EFFECT OF SUGAR SYRUP ON BEE HEALTH

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CERTIFICATE

This is to certify that thesis entitled, "**EFFECT OF SUGAR SYRUP ON BEE HEALTH**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **ENTOMOLOGY**, embodies the result of a piece of *bonafide* research work carried out by **MD. ANWAR MORSED, Registration Number: 07-02421** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2016

Dhaka, Bangladesh

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DEDICATED TO
MY
BELOVED PARENTS

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Date: June, 2016 **The author**

EFFECT OF SUGAR SYRUP ON BEE HEALTH

ABSTRACT

An experiment was conducted in the Apiary of Department of Entomology of Sher-e-Bangla Agricultural University to find out effect of sugar syrup on bee health on August – October 2015. The experimental setting was with four treatments consisted of four different concentration of sugar syrup. Where T_1 comprised of setting up of control where Sugar & water ratio=1: 1. T_2 consisted of ratio of Sugar & water =1: 1.10. T_3 having the ratio of Sugar & water = 1: 1.20 & T_4 comprising the ratio of Sugar & water =1: 1.30. The study was replicated 6 times following Randomized Complete Block Design (RCBD). The highest percentage of eggs (22.25%) were deposited in the hives treated with the sugar syrup at 1:1.30 ratio. The highest percentage of larva (24.75%) was found in the colony treated with sugar syrup @ sugar: water = 1:1.30. and the lowest percentage of eggs & larvae were found in the control (T_1=sugar: water = 1:1. They significantly differed from each other. The highest percentage of pupa (23.08%) was recorded in the sugar syrup consisted of sugar: water = 1:1.30 treated hives whereas the lowest percentage of pupa (7.95%) was observed in the control colony (T_1=sugar: water = 1:1) hive. The lowest (0.21) mean mortality of bee was recorded in the hives treated with sugar syrup having 1:1.30 ratio compared to all other treatments including control. The highest mortality (2.96) was observed in sugar syrup with the ratio of 1:1.10 which might be due to toxicity of the environmental condition. Considering the above findings the Sugar syrup consisting of sugar: water = 1:1.30(T_4) was the most effective diet on bee health.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

The honey bee, man's oldest insect friend, gives his honey, beeswax, pollen, propolis, royal jelly and bee venom (apitoxin) which are very valuable products. Most important of all, the polination of many crops is done by honey bee. Mankind knows this marvelous insect since the prehistoric times. The art of their management in hives and extracting surplus honey is called beekeeping. Beekeeping is a valuable and profitable venture to supplement farmer's income. At present beekeeping activity is practiced on a part-time basis in Bangladesh (Anonymous, 2005). Bangladesh government and other non-government organizations, including Bangladesh Institute of Apiculture (BIA), Proshika and Mouchak Unnayan Sangstha (MUS) etc. have taken various schemes to provide technological support for training on beekeeping, developing, marketing honey and supplying necessary equipment for the economic production of honey in the country.

Honey bees (*Apis mellifera*) are dependent on the supply of floral pollen and nectar. The activity of the honey bee is controlled largely by ambient conditions. In some habitats where the weather fluctuates annually, as in the 'Sub-tropical region', the warm season coincides with the lack of flowers and is considered the "dearth period" (Eisikowitch, 2004). In the cold season, when the flowers appear, the bees are at full activity, collecting and storing food, along with fulfilling their reproductive duties. Although bees are physiologically capable of being active in hot deserts, they suffer from the lack of food sources and water, the latter being used for cooling hives in addition to its physiological function. Honey bees are thus restricted to areas where blooming occurs at least for part of the year (Echazarreta and Paxton, 1997).

Honey bee is a social insect which has little chance to survive without group and dearth period is nothing but a specific time of a year, when natural scarcity of particular flower and pollen is observed. Dearth period is very important period for honeybees because, their life cycle hampered and normal life process is deviated in this period of time. For successful management

and rearing of honey bees in dearth period, it is imperative to adopt advanced beekeeping measures for colony development. The annual cycle of colony development of European honey bee (*Apis mellifera*) is described in detail in many independent studies in temperate climates from North America (Farrar, 1937; Avitabile, 1978), Europe (Wille and Gerig, 1976; Liebig, 1996) and Asia (Gong, 1980). Under temperate conditions, the colony brood rearing cycle is characterized by complete cessation of brood rearing in the late fall and reduction of colony size during the winter (Avitabile, 1978). Limited brood rearing may be initiated during winter months and brood rearing leading to colony expansion is often initiated before nectar and pollen become available (Seeley, 1978). Furthermore, queen rearing is essential for improving existing stock, but has not been practiced successfully with *Apis mellifera* inspite of many attempts (Fletcher and Tribe, 1977). This species is very new in Bangladesh and the information in this country regarding queen rearing is also scanty.

So, for successful honey production and for survival of the *Apis mellifera* in dearth period artificial supplement of food is necessary. There are some nectar and pollen substitutes, which are not of same quality. Sugar syrup (1:1) is one of the most popular nectar substitutes whereas soyabean flower, mung bean flour, corn flour, mixed flour etc. are different pollen substitutes for honey bee during dearth period. The efficacy of such nectar and pollen substitutes in the maintenance of honeybee colonies is necessary to evaluate.

OBJECTIVE

The present study was carried out considering the following objective:

1. To know about the management of *Apis mellifera* during dearth period.
2. To know appropriate sugar syrup concentration, to maintain bee health.

