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Short Communication

Pollen Collection and Pollen Foraging Behaviour of Honeybees (*Apis mellifera*) during Different Time Intervals from *Brassica campestris* L.

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ABSTRACT

The pollen collection by honeybees (*Apis mellifera* Linguistica) from *Brassica campestris* was examined during February - March 2015 at National Agricultural Research Centre, Islamabad. Twenty five honeybee colonies were used which had similar number of worker bees, brood and stored food. In order to study the foraging activity of honeybees in the field condition, the number of pollen foragers returning to the hive entrance was recorded for 10 min duration on hourly basis between 0800 h to 1600 h for 3 days per week. The data was collected at 0800–1000 hours (early morning foraging activity), 1000-1200 hours (late morning foraging activity), 1200-1400 hours (Noon foraging activity) and 1400-1600 hours (afternoon foraging activity). The pollen collected in the pollen trap trays at regular intervals for a period of one month using pollen traps fitted at the entrance of the hives and left for a period of 8 h. The pollen loads were weighed fresh and preserved in the compact/ air tight containers in the refrigerator. Our results showed maximum foraging ratio (59.88 ± 2.89) and pollen collection (145.8±8.79) during 1000-1200 hours followed by the duration of 1200-1400 hours when foraging ratio was 58.24 ± 3.03 and pollen collection was 134.4±5.49 and during 0800 – 1000 hours when foraging ratio was 48.36 ± 2.84 and pollen collection was 121.8±6.73, whereas, the lowest values were found during 1400-1600 hours when foraging ratio was 44.36 ± 3.36 and pollen collection was 117±3.77. It can be concluded that best time for pollen collection and foraging time for honeybee was 100-1200 hours.

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Authors' Contributions
RM was the main investigator, he designed the study, collected data and wrote the manuscript. SA compiled and analyzed data; GS and WA collected data and conducted the research and ZAQ and AB were co-researcher and helped in all activities. MKR provided guideline in collecting data.

Key words
Pollen, *Apis mellifera, Brassica campestris*, Foraging behavior, Collection time.

More or less 67% of all worlds' flora relies on bees for pollination. Besides that, bees also collect pollens, nectar and water to feed their larvae and adults, which cater for all nutritional requirements for their development and growth (Darclet and Silva, 2011; Funari *et al*., 2003). Pollen is the core source of protein which is important for brood rearing and the glandular development of young worker bees. The nurse honeybees utilize pollen, and then their hypopharyngeal glands help in secreting food for the brood. As a result, the pollen requirement in a honeybee colony is synchronized with regards to the amount of brood (Jeffrey and Allen, 1957; Claudia and Tarpy, 2000; Samantha *et al*., 2005). The honeybees visit a wide variety of plants for collecting pollen, so the chemical composition and nutritional value may differ in relation to the source. Every year, an average honeybee colony utilizes almost 40-60 kg of pollen. In the meantime of first 5-6 days of adulthood, the worker bees eat up large amount of pollen for fulfilling the protein and amino acids requirement that must ensure their full grooming and development (Fábia *et al*., 2006).

The pollen foraging shows a collective approach by honeybees belonging to a colony which organize and carefully regulate it with the passage of time. The comparative amounts of larval brood and stored pollen in the hive closely correlated with the pollen requirement of a honeybee colony (Claudia and Tarpy, 2000; Anja and Tautz, 2002). Muhammad *et al*. (2016) found that intercrop, diversity and average number of visiting pollinators contributed positively to the fruit weight and fruit quality.

The honeybees fill their crop with some quantity of honey before leaving the hive for foraging, which serves as a 'fuel' determined by the distance to the food source and foraging experience. It is experienced that the bees carry some additional amount of honey as 'glue' to build pollen masses (Ken-ichi *et al*., 2014).

The worker bees collect pollen by visiting flowers and

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take it back to the colony jam-packed in balls on the pollen basket of the hind legs. These pollen balls are scraped from the bee's legs and collected in the tray by installing a pollen trap at the entrance of the hive. A variety of pollen traps have been developed which may vary considerably in design and the position on hive, but the basic principle remains the same i.e. a mesh to take away the pollen from the bees and a tray to pull them together (Doug, 2000; Shazia *et al*., 2010). The fraction of pollen retained in any type of the pollen trap may be quite unpredictable. However, it was found that the average efficiency of these traps increased when the hives attached to them were transported to a location having different available flora (Levin and Looper, 1984).

In the tropical and sub-tropical regions where blooming of bee flora is in a permanent state, honeybees continuously collect nectar and pollen through the year. On the other hand, the search of pollen by honeybees is greatly affected by the prevailing weather situation and accessibility of pollen. Summers and rainy seasons are very insensitive for bees in tropical and sub-tropical region. Usually, no bee flora is available since June to September (Mishra and Sharma, 1997; Neupane and Thapa, 2005).

The flight activity of honey bees is greatly subjective to the weather and flow conditions along with the strength of colony and the number of foraging bees. Weather conditions usually depend on the wind intensity, air temperature and wind force. The situation of flow relies on diurnal flowering pattern, nectar and the pollen output alongside the combination of these aspects (Kapyla, 1974; Wilde *et al*., 2003).

Domagala-Lipinska (1962) and Grabowski *et al*. (2000) have shown that honeybees' flight is more efficient in the morning hours, reaching its peak by the noon and then declining by the afternoon. The number of bee foragers actively working on pollen or nectar may differ with respect to the food requirement of honeybee colony. Among the foraging bees, 60% collect nectar, 25% gather pollen and 15% bring together both substances (Wilde *et al*., 2003). Therefore, the endurance and development of the entire honeybee colony depends on the efficient foraging capacity of the worker bees (Cook *et al*., 2005). Nighat *et al*. (2000) monitored the insecticidal mortality, foraging behavior and pollination role of honeybee (*Apis mellifera* L.) in sarson, *Brassica campestris* L.

