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Article

Foraging behavior and honey production of *Apismellifera* L.

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Abstract: Honeybee, *Apismellifera* L. was reared and maintained in bee box and placed in around Bangladesh Agricultural University campus in Mymensingh to study its life cycle, behaviour, pollen gathering activity, honey production and its effect on yield of mustard. There was no relationship between sunrises, sunset, first out from the box and last entrance into the box. But positive relationship was found with day temperature to first out and last entrance. The highest number of bees collected pollen in the 3rd week of March. Maximum pollen gathering activities were found at 12.00 to 1.00 p.m. The highest amount of honey production was 4.00 kg per box in mustard and there was positive correlation between percent pollen gathering activity and honey production. The highest number of queen cell was found in the month of March. The results showed that honey bee pollination had significant effect on increase in all the plant parameters and yield.

Keywords: foraging behavior; honeybee; honey production

1. Introduction

Honeybees are very important a social insect known as the most economically valuable insect because of its honey production and pollinating activities (Lawal and Banjo, 2010). Honeybee produces honey, bee wax, royal jelly, pollen, propolis and bee venom. Honey is one of the most nutritive foods containing various kinds of sugars, proteins, free amino acid, mineral, trace element, enzymes and vitamins with a fairly high caloric value (303 calories per 100g honey). It has been used as a component of many commercially manufactured pharmaceutical products. Honeybee venom is produced in several countries and is used for the treatment of rheumatoid arthritis and several other diseases. It is also used for desensitizing hypersensitive individuals (Muzaffar, 1990). The principal role of honeybee in Agriculture is pollination. These insects are of great economic importance because they not only produce honey and bee wax but also act as primary pollinating agents of many agricultural and horticultural crops. Due to pollination, done by honeybee crop yield increases, quality of seed and fruit improves and heterosis can be exploited. Beekeeping can play a vital role in sustainable agricultural development as it increases economy without changing environmental balance. As a cottage industry, it is a source of income of the rural people. Beekeeping is one of the important components of Integrated Rural Development programs (Verma, 1990). Honeybees are the main pollinators responsible for over 98% of visits to flowers of apple. They are among the most important pollinating insects found within orchards and modern agricultural systems (Williams, 1994; Morse andCalderone, 2000).There are many species of honeybee, but four species are common these are *Apis florae, Apisdorsata, Apiscerana* and *Apismellifera*. Due to domestic nature, Apis*mellifera* is the most popular worldwide and can be easily reared, and safely

migrated from one place to other for pollination and honey production. *A. mellifera* carried heavier pollen, less aggressive, and produce more honey than the native bee *A. cerana*. It is less prone to swarming for beekeepers who naturally hope to lose their colonies as rarely as possible (FAO, 1986). Like other honeybee species *A. mellifera* has a high flight range for foraging. A worker of this species may fly maximum 2-3 km away from its colony (Abrol, 1997). There is general agreement that introduction of the exotic *Apismellifera*, in Northern India, Bangladesh, Pakistan, and Thailand is now the basis of flourishing apicultural industries. This exotic bee species produces three times more honey than the native, *Apiscerana* F., and is more suited to modern bee management technology (Verma, 1990). Most of the honey in Bangladesh will come from *Apisdorsata*. In Bangladesh, *Apismellifera* was introduced in the year 1992 on experimental basis and now in many parts of the country it is gaining popularity because of its higher honey yield. The present study is to estimate the yield of honey per box in litchi and mustard.

2. Materials and Methods

Experiments on foraging behavior and honey production of *Apismellifera* and its effect on yield of mustard crop were set up in Bangladesh Agricultural University (BAU) campus and in the field of Sutiakhali and Bhabakhali village near BAU campus, Mynemsingh. The studies were carried out from November 2013 to April 2014.

2.1. Description of the experiment site

2.1.1. Location

The experiment was conducted at three different places, such as Sutiakhali and Bhabakhali in Mynemsingh, when mustard flowers were available in the field during November 2013 to January 2014 and Horticulture farm, BAU, Mynemsingh, when litchi flowers were available in the farm during February to April 2014.

2.1.2. Climate

The experiment was carried out in subtropical climate, which is characterized by temperature, high humidity and heavy precipitation with occasional gusty wind in March to April 2014 and moderately low temperature during November 2013 to April 2014. The average monthly air temperature, rainfall and relative humidity.