CHAPTER II

REVIEW OF LITERATURE

Apis mellifera L. considered as European honey bee is the most important among all the species as a pollinator, honey and bee wax producer. It makes parallel comb. In the hives it has prolific queen having the feature like medium sized, less stinging reflex, swarming habit, nearly no absconding, good honey gatherer and can guard its nest against enemies except wasps and mites (Verma, 1990) and gentle tempered. So it can be easily domesticated. *A. mellifera* is good for migratory beekeeping and produces more honey and other hive products such as propolis and royal jelly. A considerable number of papers have been published on *A. mellifera* which are more or less relevant to the present study. Briefing of some of the results of those research works are presented below:

2.1 Space (cm^2) covered by *A. mellifera* L. eggs, larvae and pupae in the comb

Abbas *et al.* (1995) conducted a study on artificial feeding to *A. Mellifera* reared in eight honey bee colonies, each with 4 frames of bees, were fed during the rainy season. The four colonies were fed with a pollen substitute containing 55% soybean flour (also 25% sugar, 5% yeast, 5% milk powder, 10% water); another 4 colonies were fed with a diet consisting of blackgram (*Phaseolus mungo*) flour. After 3 months, the first group contained an average of 4.75 frame per colony and produced 7.12 kg honey per box, whereas the another group of colonies on an average had 5.75 frames and produced 8.62 kg honey per box. Four colonies which receive no pollen substitute had only 2.5 frame per colony having 1.87 kg of honey per box only.

Chhuneja *et al.* (1993 b) revealed that diets containing soybean resulted in significantly lower mortality of unsealed and sealed brood. Brood mortality was the lowest in colonies fed with pollen or with a diet of brewer's yeast + guar meal; mean populations in these colonies were 11650 and 9700 bees, respectively (compared with less than 7670 bees in colonies on other diets), and mean weights of individual nurse bees and foragers were significantly higher.

Pesante *et al.* (1992) showed that in an apiary, European honey bee *(Apis mellifera)* colonies giving 2 locations were fed twice a week with one litre or 3 litres of 50% sugar syrup with protein and pollen twice a week gained significantly more weight than Africanized colonies. However this was not found at the other apiary where the nectar flow was poorer. Colonies fed with one litre feeds of syrup gained more weight than those fed with 3 litres; the higher rate of feeding resulted in slower brood nest expansion and thus restricted colony development.

2.2 Space (cm^2) covered by *A. mellifera* L. pollens in the comb

Goodwin (1997) conducted trials over 4 seasons in 7 orchards using 379 *Apis mellifera* colonies to test the effects of time and frequency of feeding, volume, concentration and grade of sugar, and type of feeder. Syrup (but not dry sugar) feeding resulted in a mean increase of up to 7.9 fold in pollen collection over the flowering season, with up to 43.6-fold daily increases. Feeding of colonies with one litre of syrup/day between 08.00 h and 10.00 h consistently resulted in the greatest amount of pollen collected; grade of sugar and syrup concentration (1 or 2 M) and type of feeder (division board or top feeder) had no effect. Three liters of syrup every 3rd day (to reduce labour costs) increased pollen collection by almost the same amount. Syrup feeding increased pollen collection even when there were significant levels of competition from other flowers around the orchard, and did not affect the colonies' floral sex constancy.

2.3 Food substitutes with other effects

Cremonez (2000) used haemolymph protein measurement methods to determine the efficiency of protein diet substitute of *A. mellifera*. Groups of 120 newly emerged worker bees were kept in small cases in the laboratory and feed on bee bread or unprocessed pollen (Natural protein diet), soybean or yeast or maize meal (alternative protein diet) or a sucrose solution (non-protein diet), from adult emergence until 6 d later, the protein content in haemolymph was determined in these bees at 0, 2, 4, 6 d of adult life. Additionally, vitellogenin (a major protein in young adult worker bees) titrate was measured through rocket immune electrophoresis of the haemolymph of 6-d-old bees. A significant and progressive rise in protein titrate was

observed from 0 to the 6th day of adult life in the haemolymph of bees fed on bee bread, soybean or yeast or pollen. However, a significant reduction was recorded when fed on maize or sucrose only.

Perlin (1999) compared the relationship between food consumption and royal jelly production. The relationship between food consumption and royal jelly production was investigated at "Padre Assis" apiary, Brazil, from December 1996 to January 1997. Twenty Langstroth bee hives with nests separated by an excluding screen for queen bees were used. Treatments were applied randomly to all the hives. The effects of treatments were evaluated through the performance of beehives in the production of royal jelly. Treatment 1, comprising a powder based feed and refined sugar, resulted in an average production of 7.9 g of royal jelly per hive at each harvest. In treatment 2, comprising soybean meal and honey, the production was 4.32 g per hive. It was shown that the use of apiaries in the central region of Rio Grande do Sul for royal jelly production in December and January is successful when supplemental feeding constituting 3 parts of sugar and 1-part milk powder meal was used.

Allsopp *et al.* (1998) stated that the pentose sugar xylose has recently been reported as a major sugar in the nectar of *Prolea* and *Faurea* (Proteaceae). Honey bees are potentially important pollinators of both *Protea* and *Faurea,* the authors investigated the responses of Cape honey bees to xylose solutions. They observed that when bees were fed sucrose, glucose, fructose and xylose (all 30% w/w) and water only, survival on xylose was as poor as on water. With different glucose/xylose mixtures, survival time was inversely related to the proportion of xylose in the diet and each 5% increment in xylose causing an additional increase in mortality. It was concluded that the xylose in *Protea* and *Faurea* nectar is not there for the benefit of honey bees.

An experiment was conducted by Chhuneja *et al.* (1993 a) to find out the efficiency of supplementary food of *A. mellifera*. Compared with 7 other diets, two types of patty containing soybean resulted in significantly higher mortality of unsealed and sealed brood. Brood mortality was the lowest in colonies fed with pollen or with a diet of brewer's yeast + sugar meal; mean population in these colonies were 11650 and 9700 bees, respectively

(compared with less than 7670 bees in colonies on other diets) and mean the weight of individual's nurse bees and foragers were significantly higher.

