subjected to further investigation in order to be adopted under dearth conditions.

Keywords: *Apis mellifera*, feeding, Hashab, moringa, mesquite, dearth period.

Honeybees usually collect their food (nectar and pollen) from plants. Nectar is the source of carbohydrates while pollen is the source of proteins, minerals and vitamins. Pollen is therefore essential to individual bees and colony development. It plays important role in providing larvae and young bees with structural elements (Somerville, 2000, and Alghamdi, 2002), and in the production of royal jelly for queen feeding (Alqarni, 2006). As pollen is not always available, and that the imported pollen is expensive and can transmit diseases, an alternative protein source is sometimes necessary to ensure bee health and continuity of colony development, as well as to maintain colony strength for pollination, overwintering, and honey production (Herbert, 2000). The key to produce efficient feed is obviously through using the most nutritive ingredients with regards to palatability, animal health and overall cost (Wilson *et al.*, 2005).

In the Sudan, few supplementary diets, mainly of sorghum flour, are sometimes provided, but are not available in commercial

amount. As a result, beekeepers always lose >50% of their honeybee colonies during the dearth period. Thus, a study was conducted at the apiary of the Ministry of Agriculture, AlFaki-Hashim, Khartoum North, during the dearth period (May-September 2014) to evaluate the possibility of using some natural protein sources as pollen substitutes. Seeds of three different plants: Gum Arabic tree "Hashab" (*Acacia Senegal*), moringa (*Moringa oleifera*) and mesquite (*Prosopis chilensis*), each mixed with honey, powder sugar, and yeast, were tested. The protein and fat contents of all seeds were analyzed using kjeldahl (1883) method. After being ground into fine powders, a paste (pancake) was prepared from each type of seeds according to Mohanna (1977). Such a pancake contained: 2 parts of the ground seeds + 1 part honey + 0.5 part powder sugar + 0.25 part yeast (by weight), where 2 drops of lemon syrup was added. So, three feeding substitutes (i.e., Hashab, moringa and mesquite) were prepared for the test, based on pollen source. The worked pancakes were cut into pieces of 250 g, and each piece was put into transparent plastic to prevent it from drought, and was then placed on top of the brood combs to facilitate the arrival of the bees for feeding (Taber, 1973, and Doull, 1973). Bee colonies were provided, each with a new prepared weighed pancake every 12 days, while the previous one was removed and weighed to calculate the amount of consumption.

Sixteen Carniolan honeybee (*Apis mellifera carnica* Pollmann 1879) (Hymenoptera: Apidae) colonies were used, divided into 4 groups following a Completely Randomized Design. Each group was fed with one of the three prepared pancakes, while the 4th group was left as a control. Each colony was supplied with a piece of 250 g pancake from the required pollen substitute at each time. All colonies were fed sugar syrup (1:1 volume) every 12 days during the whole experimental period. Parameters of the study included: 1) sealed workers brood area (in^2), measured every 12 days using Jeffree (1958) method, 2) colony strength, measured by counting the number of combs covered with bees from both sides every 12 days. Consumption of diet was estimated by subtracting the weight of the left quantity from the provided pancakes weight every 12 days in all colonies, using the formula:

Weight of Consumed diet = Weight of provided diet - Weight of the left diet.

Obtained data were statistically analyzed, and the LSD was used for means separation.

Results showed that feeding on different treatments significantly enhanced brood rearing as compared with the untreated control (Table 1). The colonies fed Moringa Pancakes gave the best significant result, followed by those fed Hashab and Mesquite pancakes which were statistically similar. All colonies of the experiment reared significantly the highest number of worker brood during August, as compared with the control, without significant differences among the three treatments; and that the colonies fed Hashab reared the highest brood area (493.25$\pm$71.34 in^2). The three treatments attained significantly higher sealed workers brood area than the control during the whole experimental period (Table 1).

Table 1. The mean of variable sealed workers brood area (in^2).

Treatment	May Mean±SE	June Mean±SE	July Mean±SE	August Mean±SE	September Mean±SE	Overall Mean±SE
Hashab Pancakes	22.50±4.79	152.00±39.60	145.00±12.75	493.25±71.34	241.25±27.41	834.50±214.14
Moringa Pancakes	36.25±10.08	284.00±28.55	194.50±06.59	357.50±59.91	136.25±21.35	1008.50±68.63
Mesquit Pancakes	41.25±08.26	176.50±30.09	185.00±11.02	431.25±03.07	357.50±8.54	934.50±228.48
Sugar syrup(control)	36.50±08.50	87.00±24.06	41.25±03.17	113.25±20.45	69.50±6.95	321.00±035.36
LSD 0.05	25.08	95.82	28.31	147.03	56.16	496.94

At the beginning of the experiment, at May, no significant difference in comb number covered by bees was found among all the colonies used. The colonies fed Moringa pancakes significantly surpassed the colonies fed Mesquite and sugar syrup, but similar to those fed Hashab during June (Table 2). During July, the colonies fed Moringa, Hashab and Mesquite pancakes showed similar population density, and the same comb number covered by bees (5.125±0.13). However, the colonies fed sugar syrup obtained significantly the least number of combs (2.5±0.20). August and September data showed highly significant differences in the number of combs covered by bees among the different treatments. The colonies fed Hashab pancakes obtained significantly the highest number of combs covered by bees, whereas the bees in the colonies fed sugar syrup covered the least mean number of combs (Table 2).

