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Foraging rhythm of bees in relation to flowering of sweet basil, *Ocimum basilicum* L.

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Sixteen species of insects belonging to four families of Hymenoptera visited flowers of *Ocimum basilicum*. Among them, non-*Apis* bees represented 85% of all flower visitors. Nectar was the main attractant for floral visitors. Besides *Ocimum*, agricultural crops such as cucumber, bitter gourd, brinjal, etc. in adjacent fields were visited by the same species of flower visitors. Hence, if planted near the agricultural fields, *Ocimum* sp. could attract pollinating insects for enhancing crop productivity.

Keywords: Agricultural crops, foraging rhythm, non-*Apis* bees, *Ocium basilicum*.

WILD basil, *Ocimum* sp. belonging to the family Lamiaceae, is a well-known medicinal herb commonly grown in India. Its aroma and exposed nectar attracts a large number of insects including pollinators. This plant because of its protandrous[1] property requires pollen vectors for its cross pollination. However, very little is known about the pollination mode of this important herb[2]. Therefore, the pollinator spectrum of *Ocimum* sp. was studied. In addition, the insect visitors of flowers of agricultural crops grown in nearby fields were also monitored. Assemblage of flower visitors was compared between wild Basil and agricultural crops to elucidate the importance of basil as a pollinator reservoir.

The study was conducted in the trial field of agricultural crops at SKUAST, Jammu Campus during late September 2012. Shrubs of wild *Ocimum* sp. growing naturally across the agricultural field were monitored regularly at peak flowering period during the daytime at an hourly interval. Representative samples of flower visitors were collected and identified up to RTUs[3] with the help of literature and then confirmed by experts. Collections were also made from nearby crops like cucumber, brinjal, bitter gourd and pea to examine the similarity of flower visitors between these crops and wild Basil.

Ocimum sp. (Wild Basil) started flowering in mid-September and continued up to the onset of mid-November. Flowers are bright purple/violet coloured with exposed nectar and a sweet aroma. Sixteen species of flower visitors belonging to four families in the order Hymenoptera were recorded (Table 1). The frequency of visits for Ocimum flowers was highest between 1100 and 1300 h (Figure 1). It was also evident that besides *Apis dorsata* and *A. mellifera*, non-*Apis* bees and solitary bees belonging to genera *Amegilla*, *Xylocopa*, *Thyreus*, *Nomia*, *Anthidium* and *Megachile*, were more frequent visitors (85% visits), collecting nectar and pollen from *Ocimum* flowers (Figures 2 and 3). Reports of visits by solitary bees, viz. *Megachile bicolor*, *Megachile disjuncta*, *Megachile lanata* and *Anthedium* sp., *Amegilla* spp., *Thyreus* and *Xylocopa* spp. are new records of efficient flower visitors and prospective pollinators of wild basil from this geographic area. The majority of flower visitors collected only nectar (81%) while a few collected both

Table 1. Flower visiting insects in *Ocimum* sp. in Jammu

Insect order	Insect morpho species	Family	Foraging preference
Hymenoptera	*Andrena* sp.	Andrenidae	N, P
	Amegilla zonata	Apidae	N
	Apis dorsata	Apidae	N, P
	Apis mellifera	Apidae	N, P
	Ceratina (*Pithitis*) *smaragdula*	Apidae	N
	Xylocopa latipes Drury	Apidae	N
	Xylocopa pubescense	Apidae	N
	Thyreus histryo	Apidae	N
	Halictus sp.	Halictidae	N
	Nomia sp.	Halictidae	N, P
	Megachile bicolour (Fabricius)	Megachilidae	N
	Megachile hera Bingham	Megachilidae	N
	Megachile lanata (Fabricius)	Megachilidae	N
	Megachile disjuncta	Megachilidae	N
	Megachile cephalotes	Megachilidae	N
	Anthedium orientale	Megachilidae	N

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Table 2. Comparative list of insect pollinators on various host plants in agricultural field

Insect foragers	Wild basil	Cucumber	Brinjal	Bitter gourd	Leguminous crops	Oilseed crops
Andrena sp.	+	+	+	+	+	+
Amegilla zonata	+	+	+	+	+	+
Apis dorsata	+	+	+	+	+	+
Apis mellifera	+	+	+	+	+	+
Ceratina (*Pithitis*) *smaragdula*	+	+	+	+	+	+
Xylocopa latipes Drury	+	+	+	+	+	+
Xylocopa pubescense	+	+	+	+	+	+
Thyreus histryo	+	–	–	–	+	+
Halictus sp.	+	+	+	+	+	–
Nomia sp.	+	+	+	+	–	–
Megachile bicolour (Fabricius)	+	+	–	+	+	+
Megachile hera Bingham	+	+	–	+	+	+
Megachile lanata (Fabricius)	+	–	–	+	+	+
Megachile disjuncta	+	–	–	–	+	+
Megachile cephalotes	+	+	–	+	+	+
Anthedium orientale	+	–	–	–	+	–

+, Presence; –, Absence of the insect species.

