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*Journal homepage: <http://www.journalijar.com>***INTERNATIONAL JOURNAL
OF ADVANCED RESEARCH****RESEARCH ARTICLE****Testing the effect of dearth period supplementary feeding of honeybee (*Apis mellifera*) on brood development and honey production****Tolera Kumsa Gameda**

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Corresponding Author*Tolera Kumsa Gameda**Email: tolekume@yahoo.com**Abstract**

In many countries of the world, there have been many attempts to reduce the loss of honey bee colonies dearth period by improving the conditions. Supplementary feeding of honeybee colonies assists the shortfalls of naturally occurring pollen and nectar. The experiment was conducted in Gedo Research Station of Holeta Bee Research Center, Ethiopia from September 2011 to June 2013. Two treatments each with seven bee colonies were established with uniform strength. The first group was fed with pea flour while the second group was fed with sugar syrup. Feed consumption rate (gram/colony), brood and stored pollen area in cm², colony strength in terms of frames covered by bees, cost of feeding and honey yield were collected and analyzed. When there was scarcity of pollen in study area, each colony consumed an average of 348.9 gram per day of pea flour in dry season (February to March) and 128 gram/day in rainy season (July to August). There was significant difference ($p < 0.05$) in brood production and adult bee population between feeding treatments during the dearth periods. Colonies fed on pea flour built more brood area ($1274.3 \pm 95 \text{ cm}^2$) and more adult bee population (9.7 ± 1.6 frames of bees) as compared with colonies fed on sugar syrup built $924.8 \pm 63 \text{ cm}^2$ brood area and 7.3 ± 1.5 frames of honeybees. When natural pollen is become available in study area, the consumption of pea flour steadily decreased to the level colonies rejected to consume. In time of honey flow season, honey produced from pea flour treatment was found to be significantly greater ($p < 0.05$) compared to honey produced from colonies fed on sugar syrup. The mean honey yield was 26.8 ± 2.2 colonies fed on pea flour and 21.3 ± 1.8 kg for colonies fed on sugar syrup respectively. Therefore pea flour feeding was found better in dearth period colony maintenance, honey production and also reduce the cost of sugar feeding.

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INTRODUCTION

Over the world, almost every place has specific period when there is dearth of floral resources for honeybees (Prakash et al, 2007). Beekeeping in Ethiopia traditionally utilized flowering events which provided sufficient quantities of nectar and pollen to stimulate colonies to increase worker bee populations. However, it is major problem to maintain optimum colony population during dearth of flora. The shortage of pollen availability leads to declining brood rearing of colonies eventually resulting in weaker colonies. Such colonies are also vulnerable to natural pests and predators of bees. Special care should be taken in seasonal honeybee colony management. The first option is to feed the bee colonies with protein rich artificial diet so that brood rearing activity can be enhanced and strength of colonies is maintained in dearth periods (Mattila and Otis, 2006, Marghitaş et al., 2010, Morais et al, 2013). The other option is migrating honeybee colonies from resource poor to resource rich; however, it requires lots of labour, time and money (Kumar et al., 2013).

Before pollen and nectar are available, providing colonies with supplementary feeding helps to survive and maintain throughout dearth period and help the colony to start early brood production (Pernal and Currie, 2001; Kalev et al., 2002; Neupane and Thapa, 2005 and Prakash, et al., 2007). Optimum population of honeybee colonies during dearth seasons ensures the early building-up and more foraging bees during subsequent honey-flow time to produce more honey (Somerville and Collins, 2007; Sihag and Gupta, 2013). The use of sugar syrup or pollen supplement or both are useful for dearth period feeding in order to build larger forgers for maximum honey crop (Somerville and Collins, 2007). Low cost and acceptable diet for colonies is a prime need where beekeepers cannot afford high cost feeding investment. Different type of supplementary feed have been tried to provide for colonies to survive dearth periods in Ethiopia, however, the effect of supplementary feeding on various honeybee colony performances were not yet quantified. This study therefore carried out to test and proves the effect of locally available and cheap protein sources on colony production, growth and productivity.

