

Diversity of Floral Visitors and Foraging Behaviour and Abundance of Major Pollinators on Fennel Under Semi-arid Conditions of Rajasthan

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Abstract: A field investigation was conducted to worked out the floral visitors and foraging behaviour of major insect pollinators on fennel crop in semi-arid region. Fennel flowers were visited by 25 floral visitors viz., Hymenoptera (8 species), Diptera (7 species), Hemiptera (3 species), Coleoptera (3 species), Neuroptera (1 species) and Lepidoptera (3 species). Most of the floral visitors started their foraging activities from 08.00 h and then gradually increased and reached to maximum between 12.00 to 14.00 h afterwards their population declined gradually and became negligible or completely ceased at 18.00h. Honeybee species *Apis florea* F was recorded as most prominent pollinator of fennel followed by *A. mellifera* and *A. dorsata*. Two honeybee species *A. florea* and *A. dorsata* were visited the crop from their natural habitat, whereas, *A. mellifera* was visited the crop from honey bee colonies 200 m stationed from the experimental site. Honeybee species *A. mellifera* performed higher foraging rate followed by *A. dorsata* and *A. florea* on fennel. Bee attractants (jiggery solution and sugar solution @ 10ml/lit.,) enhance the floral visitor's activity on the crop during peak hours.

Keywords: Floral visitors, diversity, foraging behaviour, fennel, semi-arid region, Rajasthan.

INTRODUCTION

Intensification and diversification are the pressing needs of today for sustenance of seed spices in the country. India is blessed with 63 spice crops, among them, 20 spices are considered as seed spices, growing in 36 per cent area of total spices but the foremost seed spices group includes fennel (*Foeniculum vulgare* Mill.), Coriander (*Coriandrum sativum* L.), cumin (*Cuminum cyminum* L.), fenugreek (*Trigonella foenum-graecum* L.), dill (*Anethum sowa* Roxb., *A. graveolens*), ajwain (*Trachyspermum ammi* L.), nigella (*Nigella sativa* L.), celery (*Apium graveolens* L.), caraway (*Carum carvi* L.) and few others crops (Free, 1993; Singh et al., 2011 and Kumar et al., 2014). Amongst seed spices, fennel (*Foeniculum vulgare* Mill.) is also an important seed spice crop. In India, it is growing in Rajasthan, Gujarat, Karnataka, Maharashtra, Uttar Pradesh, Punjab and Bihar, producing 1.35 lakh tonnes seeds

from 94.07 thousand hectare area (Anonymous, 2013). Rajasthan, Gujarat and Uttar Pradesh are the leading fennel producing states of the country. Fennel seeds used in soup, pickle, sauce, and chocolates like foodstuff to make them aromatic and attractive for consumers. It contains good quantity of oleoresin and ethanol, created an excellent platform in the international market. In spite of that, it also has marvelous medicinal properties; work in various ailments' recoveries.

Fennel (*F. vulgare*) is cross pollinated in nature (Narayana et al., 1960). Pollination in fennel is largely reliant upon the insect pollinators visited the crop during flowers' blooming stage. However, among the huge populations of floral visitor, potential insect pollinators are able to transfer the viable pollen from anthers to receptive stigma of female flower. Honeybee species, *Apis florea*, *A. dorsata*, *A.*

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mellifera are to be considered as major pollinators of seed spices, significantly enhance the yield (Meena *et al.*, 2015). Apart from honeybee species, a number of floral visitors *i.e.* *Episyrrhus balteatus*, *Ceratina sexmaculata* Smith, *Eristalis* sp., *Musca domestica*, *Musca* sp. 1, *Oxycarenus leatus* Kirby., *Dysdercus koenighii* F., *Chrysoperla zastrowi sillemi* L., *Menochilus sexmaculatus* F., *Coccinella septempunctata* L., and few lepidopteran caterpillars visit the flowers of seed spices including fennel over the season. Such floral pollinators play a vital role to enhance the production and quality of the seed spices. Of the total pollination activities performed by the insects, honey bees contribute nearly 80 per cent of total insect pollination. Earlier a meager research was done in this field; however, it shows that the fennel is being a cross pollinated crop, and a detailed pollination studies are needed to find the precise role of pollinators in proportionally enhancement of crop yield in term of quantity and quality. Keeping this in view, the present study was conducted at NRCSS, Ajmer a semi-arid region of Rajasthan.

