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ABUNDANCE AND VISITATION RATE OF APIS POLLINATORS ON FLOWERS OF SOME MULTIPURPOSE TREE SPECIES GROWN IN MUZAFFARPUR, BIHAR, INDIA

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ABSTRACT

We investigated abundance and visitation rate of four honey bee (*Apis*) species on flowers of *Litchi chinensis*, *Mangifera indica*, *Phyllanthus emblica* and *Psidium guajava*, commonly grown in Muzaffarpur district (Bihar state, India). This observation revealed that the maximum flowers were visited during morning hours than those of the afternoon and evening hours. The temperature and humidity are likely to be the important factors which affect the abundance and visitation rate of honey bees. The present study can serve as a ready reference for researchers and beekeepers, especially in management of honey bee colonies and in understanding their foraging behaviour.

KEYWORDS: Honey Bee, Bee Forage, Hourly Abundance, Visitation Rate

Pollinators are as crucial as light and water for cross pollinated plants (Levin, 1971). They ensure reproduction, fruit and seed set development, so that affects the quality and quantity of the products derived from the vast majority plants (Free, 1993), both in agro-ecosystems and natural ecosystems. In turn, plants provide food and nesting resources for pollinators. Majority of the fruit, vegetable, pulses, oilseeds, spices and plantation crops are pollinators dependent (Singh, 1997). The most recognizable pollinators are the various species of honey bees, which are plainly adapted to cross pollination, especially in bee forage plants (Treherne, 1923). Recently, the Food and Agriculture Organisation of the United Nations (FAO) estimated that out of some 100 crop species which provide 90% of food worldwide, 71 of these are bee-pollinated. Honey bees provide a critical ecosystem service by ensuring stable pollination to agricultural and wild plant communities. They typically are fuzzy and carry an electrostatic charge. Both features help pollen grains to adhere their bodies, but they also have specialized structures on the hind legs i.e., pollen basket.

Beekeeping is in practice since epic era as revealed in various scriptures. The great epic 'Ramayana' describes about existence of 'Madhuban' (literally honey forest) in Kiskindya maintained by king Sugriva (Ghosh, 1994). Modern scientific beekeeping came in existence in 18th century in India. Four species of honey bees are common throughout the country viz. *Apis cerana, A. dorsata, A. florea and A. melifera* which can be easily observed on the flowers of be forage plants. Of these, *A. ceranaand A. melifera* are successfully domesticated. In Bihar state, Muzaffarpur is the leading district in production of honey and horticultural crop like litchi and mango.

The present study was aimed to assess the abundance and visitation rate of four honey bee species on flowers of *Litchi chinensis*, *Mangifera indica*, *Phyllanthus emblica* and *Psidium guajava*, commonly grown multipurpose trees in Muzaffarpur district (Bihar state, India).

MATERIALS AND METHODS

Experimental Site

The present investigation was carried out in Khabra Village area of Mushahari block, Muzaffarpur district (Bihar state, India), is located 2 Km towards south from district headquarters, Muzaffarpur; 4 Km from Mushahari while 69 Km from state capital Patna. Geographically, Khabra situated at 26º 06′ 01.37″ N latitude and 81º 22′ 22.95″ E longitude with altitude of 54 m asl. The populated area is surrounded by the agricultural land with scattered tree populations comprises of species like *Dalbergia sissoo, Eucalyptus* spp*., Litchi chinensis, Mangifera indica, Moringa oleifera, Neolamarckia cadamba, Phyllanthu semblica, Psidium guajava* and *Terminalia* spp. The main crops grown in the area are oil seeds, vegetables and pulses. Khabra is the semi-town village, the main source of livelihood to a large proportion of the population are fruit production, labor activities and small scale business. The area has a humid subtropical climate with extremely hot summers (March to June) and foggy, chilly winter (November to February).