2.2. Equipments for observation and maintenance of the bee boxes

2.2.1. Bee box: The bee box is a wooded box of 51 cm x 41 cm x 27 cm. which is set on a stand of 30 cm height. Each bee box contains the brood chamber, the super chamber and the upper cover. The detail dimensions of a bee box are presented in Table 1.

Table 1. Dimension of the bee box.

Name of the different parts	Length (mm)	Width (mm)	Height (mm)	Thickness wood (mm)
Floor board	530	410	-	20
Chamber	470	370	230	20
Frame of chamber				
i)Top bar	490	25	-	20
ii)Side bar	230	30	-	15
iii)Bottom bar	450	15	-	15
Top cover	570	450	55	15
Entrance gate	100	20	-	-
Bee space	8	-	-	-

2.2.2. Comb foundation

The invention of comb foundation for use with movable frames marks another milestone in the history of beekeeping. Comb foundation is a thin sheet of bees wax stamped with a pattern of hexagons of size equal to the base of natural brood cell. Providing of beeswax foundation accelerates comb construction, thus making better honey harvests possible. It also leads the bees to construct comb with cells of uniform size.

2.3. Equipments for handling bees

The smoker consists of a container made of tin for blowing air into the base of the fire pot and thus smoke come out from the funnel of the smoker. It is used to drive away the bees from the comb when needed. Other equipment such as Bee veil, hand glove, bee brush, knife, and hand netare very important for the culture of bee.

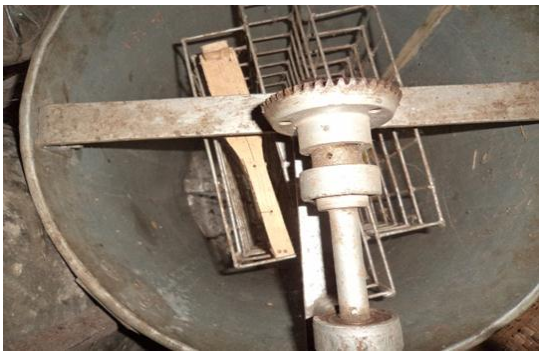

Figure 1. Honey extractor.

2.4. Feeder pot

Feeding pot is used to feed the colonies with sugar syrup as a food supplement during dearth period and to medicate them far and treatment of the diseases. The feeder pot is a rectangular container whose length and width as like as a frame. The feeder pod is placed into the box with the replacing a frame.

1.5. Honey extractor

The honey extractor is device that spins the combs so rapidly (up to 300 rpm) that the honey is extracted out of them by centrifugal force. The honey extractor makes it possible to save the comb for re-use by the bees and increase honey crop accordingly. Four-farmed extractor was used for honey extraction. The honey cell of the comb is uncapped before ripen and mature stage but the cell become capped at ripen andmature. The knife is used for removal of the cell capping from the honeycomb sealed by wax capping. After removal of comb capping the comb was placed in the honey extractor for rotation.

2.6. Other equipments

Stand, water pots, net, pots of different sizes (for preserving honey), counter (for countering honeybees) etc.

2.7. Observation of boxes

Observation of boxes was done at every 7th day interval. After every 6 days each boxes and frame were checked carefully done to remove queen cell or cells and excess drone cells. If more than one queen developed in a box they fight each other and died or swarm. Drone cell was removed when drone present more than the worker cell. Sometime larval and pupal conditions were observed in the frame and the task was continued up to the entire period of the experiment. Same time number of queen cells present per box was recorded.

2.8. Mustard yield

Pollination effect of honeybee was observed in two different fields of mustard crop in Sutiakhali village. The fields were at least three kilometer apart from each other and with same flowering condition. One bee box full with 10 frame bees were setup in the Sutiakhali field but in Bhabakhali char mustard field was without bee box. Honey was extracted from the box regularly. Four harvests were conducted from the box. When the mustard started to ripen 10 mustard plants were randomly collected from both Sutiakhali and Babakhali field. After collection of mustard plant the data on number of pod plant^{-1}, number of seed pod^{-1}, weight of seed pod^{-1} and total weight of seed plant^{-1} was recorded. And also mustard was collected in an area of 10 m^{2}from Sutiakhali and Babakhali fields: the yield was calculated in kg ha^{-1}.