MATERIALS AND METHODS

The present investigation was conducted at farm, ICAR- National Research Centre on seed spices, Ajmer, Rajasthan during *Rabi* season 2013-14. The centre is located at an altitudinal of 26° 27' N and longitude 74° 42' E with 200 MSL elevation, surrounded by the hills of Aravalli range. The location has semi-arid climate. The region receives an average annual rainfall ranged from 250-550 mm, whereas temperature raises up to 48 °C in summer and fall to 3-4°C in winters. The relative humidity fluctuates around 50-75 % during winters.

A field experimental trial was conducted to find the diversity of floral visitors and foraging behaviour and abundance of *Apis mellifera* Lin., *Apis dorsata* (F.), and *Apis florea* (F.) on fennel. The seeds of fennel variety Ajmer Fennel-1 (AF-1) were sown in plots sized of 5 × 4 (20 sq. m) under the geometry of 60 × 25 (L × P). Five treatments (mode of pollination) *viz.*, open pollination, plants treated Jiggery solution (10%), sugar solution (10%), organic salt (5 ml/lit) and bee pollination (caged) were

applied in Randomized Block Design replicated four times. All the required agricultural practices were followed as per package of practices adopted for fennel crop at the institute.

Diversity of insect pollinators was studied by sweep-netting the insect visitors initiated with 30% flowering and continue throughout the flowering period. The specimens of floral visitors were collected, preserved and identified with help of informations and literatures available at NRCSS, Ajmer. All floral visitors were occurred on the fennel crop from their natural habitat, whereas honeybee species, *Apis mellifera* were visiting the crop from the preciously keeping colonies stationed from 200 meter distant location at the farm. The abundance of important floral visitor was studied from 1 m² bloom area of fennel for a period of 2 minutes in four replications.

The visual observations were recorded at full blooming stage for 10 pleasant, clear and sunny days starting from early in the morning at 06.00 to 18.00 h. Initially, the observations were recorded at hourly intervals and after that it was sifted to two hourly intervals due to advancement of the visitors on flowers. The foraging rate of *Apis* pollinators was also studied by counting the number of umbels visited minute⁻¹ and the number of plants visited by the foragers minute⁻¹ was also recorded. Investigation on the impact of different mode of pollination on populations of important pollinators was also studied. The observations on insect visitor's population were recorded by visual counting as well as with the help of hand lens as needed for small hymenopterans and other insects. The average of visitors was computed and statistically analyzed.

RESULTS AND DISCUSSION

The data of pollination studies on various parameters in fennel were recorded and presented as under given headings.

Diversity of Floral Pollinators

The diversity of various floral visitors associated with fennel was showed that, the fennel flowers were visited by 25 insect species belonging to 14 different families from 6 orders (Table 1).

Table 1
Diversity of floral visitors visiting fennel (*Foeniculum vulgare* Mill.)

Insect visitors	Family	Mean population days ⁻¹	Proportion (%) of total visitors
<i>Hymenoptera</i>			
<i>Apoidea</i>			
<i>Apis dorsata</i> Fabricius	Apidae	28.0	7.6
<i>Apis florea</i> Fabricius	Apidae	126.4	34.4
<i>Apis mellifera</i> Linn.	Apidae	46.3	12.6
<i>Ceratina sexmaculata</i> Smith	Apidae	2.1	0.6
Total Apoidea		202.8	55.2
<i>Other Hymenoptera</i>			
<i>Polistes hebraeus</i> Fabricius	Vespidae	1.3	0.3
<i>Camponotus</i> sp.	Formicidae	2.5	0.7
Unidentified hymenoptera sp. 1		7.3	1.9
Unidentified hymenoptera sp. 2		3.8	1.0
Total other Hymenoptera		14.9	4.1
Total Hymenoptera		217.7	59.3
<i>Diptera</i>			
<i>Episyrphus balteatus</i>	Syrphidae	37.3	10.2
<i>Eristalis</i> sp. 1	Syrphidae	26.5	7.2
<i>Eristalis</i> sp. 2	Syrphidae	11.3	3.0
<i>Musca domestica</i>	Muscidae	13.2	3.4
<i>Musca</i> sp. 1	Muscidae	23.2	6.3
<i>Musca</i> sp. 2	Muscidae	3.0	0.8
<i>Musca</i> sp. 3	Muscidae	0.8	0.2
Total Diptera		115.3	31.4
<i>Hemiptera</i>			
<i>Dysdercus koenighii</i> F.	Pyrrhocoridae	4.8	1.3
<i>Oxycarenus laetus</i> Kirby.	Lygaeidae	2.5	0.7
<i>Bagrada hilaris</i> (Burmeister)	Pentatomidae	1.6	0.4
<i>Coleoptera</i>			
<i>Coccinella septempunctata</i>	Coccinellidae	13.3	3.6
<i>Menochilus sexmaculatus</i> F.	Coccinellidae	6.8	1.8
Yellow beetle-unidentified	Chrysomelidae	0.5	0.1

