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The Effect of Feeding with Candy and Vitamins on the Biological Activity of the Honeybee Colony *Apis mellifera* L. in a Closed Apiary During Winter

Mutassim Ibrahim Shamoon^{1*}, Sahil Al-Jamil²

¹⁻²Department of Plant Protection, College of Agriculture and Forestry, University of Mosul, Iraq

* Corresponding Author: **Mutassim Ibrahim Shamoon**

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Abstract

This work examines the effect of different feeding on honeybee activity during winter in a closed apiary designed to raise bees during cold conditions. The results shows that there were significant differences in the brood area among the treatments (untreated-reference, candy, and vitamin) of honey bee colonies inside the closed apiary, where both the candy and vitamin treatments excelled, and the average brood area reached (69.26, 62.90) inch², respectively. Which outperformed the reference colonies- which had an average brood area of (55.00 inches²). There were also significant differences in the average area of honey, as the reference honeybee colonies outperformed the colonies with treatments. The average area of honey was (236.00 inch²) for the reference colonies, while the average area of honey in the colonies with candy and vitamin treatments was (172.83, 197.20) inch², respectively. No significant differences in the average pollen area in the three treatments (untreated, candy, vitamin) where the pollen averages reached (15.53, 17.53, 16.30) inch², respectively, inside the closed apiary during Winter.

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1. Introduction

The honeybee is an insect that consists of three main body parts: the head, thorax, and abdomen (Davis and Cullum-Kenyon, 2016)^[6]. A bee colony usually consists of a single queen bee who lays eggs inside it and 10,000-60,000 worker bees. The worker bees are responsible for cleaning the hexagonal cell, serving the brood, guarding their colonies, searching for nectar and pollen, collecting them from flowers, transporting them and storing them, as well as making and building the wax comb. The colony also has 1000-2000 males whose main task is to mate with a virgin queen outside the colony. A honeybee colony collects about 10-26 kg of pollen annually from flowers as a source of protein and amino acid composition necessary for colony survival (Brodschneider and Crailsheim, 2010)^[5].

An adequate amount of protein and carbohydrate stored in a honeybee colony is believed to help it withstand various conditions and survive (Brodschneider and Crailsheim, 2010)^[5]. When the necessary vegetation for bees is not available in adequate quantities, the bees can starve, and they begin to consume stored honey and pollen. Therefore, the beekeepers provide commercially available pollen substitutes to meet the honeybees basic diet and maintain colony strength (Kumar Agrawal., 2014)^[10].

Many artificial diets have been formulated as pollen substitutes for the survival and development of honeybee colonies. Various factors associated with colony health were analyzed feeding with different pollen substitutes to honeybees, such as fertility, reproductive performance, pollen amount, closed brood area, and honey amount when (2021, Paray *et al.*, 2021)^[12].

Adequate nutrition is critical for honeybees, *Apis mellifera*, to colony survival (Brodschneider & Crailsheim, 2010)^[5]. The various reasons for the loss of honey bee colonies may be due to their lack of proper nutrition, such as a decrease in food due to change in natural pastures (Naug, 2009)^[11] or excessive honey harvesting by beekeepers (Brodschneider & Crailsheim, 2010)^[5].

To maintain colony growth and continuity, honey bees collect pollen and nectar from spring to autumn (Klein *et al.*, 2019)^[9] and store food in the forms of bee bread and honey for times of food shortages in Winter (Winston, 1987)^[14].

Materials and methods

This research was conducted in Bartella – a district / Nineveh Governorate – Northern Iraq using a completely closed

apiary surrounded by wooden walls covered with rainproof sheets that protects the wood from rain. On top, the roof consists of an iron shed with insulating cork placed underneath it, with windows at the top. The area of the closed apiary is (6x3) meter. The beehives were placed inside the apiary with the beehives openings towards the outside, as shown in Figure (1).



Fig 1: Closed Apiary

The beehives were randomly distributed for research purposes. The apiary includes nine colonies divided into three groups- one group per treatment. Each treatment contained three replicates. The first group was left without feeding,

which is the reference group, while in the second group was fed a candy dough consisting of sugar and pollen with a ratio of (90 to 10) grams. The candy dough was placed over the frames as shown in Figure (2).



Fig 2: Dough on honeybee frames- Group 2 treatment

The third group treatment used the same sugar and pollen dough in the second group but with added additives. The additives included the vitamins contained in a French-made

package of the type (ACTIVE' BEE VITAMINS LIQUID), as shown in the Figure (3).



Fig 3: Vitamins (ACTIVE´ BEE VITAMINS LIQUID)- Group 3 treatment

The experimental work started in November 2022, when Winter began, until the beginning of March 2023. During the Winter months, the study region is characterized by cold weather, and the vegetation consists largely of wild plants, annual plants, in addition to trees. Honeybee colonies were selected from local hybrid colonies of equal strength, and their queens were one year old, produced in the Spring of 2022 inside the apiary. Each colony contained seven frames distributed among brood, honey, and pollen.