Materials and methods

Study site

The study was conducted at Gedo station of Holeta Bee Research Center from September 2011 to June 2013. Two clearly demarked apiaries with uniform environment were used to minimize the robbing effect of honeybee during external feeding of pea flour. Two treatments each with seven colonies were established in each apiary in Zander hives and the colonies were equalized to ensure similar strength. The time to provide supplementary feeding is when flowering plants are not in bloom from February to March which is identified as dry season and from July to August identified as rainy season. The study colonies received similar seasonal colony management.

Preparation of flour for colony feeding

The selection of flour was made based on information from local beekeepers and preliminary screening of different flour (pea, chick pea and bean) depending on the consumption rate of colonies. Pea flour was selected for this study depending up on local availability, cost and high consumption rate by colonies. The preparation of pea flour is that, it was roasted and the skins of pea come out and milled to the texture and consistency to be accepted by honeybees. Water was added to the weighted powder until it turns to soften texture. Sugar syrup was prepared by dissolving one kilo gram of crystal sugar in one liter of fresh water (1:1).

Supplementary feeding

Feeding of pea flour was done externally to provide bees' easy access to collect as did for natural pollen. It was confirmed by Saffari et al (2010) that honeybees by nature need to buzz to collect powdery substances which is an easy method and consumes minimum time and labour. Sugar syrup was used as positive control of supplementary feeding and fed internally as conventional feeding according to Avni et al (2009). Supplementary feeding was suspended when pea flour consumption stopped by honeybees because of the availability of natural pollen (Mattila and Otis, 2006). Both treatments were free accessed to collect naturally available flora if any in the area.

Brood and adult bee estimation

Colonies were assessed following a standard procedure including the estimate of adult bee populations using the number of combs covered with bees, areas of brood coverage and pollen stored in the colonies using a grid that cover the entire side of combs and was measured after every 21 days interval (Keller, et al, 2005, Sena, et al, 2012, Kumar et al, 2013). Finally honey was harvested and recorded.

Statistical analysis

All recorded results were statistically tested using comparisons of T-test and linear regressions and presented using tables and graphs. Finally, the cost of feeding was calculated and compared to find the cheapest supplementary feeding.

Result and discussion

Consumption of pollen supplement

The consumption rate of pea flour was recorded for five successive days depending up on the consumption progress. The mean pea flour consumption (gram/colony) of honey bees was found to be progressive for the first three days and started to decline on fourth and fifth days (Figure 1). Colonies preferentially collected and utilized all sugar syrup in three days. The mean daily consumption of pea flour is 348.9 gram per colony in dry seasons (February to March) and 128 gram per colony in rainy season (July to August). The reason is it was observed that honeybees stored enough flour in combs for further consumption.

Linear regressions showed that there was a positive relationship that was highly significant ($p < 0.001$) between the amounts of flour consumed and increase brood area and change in adult population. Pollen supplementary from locally-available ingredients can be a valuable resource for beekeepers to maintain and increase brood rearing conditions of colonies (Morais et al., 2013). Pea, chickpea and soybean flour feeding has long been local ingredient of choice in pollen supplements due to easily availability, relatively high protein content and price as compared to other bee feeding materials (Somerville, 2005).