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Selection of Tree Species and Pollinators

Field surveys were conducted to the Khabra village (Muzaffarpur, Bihar) and its vicinity during 2016, for observation of bee forage plants and their socio-economic values with help of a semi-structured questionnaire. Based on the field data (availability, flowering period, utility), four plant species were selected viz., *Litchi chinensis, Mangifera indica, Phyllanthus emblica* and *Psidium guajava* for present study.

Table 1: Details of tree species selected for present study from Khabra (Muzaffarpur, Bihar)

Parameters	*Litchi chinensis*	*Mangifera indica*	*Phyllanthus emblica*	*Psidium guajava*
Botany				
Occurrence	Planted	Planted, wild	Planted, wild	Planted
Availability	Abundant	Abundant	Common	Common
Nature	Evergreen	Evergreen	Evergreen	Evergreen
Local name	Linchi	Aam	Aanwla	Amrood
Family	Sapindaceae	Anacardiaceae	Phyllanthaceae	Myrtaceae
Flowering	February-March	February-April	March-April	April-June
Inflorescence	Terminal, thyrsus	Terminal, panicle	Axillary, fascicles	Axillary, solitary
Flower	Fragrant	Fragrant	Fragrant	Fragrant
Density flowers (m^2)	450–600	850–1000	500–700	6–10
Pollination	Cross	Cross	Cross	Cross
Propagation	Seed, cuttings	Seed, cuttings	Seed	Seed
Utility				
Commercial value	Fruits, candy, juice	Fruits, timber, pickle, candy, jam juice	Fruits, murabba, pickle	Fruits, juice
Horticultural value	Social forestry, Agroforestry	Social forestry, Agroforestry	Social forestry, Agroforestry	Social forestry, Agroforestry
Ornamental value	Garden, Avenue	Garden, Avenue	Garden, Avenue	Garden, Avenue
Cultural value	Fruits are used at few religious ceremonies.	Considered sacred tree, leaves & fruits area used at various religious ceremonies and rituals.	Considered sacred tree, fruits area used at various religious ceremonies and rituals.	Fruits are used at various religious ceremonies and rituals.
Other uses	Medicinal, wood used in agricultural tool and handles	Medicinal, wood used in agricultural tool and handles	Medicinal, wood used in agricultural tool and handles	Medicinal, wood used in agricultural tool and handles

Data Collection and Analysis

We followed the method used by Kumar et al. (1989) and Sharma et al. (2001) with slight modifications. At the time of blooming of selected species, all the flowering branches within 1 m^2 were marked as experimental plots on the canopy. Population abundance of honey bees recorded at weekly intervals (n=4 days). In a single observation of 5 minute per experimental plot, (i) number of *Apis* foragers visiting in plot; (ii) number of flowers visited by a forager; and (iii) their times of commencement and cessation recorded simultaneously. Observation repeated four times (n=4) in each period of 2 hour, starting from morning to evening (6:00 hrs. to 18:00 hrs.). Temperature and humidity at the time of each observation was recorded with operation manual for Temperature and Humidity meter (MEXTECH TM-1).

RESULTS

Relative Abundance

Out of four tree species, the highest number of *Apis* visitors were recorded on *Litchi chinensis* (18.13 ind./ 5 min./ plot; n=24) followed by *Phyllanthus emblica* (5.32 ind./ 5 min.) while minimum in *Psidium guajava* (Fig. 1). There was not much difference in the abundance of *Apis* spp. visiting *Mangifera indica* (3.11 ind./ 5 min.) and *Psidium guajava* (3.0 ind./ 5 min.) flowers. All the four *Apis* spp. showed highest abundance on *Litchi chinensis* (Table 2). Minimum abundance of *A. cerana, A. melifera* and *Trigona* sp. was observed on *Psidium guajava* while *A. dorsata* and *A. florea* showed lowest abundance on *Mangifera indica*.