Vital characteristics were measured using a Langstroth frame

divided by a metal wire into small squares, as shown in Figure (4). The area of each square is one-inch², representing (20) hexagonal cell, and thus one frame consists of 136 inches², which is the area of the frame from the inside- resulting in 272 inches² for both sides. To measure the brood space, the frame was placed over the brood frame and the number of squares occupied by the brood on both sides of the frame was measured. Readings were taken every two weeks (Al-Naji, 1980) [3]. The area of stored pollen and stored honey was measured using the same method as for brood area.



Fig 4: A Langstroth hive frame

Data collected were statistically analyzed using a randomized complete block design (RCBD). The hives within each apiary were randomly distributed and differences in means were calculated using Duncan's multiple range DMRT test using the GENSTAT v19 package (Goedhart & Thissen 2010) [8] with a 5% probability level.

Results and Discussion

1. Brood area

Table (1) shows the average measurements of the brood area inside the beehives for the different treatments. The statistical analysis shows that there are significant differences in the average brood area in the three groups inside the closed

apiary. The candy and vitamin treatments excelled, and the average of brood area during the study period reached 69.26 and 62.90 inches², respectively, while the average brood area was less in the reference group- which averaged 55.00 inches² during the same period.

The highest average brood area measured on the first of March for the vitamin treatment and reached 160.00 inches², while the lowest average for the brood area was on the tenth of February and reached 11.67 inches² in the vitamin treatment as well. For the average of the three groups, the highest average brood area was on the first of March, averaging 151.67 inches², while the lowest average brood area was on the fourteenth of January, averaging 15.33 inches². This indicates that providing nutrition to honey bee hives helps increasing the brood area compared to hives

without feeding. This is consistent with what Al-Basha (2019)^[2] reported that the vitamin nutrition provided to the bees gave the highest brood area. The vitamins were from the brands Beevitamin (5 ml) and Super protein (5 ml) added to the sugar solution dissolved in water at a ratio of (1:1). Also, Al-Basha (2019)^[2] used pollen paste mixed with honey and the sugar solution, plus vitamins from the Beeagra brand at a ratio of (20 gm pollen, 15 gm) Honey, 50 mg vitamin). Al-Atbi (2009) also reported that the brood area increased significantly when adding the commercial protein Bee-pro 500 g mixed with (casein 5 g, Juvral 10 g, powdered sugar 1000 g, water 750 ml) compared to Control treatment. This shows that honeybee hives that are fed give better results in terms of brood space compared to unfed hives raised under the same environmental conditions.

Table 1: Brood area inside the beehives in the closed apiary during winter

Date	Control	Candy	Vitamin	Average Date
4-Nov-2022	114.33 C	116.67 BC	114.67 C	115.22 B
18- Nov-2022	90.67 CDE	114.33 C	99.00 CD	101.33 B
2-Dec-2022	62.33 EFG	92.33 CD	82.00 DEF	78.89 C
16-Dec-2022	39.00 G-L	58.67 FGH	45.67 GHI	47.78 D
30-Dec-2022	16.67 JKL	30.67 H-L	41.67 G-K	29.67 EF
14-Jan-2023	11.67 L	19.33 IJKL	15.00 KL	15.33 F
27-Jan-2023	23.67 IJKL	29.00 IJKL	14.33 KL	22.33 F
10-Feb-2023	18.33 IJKL	23.33 IJKL	11.67 L	17.78 F
24- Feb-2023	23.33 IJKL	63.33 EFG	45.00 GHJI	43.89 DE
1-Mar-2023	150.00 A	145.00 AB	160.00 A	151.67 A
Average transactions	55.00 B	69.26 A	62.90 AB	

*Numbers with the same letter between the means are not statistically significant at the 5% significance level.

2. Honey area

Table (2) shows the measurements of the honey inside the apiary during winter. The results show that there are significant differences in the average area of honey for the three treatments inside the closed apiary. The reference untreated group outperformed, and the final average area of honey reached (236.00 inches²), while the area of honey was less in both treatments (vitamin, candy) and gave an average of (197.20, 172.83) inches², respectively, during winter.

Table (2) also shows that the highest average area of honey was on the fourth of November for the comparison, candy, and vitamin- which reached (394.00, 390.6, 383.67) inches², respectively, while the lowest average area of honey was 26.67 inches² on the first of March for candy treatment. The highest average area of honey in the three apiaries for the three treatments combined was on the fourteenth of

November- averaging 389.44 inches² in honey area, while the lowest average was on the first of March- averaging 43.33 inches² in honey area. This gradual decline of honey inside the beehives during Winter is due to the continuous feeding of honey by the workers to generate the heat necessary to warm the honeybee colony as well as feeding the brood. This is consistent with the observation of Shamoan (2022)^[13] that honeybees consume large quantities of honey with low temperatures during winter for the purpose of feeding the brood and thermoregulation necessary for the swarming bees to ensure their survival. Therefore, the readings indicated that the honeybee hives that were fed during winter had a greater consumption of honey due to their continued production of brood to a greater extent than the control hives that were not fed.