Augustijn (1994) showed that in honey bees *(Apis mellifera)* colonies of an apiary, the period of October flight activity declined from a maximum of 28000 bees/day at the beginning of August to nearly zero at the end of October. Activity increased temporarily during sugar feeding. Mortality increased dramatically after the onset of feeding, perhaps because of the increased activity demanded of younger bees, which processed the sugar solution. During feeding, flight activity started later in the day and the proportion of short flights increased.

Bailey and Ball (1991) found that semi-refined cane sugar was harmless but that semi-refined beet sugar decreased the life of bees. So, impurities in his unrefined beet sugar must be toxic. Nectar is the major source of carbohydrate in the natural diet of honey bees. It may contain 5 to 75 percent soluble solids (sugars) although most nectars are in the range of 25 to 40 percent. The primary sugars are sucrose, glucose and fructose. As nectar is manipulated and finally stored as honey, much of the sucrose is inverted to approximately equal parts of glucose and fructose. A normalized honey bee colony may use the nectar equivalent of 300 to 500 pounds a year.

Moeller *et al.* (1978) undertook a study to find out the necessity of carbohydrate substitute in the management of honey bee colonies. They reported that, proper colony management should ensure adequate honey reserves or stores in the hive at all times, but feeding sugar may sometimes be necessary. Whenever the honey supply in the colony is low and nectar in the field is in short supply due to adverse weather, the colonies should be fed sugar supplement. Brood rearing requires a large quantity of honey and pollen. Cane or sugar beet, isomerized corn syrup and type-50 sugar syrup are satisfactory substitutes for honey in the natural diet of honey bees. The last two are supplied only as a liquid for bees.

Standifer *et al.* (1977) conducted a study to assess the general food requirements of honey bees, *A. mellifera* and presents formulas for supplementary diets and methods of feeding such

foods to bee colonies. In early spring, before pollen and nectar are available or at other times of the year when these materials are not available for bees in the field or in the hive, supplementary feeding may help the colony survive or sustain brood rearing and colony development. None of the protein supplemental foods fed to honey bees is a complete replacement for natural pollen; however, several brewer's yeast products, wheat and soybean flour, fed singly or in combination, can be used to improve the nutrition of colonies when natural pollen is scarce. Cane or beet sugar and isomerized corn syrup can be used to supplement the bees' diet of nectar or honey.

Doull (1975) observed that sugar syrups produced by the hydrolysis of wheat starch were detrimental to bees in confinement. He suspected undigested polysaccharides, particularly starch, to be harmful. He obtained better results sucrose than with his invert syrups.

Doull (1974) observed that sugar syrups produced by the hydrolysis of wheat starch were detrimental to bees in confinement. He suspected undigested polysaccharides, particularly starch, to be harmful. He obtained better results with sucrose than with the invert syrups.

Siddiqui (1970) reported that honey and nectars contain traces of toxic sugars such as raffinose, mannose, and galactose. Sub lethal levels of these sugars in pollen, honey, or nectar could modify effects of sugars in supplementary diets.

Bailey (1966) found that semi-refined cane sugar was harmless but that semi-refined beet sugar decreased longevity of bees. So, impurities in unrefined beet sugar might be toxic. Nectar is the major source of carbohydrate in the natural diet of honey bees. It may contain 5 to 75 percent soluble solids (sugars) although most nectars are in the range of 25 to 40 percent. The primary sugars are sucrose, glucose, and fructose. As nectar is manipulated and finally stored as honey, much of the sucrose is inverted to approximately equal parts of glucose and fructose. A honey bee colony may use the nectar equivalent of 300 to 500 pounds a year.

Piskovoi *et al.* (1964) found that sugar syrup, caused dysentery and mortality in caged bees.

Bees in overwintering colonies with honey stores containing 0.35 to 1.16-% salt were died prematurely. Refuse high in flour or dextrins, when added to water, ferments and kills bees. They routinely feed powdered cellulose without harm to caged bees. Furthermore, many pollen walls are indigestible but harmless.

CHAPTER III

MATERIALS AND METHODS

The present study on the "Effect of sugar syrup on bee health" was undertaken at an apiary of the Department of Entomology, SAU during August to October 2015. The detailed methodology and other related procedures followed in the studies are described under the following sub-headings:

3.1 Experiment site

A study was conducted on *Apis mellifera* L. at the Sher-e-Bangla Agricultural University farm Dhaka ($90^0$33´ E longitude and $23^0$77´ N latitude), from August–October of 2015.

3.2 Climate

The climatic condition of Sher-e-Bangla Agricultural University, Agargaon is moderate. Maximum and minimum mean temperature ranged from 34 °C to 25 °C, respectively during August to October 2015 (Appendix 1). Average relative humidity was the highest in August and the lowest in October 2015 during the experimental period (Appendix 1).

3.3 Honey bee *(Apis mellifera* L.)

To study the effects of sugar syrup on bee health, *Apis mellifera* L. colonies of the same species were selected. From each of the colony three frames were selected randomly for data collection.

3.4 Design and layout of the experiment

The experiment was set up in a Randomized Complete Block Design (RCBD). Four different concentration of carbohydrate substitutes were considered as the 4 different treatments viz., Sugar: water (1:1.10), Sugar: water (1:1.20), Sugar: water (1:1.30) and Sugar: water (1:1) as control. The treatments were randomly allotted with 6 replications. Number of Bee-boxes was 24.