Table 2: Abundance and visitation frequency of honey bees in different hours of the days with weather data

Variable	Abundance of insects visitors at different hours of the day							
Litchi chinensis	**6:00-8:00**	**8:00-10:00**	**10:00-12:00**	**12:00-14:00**	**14:00-16:00**	**16:00-18:00**	**Mean±S.E.**	**Time spent**
A. cerana	47	61	55.5	18	15	32	38.1±7.9	15
A. dorsata	8.5	6.9	17	2.1	8	5.1	07.9±2.0	10
A. florea	26	29	30	0	9	4.7	16.5±5.5	45
A. melifera	30	33	35	9	11	23	23.5±4.6	17
Trigona sp.	5	8	6	0	4	5	04.7±1.1	33
Mean±S.E.	23.3±7.6	27.6±9.9	28.7±8.4	05.8±3.5	09.4±1.8	14.0±5.7	18.13	24.0±6.5
Temperature (ºC)	17	22	24	26	29	24	23.7±1.6	
Humidity (%)	71	57	52	49	43	59	55.2±3.9	
Mangifera indica								
A. cerana	3	6	5	1	5	5	04.2±0.7	09
A. dorsata	1.6	3	2	0	1.2	2	01.6±0.4	10
A. florea	3	3.6	2.1	2	2.8	1	02.4±0.4	16
A. melifera	5.5	8	6	0	3.7	4.8	04.7±1.1	20
Trigona sp.	3.4	3	5	0	2.7	2	02.8±0.7	11
Mean±S.E.	03.3±0.6	04.7±1.0	04.0±0.8	00.6±0.4	03.1±0.6	03.0±0.8	03.11	13.2±2.1
Temperature (ºC)	20	23	26	27	34	29	26.5±2.0	
Humidity (%)	63	50	52	45	38	47	49.2±3.4	
Phyllanthus emblica								
A. cerana	6	5	4	0	2.6	3.8	03.6±0.9	25
A. dorsata	4	4	2	0	5.1	0	02.5±0.9	17
A. florea	17	19	16	2	9	8	11.8±2.7	38
A. melifera	6.6	6	4.3	0	5	3.1	04.2±1.0	24
Trigona sp.	2.1	8.2	6.5	2.3	2	6	04.5±1.1	31
Mean±S.E.	07.1±2.6	08.4±2.7	06.6±2.5	00.9±0.5	04.7±1.2	04.2±1.4	05.32	27.0±3.5
Temperature (ºC)	20	24	27	28	35	31	27.5±2.1	
Humidity (%)	65	52	47	45	39	44	48.7±3.7	
Psidium guajava								
A. cerana	3.2	6	3.1	0	1.1	2	02.6±0.8	11
A. dorsata	5	4.2	3	1	3	1	02.9±0.7	08
A. florea	3.9	5	3.1	0	1.6	3	02.8±0.7	29
A. melifera	7	4	5	0	4.7	4	04.1±0.9	14
Trigona sp.	3	5	3	0	3	2	02.7±0.7	22
Mean±S.E.	04.4±0.7	04.8±0.4	03.4±0.4	00.2±0.2	02.7±0.6	02.4±0.5	03.00	16.8±3.8
Temperature (ºC)	19	23	30	32	37	33	29±2.7	
Humidity (%)	62	49	45	36	39	45	46±3.7	

Hourly Abundance

In hourly interval, maximum visitors observed in morning hours (Fig.1, Table2). In *Litchi chinensis*, maximum abundance of *Apis* spp. was recorded 10–12 hrs. (28.7 ± 8.4 ind./5 min./ plot), followed by 8:00–10:00 hrs. (27.6±9.9) while minimum (5.8±3.5) during 12:00–14:00 hrs. Similar trend was observed for *Mangifera indica*. In the *Phyllanthus emblica* and *Psidium guajava* maximum *Apis* spp. visited during 8:00l–10:00 hrs. followed by 6:00–8:00 hrs.