Table 2: Area of honey inside the beehives in the closed apiary during winter.

Date	Control	Candy	Vitamin	Average Date
4-Nov-2022	394.00 A	390.67 A	383.67 A	389.44 A
18- Nov-2022	369.33AB	314.00 CD	329.00 BCD	337.44 B
2-Dec-2022	354.67ABC	293.00 DE	320.67 CD	322.78 B
16-Dec-2022	314.67 CD	222.00 GH	244.33 FG	260.33 C
30-Dec-2022	267.00 EF	155.67 IJKL	185.33 HIJ	202.67 D
14-Jan-2023	196.67 HI	111.33 LMNO	160.00 IJK	156.00 E
27-Jan-2023	168.67 IJK	89.67 NOPQ	132.33 KLMN	130.22 EF
10-Feb-2023	145.00 JKLM	78.67 OPQR	105.00 MNOP	109.56 F
24- Feb-2023	86.67 OPQ	46.67 QRS	71.67 OPQR	68.33 G
1-Mar-2023	63.33 PQRS	26.67 S	40.00 RS	43.33 G
Average transactions	236.00 A	172.83 C	197.20 B	

*Numbers with the same letter mean that they are not statistically significant at the 5% significance level.

3. Pollen area

Table (3) shows that there are no significant differences in the average pollen area in the three treatments, with an average pollen area of 15.53, 17.53, and 16.30 inches², for the reference, candy, and vitamin treatments, respectively.

The highest average pollen area was (38.33) inches² on the first of March for the Candy treatment, while the lowest average pollen area was (0.33) inches² on the 10th of February for the comparison treatment. For the three treatments, the highest average pollen area was (34.11 inches²) on the fourth of November, while the lowest average pollen area was (1.44 inches²) on the 10th of February.

The results show that the decrease in the pollen inside the

beehives was due to brood feeding, as well as the inability of the foraging bees to leave the hive to collect pollen due to the low temperatures in winter. This is consistent with DeGrandi-Hoffman *et al.* (2010)^[7] that brood bees consume bee bread and transform it by their pharyngeal glands, which produce a protein-rich gel that is used to feed the developing larvae. Blazyte-Cereskiene *et al.* (2010) also reported that foraging bees decrease or stop wandering outside the hive due to lower ambient temperatures during winter, and that the number of foraging bees increased ten times when the temperature rose to 12 °C. Therefore, there were no significant differences between all treatments in terms of pollen area during winter.

Table 3: Pollen area inside the beehives in the closed apiary during winter

Date	Control	Candy	Vitamin	Average Date
4-Nov-2022	34.33 AB	34.66 AB	33.33 AB	34.11 A
18- Nov-2022	33.33AB	33.00 AB	29.33 A-E	31.88 AB
2-Dec-2022	27.667 A-F	30.66 ABC	26.00 A-G	28.11 AB
16-Dec-2022	18.00 A-H	15.00 A-H	22.33 A-H	18.44 BC
30-Dec-2022	5.33E-H	10.33 B-H	10.33 B-H	8.66 CD
14-Jan-2023	1.33 H	3.66 FGH	4.00 FGH	3.00 D
27-Jan-2023	2.66 GH	2.667 GH	3.33 FGH	2.88 D
10-Feb-2023	0.33 H	1.00 H	3.00 GH	1.44 D
24- Feb-2023	2.33 GH	6.00 D-H	8.00 C-H	5.44 CD
1-Mar-2023	30.00 ABCD	38.33 A	23.33 A-H	30.55 AB
Average transaction	15.53 A	17.53 A	16.30 A	

*Numbers with the same letter mean that there are not statistically significant at the 5% significance level.

Conclusions

1. Honey bee colonies that were fed gave better results in terms of brood area compared to unfed colonies raised under the same environmental conditions.
2. Honey bee colonies that were fed during winter had greater honey consumption due to their continued production of brood to a greater extent than unfed control hives.
3. There were no significant differences between all treatments in terms of pollen area during winter.
4. There were no significant differences between the honeybee colonies that were fed with candy paste alone and the hives that were fed with candy paste with vitamins added, especially in terms of brood area and pollen.

Recommendations

1. It is preferable to continue feeding the hives during winter to give more brood area.
2. It is preferable to use alternatives to pollen that contain beneficial natural substances that help bees increase their activity more.

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