However despite the significance of pollen, little is known about the active foraging time of honeybees in Pakistan that during what time interval of the day honeybees do active foraging and in particular, collect more pollen. The present study was aimed to determine the foraging ability of the honeybees to collect the pollen during different day times.

Materials and methods

The experiment was conducted in the *Brassica* crop grown at National Agricultural Research Centre, Islamabad during March 2015. Twenty five honeybee (*Apis mellifera*) colonies, all equalized to have similar number of worker bees, brood combs and stored food (*i.e.* honey) were transported to the experimental site on the onset of flowering and kept there for 2 months over the period of the experiment. The experimental area had a natural water source nearby, enough for fulfilling the water requirement of the apiary.

In order to study the pollen collection and foraging activity of honeybees, the pollen traps were installed at the entrance of each hive. The number of pollen foragers returning to the hive entrance was recorded for 10 min duration on hourly basis between 0800 – 1000 hours (early morning foraging activity), 1000-1200 hours (late morning foraging activity), 1200-1400 hours (early noon foraging activity) and 1400-1600 hours (afternoon foraging activity).

The observations included three steps *i.e.* installing pollen traps at the entrance of the hive, recording number of pollen carrier bees returning to the hive, calculating quantity of bee pollen collected in the pollen trap trays and weighing the total weight of bee pollen collected by each hive. These observations were recorded in the experimental site under good weather conditions for foraging bees: temperature ≥ 15°C, low wind, no rain, and dry vegetation as followed by Cartin *et al*., (2008). Foraging efficiency of a honeybee colony was calculated in terms of number of bees with pollen load entering the hives were counted for a specific period during the four time intervals. The pollen collected in the trays were collected at regular intervals for a period of one month using pollen traps fitted at the entrance of the hives and left for a period of 8 hours. The pollen loads were weighed fresh by using standard electronic scale and preserved in the compact / air tight containers in the refrigerator. Collected pollen were cleaned and preserved separately for each duration of time. The pollen foraging ratio (PFR) was calculated according to Wilde *et al*. (2003) as:

$$\text{PFR} = \frac{\text{Pollen foragers}}{\text{100 total foragers}}$$

The comparison of pollen collected in traps by several honeybee colonies placed at one location were found less problematical as they were carried out using the same trap type and identical experimental procedures.

Furthermore, the pollen influx into the honeybee colonies at the apiary was calculated by computing the 'r' value, the mean rate of pollen harvested by the pollen traps on the colonies: (O'Neal and Waller, 1984). The influx is calculated by computing the pollen harvest from pollen traps.

$$r = \frac{\text{Total amount of pollen collected}}{\text{No. of colonies X No. of days}}$$

The data was subjected to statistical analysis using Analysis of variance (ANOVA). The differences of means were tested for significance using the Duncan test.

Results and discussion

Foraging bees can be classified as bees which move out of the hive and perform different foraging activities such as nectar, pollen, water and resin collection (Maria and Thrasyvoulou, 2007). Table I shows the starting and ending of *Apis mellifera* foraging time. The mean timing of all the four groups differed significantly with each other. The highest foraging ratio was observed during the time between 1000-1200 hours showing the mean value 59.88 ± 2.89 followed by 1200-1400 hours showing the mean value 58.24±3.03. The starting and ending time periods *i.e.* 0800-1000 and 1400-1600 hours showed lower mean values of 48.36±2.84 and 44.36±3.36, respectively. Similarly the pollen collected through pollen traps during different time periods was in correlation with the foraging ratio *i.e.* the highest pollen was collected during 1000-12000 hours showing mean value 145.8±8.79 followed by the mean value 134.4±5.49 for the hours 1200-0200. The pollen collection during the hours from 0800-1000 were significantly low showing mean value of 121.8±6.73 followed by the least pollen collected during the timings between 1400-1600 which showed mean values of 117±3.77. Thus the best foraging time and peak activity for foraging bees was 1000-1200 hours followed by 0200-0400 hours (Table I).

Table I.- Pollen collection and pollen foraging ratio during different time intervals.

Group number	Pollen collection (Mean ± SE)	Pollen Foraging Ratio (Mean ± SE)
I (0800-1000 hours)	121.8±6.73	48.36 ± 2.84
II (1000-1200 hours)	145.8±8.79	59.88 ± 2.89
III (1200-1400 hours)	134.4±5.49	58.24 ± 3.03
IV (1400-1600 hours)	117±3.77	44.36 ± 3.36

These results are in agreement with earlier results of Stephen and Currie (2001) showing maximum foraging rate during the afternoon period than the morning period depicting values of 36.02 foragers/min and 17.66 foragers/min, respectively. Similarly these results are in confirmation with the observations that foraging bees visited onion flowers between the periods from 0815 to 1630 hours with 1100 to 1200 hours was the peak foraging time (Banu and Duman, 2005). Hari *et al.* (1994) reported maximum foraging activity of *A. mellifera* on *Brassica juncea* during 1300 hours. The findings are also in accordance with Domagala-Lipinska (1962) and Grabowski *et al.* (2000) that foraging rate starts increasing early in the morning, reaches its peak in the midday and later on declines in the afternoon. It can be concluded that best time for pollen collection and foraging time for honeybee is 1000-1200 hours.

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Conflict of interest statement

We declare that we have no conflict of interest.

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