Entomology

Effect of artificial pollen substitute diets on diets consumption, brood area, and colonies strength of *Apis mellifera* L. colonies during dearth period

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Abstract

Honey bees play a good role in the production of valuable products and pollination of different plants. pollen diets are one of the most important ingredients for honey bees to develop and build up colonies. Many honey bees colonies lose due to nutritional stress, we check the effect of four different pollen diets (D_1, D_2, D_3, and D_4 50g each D_5 is control colony) on brood and colonies strength in honey bees *Apis mellifera.* Results indicated that mean consumption of diets was D_1, D_2, D_3, and D_4 (38.47g, 49.53 g, 33.60 g, and 46.0 g) and brood area was (1357.0 cm^2,1567.3 cm^2, 1251.8 cm^2, and 1456.3 cm^2) respectfully, and good effect on population increasing in selected colonies about 50%, 60%, 46%, and 50%. And control colony D_5 remained the same brood area and frame population before and after treatment. Pollen substitute diets can be effective in stimulating honey bee colonies to rear brood. All diets tested here were not equally effective in brood rearing. Our results showed that the artificial pollen diets correlation $p \leq 0.05$ an effect on honey bees health and increased colonies strength.

Keywords: pollen diets, honey bee, brood area, colonies, population

Introduction

Honey bees are known producers of honey, royal jelly, propolis, and bees-wax, and bee venom. They also play a major role in the pollination of several valuable agri crops through cross-pollination. Apart from increasing the yield of different crops, they significantly improve the quality of seeds/fruits. Of late, beekeeping has been recognized as one of the essential inputs in agriculture (Sihag. 2001) [11].

The protein obtained from pollen plays a major role in colony reproduction and the life of honey bees. A shortage of pollen or store of poor-quality pollen results in short growth and weight gain of young bees reduced durability and hypopharyngeal glands. This leads to insufficient royal jelly production to support normal growth and development of larvae or egg production by the adult queen (Standifer and Mills. 1977) [12], (Zahra and Talal. 2008) [13] Tested the effect of certain chickpea, green gram and horse gram, soybean, maize, wheat, and gram as horse powder mixed with honey, water, and soybean, which indicated the best way for visiting bees (Pande and Karnatak. 2014) [8]. Pollen provides honey bees with protein and a honey bee colony consumes about 18 kg of pollen per year. During certain periods of the year, weather conditions are not suitable for bees and the availability of food (nectar and pollen) resources is very low during the death period. In this case, the colony may be available a pollen substitute, which is food likely to completely replace pollen. Pollen substitute which is mostly used by beekeepers consists of a mixture of soybean flour, cornflour, powdered scanned milk and dried brewer's yeast, Some newly developed pollen substitutes appear to rival pollen in acceptability and nutritional value to honeybees (Saffari *et al*. 2010) [10]. The consumption of supplies is determined by the period of starvation, which is marked by a lack of food. Brood raising, honey production, and overall colony growth and development are all affected when nectar and pollen are insufficient (Di Pasquale *et al*. 2013) [3]. In the past era, habitat degradation and dispersion have proved to be a serious problem for pollinators, resulting in a decrease in the availability of flower supplies for bees (Biesmeijer *et al*. 2006) [1]. Results show that if the bee's availability to pollen is limited, brood rearing and colony life duration are lowered. Foragers die younger than their siblings who work in the hive when there isn't enough food. As the most prevalent pollen types, an Asteraceae, Moraceae, and Myrtaceae pollen mix was generated. The pollen diet based on Asteraceae was shown to have a low adult worker survival rate. Because consumption was negatively linked with the proportion of Asteraceae in the combination, this type of pollen was unpleasant to bees (Frias *et al*. 2016) [4]. Pollen's nutritional value varies from plant to plants. Bee bread is just a combination of nectar and salivary enzymes from bees (Mohammad *et al*. 2020) [6].