Insect visitors	Family	Mean population days ⁻¹	Proportion (%) of total visitors
<i>Neuroptera</i>			
<i>Chrysoperla zastrowi sillemi</i> L.	Chrysopidae	0.2	0.1
<i>Lepidoptera</i>			
<i>Plutella xylostella</i> L.	Plutellidae	1.3	0.3
<i>Helicoverpa armigera</i> H.	Noctuidae	0.5	0.1
<i>Pieris brassicae</i> L.	Pieridae	2.5	0.7
Total others		34.0	9.26
Grand total		367.0	

Occurrence of these floral visitors was recorded on fennel flowers right from initiation of flowering to withering and even up to harvesting of crops in unusual manner of intensity. Apoidea (55.2%) other Hymenoptera (4.1%) and Diptera (31.4%) were found three major groups, contributing 90.7 per cent of the total floral visitors. Hymenoptera (8 species), Diptera (7 species), Hemiptera (3 species), Coleoptera (3 species), Neuroptera (1 species) and Lepidoptera (3 species) were noticed on crop. Honeybee species *Apis florea* was the most prominent pollinator (34.4%) on fennel during cropping season in semi-arid region of Rajasthan followed by *A. mellifera* (12.6%) and *Episyrphus balteatus* (10.2%), *A. dorsata* (7.6%), and *Eristalis* sp.-1 (7.2%).

Among insect pollinators visited the fennel flowers, order Hymenoptera was the most diverse group included 8 species contributing 59.3 per cent of total floral visitors. Seven insect species of Diptera visited the fennel flowers contributed 31.4 per cent of total floral visitors, existed next to Hymenoptera. Among Dipterans, *Musca* sp.-1 was the most prominent (6.3%) followed by *Musca domestica* (3.4%) and *Eristalis* sp.-2 (3.0%). The other insect species visited the fennel flowers were *Coccinella septempunctata* (3.6%), *Menochilus sexmaculatus* F. (1.8%), *Dysdercus koenighii* F. (1.3%), *Pieris brassicae* L. (0.7%) and some other species having very less or no pollination value and also be harmful to crop (table 1). A very little research work was done so far in India in this field; however, honeybees (*Apis cerana* F., *A. florea* F. and *A. mellifera* L.) and syrphid

flies are the most common pollinators of fennel (Youngken 1956 and Narayana, 1960) support the present findings. Coriander flowers were visited by 34 insect species as floral visitors in Karnal (Haryana) and Hymenopterans contributed as most prominent group of pollinators, get support the present findings (Choudhary and Singh, 2007). *Apis mellifera* as the most dominant floral visitor of coriander has also been reported earlier from Italy and Haryana (Ricciardelli et al., 1979; CCSHAU, 2001) and *A. dorsata*, *A. florea* and *Trigona irridipennis* from India (Deodikar and Suryanarayana, 1977; Shelar and Suryanarayana, 1981 and Baswana, 1984).

The honeybee species contributing for pollination in fennel in large proportions are described as under (Figure 1-3).

***Apis dorsata* F. (Hymenoptera: Apidae)**

Rock bee is a native of Asia. It is largest amongst all the honeybees, ferocious in nature, almost black in colour (Figure 1). It is found mainly in the open branches of trees, along the sides of steep rocks in the forest and comparatively high places. Each colony consists of a single comb. A colony normally comprises of one queen, thousands of workers (female sterile bees) and several hundreds of drone (male bees) in all the species of honeybees. They have high stinging reflex and frequent migratory habit. Honey production is good, produce plenty of honey about 35-40 kg per year from a single productive colony. The rock bee represents a major

portion in pollination of fennel and fenugreek but it cannot be domesticate and use in manmade pollination in these crops.

***Apis mellifera* L. (Hymenoptera: Apidae)**

In India, *Apis mellifera* was successfully introduced in 1960 at the foot hills of Himachal Pradesh and agricultural plains of Punjab and subsequently it spread throughout the country. Bees are medium sized, golden colour and quiet in nature (Figure 2). They are less prone to swarming and absconding. Each colony has many combs and prefers darkness. On the basis of good beekeeping source or bee-plants, migratory habits and greater yield, it becomes more popular in the country. They produce on an average 35-50 kg of honey per year from a single colony.



Figure 1: *Apis dorsata* F. visiting fennel flowers



Figure 2: *Apis mellifera* Linn. visiting fennel flowers



Figure 3: *Apis florea* F. visiting fennel flowers