Plate 01: Experimental site

Plate 02: Experimental site

3.5 Treatments

The following four treatments were considered for this study:

T_1 (Control) = Sugar: water (1: 1)

T_2 = Sugar: water (1: 1.10)

T_3 = Sugar: water (1: 1.20)

T_4 = Sugar: water (1: 1.30)

3.6 Preparation of sugar syrup

The sugar syrup was prepared with the mixture of sugar and water at different ratio. In a sauce pan a certain amount of sugar was taken and then desired amount of water was poured on it and heated by gas burner. After 20 minutes the sugar became dissolved into water and then the solution was poured on a bucket across a soft cotton cloth to clean it. When the solution became cold it was poured to the sugar syrup pot within the hive of the colonies.

3.7 Application of sugar syrup

Sugar syrup was applied on the feeding pot inside the selected colony. This was done is the evening, at 07 days interval.

3.8 Collection of data

Data were collected from the three selected frames of the experimental colonies to maintain the homogeneity of honey bee population. From the first data collection 07 days interval was followed for the subsequent data collection date. Data were collected on the basis of the following parameters:

Crop growth and yield contributing characters

1. Weight of bee-box (kg) at 07 days interval.
2. Number of occupied frame/box.
3. Number of partially occupied frame/box.
4. Number of egg/frame.
5. Number of larvae/frame.

6. Number of pupae/frame.
7. Number of worker bee/ frame.
8. Number of drone/ frame.

3.8.1 Space (cm^2) covered by eggs in the comb

The total space (cm^2) of the comb covered by eggs was recorded for each treatment from all the selected colonies and the mean was calculated.

3.8.2 Space (cm^2) covered by larvae in the comb

The total space (cm^2) of the comb covered by larvae was recorded for each treatment from all the selected colonies and the mean was calculated.

3.8.3 Space (cm^2) covered by pupae in the comb

In this case the total area (cm^2) of the comb covered by pupae was measured for each treatment from each of the selected colony and the mean was determined.

3.8.4 Number of worker per 4 cm^2 area

Total numbers of workers covering within a 4 cm^2 space of the frame were counted from each of the frame and the mean was recorded.

3.8.5 Number of drone per frame

Number of drone per frame was counted for each of the colony and the mean was calculated.

Plate 03: Observation of the growth and development of a colony.

Plate 04: An occupied frame with queen, worker, drone and larvae.

Plate 05: General discussion with supervisor and co-workers in experimental site.

In the experimental period, the relative area covered by eggs, larvae, pupae and pollen inside the frame of the hives was measured visually by making a plastic paper similar to the size of frame. The plastic paper was marked horizontally and vertically in centimeter distance to make a cm graph. The plastic paper was set on each side of frame to measure the percentage area covered by eggs, larvae, pupae and pollen. Weekly average mortality was also recorded. Required number of frame (occupied frame/built frame) was also recorded for every colony. Data on aforesaid parameters were collected from each hive of the experimental colonies at seven days interval during the month of August and September. Percentage of eggs, larvae, pupae and pollen present were calculated by the following formula:

$$\text{Percentage (\%) of eggs in the hive} = \frac{\text{Area covered by eggs (cm}^2\text{)}}{\text{Total occupied area (cm}^2\text{)}} \times 100$$

$$\text{Percentage (\%) of larvae in the hive} = \frac{\text{Area covered by larvae (cm}^2\text{)}}{\text{Total occupied area (cm}^2\text{)}} \times 100$$

$$\text{Percentage (\%) of pupae in the hive} = \frac{\text{Area covered by pupae (cm}^2\text{)}}{\text{Total occupied area (cm}^2\text{)}} \times 100$$

$$\text{Percentage (\%) of pollen in the hive} = \frac{\text{Area covered by pollen (cm}^2\text{)}}{\text{Total occupied area (cm}^2\text{)}} \times 100$$

Numbers of dead bees were counted daily inside the hive and in front of hive. Number of occupied/built frame was recorded weekly. Built frame were supplied on the basis of bee population to allow enough room inside the hive. Built frame were taken out when the population are not in sufficient quantity.

3.9 Statistical analysis

The data for each parameter was analyzed statistically to find out the variation among the treatments. The percent data were transformed by square root transformation. The analysis of variance for different parameters was done by using the computer based software MSTAT-C (Russell, 1986) and the mean were separated by Least Significance Difference (LSD) test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

Different ratios of sugar syrup as food source has significant effect on honey bee egg laying, larval and pupal development and pollen deposition inside the hive. The detailed results of the study on the "Effect of sugar syrup on bee health (*Apis mellifera* L.)" have been presented and discussed under the following sub-headings:

4.1 Effect of different sugar syrup as source on egg, larva, pupa, pollen deposition and number of occupied frame of *Apis mellifera* L.

Bee populations are affected by different concentration of sugar syrup as food source (Table 1). The effect of this carbohydrate substitutes on queen's ability to lay eggs was evaluated during the experimental period (Table 1). The highest percentage of egg (22.25%) was deposited in the hives treated with the sugar syrup (1:1.30) which was statistically similar to those found in hives treated with sugar syrup (1:1.20) but these were statistically differed significantly from those hives which were treated with sugar syrup (1:1.10) and control sugar syrup (1:1).

Statistically the lowest percentage of egg (5.45%) was obtained in the untreated control hives where sugar syrup at 1:1 was supplied. Significantly the highest percentage of larva (24.75%) was found in the colony treated with sugar syrup (sugar: water = 1:1.30) which was followed by sugar syrup (sugar: water = 1:1.20) (19.58%), sugar syrup (sugar: water = 1:1.10) (12.13%) and in control (sugar: water = 1:1) hives (6.97%) and they significantly differed from each other (Table 1).

Table 1: Effect of different concentration of sugar syrup as substitutes on *Apis mellifera* L. eggs, larvae, pupae, pollen and occupied frame.

