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Diversity of insect pollinators in coriander (*Coriandrum sativum* Linn.) VAR. ACR-1 under Semi-Arid region of Rajasthan

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Abstract
The diversity of various insect visitors associated with coriander (*Coriandrum sativum* Linn) was carried out under open field conditions at research farm, National Research Centre on Seed Spices, Tabiji, Ajmer in semi-arid region of Rajasthan. The coriander flowers were visited by 28 insect species belonging to18 families and 6 orders. Among these insect visitors, 10 species were recorded from Hymenoptera (53.05%), 4 unidentified species of hymenoptera from different families (4.58%), 8 species of Diptera from two families (36.09%), 3 species of Hemiptera from three families, 3 species of Coleoptera from two families, 1 species of Neuroptera and 3 species from Lepidoptera of three familieson coriander crop. were the three major groups comprising 93.72 percent of the total visitors recorded on coriander ecosystem. Among all pollinators, Apis florea was recorded as most dominating species (34.1%) followed by *Apis mellifera* (11.92%), *Episyrphus balteatus De Geer* (9.44%), *Eristalis sp.* (8.32%) *Musca sp.* 1 (7.73%), *Apis dorsata* (6.37%) and *Episyrphus sp.* (4.75%).

Keywords: *Apis mellifera, Apis dorsata, Apis florea*, foraging, diversity, coriander

Introduction
Coriander (*Coriandrum sativum*) is an annual herbaceous plant, belongs to the family Apiaceae (Umbelliferae). Its origin is considered to be Europe to Southwestern Asia. The genus Coriandrum includes the cultivated plant species *Coriandrum sativum* and the wild species *Coriandrum tordylium*. *C. sativum* L. is the only true species of the genus having chromosome No. 2n=22 (Simon, 1990). India is the largest producer, consumer as well as exporter country in the world.

India alone produced 314 thousand metric tons of seeds from an area of 447 thousand hectare along with average productivity of 0.7 MT/ha during the year 2013-14 (Anonymous, 2014). In the country, coriander is mostly growing in Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Maharashtra, Uttar Pradesh and Bihar. Rajasthan is the leading coriander producing state with its share of about 60% in the total area and production of the country.

Coriander plants are erect, branched having 60-100 cm height usually but it can goes even up to 150 cm in case of coriander variety ACr-1with tape root, stem are erect hollow, leaves dimorphic alternate. Flowers are small, zygomorphic and inflorescence compound umbel type. Fruits are schizocarp, round to globular, 2 to 3.5 mm in size, yellowish brown at maturity, green when young ribbed composed of two concavo-convex mizocarps with inner face of carpel having two vittae (Shanmugavelu *et al*., 2002) [8].

Coriander is a highly cross pollinated nature of crop, allowed a large population of insect pollinators during flowering for their pollination. A number of insects are responsible for pollination in various ways. It includes a number honeybee's species *i.e. Apis florea, Apis mellifera, Apis dorsata* along with many Hymenopteran (Deodikar and Suryanarayana, 1977; Shelar and Suryanarayana, 1981; Baswana, 1984) [3, 4], syrphids (Chaudharyand Singh, 2007) [9] and other diptera flies, moths and butterflies, many unidentified hymenoptera and natural enemies like Coccinellids and Chrysoperla. Among the various insect pollinators from different orders and families, honeybees perform the most important role in pollination of seed spices. Of the 95 percent cross pollinated flowers, 85 percent depend on insect pollination (Carruth, 1950) [1]. Among the various reasons for low yield, insufficient pollinators during blooming are to be considered as one of the major limiting factor for lowering the production per unit area. So in this study there is need to identify the diversity of pollinators and their behavior which can be helpful for pollination in coriander.

