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## STUDIES ON DIVERSITY AND ABUNDANCE OF INSECT POLLINATORS IN CORIANDER (*CORIANDRUM SATIVUM* L.) AND BLACK CUMIN (*NIGELLA SATIVA* L.) GROWING AREAS OF NEW GANGETIC ALLUVIUM OF WEST BENGAL, INDIA

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### ABSTRACT

Among the seed spices coriander (*Coriandrum sativum* L.) and black cumin (*Nigella sativa* L.) are the dominant seed spices which possess potential export market. Understanding the abundance and diversity of insect fauna that are actively involved in cross pollination is crucial for the production of higher quality seed yield. During the study period (*rabi* season 2018-19 to 2019-20) total 25 insects belonging to 13 genera were observed in coriander growing areas. Further, order Hymenoptera comprised of (86.38%) abundance among all insect visitors in Hoogly when compared to North 24 parganas (67.48%) and Nadia (70.71%) and Shannon diversity indices of insect visitors in New Gangetic alluvial areas was (2.20), evenness (0.68) and richness was about (3.22) during survey. During black cumin blooming period a total of 15 insects belonging to 12 genera were observed. Further order Hymenoptera comprised of (90.96%) abundance among all insect visitors in Hoogly when compared with Nadia (87.98%) and diversity indices of New gangetic alluvial zone was (1.81) which indicates insect visitors are moderately diversified and J value or evenness within the 4 orders of insect visitors being more in Hoogly district (0.74) as compared to Nadia during survey.

**Key words :** Diversity, Abundance, Cross pollination, Shannon diversity index, Evenness.

### Introduction

One-third of the world's crops require pollination to set seeds and majority of them are pollinated by bees. These pollinators also provide an important ecosystem service that is essential for sustaining wild floral biodiversity. Concern over the declining pollinator population followed by sudden disappearance of honey bee colonies are well documented in North America and Europe but have not yet been well researched in other parts of the world including India. The dramatic decline in overall pollinator populations is a critical issue for agriculture production. In order to sustain pollinator services associated with agricultural ecosystems, far more understanding is needed of the multiple goods and services provided by pollinator diversity and the factors that influence their decline and activity. India is fortunate to have four species of honeybees. By adopting a strategy

to increase the number of honeybee colonies, it can become a major producer and exporter of honey and beeswax. It has been estimated that the total annual economic value of crop pollination worldwide is about € 153 billion (Gallai *et al.*, 2009). Historically, India has been recognized as "The home of spices" in the world. India is the world's largest producer, consumer and exporter of seed spice. Seed spices constitute an important group of agricultural commodity and play a very significant role in our national economy. Among them, coriander and black cumin are the prominent seed spices. Coriander constituted 10.35 per cent of total seed spices export with 18.28 per cent of earning during 2012-13. It is the only seed spice included in National crops forecasting system. Coriander (*Coriandrum sativum* L.) is an annual herb belonging to the family Umbelliferae. The flowering phenology of coriander ensures better cross pollination.

Cross pollination in coriander is carried out by different insects among which honey bees are the major pollinators (80.30%) in coriander (Ricciardelli *et al.*, 1979). The bee pollination increased the yield to the extent of 49.86 percent in coriander (Anonymous, 2000). Black cumin (*Nigella sativa* L.) next prominent seed spice after coriander, belongs to the family Ranunculaceae is an annual herbaceous plant. The cumin export during April to December 2016 was 91,000 tons against 67,300 tons exported during 2015-16. It is a hermaphroditic species with determinate flowering patterns, starting with the flower terminating the main shoot and ending with the flowers on the lower most branches. The flowers of Black cumin are visited by honeybees (Ricciardelli and Oddo, 1981).

### Materials and Methods

A survey was conducted for pollinators diversity in coriander and black cumin crop in 3 districts of New gangetic alluvial area which are 50km apart (Table 1). The study had been taken up in 2-4 villages from each district through roving and fixed plot survey. Roving survey had been conducted through direct observation, sweep netting and by setting up yellow pan traps. One square meter cropping area was selected randomly to record different species of insect pollinators and numbers of each species visiting the umbles /flower for every seven days

between 0700 to 1500h of the day at two hourly intervals for 5 minutes during peak flowering period of the crops. At each observation time unit, at least five to ten flowers had been constantly observed for five minutes to record the insect visitors. Pollinators visiting the crop on three spots each of one square meter area were collected, preserved and identified with the help of insect taxonomists and literatures available with Department of Agricultural Entomology, BCKV, Centre for pollination Studies, University of Calcutta and ZSI, Kolkata, West Bengal India.

