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Foraging Behavior of *Apis mellifera* and *Apis dorsata* on Onion (*Allium cepa* L.) Flower

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Abstract
Investigations were carried out at the Raninagar village of Chakdaha block in Nadia district of West Bengal during 2015-16 to study the foraging behavior of *A. mellifera* and *A. dorsata*in Onion (*Allium cepa)* crop. It was found that Foraging activity of *A. mellifera* started much earlier than *A. dorsata* and the peak activity was reached by 11am as against 1pm in the latter during February. *A. dorsata* visited more number of umbels but fewer numbers of florets per min than *A. mellifera*. Pollination had no impact on number of umbels produced/plant.

Keywords: Apis mellifera, Apis dorsata, Onion

Introduction
Onion (*Allium cepa* L.) is an extremely important vegetable crop. A global review of major vegetables shows that onion ranks second after tomato in area. Approximately, 36 million tons of onions are produced on 2-5 million ha globally. India is the 2nd largest producer of onion in the world next only to China, with 19.90% share in world total production, but the productivity of onion in India is very low, i.e., 16.29 tones/ha as compared to China and other countries like Egypt, Netherlands, and Iran etc. In India 187.36 lakh MT onion is produced over 11.50 lakh ha area (Anon., 2015). The major onion producing states of India are Maharashtra, Gujarat, Orissa, Karnataka, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Bihar, Punjab and Rajasthan, with Maharashtra as the leading onion producing state contributing 33%, followed by Karnataka 17% and Gujarat with 10% of onion production of India.
According to Banik, (1990), the pollination activity of wind has little effect (10%) on onion pollination because of its sticky pollen, other pollinators were 3% and honey bees were 87% in onion pollination. Honeybees are primary pollinators for the majority of the world's angiosperms (Ollerton *et al*., 2012), pollinating one or more cultivars of 66% of the world's 1500 crop species which is accounting for 15-30% of food production. About 80% of crop insect pollination is accomplished by honeybees (Singh and Singh, 2008).Without this service, many interconnected species and processes functioning within both wild and agricultural ecosystems could collapse (Kearns *et al*., 1998). The hind legs of honeybees are modified into a structure called the corbicula (also known as the "pollen basket") where the pollen grains are collected from flowers. The European or western honey bee *Apis mellifera* L. (Hymenoptera: Apidae) is the most commonly managed pollinator worldwide. Bees stand out as the dominant pollinating group in different geographical regions (Kearns, 1992) and India has vast potential for Beekeeping. At present there are about 1.5 million bee colonies in India and the diversity in flora and fauna provides more opportunities for the development of beekeeping industry. Therefore, the National Commission on Agriculture had visualized the need for deploying about 150 million bee colonies for pollinating the agricultural crops in the country.
As of now, honeybees have proved to be effective pollinators of a variety of crops including horticultural crops, oilseeds, forage crops, fibre crops and cereal crops. The potential benefits, due to bee pollination, in the form of increase in yield vary from 2 % to 33150 %. Studies reveal that the income generated through enhancement in crop yield is much more than the income generated from honey production.Keeping this view in mind, the present investigation has been aimed at finding out the foraging efficiency and the rate of work done by honeybees (*A. mellifera* and *A. dorsata*) in onion.

Methodology
Field experiments were conducted at Raninagar, village Chakdaha, district Nadia (West Bengal), to study foraging behavior and efficiency of two important honey bee pollinators Namely, *Apis dorsata* and A. mellifera workers on onion flowers under field condition during February, 2016.

The diurnal activity/ circadian cycle of the foraging workers were studied throughout the day. For this, the number of foraging bees of both the species present per square meter area was recorded at 2 hourly intervals starting from 7.00 AM to 5.00 PM.

In addition, the rate of work of the foragers was also studied by recording the, number of umbels and flowers visited per forager per minute. Comparison of foraging efficiency of the two honey bee species was done through 't' test.

Result and Discussion

The foraging activity of two most pre-dominant pollinators i.e., *A. mellifera* and *A. dorsata* were studied during the blooming period of onion. For this observations were taken on various aspects namely, number of flowers and number of umbels visited per min and the diurnal activity of these two species studying from 7am- 5am.

Diurnal activity of the pollinators *(Apis mellifera* and *Apis dorsata)*

Only a few *A. mellifera* workers (0.06/m^2) were found to visit onion flower at 7am. The number of *A. mellifera* workers present per square meter area increases sharply at 9am (0.40/m^2) which further increased and reached its peak (0.60/m^2) at 11am. After that, the no. of pollinators decreased a bit. The foraging activity declined somewhat from 1pm onwards and the number of *A. mellifera* workers present / sq.m were 0.50 and 0.46 respectively at 1pm and 3pm. At 5pm however the no. *of A. mellifera* workers /m^2 decreased further to 0.33/m^2 but foraging activity continued even beyond that. On the contrary, no *Apis dorsata* workers were recorded in the field at 7am. This species started foraging before 9am when only 0.13 workers were recorded per square meter. Foraging activity gradually increased and reached its peak at 1pm when 0.86 workers were recorded /square meter. High foraging activity was recorded up to 3pm (0.73workers/m^2) which gradually declined to 0.40 workers/m^2 at 5pm.