2.9. Calculate honey production

The honey production of *Apismelliferaw*as studied in both mustard and litchi fields. In case of mustard, the honey yield was recorded 15th November 2013 to 15th December 2013. In case of litchi the data were recorded from 3rd March to 2nd April 2014.

2.10. Statistical analysis

The data for various parameters were analyzed statistically using MSTAT-C software for analysis of variance. The means were separated using Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

Results obtained from the present study on life cycle foraging behavior and honey production of *Apismellifera* L. and its effect on yield of mustard crop are presented below.

3.1. Behaviour of *Apismellifera* L.

The first out and last entrance of bees in the box was observed to find out the relationship with the sunrises, day temperature and sunset. There was no relationship between first out of bees and sunrises but observed positive relationship between first out and day temperature (Figure 2). When day temperature increased, bees are out from the box earlier but when day temperature low, bees were out from the box lately. There was no relationship between last entrance and sunset but positive relationship was found in the day temperature and last entrance of bees (Figure 3). When day temperature was increased bee entrance in the box delayed.

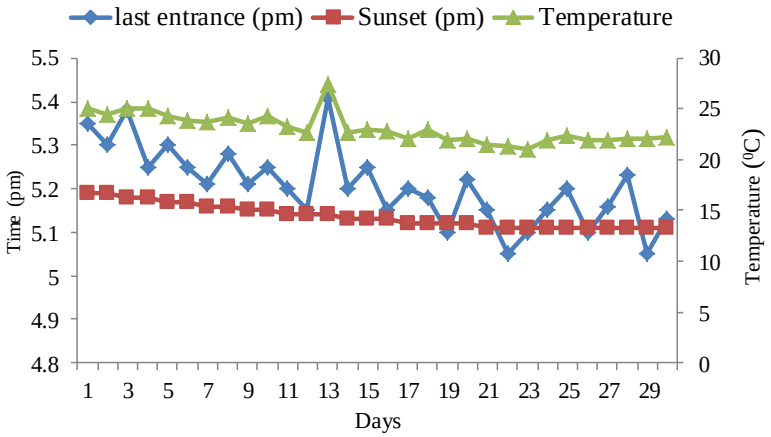

Figure 2. Relationship among first out of bees, sunrise and temperature.

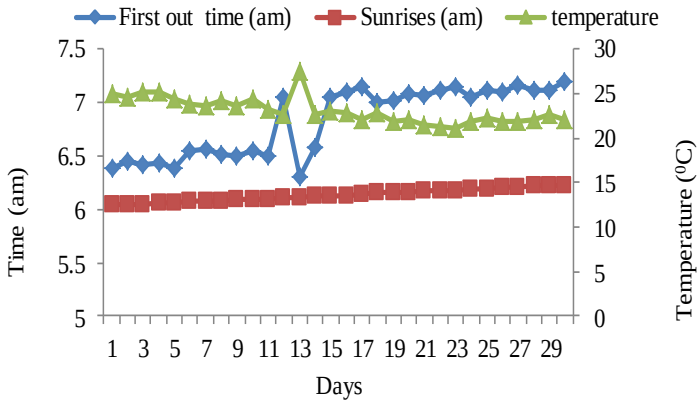

Figure 3. Relationship among last entrance of bees, sunset and temperature.

Joshi and Joshi (2010) reported that honeybee workers started activity at 6.17 a.m. but this commencement time can be greatly impacted by the region. Alqarni (2006) found that a higher number of bees workers started activity at 8 am than at 10 am under desert conditions. But Bisht and Pant (1968) stated that activity of bees is dependent upon the availability of pollen yielding flower and the environmental conditions like sunrise, sunset, and day temperature etc.

3.2. Pollen gathering activity

Honeybees gather nectar and pollen from plants as their food. Most foraging was done within one to 2 km of the hive. Every minute the bees remove pollen from their bodies with their pollen brushes and collect surplus

pollen in their baskets. Pollen gathers activity of *A. mellifera* was observed in litchi orchard three times in a day from 3 March to 2 April 2014. Number of bees with pollen and without pollen and their percentage are presented in Table 2.

The percentage of pollen carry was significantly ($p<0.05$) affected in different working hours in the month of March. The highest percentage of bees with pollen carry was found at noon (12.00 to 1.00 pm) to 1.00 pm. The lowest percentage of bees with pollen carry was found at the morning (7.00 to 8.00 am). The pollen gathering activity of bees was increased with the increase of temperature and decreased with the increased of humidity. The highest number of bees (1508) with pollen was recorded at 12.00 to 1.00 pm. The lowest number of bees (44.00) with pollen was recorded at the time of 7.00 to 8.00 a.m.