But the success of beekeeping in a region depends upon the prevailing climatic conditions, availability of bee forage, and management practices. All good beekeeping conditions can be nullified if the management of an apiary is poorly planned. Therefore, the management of bee colonies in a particular region is a very important aspect that a beekeeper should carefully concentrate on for higher honey production and pollination of crops (Chhuneja *et al*. 2018) [2].

Honey bee, *A. mellifera*, depend mainly on nectar and pollen as sources of nutrients. Nectar provides bees with carbohydrates whereas pollen provides them with the remaining dietary requirements such as proteins, lipids,

vitamins, and minerals. Lack of pollen in the field is a serious problem for beekeepers. Supplying bee colonies with an alternative artificial pollen substitute is necessary for honeybee colonies, especially when natural resources of nectar and pollen are unavailable for the development of young bees, rearing brood reproduction, and maintenance of colonies. Honey production is an important target for all beekeepers worldwide as well as in Pakistan. Improving the efficiency of beekeeping depends on providing proteinaceous pollen substitute feed to honey bees colonies during the death period. Providing pollen substitutes will stimulate colony strength which will help in maximizing honey production and overcome parasites and diseases damage. Therefore, the purpose of our study was the assessment of pollen substitute diets by measuring the diet consumption, brood area, and colony strength in *A. mellifera* colonies.

Materials and Methods

This experiment was conducted at Honeybee Research Institute, National Agriculture Research Centre, Islamabad on 45 queen right *Apis mellifera* colonies during the death period (July to August 2019). All the selected colonies had six-month-old queens with good egg potential and worker strength. Honey bee colonies of each group that had been standardized one week before, based on five bees and two brood frames. Colonies were placed at 3m distance from each other. Selected honeybee colonies were numbered, labeled, and divided into 5 groups; three colonies were used for each treatment and control following Completely Randomized Design (CRD) with three replications. The following treatments were used:

D_1 = 50 g of diet A (20 g soybean flour + 10 g Brewer's yeast + 20 g powdered sugar +150 ml sugar syrup.

D_2 = 50 g of diet B (20 g soybean flour + 5 g Brewer's yeast + 7 g honey + 8 g Turmeric and Fenugreek powders + 0.5g A, D and E vitamins + 9.5 ml orange juice + 150 ml sugar syrup.

D_3 = 50 g of diet C (20 g maize flour + 10 g Brewer's yeast + 20 g powdered sugar + 150 ml sugar syrup.

D_4 = 50 g of diet D (20 g maize flour + 5 g Brewer's yeast + 7 g honey + 8 g Turmeric and Fenugreek powders + 0.5 g vitamins A, D, and E + 9.5 ml orange juice + 150 ml sugar syrup.

D_5 = Control (150 ml sugar syrup only).

All the tested diets were fed in patties that were directly placed over the brood nest of tested bee colonies and covered with plastic sheets to avoid drying (add to feed these colonies with sugar syrup). All tested diets were fed to colonies at the weekly interval and each colony was provided with a 50g tested diet. Before feeding the colonies, the unconsumed portions of the patty diets were removed from the colony and weighed to estimate consumption. The pretreatment and post-treatment data of sealed/unsealed worker brood area was measured with the help of a measuring frame (wire grid) with divisions giving an area of one square inch each and then converted into cm^2 by multiplying with 2.54. Adult bee populations were made by estimating the number of combs covered with bees. The data was analyzed statistically by using a Completely Randomized Design with a one-way Analysis of Variance (ANOVA). The least significant difference (LSD) was applied to determine the difference between the treatment at a significance level of $p \leq 0.05$ using Statistic 8,1 computer programmer.