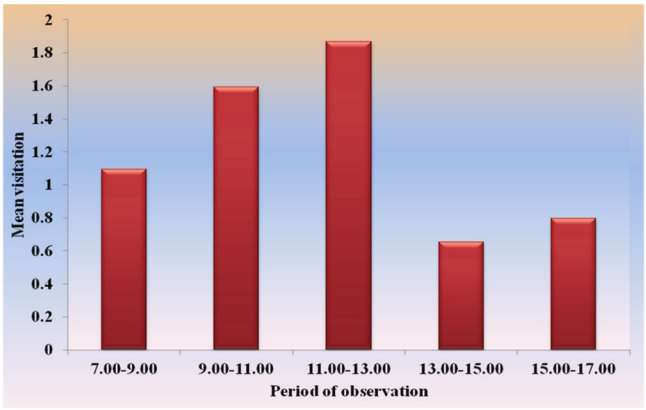

Figure 1. Foraging activity of various insects on wild basil.

pollen and nectar (19%) (Figure 4). Periodic observation on the activity of some most frequent flower visiting insects on wild basil reveals that foragers initiated their activities around 0745 a.m. and attained a peak between 11.00 the 13.00 h followed by a gradual decline in foraging activities (Figure 1). Interestingly, a less pronounced second peak was recorded between 15.00 and 17.00 p.m. Foraging activities diminished thereafter and ceased with decreasing light intensity and floral resource availability. Temporal distribution of flower visitation showed a clear demarcation on resource utilization patterns which correspond to the nectar production rhythm in flowers. Nectar production was higher during the earlier part of the day and decreased thereafter. The visiting pattern of flower visitors also followed the same trend, indicating that foraging rhythm of insect visitors parallels resource availability in flowers.

Daily rhythms of flower visits by bee species depend on, the body size of the species, the daily patterns of variation in weather and nectar standing crop, and the effects of weather on the daily rhythm of variation in nectar standing crop. They found that larger bee species were more active in cooler and more humid hours of the morning. Smaller species foraged later, during warmer and drier hours. Throughout the day, nectar volume decreased and pollinator visits followed the same trend[4].

Xylocopa spp. with a large body shape and buzzing characteristics of foraging was recorded to be the most frequent forager with 26% frequency amongst visits recorded. Amongst small bodied bees, *Amegilla* spp. and species belonging to the family Megachilidae were found to be the most important flower visitors of this important medicinal shrub with 52.5% frequencies amongst all flower visitors and represented by six species (four species of Megachilidae and two species belonging to genus *Amegilla*). Simultaneously, observations recorded on flower visitors of other crops such as cucumber, brinjal, bitter gourd, various leguminous and oilseed crops, in the agricultural field revealed a similarity with the flower visitors of sweet basil (Table 2).

Wild basil attracts a large number of pollinators belonging to three major insect orders, viz. Hymenoptera, Diptera and Lepidoptera. Diverse spectrum of flower visitors foraging on nectar and pollen of *Ocimum* sp. utilizes the available resource to the maximum. The capacity of attracting a wide range of flower visiting insects can open an important aspect of pollination. Previous work in this line also showed efficiency of *Andrena* sp. in pollination of many agri-horticulture crops[5–7]. Megachilid bees were reported as well-known pollinators of many important plants in different parts of the world, mostly in captive condition[8–12]. *Amegilla* sp. was reported as a chief pollinator in greenhouse for tomatoes[13]. All open treatments of the five variants of three *Ocimum* species namely *Ocimum canum*, *O. basilicum*, and *O. americanum* were mediated by insect visits and produced more