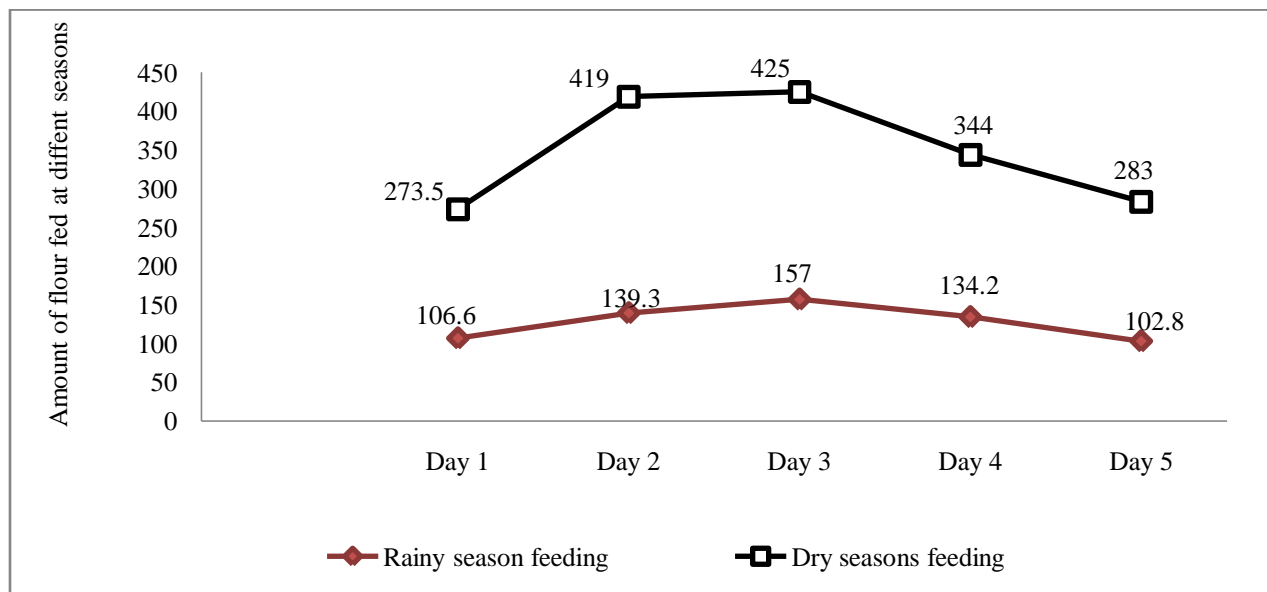


Figure 1. Mean consumption rate of pea flour

Dearth period supplementary feeding of honeybee

Findings of the present study showed that colonies fed on the pea flour significantly ($P < 0.05$) produced more brood compared to colonies fed on sugar syrup during dearth period. The mean amount of brood produced from colonies fed on pea flour is $1274.3\text{cm}^2 \pm 195\text{cm}^2$ in dearth period, while mean dearth period brood production for colonies fed

on sugar solution (SS) was $924.8\text{cm}^2 \pm 163\text{cm}^2$ (Table 1). During poor conditions when pollen and nectar were in short supply, pollen supplement maintain the colony strength throughout dearth period and help the colony improve brood strength as would be expected (Prakash, et al., 2007). Similar results were obtained from feeding of soybean flour singly or in combination with other flour indicate its high potential for improving colony maintenance, build brood production during a shortage of natural pollen (Al-Gamdi, 2002, Dastouri et al, 2007, Abusabbah, et al 2012). Moreover, findings of the present study showed that the colonies fed on pollen supplement reared significantly more brood as conformed by Kumar et al (2013) and Nabors (2000) who reported feeding supplemental pollen to colonies improved their performance, as would be expected during a shortage of natural pollen.

Adult bee populations also significantly different ($p < 0.05$) with an overall average of 9.7 ± 2.6 frames of bees fed on pea flour compared to 7.3 ± 1.5 frames of bees fed on sugar syrup in identified dearth seasons. The results presented in Table 1, showed that highly significant difference between treatments in their effects to increase brood area/ cm^2 , bee population and honey production. It was greater for the pea flour compared to the sugar syrup feeding. The result is in close agreement with Kumer and Agrawal (2013) who reported that number of bee covered on frames are positively affected by feeding protein-rich diet to bees. It was suggested also by Somerville and Collins (2007) that colonies maintained with pollen supplements in dearth periods would be in a better position to develop early brood production, hoard nectar and stored surplus honey in honey-flow time.

As the natural flower progressed in September to January and April to May, the natural pollen would become available to the colonies making them less reliant on supplements and consumption of pea flour steadily decreased to the level honeybees refused to collect the flour. Somerville (2005) who indicated that good flowering conditions provided pollen and nectar requirements and bees did not generate significant response to consume any supplementary feeding.