In field surveys transect sampling techniques had been followed in large sized plots. Passive method of recording the activity of flower visitors in the field had been done by setting up of yellow pan traps, at the base of the plants.

The physical parameters like GPS location, elevation, temperature, RH, Light intensity and time had been recorded during study. Rainy and foggy days had been excluded from the study as insects were less active in such days.

Shannon Weaver diversity index (for assessing relative abundance, species richness and evenness) and Berger- parker index (for assessing dominance of insect species) (Belavadi and Ganeshiah, 2013) were used for

**Table 1 :** Location of survey site.

District	Village	No. of Farms visited	Latitude and Longitude	Crop
North 24 pargnas	Amragachi,	2	22°54'50.6" N088°33'17.0" E, Ele-7m	Coriander
			22°54'45.7" N 088°33'17.4" E, Ele-7m	
	Rajbariya	2	22°54'55" N088°33'6"E, Ele-8m	Coriander
			22°54'57.7" N088°33'08.7" E, Ele-9m	
	Maricha	2	22°55'29.9" N088°32'04.9" E, Ele-12m	Coriander
			22°55'29.8" N088°33'05.1"E, Ele-14m	
Nadia	Muragacha	1	22°58'28.6" N088°32'53.8" E, Ele-9m	coriander
	Anchalarati	2	23°00'44.9" N088°26'45.5" E, Ele-5m	Coriander
			23°00'48.1" N088°26'41.7" E, Ele-9m	
	Chasarati	3	23°00'44.3" N088°26'37.7" E, Ele-5m	Black cumin
			23°00'45.0" N088°26'37.8" E, Ele-7m	Coriander
			23°06'06.2" N088°33'04.5" E, Ele-13m	Black cumin
	Biruhi	1	22°59'57.9" N088°32'26.5" E, Ele-10m	Coriander
	Khorgachhi	1	23°02'32.9" N088°32'12.0" E, Ele-12m	Coriander
Chandrapur	1	23°06'06.1" N088°33'04.5" E, Ele-16m	Coriander	
Hoogly	Balaghar	2	23°05'40" N088°29'52" E	Black cumin
			23°05'40" N088°29'52" E	Coriander

calculating diversity of pollinators by using the formulae given below.

Shannon Wiener diversity index:  $H = -\sum (p_i) \times \ln (p_i)$

H = diversity index,  $p_i$  = proportion of total sample represented by species *i.e.*, Divide no. of individuals of species *i* by total number of samples.

S = number of species, = species richness

$H_{max} = \ln(S)$  Maximum diversity possible, E = Evenness =  $H/H_{MAX}$

## Results and Discussion

### Insect visitors in coriander

Data on diversity of insect visitors/pollinators on coriander flowers been presented in Table 2. In the study area of coriander, total twenty five insect species belonging to eleven families were recorded, in which seven each belonged to orders Hymenoptera and Lepidoptera, six belonged to Diptera, three belonged to Coleoptera. The hymenopterans, lepidopterans and dipterans were

the major floral visitors. The relative abundance of insect pollinators was recorded in North 24 parganas during the blooming period of the crop (percentage of insect fauna/sq.m/5 min). Among flower visitors Hymenopterans had the major proportion of the visiting (67.48%) followed by Dipterans (23.39%) (Table 2). The next notable visitors were Coleopterans (7.17%) and least was with Lepidopterans (1.97%). The relative abundance of insect visitors was recorded in Nadia during the blooming period (Fig. 1), hymenopterans recorded the major proportion of the visiting (70.71%) followed by Dipterans (21.2%). The next notable visitors were Coleopterans (5.17%) and least was recorded in Lepidopterans (2.9%). The relative abundance of insect visitors was recorded in Hoogly district during the blooming period, order Hymenoptera had the major proportion of the visitors (86.38%) followed by order Diptera (7.21%). The next notable visitors were with order Coleoptera (4.17%) share and least was recorded in order Lepidoptera (2.25%). It further revealed that over all relative abundance in New Gangetic alluvial