Results

The results of different pollen substitute diets and their results indicating before and after treatment data of bee population and brood area and after treatment data of diets consumption, bee population, and brood area cm^2 are presented in Table (1). Results indicated that diet (D_2 = 50 g of diet B (20 g soybean flour + 5 g Brewer's yeast + 7 g honey + 8 g Turmeric and Fenugreek powders + 0.5 g A, D and E vitamins + 9.5 ml orange juice + 150 ml sugar syrup) was consumed in maximum quantity (49.53 g). The next preferred diet was (D_4 = 50 g of diet D (20 g maize flour + 5 g Brewer's yeast + 7 g honey + 8 g Turmeric and Fenugreek powders + 0.5 g A, D and E vitamins + 9.5 ml orange juice + 150 ml sugar syrup) with the mean consumption of 46.0 g, mean diets consumption of D_1 = 50 g of diet A (20 g soybean flour + 10 g Brewer's yeast + 20 g powdered sugar +150 ml sugar syrup.) was 38.47 and Mean consumption for D_3 = 50 g of diet C (20 g maize flour + 10 g Brewer's yeast + 20 g powdered sugar + 150 ml sugar syrup was 33.6 g which was lowest from all diets (Table 1).

Table 1: Effect of different pollen substitute diets on diets consumption, bee population, and brood area cm2 in honey bee *Apis mellifera* colonies

Treatment	Before treatment		After treatment		
	Bee population per frame	Brood area (cm^2)	Food consumption (g)	Bee population per frame	Brood area (cm^2)
D_1Soybean	4	996.35	38.47	6	1357.0
D_2Soybean	5	1216.67	49.53	8	1567.3
D_3Maize	3	1064.52	33.60	4.5	1251.8
D_4Maize	4	886.33	46.0	6	1456.3
Control	3	875.00	0	3	910.00

Means within the columns followed are statistically significant at $p \leq 0.05$.

Maximum brood area (1567.3 cm^2) was recorded in the colonies fed with D_2 soybean diet after treatment applications which were statistically different from all other diets except the D_4 maize diet. The next preferred diet was D_4. The brood area observed, in this case, was 1456.3 cm^2 after treatments and it was also statistically better than all other treatments except D_2. The brood area in D_1 and D_3 was 1357.0 cm^2 and 1251.8 cm^2, respectively. Minimum brood area (910.0 cm^2) was observed in control colonies which were lowest than all other treatments.

The data of bee population (mean number of frames covered with bees) showed that the maximum 8 bee frames/colony was observed in D_2 and followed by D_4 (6 bee frames/colony), D_1 (6 bee frames/colony), and D_3 (4.5 bee frames/colony), respectively. The lowest (3 bee frames/ colony) was recorded in D_5 control (untreated) colonies after treatments.

Discussions

Pollen substitute diets can be effective in stimulating honey bee

colonies to rear brood but they must be both palatable to bees and nutritious. Whereas, providing bee colonies with D_2 induced the highest amount of worker brood area cm^2 followed by D_4, D_1, and D_3 especially during the death period (July-August 2019). Tested diets were differed in their consumption by bees, D_2 was almost completely in comparison with the other diets.

In this study, our result showed that artificial pollen diets directly affect honey bees' health in the death season and also increase the population of colonies.

Worker bees have a low amount of polyunsaturated fatty acids in their cell membranes when they are born, but this increases rapidly as a result of pollen consumption rate during the first week of life. Low polyunsaturated fatty acid contents in the body of bees provided soybean protein diets may have an impact on bee survival. Shortfalls of linoleic and linolenic acids have also been related to failure in pupal and adult ecdysis (Nation. 2008) [7]. The amount of iron in the food appeared to affect the rate of growth in iron concentration in fat bodies. The bee's direction in reference towards the earth's magnetic field is improved by the iron-rich granules, that is essential for orientation for foraging (Kuterbach and Walcott. 1986) [5]. pollen supplements plus redgum and pollen supplements plus redgum + soy flour extract, and redgum Only substitute and pollen substitute diets had such a favorable relation between pure protein consumption and increase body weight of bees (Peng *et al*. 2012) [9].

Conclusion

The study reported that the artificial pollen substitute diets can have good effects on honey bee's health, rear brood, and increasing colonies strength. In the time of death period, the pollen diets are recommended for colonies maintenance and population increasing. All diets tested here were not equally effective in stimulating brood rearing or the number of combs covered with bees. Pollen substitute diets must have both palatable to bees and nutritious. Whereas they make available to honey bee colonies especially during the death period.

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