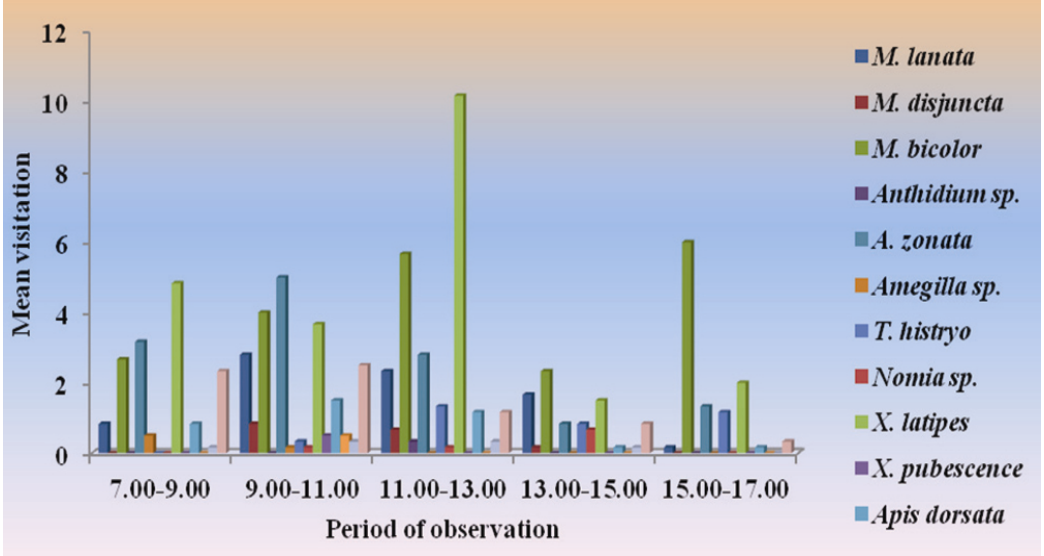

Figure 2. Species-wise foraging pattern of insects in wild basil.

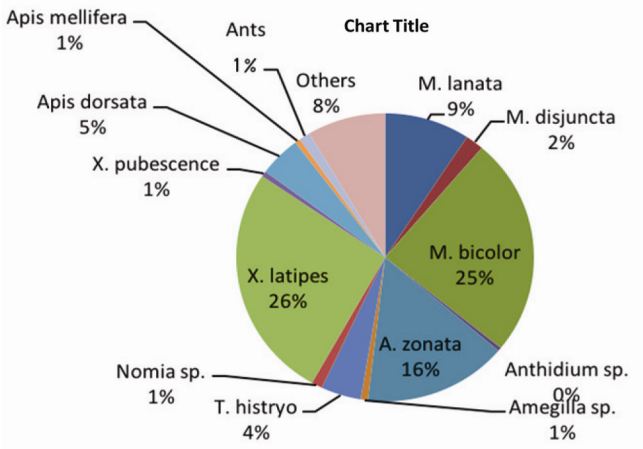

Figure 3. Bee visitation data on basil, *Ocimum basilicum* L. of different bees.

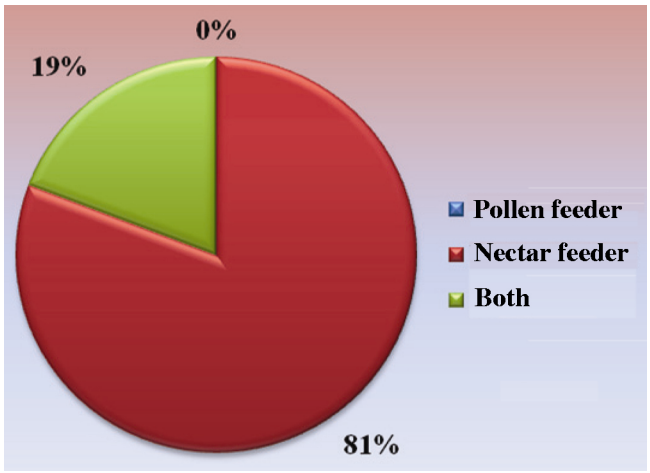

Figure 4. Foraging preference of various insect visitors of *Ocimum* sp.

fruits and seeds than bagged treatments. The floral foragers comprising of bees, wasps and butterflies visited the *Ocimum* species to collect pollen or nectar in the open treatments and resulted in higher fruit and seed set in all the *Ocimum* species studied[14].

The flowers of *Ocimum americanum* are open during 5:30–13:30 h and during 7:00–13:00 h in *O. basilicum* respectively. Certain bee species like *Apis florea*, *A. cerana indica*, *Amegilla* sp. and *Pseudapsis oxybeloides* and the butterfly *Surandra quercetorum* are the most frequent and consistent visitors and are pollinators for both plant species[15].

Pollinator pool of associated crops in nearby fields revealed striking similarity with wild basil. In this aspect this plant species has great prospect to serve as pollinator reservoir during the pollinator deficient time. Many of the Hymenopteran flower visitors of basil, as enlisted in the current study, were found to contribute considerably in the pollination process and successful fruit set of important forest trees like *Santalum album*, *Jatropha gossypiifolia*, *Euphorbia geniculata* and *Paulownia fortunae*[16–19]. In a similar study, enhancements of floral resources in surrounding landscape and in local crop fields were found to mitigate adverse human impacts on pollinator diversity and pollination services[20]. It was further found that intercropping with flowering basil (*Ocimum basilicum*) increases the local abundance and richness of bees and improves fruit and seed production of bell pepper (*Capsicum annuum*). The increase in the number of bees visiting the peppers was due to the stronger attraction of *Paratrigona lineata*, *Apis mellifera* and *Tetragonisca angustula* to basil in the intercropping plots. The pepper fruits produced in the intercropping were wider, longer, and heavier and developed more seeds than the fruits produced by single-cropping.

This clearly indicates that during pollinator deficiency of agricultural crops, *Ocimum*, if grown nearby the agriculture field, can harbour pollinator pool resulting good yield in agricultural crops.

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