**Table 2 :** Relative abundance of floral visitors in coriander fields of new Gangetic alluvium of West Bengal.

Insect visitors	North 24 parganas		Nadia		Hoogly		New Gangetic alluvial area	
	Mean	Relative abundance	Mean	Relative abundance	Mean	Relative abundance	Mean	Relative abundance
<i>Apis dorsata</i>	7.75	22.14	6.10	19.28	6.57	17.80	6.80	19.72
<i>Apis cerana indica</i>	6.35	18.14	6.61	20.89	9.84	26.65	7.60	22.02
<i>Apis florina</i>	5.33	15.23	4.91	15.51	6.34	17.17	5.53	16.01
<i>A. mellifera</i>	2.89	8.25	3.72	11.76	7.89	21.37	4.83	14.00
<i>Halictus sp.</i>	1.21	3.46	0.84	2.66	1.25	3.39	1.10	3.19
<i>Nomia sp.</i>	0.09	0.26	0.15	0.46	0.00	0.00	0.08	0.23
<i>Vespa</i>	0.00	0.00	0.05	0.15	0.00	0.00	0.02	0.05
<i>Episyrrhus balteatus</i>	1.31	3.75	1.00	3.16	0.75	2.03	1.02	2.96
<i>Ischiodon scutellaris</i>	0.95	2.72	0.43	1.35	0.36	0.98	0.58	1.68
<i>Erythrinus arvorum</i>	0.36	1.03	0.20	0.62	0.25	0.68	0.27	0.78
<i>Allobuccha sp.</i>	0.14	0.39	0.10	0.33	0.55	1.49	0.26	0.76
<i>Musca sp.1</i>	4.95	14.15	4.65	14.69	0.75	2.03	3.45	9.99
<i>Sarcophaga bercaea</i>	0.46	1.32	0.33	1.05	0.00	0.00	0.26	0.77
<i>Tawny coaster</i>	0.04	0.12	0.19	0.61	0.25	0.68	0.16	0.47
<i>Grey pansy</i>	0.00	0.00	0.08	0.24	0.00	0.00	0.03	0.07
<i>Eurema hecaba</i>	0.13	0.37	0.30	0.94	0.25	0.68	0.23	0.65
<i>Lampides boeticus</i>	0.01	0.02	0.06	0.20	0.00	0.00	0.02	0.07
<i>Papilio demoleus</i>	0.03	0.08	0.04	0.13	0.00	0.00	0.02	0.07
<i>catopsilia Pomona</i>	0.08	0.23	0.08	0.26	0.00	0.00	0.05	0.16
<i>Polyommatus Icarus</i>	0.40	1.15	0.17	0.52	0.33	0.89	0.30	0.87
<i>Coccinella transversalis</i>	1.35	3.87	0.93	2.95	0.75	2.03	1.01	2.93
<i>coccinella septumpunctata</i>	0.97	2.77	0.52	1.64	0.54	1.46	0.68	1.96
<i>Micrispis discolor</i>	0.19	0.53	0.18	0.58	0.25	0.68	0.21	0.60
Total	34.98	100.00	31.62	100.00	36.92	100.00	34.51	100.00