Many authors reported foraging activities of honeybees during the morning hours. Ibrahim and Selim (1992) found that foraging activity was the greatest in the morning between 08:00 to 10:00. Murrell and Nash (1981) observed that maximum number of foragers was found at the time of 10:30 a.m. Rashad (1975) reported that high relative humidity decreased pollen collection. Praagh *et al*. (1987) revealed that pollen collection at 85% RH remained fairly stable, but it declined to a low level at 65% RH, when both the number of foragers and the collecting efficiency of each bee decrease. Hossain (1992) recorded that there was a significant negative correlation between relative humidity and foraging and pollen collection activity Oh and Woo (1990) reported maximum level of activity at 13:00 h. Mamood *et al.* (1996) observed honeybees foraging on the flowers most actively between 10.00 to 11.00 am.

Pollen gathering activities of honeybees are dependent upon the availability of pollen yielding flowers and the environmental condition like sunrise, sunset, day temperature and humidity. In the litchi seasongreatest pollen gathering activities were found in the 3rd week of March because at that time all litchi flowers were blooming in the litchi orchard. In the 1st and 4th week of March pollen gathering was lowest because all litchi flowers were not blooming. In the 4th week of March pollen gathering activities were lowest.

Bisht and Pant (1968) stated that pollen-gathering activity is dependent upon the availability of pollen yielding flower and the environmental conditions like sunrise, sunset, day temperature and humidity.

Table 2. Pollen gathering activity of *Apismellifera* L. on litchi from 3 March 2014 to 2 April 2014.

Week	No. of bees with pollen			No. of bees without pollen			Percentage of pollen carry		
	7.00-8.00 am	**12.00-1.00 pm**	**5.00-6.00 pm**	**7.00-8.00 am**	**12.00-1.00 pm**	**5.00-6.00 pm**	**7.00-8.00 am**	**12.00-1.00 pm**	**5.00-6.00 pm**
1st	132.29	1085.43c	204.14	503.29	991.57	433.57	21.22c	52.40c	31.02d
2nd	252.00	1149.71b	282.29	681.57	1013.14	449.14	25.61b	53.76b	33.98b
3rd	153.14	1353.43a	208.57	428.57	1049.71	409.14	27.01a	56.43a	35.26a
4th	44.00	1091.14c	275.57	196.86	1012.29	473.43	18.10d	51.98	32.09c
SE±	28.99	36.82	22.63	77.85	27.09	21.59	1.19	0.61d	1.89
LSD	87.31	105.66	73.45	241.65	90.94	71.80	3.41	1.77	6.33
Level of sig.	NS	*	NS	NS	NS	NS	*	*	*

*= 5%level of significant
NS = Non Significant

3.3. Honey production by *Apismellifera* L.

Honey production was significantly ($p<0.01$) influenced by different time of harvesting (Table 3).Highest amount of honey production was found in 1st weekof December 2013 (4.00 kg per box) in mustard crop. The lowest amount of honey was harvested in 4th week of November followed2ndweek of December and 3rd week of November 2013 (3.30 kg per box). For litchi the highest amount of honey in the box was 3.8 kg per box was harvested in 3rd week of March and the lowest amount of honey 3 kg per box was recorded in the 1st and 4th week of March (Figure 4). Higher amount of honey is harvested in mustard season than litchiseason.

In this study the highest quantity of honey harvested in 4 colonies was 13.88 kg in mustard and 13.1 kg in litchi. Chaudhary (1997) extracted 80 kg of honey from 10 colonies during the first 15 days of the honey flow season. Chaudhary (2000) conducted an experiment on the performance and prospects of *Apismellifera* in southwestern Haryana, India. He extracted an average of 18.5 kg honey per colony during February-March from rape seeds. Zhen-Ming *et al*., (1990) found that the European honeybee, *Apismellifera* was the most important species in Chinese agriculture. In European honeybees, the honey output of each colony is 30 kg/year and the highest can

be as much as 150-200 kg. Verma (1990) reported that the, *Apismellifera* introduced by Friz Maurer in 1980 in Bhutan and he (Maurer) obtained an average honey yield of 30 kg/colony/year.
The relationship between percent of pollen carrying bees and honey production is shown in Figure4.The result showed highly positive relationship between percentage of pollen carrying and honey production (r = 0.8925). Generally honeybees collected pollen with their legs and nectar in their mouth so, high percentage of pollen carrying indicate higher amount of nectarcollection.