Table 1: Effect of feeding of pea flour and sugar syrup on brood area, honeybee population, stored pollen and honey production

Test group	Feeding treatments	Mean (cm^2) \pm SD	T-stat	Sig
Dearth period brood area in cm^2	Pea flour	1274.3 ± 49	1.83	0.040
	Sugar syrups	924.8 ± 36		
Dearth period bee population on frames	Pea flour	9.7 ± 2.6	1.78	0.035
	Sugar syrup	7.3 ± 1.5		
Active season natural pollen store in cm^2	Pea flour	276.2 ± 16	0.9	0.224
	Sugar syrup	233.3 ± 13		
Active season brood production in cm^2	Pea flour	3851 ± 74	1.96	0.013
	Sugar syrup	3337 ± 55		
Honey yield in kg	Pea flour	26.8 ± 2.2	2.0	0.02
	Sugar syrup	21.3 ± 1.8		

After natural pollen is become available, the brood areas progressively increased and significantly different ($p=0.013$) between treatments. The mean amount of brood produced in the early honey-flow was $3851 \pm 174\text{cm}^2$ for colonies fed on pea flour, while mean brood production for colonies feeding on sugar syrup was $3337 \pm 155\text{cm}^2$ before additional supers were given. This indicated that feeding of pea flour provided the positive results that pushed the queens to initiate early egg lay to increase brood production resulted in more foragers for surplus honey production in honey-flow time (Table 1). Sugar syrup feeding also stimulated honeybees to increase the natural pollen income and become capable of producing brood. It has long been recognized as having a stimulatory effect, such as an increase pollen-gathering and egg-laying activity as well as increased hygienic behavior of honeybee (Madras-Majewska, et al, 2005, Prakash, et al., 2007, Sammataro and Weiss, 2013). Very often one or two distinct honey-flow was observed in study areas, which are likely to be associated with the flowering of a locally available plant species. *Bidens pachyloma*, *Guizotia scabra* and *Vernonia amygdalina*, flowered step by step from September to January and *Eucalyptus* species and *Croton macrostachys* flowered from April to May as useful honeybee forage in the study area.

Honey yields

Honey was harvested in late January and sometimes in October. It should be noted that first year was not a very good year for honey production, because of the unsuitable weather conditions in the area. There was statistically

significant differences in honey yields between treatments ($P=0.02$). Colonies received pea flour tended to produce more honey (26.8 ± 2.2 kg) compared to colonies received sugar syrup (21.3 ± 1.8 kg). Mladenovic et al. (1999) who have used ingredients soya flour, molasses, and skimmed milk powder as pollen supplement and evaluated for their performance which indicated an increase in honey production by the colonies. This statement is also supported by the finding of Nabors (2000) and Mattila and Otis (2006) that feeding with pollen supplements increased the yield of honey harvested.

Cost of supplemental feeding

Pea flour is attractive to honeybees, easily available at local condition and cheap. The cost analysis of feeding indicated that return from honey yield exceeded costs of supplementary feeding for both treatments. Moreover, feeding pollen supplement resulted in better return than sugar feeding Table 2.

Table 2. Supplementary feeding cost of honeybees

Feeding materials	Total revenue from sale of honey	Cost of feeding	Net Revenue
Pea Flour Supplement	26.8kg of honey per harvest x 60 ETH birr = 1596 ETH birr	4 kg pea flour x 20 ETH birr including labour cost= 80 ETH birr	1516 ETH birr
Sugar Syrup Supplement	21.3kg honey per harvest x 60 birr = 1278 ETH* birr	6kg of sugar x 20 ETH birr = 120 ETH birr	1158 ETH birr

*20 ETH birr = 1USD

Conclusion

It is important to seriously consider the nutritional requirement of honeybee colonies to provide long lasting benefits for the performance of the colonies throughout the year. The evidence from the experiment and analyzed parameters indicates that in order to maintain brood rearing and colony population at a time of pollen dearth, providing honeybee colonies with supplementary feeding is crucial. According to the experiment result pea flour experimental group have good influence on dearth period brood production, colony population and honey production. However, several authors suggested that yeast products mixed with pulses power and sugar syrups fed colonies in combination are very palatable and contain the essential nutrients required for growth and development of colony. Therefore, detailed experiments will be needed to assess appropriate recipe of dearth period supplementary feeding of honeybee that contain all balanced diet.

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