Consumption of diets revealed no significant difference among the different treatments during May, June, August and September (Table 3). During July the colonies fed Mesquite pancake consumed significantly more than those fed Hashab and Moringa pancakes which consumed similar quantities. Results of food consumption during the whole experimental period revealed no significant differences among treatments (Table 3). This reflected that the three diets were significantly equally accepted by bees with high palatability.

In general, significantly more brood was reared in colonies fed Moringa, Hashab and Mesquite diets compared with the control. This proved that increasing the dietary protein content from 24% to 37% enhanced the brood rearing and hence increased population density which resulted in healthy colonies. The findings agreed with several researchers who reported that providing bees with palatable and nutritious pollen substitute is effective in stimulating brood rearing (Nabors, 2000; Mattila and Otis, 2006, and DeGrandi-Hoffman *et al*., 2010).

The data also showed that the honey bees were attracted and consumed large amounts of the different pancakes. This is because the diets composed mainly of honey that increased honeybee's response towards these patties according to many researchers (Scheiner *et al*., 2004; Keller *et al*., 2005a, and 2005b, and Schmidt and Hanna, 2006). The patties also rich in protein content which increased the palatability of the diets, as mentioned by Waller *et al*. (1970). In addition, the presence of lemon juice also increased the palatability and positively affected the consumption rate. This agreed with Herbert and Shimanuki (1980), khanbash and El Medany (2005) and Al-Ghamdi *et al*. (2011)

Table 2.The mean of variable number of combs covered by bees.

Treatment	May Mean±SE	June Mean±SE	July Mean±SE	August Mean±SE	September Mean±SE	Overall Mean±SE
Hashab Pancakes	4.00±0.00	5.16±0.10	5.12±0.13	4.82±0.40	6.25±0.25	5.00±0.12
Moringa Pancakes	3.75±0.25	5.65±0.14	5.12±0.13	3.65±0.38	5.50±0.29	4.87±0.09
Mesquit Pancakes	3.50±0.29	4.98±0.31	5.12±0.13	4.47±0.18	4.50±0.65	3.66±0.84
Sugar syrup(control)	3.25±0.25	3.32±0.31	2.50±0.20	1.75±0.17	2.00±0.00	2.36±0.16
LSD 0.05	0.70	0.65	0.46	0.93	1.16	1.34

Table 3.The mean of variable consumption diet.

Treatment	May Mean±SE	June Mean±SE	July Mean±SE	August Mean±SE	September Mean±SE	Overall Mean±SE
Hashab Pancakes	65.03±00.87	595.81±28.78	433.06±2.65	508.02±93.49	211.11±1.01	1682.42±299.40
MoringaPancakes	76.06±13.54	540.51±03.68	433.20±1.75	612.88±25.51	211.82±2.00	1874.44±023.23
MesquitPancakes	51.58±00.44	352.11±119.47	442.35±0.96	659.17±04.49	210.01±1.15	1645.79±485.46
LSD 0.05	40.46	227.06	6.14	179.17	4.65	1054.33

The colonies fed Moringa pancake consumed the largest quantity compared to those fed Hashab and Mesquite pancakes. This reflected the increase in the brood area, which could be an indication to a strong relationship between the consumed amounts of food and the increase in the sealed brood area. DeGrandi-Hoffman *et al*. (2008) reported that higher food consumption was significantly correlated with increase in brood area and adult population size. The colonies fed Hashab pancakes consumed intermediate quantity and reared the lowest number of sealed worker brood but they are the highest in colony population. This indicated that the bees fed Hashab pancakes lived longer, and this could be attributed to the largest protein content and lowest fat content (5.7%) in Hashab seeds, as similarly obtained by De Jong *et al*. (2009) and Gregory (2006).

As indicated in the results, in general, there is no significant difference between the colonies fed the three different pancakes as with respect to the quantity of diet consumption, sealed brood area, and colonies strengths. However, it could be concluded that, feeding honey bees with different pollen substitutes rich in dietary protein content (24% to 37%), like Moringa, Hashab and Mesquite pancakes, effectively stimulated bees to feed the queen and to rear more brood and hence to increase the sealed brood area and the population density; thus ending with healthy strong colonies. In contrast, the colonies fed merely on sugar syrup without pollen substitutes reared significantly the lowest area of sealed brood and lowest population density, ending with a weak strength that caused migration of some colonies. Therefore, it could be stated that high quality replacement for pollen can completely replace the natural bee pollen in the diet, especially if compared to the impoverished sugar syrup, without protein supplement. This conception is consistent with that attained by Brodchneider *et al*. (2012).

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