Treatments	Sugar syrup at the ratio of	Egg/hive (%)	Larva/hive (%)	Pupa/hive (%)	Pollen/hive (%)	No. of occupied frame
T1 (Control)	Sugar: water (1:1)	5.45 (13.60) c	6.97 (15.09) d	7.95 (15.96) d	2.85 (9.24) c	3.00 c
T2	Sugar: water (1:1.10)	11.91 (20.99) b	12.13 (21.23) c	13.16 (22.10) c	4.50 (13.55) b	4.00 b
T3	Sugar: water (1:1.20)	18.75 (25.65) a	19.58 (26.26) b	19.58 (26.27) b	5.75 (13.86) b	4.21 b
T4	Sugar: water (1:1.30)	22.25 (27.44) a	24.75 (29.16) a	23.08 (28.02) a	8.45 (15.83) a	4.79 a
CV (%)	-	10.21	12.51	14.96	13.23	11.69
Level of significance		**	**	**	**	**

Mean followed by uncommon letters differed significantly (P<0.001) from each other by LSD. T_1 (Control) = Sugar: water (1: 1) , T_2 = Sugar: water (1: 1.10), T_3 = Sugar: water (1: 1.20), T_4 = Sugar: water (1: 1.30).

The highest percentage of pupa (23.08%) was observed in the sugar syrup (sugar: water = 1:1.30) treated hives whereas the lowest percentage of pupa (7.95%) was observed in the control (sugar: water = 1:1) hive.

Significantly the highest percentage of pollen deposition (8.45%) was evident in the hives treated with sugar syrup (sugar: water = 1:1.30) which was followed by the hives treated with sugar syrup (sugar: water = 1:1.20) (5.75%), sugar syrup (sugar: water= 1:1.10) (5.50%) and the latter two were not significantly different. The lowest percentage of pollen deposition (2.85%) was observed in the control treatment (sugar: water= 1:1) hives, (Table 1).

Significantly the highest number of occupied frame (4.79) was observed in the hive treated with sugar syrup (sugar: water = 1: 1.30) which was followed by sugar syrup (sugar: water = 1:1.20), sugar syrup (sugar: water = 1: 1.10) though the latter two were statistically similar. The lowest number of occupied frame (3.00) was recorded in the control treatment (sugar: water = 1:1) hives, (Table 1).

From these results it is evident that sugar syrup (sugar: water = 1: 1.30) provided better colony development than that of the other treatments. It is also clear that the colonies of control treatment (sugar: water = 1:1) resulted weak colonies with lower population as their occupied frame was reduced in number than those initially present. This result is similar to those obtained by Detroy *et al*. (1981) who reported that the sugar syrup is consistently the best food for containerized bees.

4.2 Weekly egg laying during the study period

The highest percentage of egg (27.5%) was laid by honey bee queen in the 5th week of treatment using sugar syrup (sugar: water = 1:1.30) (T_4) (Figure 1). Similar pattern was also observed in the hives treated with sugar syrup (sugar: water = 1:1.20) (T_3) but lower compared to other treatments.

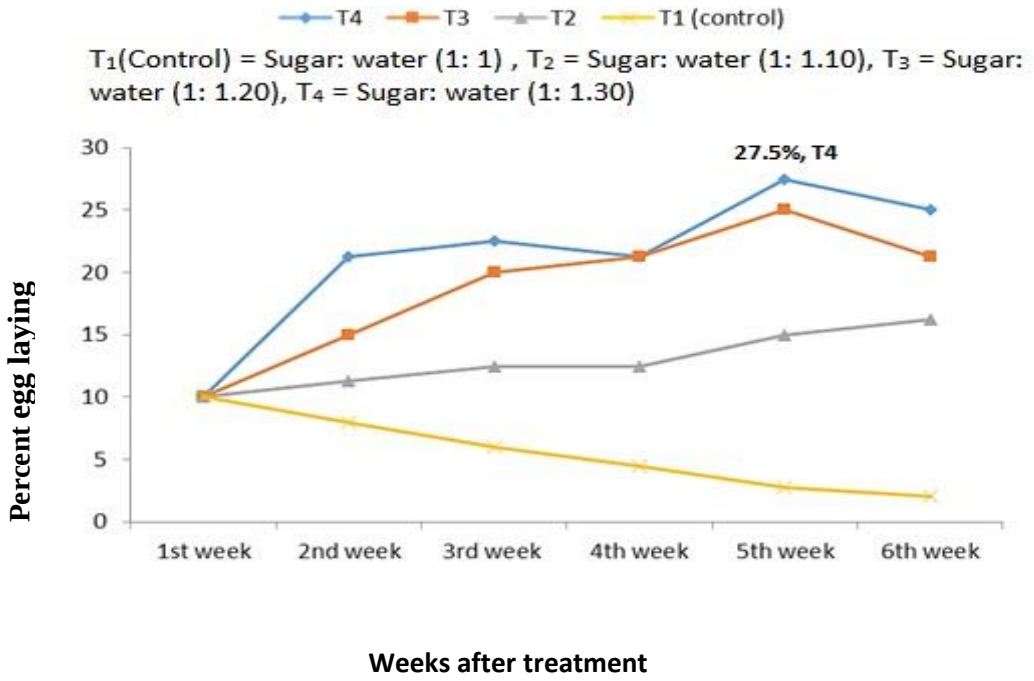

Figure 1: Weekly egg laying performance of honey bee queen feeding with different concentration of sugar syrup as carbohydrate substitutes during dearth period.

Decreasing trend of egg laying was observed in the control treatment reached at a very low level (2%) in the 6th week of the study period.

4.3 Weekly larval hatching after treatment during the study period

The highest percentage of larva (32.5%) hatched on the 5th week after applying sugar syrup (1:1.30) as substitute which was higher than any other treatments (Figure 2).