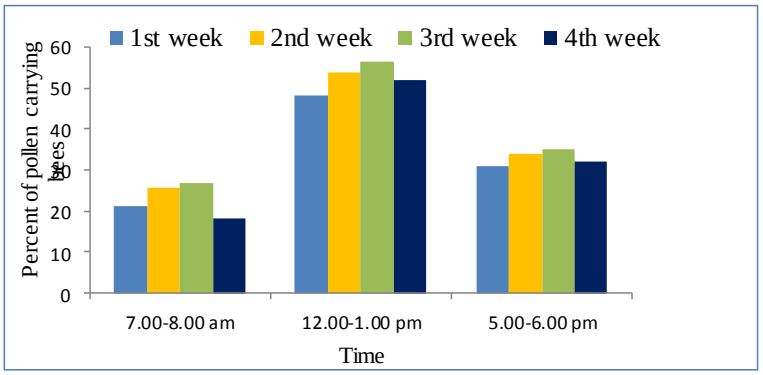

Figure 4. Percentage pollen carrying bees in different time of four weeks of the month of March 2014.

Table 3. Yield of honey in mustard and litchi.

Harvest	Mustard		Litchi	
	Period of harvest	**Yield of honey per box (kg)**	**Period of harvest**	**Yield of honey per box (kg)**
1	3rd week of November	3.30b	1st week of March	3.00b
2	4th week of November	3.50ab	2nd week of March	3.30ab
3	1st week of December	4.00a	3rd week of March	3.80a
4	2nd week of December	3.30b	4th week of March	3.00b
SE±		0.028		0.025
LSD		0.35		0.18
Level of sig.		**		**

** = 1% level of significant

3.4. Queen cell formation during November 2013 to April 2014

Queen cell looks like the shell of a peanut (Figure 5). The number of queen cell was lowest when the bee colony was weak and pollen and nectar source declined. The highest number of queen cell was formed due to increased feeding of pollen and nectar source. Those queen cells remove for maintenance of bee box. But queen cell were not removed for colony multiplication. During the study period number of queen cell formation was significantly ($p<0.01$) different (Table 4). The highest number of queen cell was found in the month of March (25.5). The lowest number of queen cell was found in the month of November (2.25) which was statistically similar to that found at the month of December (3.25), January (3.50) and February (3.50). It may be due to increase of pollen and nectar source of the colony. Queen cell was used for colony multiplication.

Figure 5. Queen cell formation

Table 4. Average number of queen cell formed per box in different month (November 2013 to April 2014).

Months	**Average no. of queen cell formed per box**
November	2.250c
December	3.250c
January	3.500c
February	3.500c
March	25.500a
April	10.750b
CV (%)	18.479
LSD	2.266
level of significanc	**

** = 1%level of significant

4. Conclusions

Honeybee, *Apismellifera* L. was reared and maintained in bee box and placed in around Bangladesh Agricultural University campus in Mymensingh to study its behavior, pollen gathering activity, honey production and its effect on yield of mustard. There was no relationship between first out of bees and sunrises but it was observed positive relationship between first out and day temperature. When day temperature increased bees were out from the box earlier but when day temperature low bees were out from the box lately. When day temperature increased, bee entrance in the box was delayed. The highest percentage of pollen carrying activity was recorded at the time of 12.00 to 1.00 p.m. The lowest pollen gathering activity was recorded at the time of 7.00 to 8.00 a.m. In 1st and 4th week of March pollen gathering activities were lowest. Highest amount of honey production was found in 1st week of December 2013 (4.00 kg box^{-1}) in mustard crop. The lowest amount of honey was harvested in the 2nd week of December and 3rd week of November, 2013 (3.30 kg per box). The highest number of queen cell was found in the month of March 2014 (25.5) because maximum amount of pollen and nectar were found at that time. The lowest number (2.25) of queen cell was found in the month of November. The yield of mustard in bee box setted and without bee box setted field were calculated 1450 kg per ha and 1150 kg per ha respectively.

Conflict of interest

None to declare.

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