Material and Methods

The present investigation was conducted at the institute's farm, NRC on Seed Spices (ICAR), Tabiji, Ajmer during *Rabi* season of 2014-15. The mean annual rainfall is 590 mm, mostly received from south-west monsoon during the last week of June to October. The experiment consist of 6 treatments **(**Without insect pollination (WIP)-Caged, Open pollination, Bee pollination with *Apis mellifera* –Caged, Sugar solution (10%), Jaggery solution (10%), Organic control (Organic salt 5ml/lit)) with randomized block design (RBD) and it replicated four times. A replicated field trial was conducted to estimate the diversity of different kinds of floral visitors visiting the coriander crop right from initiation of flowering to harvesting of crop. There was no plant protection practices applied during the course of investigation for natural occurrence of insect visitors. The observations on diversity of floral visitors were taken by sweep-netting the insect visitors throughout the flowering period as per standard protocol. The insect visitors were identified by comparing with references available at the Library, National Research Centre on Seed Spices, Ajmer.

The abundance of insect visitors was studied from $1m^2$ bloom area for a period of two minutes in all four replications. The observations were made at partial (30% to 40%) crop flowering at hourly intervals (06.00 to 10.00 h) and two hourly intervals (10.00 to 16.00 h) and again at hourly intervals (16.00 to 18.00 h) for 10 calm, clear and sunny days.

Result and Discussion

A field experiment was conducted on diversity of various insect visitors associated with coriander at research farm, National Research Centre on Seed Spices, Tabiji, Ajmer under open field conditions. The data on average population of insect visitors (table 1) revealed that, the coriander flowers were visited by 28 insect species belonging to different order and families' right from initiation of flowering to withering and even up to harvesting of crops. Among these insect visitors, 10 species were from Hymenoptera *viz*., *Apis dorsata*, *Apis florea*, *Apis mellifera*, *Trigona* sp. of Apidae; *Polistes hebraeus* of Vespidae; *Camponotus* sp. of Formicidae and 4 species of unidentified hymenoptera from different families. These finding supported by Arya *et al.* (1994) [6] recorded 20 species of insect pollinators, of which 12 belonged to Hymenoptera, 5 to Diptera and 3 to Lepidoptera and Choudhary and Singh (2007) [9] reported the 34 insect visitors on coriander ecosystem and among them, most of the visitors belong to same category (species with orders and families). Singh *et al.* (2010) also found those honeybees; stingless bees, many kinds of flies; moths and other insects on coriander to play an important role in pollination of the crop also supported the present findings.

In Diptera, a total of 8 species were noticed on coriander flower's ecosystem at Ajmer in semi-arid region of Rajasthan *i.e. Episyrphus balteatus* De Geer, *Episyrphus* sp., *Eristalis* sp. 1 and *Eristalis* sp. 2 of Syrphidae and *Musca domestica* and *Musca* sp. 1 to 3 of Muscidae. 3 insect species, *Dysdercus koenigii* F. (Pyrrhocoridae), *Oxycarenus laetus* Kirby (Lygaeidae) and *Bagrada hilaris* (Burmeister) of Hemiptera were reported on coriander flowers. Coleoptera (3 species, *Coccinella septempunctata* L., *Menochilus sexmaculatus* Fab. of Coccinellidae and *Raphilopalpa foevicolis* of Chrysomellidae family), Neuroptera (*Chrysoperla carnea*) and adults of Lepidoptera (3 species *Plutella xylostella* L., *Helicoverpa armigera* H. and *Pieris brassicae* L.) were also noticed on coriander crop. Many other workers reported the honeybees as main pollinators of coriander (Abrol, 1985; Sihag, 1986 and Kant *et al.*, 2013) [5, 13]. Similar studies on coriander could not be available from the literature; however, Mahy *et al.* (1998) [7] recorded the dominance of insects of Hymenoptera, Diptera and Lepidoptera in the pollination system of *Calluna vulgaris.* Kuberappa *et al.* (2007) [11] recorded 10 species of insect pollinators on Vishnu tulsi (*O. sanctum*) belonging to order Hymenoptera (*Apis cerana, A. florea, A. dorsata, Trigona iridipennis, Vespa cincta* and unidentifield hymenopterans) and Diptera (*Musca domestica, Lucilia cuprina* and *philoliche longiatarsus*). Jacquemart *et al.* (2007) [10] recorded 49 different insect species, belonging to 18 families of Diptera and Hymenoptera on buckwheat.