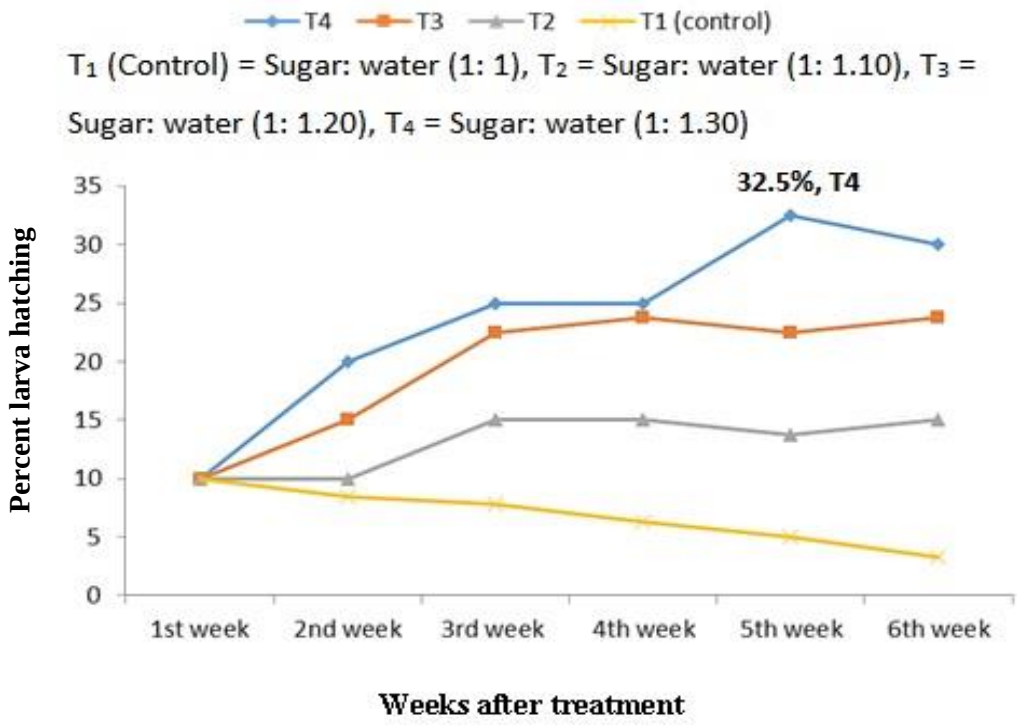

Figure 2: Weekly differences on larval percentage of honey bee feeding with different concentration of sugar syrup as supplemental carbohydrate containing foods during dearth period.

4.4 Weekly pupation after treatment during the study period

The highest percentage of pupae (31.25%) was formed on the 4th and 6th week in the hives in the treatment with sugar syrup (1:1.30) (T_4) which was higher than any other treatments (Figure 3).

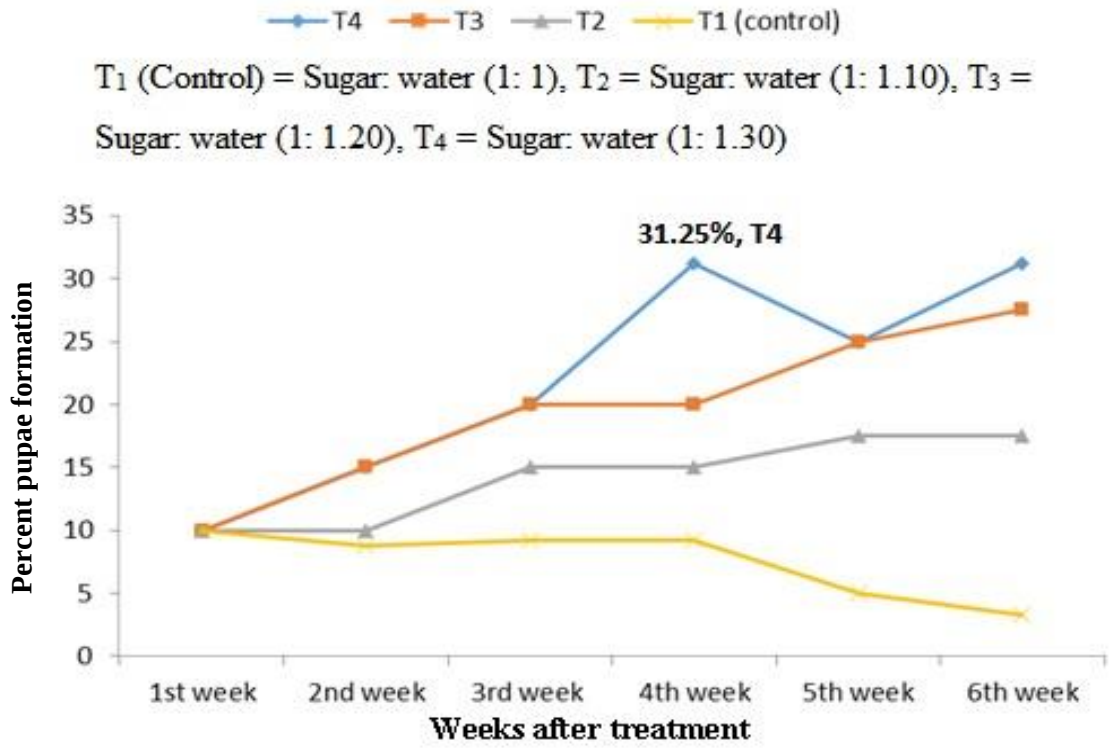

Figure 3: Weekly pupation when feeding with different concentration of sugar syrup as carbohydrate supplements during dearth period.

It is evident that alternative food supplement is required for colony brood development in terms of egg, larvae and pupae production. The brood percentage always found higher in sugar syrup treated hives. The lowest brood in the control treatment was due to food shortage and less number of bees.