Table 1: Diurnal data for population of honeybee sp./sq.m

Time Honey bee sp.	7am	9am	11am	1pm	3pm	5pm	Total	Avg.
Apis dorsata	0.00	0.13	0.70	0.86	0.76	0.40	2.85	0.48
Apis mellifera	0.06	0.40	0.60	0.50	0.46	0.33	2.35	0.39

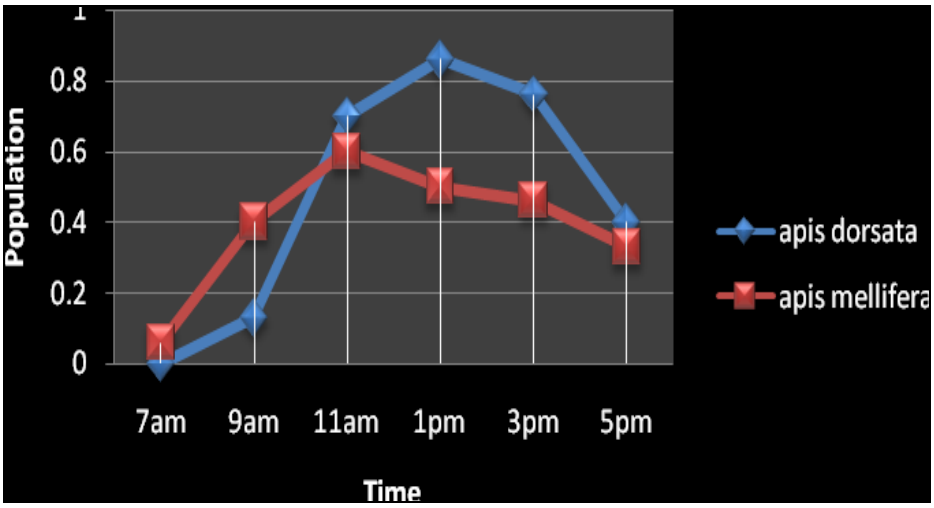

Fig 1: Diurnal data for population of honeybee sp./ sq.m

The above data clearly shows that foraging activity of *A. mellifera* starts much earlier than *A. dorsata*. In *A. mellifera* peak activity is also attained much earlier this was 11am in month of February 2016.

In proximity to present findings, Chandel*et al.* (2004), recorded that *A. dorsata* proved to be the dominant visitor (7.4 bees/m^2/min) and most efficient pollinator covering on an average 7.5 flowers per umbel per visit during peak hours of their foraging activity (12.00-14.00 h).

In an another finding, Mupade *et al.* (2009), observed that the honey bees started visiting the crop at 8.00 h, population was high during 13.00-16.00 h and declined slowly during 16.00-18.00 h. In case of open pollination, intensity of *Apis dorsata* significantly reached at its peak between 12-14 h. The intensity of *A. dorsata* was more between 12-14 h (2.66 bees/min).

Rate of work done (No. of umbels and flowers visited per min) by *Apis mellifera* and *A. dorsata*

In present investigation, the rate of visiting umbels/min. in *A. mellifera* was found to be maximum (3 umbels /min) at 11am and minimum (0.26) at 7am, whereas in case of *A. dorsata* it was maximum (2.86) at 1 am, minimum (1.33) at 9am and absent at 7am.

The comparative observation of foraging behavior of the two species regarding no. of umbels visited/min was found to be more for *A. dorsata* (1.78 umbels/min) than *A. mellifera* (1.67 umbels/min).

Table 2: Diurnal data for no. of umbels visited /min./bee

Time Honey bee sp.	7am	9am	11am	1pm	3pm	5pm	Total	Avg.
Apis dorsata	0.00	1.33	2.46	2.86	2.4	1.66	10.71	1.78
Apis mellifera	0.26	2.4	3	1.6	1.8	0.93	9.99	1.66

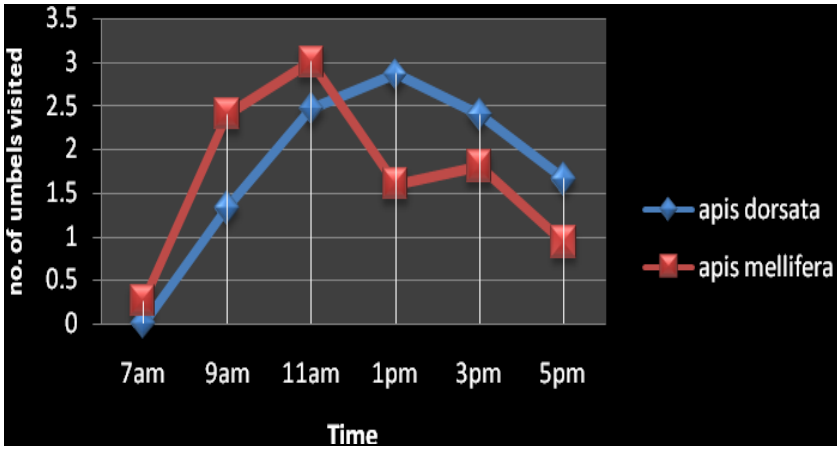

Fig 2: Diurnal data for no. of umbels visited /min./bee

In support of above finding it was found that Chandel *et al. (*2004), also observed *A. dorsata* had the maximum foraging period (06.30-18.55 h) and *A. mellifera* had the least foraging period (07.25-18.20 h) on onion seed crop.