Apoidea (53.05%), Diptera (36.09%) and other Hymenoptera (4.58%) were the three major groups comprising 93.72 percent of the total visitors recorded on coriander ecosystem. *Apis florea* was recorded as most dominating species (34.1%) among all pollinators followed by *A. mellifera* (11.92%), *Episyrphus balteatus* De Geer (9.44%), *Eristalis* sp. (8.32%), *Musca* sp. 1 (7.73%), *A. dorsata* (6.37%) and *Episyrphus* sp. (4.75%). Among, four Apoidea species, *A. florea* (34.1%) was recorded as most dominant pollinator on coriander followed by *A. mellifera* and *A. dorsata*. Among the other hymenopteran (6 species), unidentified Hymenoptera species-2 (1.46%) was important pollinator of coriander followed by *Camponotus* sp. (1.4%) and unidentified Hymenoptera species-1 (1.18%). Among eight dipteran species, *Episyrphus balteatus* (9.44%) was the most dominant pollinator followed by *Eristalis* sp. 1 and *Musca* sp. 1 (Table 1). The other insects belonging to the different orders and families were also visited the coriander flowers during winters play a vital role in pollination of coriander. The findings corroborate with that of El-Berry *et al.* (1974) [2]; Singh *et al.* (2010) [12] and Meena *et al.* (2015) [14] who reported many insect visitors on coriander crops to facilitate the pollination in coriander and others seed spices.

Among other insects, *Coccinella septempunctata* (1.57%) was the common predatory insect followed by red cotton bug, *Dysdercus koenigii* (1.29%) and *Menochilus sexmaculatus* (1.18%) contributed lot in pollination activities of coriander crop. Some other insects i.e. Lepidoptera and Neuroptera having little or no pollination value that are injurious to plant health (Lepidopteran caterpillar) as well as predacious insect, *Chrysoperla carnea* (Neuroptera: Chrysopidae) to a number of soft bodied insects but their presence may be helpful in pollination of coriander.

Table 1: Diversity of floral visitors visiting coriander in semi arid region of Rajasthan during *Rabi* 2014-15.

Insect visitors	Family	Mean population day-1	Proportion (%) of total visitors
Hymenoptera			
Apoida			
Apis dorsata Fabricius	Apidae	29.5	6.4
Apis florea Fabricius	Apidae	157.8	34.1
Apis mellifera Linn.	Apidae	55.2	11.9
Trigona sp.	Apidae	3.0	0.6
Total Apoidea		245.5	53.1
Other Hymenoptera			
polistes hebraeus Fabricius	Vespidae	1.2	0.3
Camponotus sp.	Formicidae	6.5	1.4
Unidentified hymenoptera sp. 1		5.5	1.2
Unidentified hymenoptera sp. 2		6.8	1.5
Unidentified hymenoptera sp. 3		0.2	0.0
Unidentified hymenoptera sp. 4		1.0	0.2
Total other Hymenoptera		21.2	4.6
Total hymenoptera		266.7	57.6
Diptera			
Episyrphus balteatus	syrphidae	43.7	9.4
Episyrphus sp. 1	syrphidae	22.0	4.8
Eristalis sp. 1	syrphidae	38.5	8.3
Eristalis sp. 2	syrphidae	10.0	2.2
Musca domestica	Muscidae	13.2	2.9
Musca sp. 1	Muscidae	35.8	7.7
Musca sp. 2	Muscidae	3.0	0.6
Musca sp. 3	Muscidae	0.8	0.2
Total Diptera		167.0	36.1
Hemiptera			
Dysdercus koenighii F.	Pyrrhocoridae	6.0	1.3
Oxycarenus laetus	Lygaeidae	1.5	0.3
Bagrada hilaris B.	Pentatomidae	2.0	0.4
Coleoptera			
Coccinella septempunctata	Coccinellidae	7.3	1.6
Menochilus sexmaculatus F.	Coccinellidae	5.5	1.2
Raphilopalpa foevicollis	Chrysomelidae	0.5	0.1
Neuroptera			
Chrysoperla carnea	Chrysopidae	0.2	0.0
Lepidoptera			
Plutella xylostella L.	Plutellidae	1.0	0.2
Helicoverpa armigera H.	Noctuidae	1.7	0.4
Pieris brassicae L.	Pieridae	3.3	0.7
Total others		29.0	6.3
Grand Total		462.7	

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