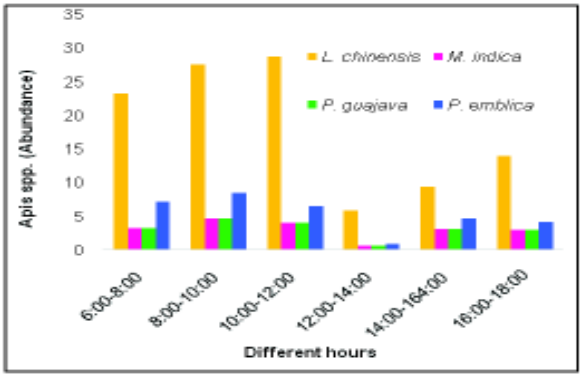

Figure 1: Average hourly abundance of honey bees

Effect of Temperature and Humidity

It was observed in the present study that the abundance of *Apis* visitors decreases with increase in the temperature; on other hand it increases with increase in humidity (Fig.2). R^2 value ranges between 0.073 (*Mangifera indica*) and 0.463 (*Psidium guajava*) for temperature and varied from 0.092 (*Mangifera indica*) to 0.594 (*Psidium guajava*) for humidity. However the R^2 value was not much high, which is an indicative of smaller differences between the observed data and the fitted values.

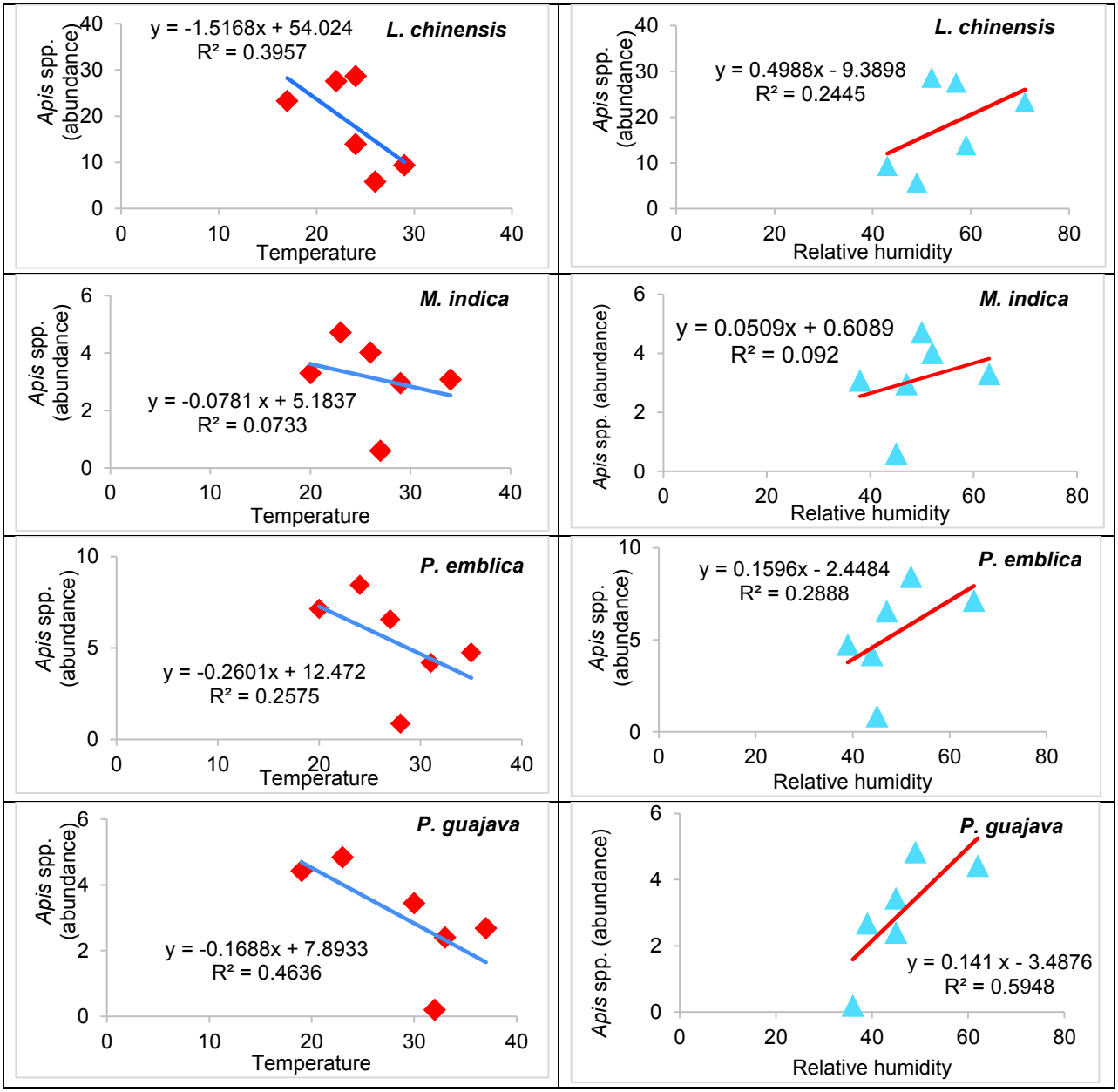

Figure 2: Effect of temperature and humidity on the abundance of honey bees

DISCUSSION

Honey bees visit plants to gather nectar and pollen from flowers as their food, which are collectively termed as 'bee forages' or 'bee pasturage' (Singh, 1982; Gaur et al., 2014). Nectar is raw material for honey while pollen provides major food to the developing brood, thus both are essential for honey bee survival (Plowright et al., 1993). Despite this joint requirement and the concurrent production of pollen and nectar by many plant species, bees do not often collect pollen and nectar simultaneously. This

behaviour implies that the criteria affecting preferences for plant species depend on nectar whether pollen or nectar is the focus of a bee's foraging (Rasheed and Harder, 1997).

The present study revealed that there were variation in the abundance and visitation rate (hourly) of *Apis* spp. on the blooms of *Litchi chinensis*, *Mangifera indica*, *Phyllanthus emblica* and *Psidium guajava*. The variation could be due to the availability and quality of nectar from particular species. Various trend of abundance of insect pollinators was observed in *Abelmoschus* sp. (Mishra et al., 1987), *Allium cepa* L. (Jadhav, 1981; Kumar et al., 1989; Priti, 1998), *Brassica* spp. (Ali, 1935; Kapil et al., 1971; Kakkar, 1981; Mahindru et al., 1995; Priti and Sihag, 1997), *Cajanus* sp. (Sihag and Rathi, 1994), *Daucus carota* L. (Kumar et al., 1985; Sharma et al., 2001), *Helianthus annuus* L. (Sharma et al., 2001), *Sesamum* (Pashte and Shylesha, 2013), *Trifolium alexandrinum* L. (Sharma et al., 2001), and spring flowering crops (Kumar et al., 1989) from India.