Similarly, the rate of visiting onion flowers per minute by honeybee species was found to be maximum (15.40 flowers/min) during 9am and minimum (0.93/min) at 7am for *A. mellifera*, whereas for *A. dorsata* it was maximum (11.46/min) during 3pm and minimum (5.26/min) at 9am and it was totally absent around 7 am. Further, the comparison in behavior and rate of visiting onion flowers by the two species shows that *A. mellifera* visits more no. of flowers (8.85flowers/min) than *A. dorsata* visiting 7.60 flowers/min.

Table 3: Diurnal data for no. of flowers visited /min./bee

Time Honey bee sp.	7am	9am	11am	1pm	3pm	5pm	Total	Avg.
Apis dorsata	0	5.26	10.86	9.46	11.46	8.53	45.57	7.60
Apis mellifera	0.93	15.4	14.13	7.06	11.4	4.2	53.12	8.85

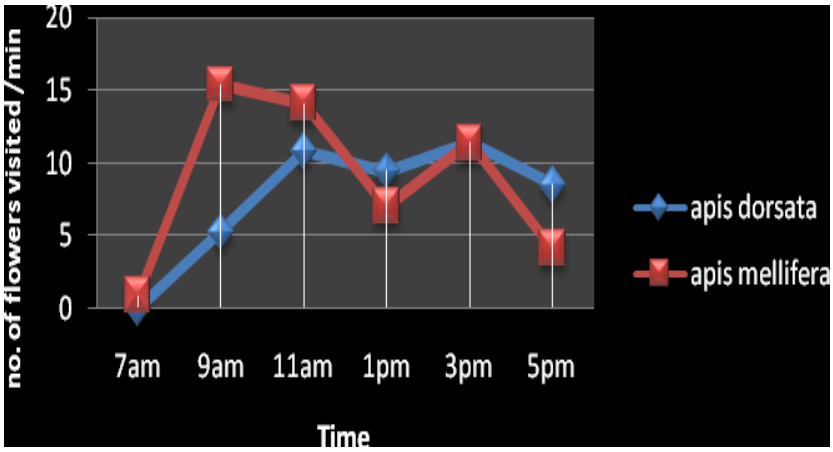

Fig 3: Diurnal data for no. of flowers visited /min./bee

The foraging behavior of the two honey bee species was found to increase during morning hours till it reaches its peak, then it falls slightly a bit and increases again during evening hours and then gradually decreased further but foraging activity continued even beyond that. Oh and Woo (1990), noticed that the insect activity increases sharply after sunshine, decreases gradually through the day and ceases before sunset. Sharma *et al.* (2001), observed the foraging behavior of *Apis spp.* on the flowers of *Allium* and found that *A. mellifera* spent least time (1.64, 8.58 and 128.47 sec.) per flower/head and tripped highest number of flowers/head (15.2, 8.2 and 1.2) per minute or 5 min followed by *A. dorsata* who spent 2.18, 2.48, 11.46 and 186.73 sec. per flower and visited 12.0, 3.7 and 1.5 flowers/head per minute. Yucel and Duman (2005), observed that Honeybee workers foraged on onion plants from 8.15 to 16.30 h with peak foraging activity between 11.00 and 12.00 h. At 09.00, 12.00 and 15.00 h, respectively, workers averaged visited 8.0, 13.0 and 4.0 flowers per minute. Georges *et al.* (2014), studied and evaluated that honey bee intensely and preferably foraged for nectar, almost throughout the day, with a peak between 8 and 9 am. The foraging speed was 47.12 ± 7.19 flowers per minute. *A. m. adansonii* was the most frequent with 40.62% and 51.48% of visits in 2010 and 2011 respectively.

Summary and Conclusion

The foraging activity of *A. mellifera* was found to start much earlier than *A. dorsata*. Peak activity in *A. mellifera* was attained at 11am i.e., much earlier as against 1pm in *A. dorsata*. The umbels visited/min was found to be more for *A. dorsata* (1.78 umbels/min) than *A. mellifera* (1.67 umbels/min). Similarily, *A. dorsata* visited fewer numbers of florets (7.60florets/min) than *A. mellifera* (8.85florets/min). It was also found that Pollination had no impact on number of umbels produced/plant.

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