4.5 Pollen deposition as influenced by concentration of sugar syrup as carbohydrate supplement

The pollen deposition by worker bees inside the hive was observed during the study period. The pollen deposition percentage was found higher in the hives treated with sugar syrup (1:1.30) (T_4) as compared to that of other treatments. The highest pollen deposition percentage (8.75%) was recorded at the end of 4th and 6th week (Figure 4).

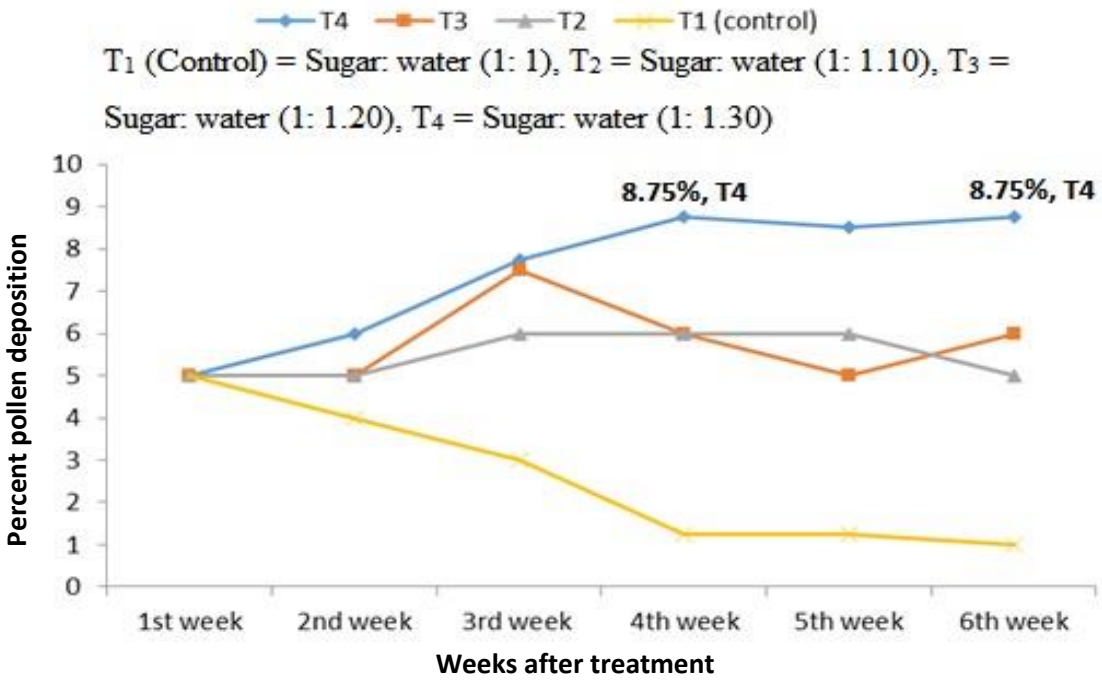

Figure 4: Weekly pollen deposition from initial deposit (5.0%) as influenced by different concentration of sugar syrup as carbohydrate supplements during the dearth period.

In the control treatment gradual decline of pollen deposition was evident up to 4th week and then remain stable in between 4th and 6th week. The lowest percent (1%) of pollen deposition was observed at the 6th week in control hives (Figure 4).

Pollen deposition percentage is affected by worker bee numbers and their good health. Hives of control had scarcity of food and, therefore, the pollen deposition percentage was lower as compared to treated hives. It is evident that sugar syrup (1:1.30) (T_4) feeding bees deposit more pollen as the hive was in good health.

4.6 Number of occupied frame during the study period

Up to second week all the treatments have similar number of occupied frame (Figure 5). On the 6th week the highest (6.0) number of occupied frame was obtained in the hives treated with sugar syrup (1:1.30) (T_4) which was higher compared to all other treatments.

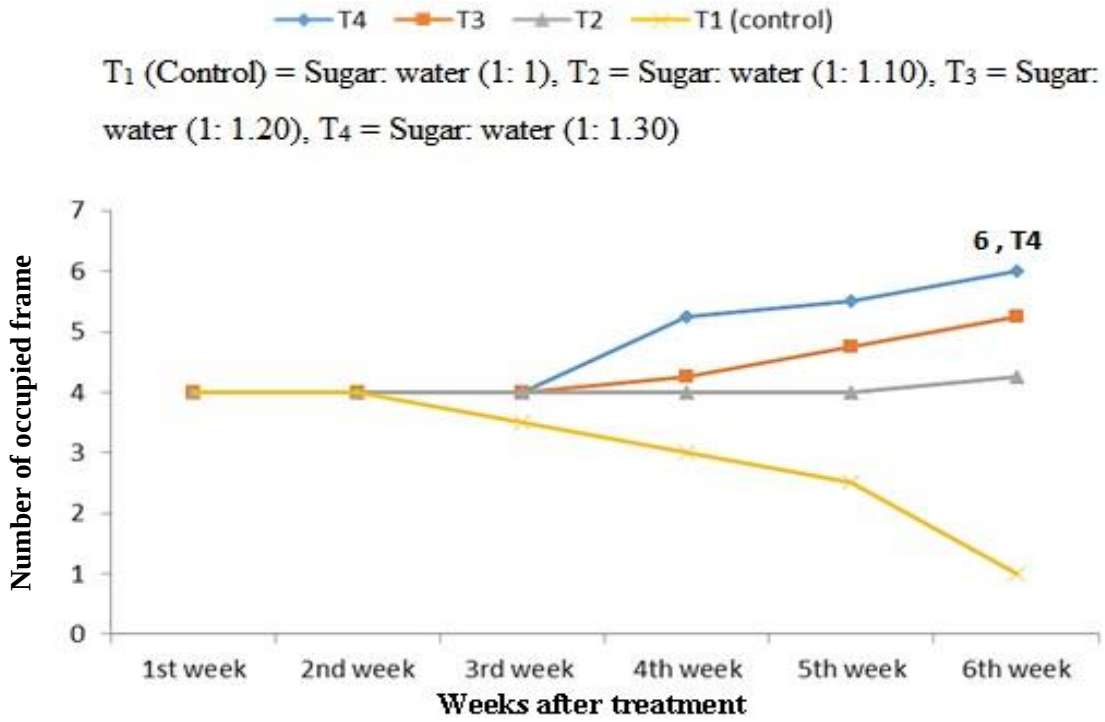

Figure 5: Weekly occupation of frame from initial number (4.0) as influenced by different concentration of sugar syrup as carbohydrate supplements during dearth period.