The abundance of *Apis* visitors decreases with increase in the temperature; on other hand it increases with increase in humidity in present study. Free (1993) reported that the metabolic activities of insects increases as the temperature increases and they visit many flowers at that time. While, nectar secretion rate is temperature dependent (Fahn, 1949; Shuel, 1952; Jakobsen and Kristjansson, 1994). The atmospheric humidity also effects the nectar secretion in plants (Park, 1929; Vansell, 1934;Scullen, 1942).Normally, the highest nectar yield is secreted at a particular temperature, that differs from species to species (Petanidou and Smets, 1996; Julier and Roulston, 2009). The density of the insect pollinators on blossoms depend on weather conditions, nectar volume and nectar sweetness (Seeley and Levien, 1987).

CONCLUSION AND IMPLICATIONS

It was concluded that the *Apis* pollinators are the efficient visitors on *Litchi chinensis*, *Mangifera indica*, *Phyllanthus emblica* and *Psidium guajava*. Higher abundance of all floral visitors occurred during morning hours than afternoon and evening hours. Temperature and Humidity were favourable for *Apis* visitors during morning hours. We also concluded that *Apis cerana* show maximum visitation on *Litchi chinensis.* Management of bee colonies around the orchards may enhances fruit productivity and seed quality besides many valuable bee products. Traditional beekeeping practices is decreasing at alarming rate due to modernisation (Tiwari et al., 2013), thus, prior to conservation and management of different cultivated bee forage plants, efforts should be made to increase beekeeping development through the country.

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