Frame from initial number (4.0) of all the other treatment was higher compared to that of control. On the 6th week the lowest (1.00) number of occupied frame was obtained inside the hives of control treatment. In the control hive the queen was absconded and resulted nonfunctioning of the hive.

It is evident that higher number of occupied frame means higher number of weight gain. Sugar syrup supplied healthy carbohydrate to the bees and probably had no toxic effect, and therefore, the sugar syrup treated hives showed better result than the control treatment. This finding was similar to that found by Pesante *et al*. (1992).

4.7 Mortality of bees inside the hive in different treatments during the study period

The lowest (0.21) mean mortality of bee was recorded in the hives treated with sugar syrup at the ratio of 1:1.30 compared to all other treatments including control (Figure 6).

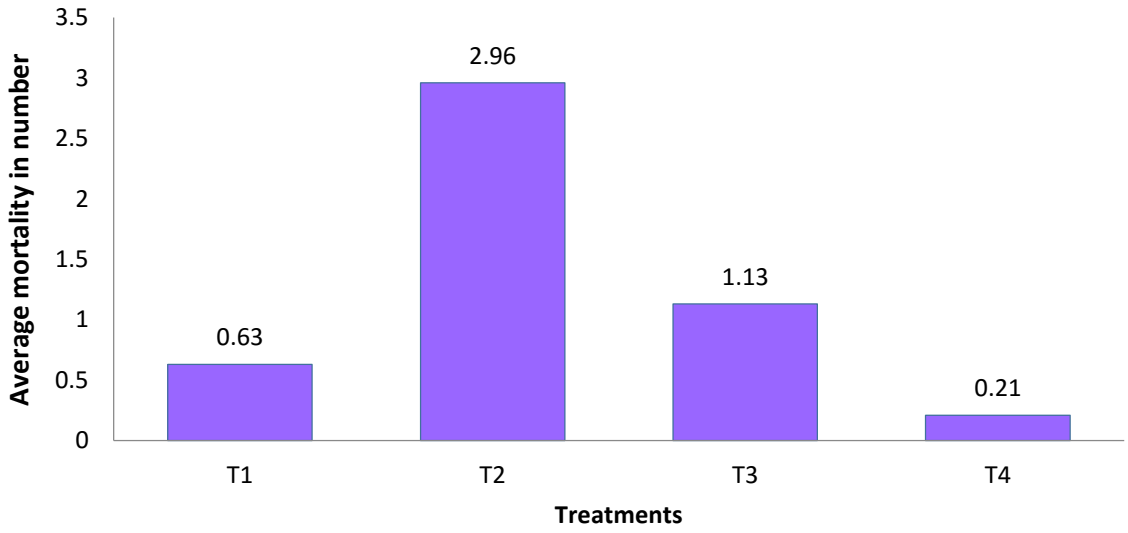

Figure 6: Average bee mortality inside the hive of honey bee treated with different concentration of sugar syrup as carbohydrate supplement during the dearth period.

In control the mean bee mortality was 0.63 which was higher than the hives treated with sugar syrup (1:1.30).

In control treatment the queen absconding was evident due to severe shortage of food which was also reported by several authors. The highest mortality (2.96) was observed in sugar syrup (1:1.10) which might be due to toxicity of the environmental condition. This result is supported by Barker and Lehner (1978) who found the highest bee survival in sucrose syrup feeding bees which is similar to the result of the present study. It may be opined that sugar syrup (1:1.30) enhances bee growth and performed the best alternative food source of carbohydrate.

CHAPTER V

SUMMARY AND CONCLUSION

The present study on the effect of different concentration of sugar syrup on bee health was undertaken in the SAU campus during August to October 2015. Four treatments consisted of four different concentration of sugar syrups viz. Sugar: water (1:1.10), Sugar: water (1:1.20), Sugar: water (1:1.30) and Sugar: water (1:1) as control. The study was replicated 6 times following RCBD, from each of the colonies three frames were selected to maintain the homogeneity of honey bee population.

On the basis of findings of study on the "Effect of sugar syrup on bee health" the following conclusions and recommendation may be made:

1. The colonies, fed with sugar syrup at the concentration of sugar: water = 1:1.30 (T_4) resulted significantly higher number of eggs, larvae and pupae as measured by the space occupied by them.

2. Similarly, statistically higher quantity of pollen and nectar are stored in colonies supplemented with sugar syrup with same concentration (sugar: water = 1:1.30) as indicated by the extended space covered by pollen and nectar.

Further study may be undertaken to find out and recommend the best concentration of sugar syrup for honey bee *Apis mellifera* L. in different situations to maintain brood rearing and colony development during dearth period.

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APPENDICES

Appendix 1: Monthly average of Temperature and Relative humidity of the experiment site during the period from August 2015 to October 2015

Year	Month	Air temperature (°C)			Relative humidity (%)		
		Maximum	Minimum	Mean	Maximum	Minimum	Mean
2015	August	34 °C	25 °C	30 °C	96%	51%	78%
	September	35 °C	24 °C	29 °C	97%	29%	77%
	October	35 °C	20 °C	28 °C	97%	32%	71%

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.