**Table 3 :** Relative abundance of floral visitors in black cumin fields of New Gangetic alluvium of West Bengal.

Insect visitors	Nadia		Hoogly		New Gangetic alluvial area	
	Mean	Relative abundance	Mean	Relative abundance	Mean	Relative abundance
<i>Apis dorsata</i>	8.47	24.90	7.86	18.50	8.17	21.35
<i>Apis florea</i>	6.31	18.55	9.24	21.75	7.78	20.33
<i>Apis cerana</i>	8.49	24.94	11.38	26.78	9.93	25.97
<i>A. mellifera</i>	5.97	17.55	10.17	23.94	8.07	21.10
<i>Halictus sp.</i>	0.69	2.03	0.00	0.00	0.35	0.90
<i>Amata phegea</i>	0.06	0.18	0.00	0.00	0.03	0.08
<i>Eurema hecaba</i> Linnaeus	0.15	0.43	0.25	0.59	0.20	0.52
<i>Danaus chrysippus</i> Linnaeus	0.06	0.18	0.00	0.00	0.03	0.08
<i>Grey pansy</i>	0.14	0.40	0.33	0.78	0.23	0.61
<i>Polyommatus Icarus</i>	0.15	0.43	0.25	0.59	0.20	0.52
<i>Ariadne Ariadne</i>	0.08	0.24	0.00	0.00	0.04	0.11
<i>Musca sp.1</i>	0.79	2.33	0.00	0.00	0.40	1.04
<i>Eristalinus sp.</i>	0.63	1.84	0.45	1.06	0.54	1.40
<i>Episyrphus balteatus</i>	0.77	2.26	1.00	2.35	0.89	2.31
<i>Coccinella transversalis</i>	1.01	2.96	1.23	2.89	1.12	2.92
<i>Coccinella septumpunctata</i>	0.26	0.76	0.33	0.78	0.30	0.77
Total	34.03	100.00	42.49	100.00	38.26	100.00

zone (Table 2) among the 7 hymenopteran species, Indian hive bee *A. cerana* F. comprised of (22.02%), followed by rock bee *A. dorsata* F. (19.72%), little bee *A. florea* F. (16.01%) and European bee *A. mellifera* (14.00%), and among non apis species *Halictus sp.* contributed (3.19%) followed by *Nomia sp.* and *Vespa sp.* (0.23 and 0.05%, respectively). Among the 6 dipteran species, *Musca sp. 1* was the major floral visitor (9.99%). Among the syrphid fly, *Episyrphus balteatus* was the major floral visitor (2.96%) followed by *Ischiodon scutellaris* (1.68%), *Erystalinus arvorum* (0.78%), *Allobucha sp.* (0.76%) and *Sarcophaga bercaea* contributed (0.77%). Among the 7 lepidopteran species *Polyommatus icarus* (0.82%) followed by *Eurema hecaba* (0.65%) *Acraea terpsicore* (0.47%), *Catopsilia pomona* (0.16%), *Lampides boeticus* and *Papilio demoleus* (0.07% each). On the other hand, among the 3 coleopteran species *Coccinella transversalis* contributed (2.93%) followed by *Coccinella septumpunctata* (1.96%) and *Micrispis discolour* (0.60%).

The Shannon-Weaver diversity index (H) is a measure of diversity that combines species richness (the number of species in a given area) and their relative abundances. It tells the level of diversity in that particular area, i.e. it is possible to say the diversity is low or high (since H generally ranges between (0 and 5). H also helps to compare diversity between communities within an area/ ecosystem and diversity between different areas. Species

richness is the most commonly used measure of diversity, but H is strong indicator of diversity.

The pollinator diversity index for all the areas nearly same and moderately dominant computed for the number of insects counted on coriander bloom. Under roving and transect survey total number of insects was counted in districts like North 24 parganas (34.98), Nadia (31.62) and Hoogly (39.92). About Seventy per cent of the total groups (*Apis dorsata*, *Apis cerana indica* F., *Apis mellifera* L. *Apis florea* and *Musca sp.1* were dominant in all the habitats. H max value (Table no.4) showed that distribution of insect visitors was highest in North 24 parganas (2.24), followed by Nadia (2.21) and Hoogly (1.99). Evenness of insect visitors was more in Hoogly comprised of (0.73) followed by North 24 parganas (0.71) and Nadia (0.69) also indicating closeness among the relative abundance of insect groups. Species richness was more in Nadia (3.22), followed by North 24 parganas (3.14) and Hoogly (2.71) shown in Table 4.

The present results are partially in agreement with the findings of Chaudhary and Singh (2007) reported 34 species of insects belonging to 18 families and 8 orders on coriander bloom at Haryana. Koul *et al.* (1989) reported large number of insect species (Isoptera, Hymenoptera, Orthoptera, Diptera, Hemiptera, Lepidoptera and Coleoptera) on coriander bloom. In the present study, among all the insects *Apis cerana* was

**Table 4 :** Diversity index, Evenness, Species richness and Dominance of insect visitors in coriander and black cumin.

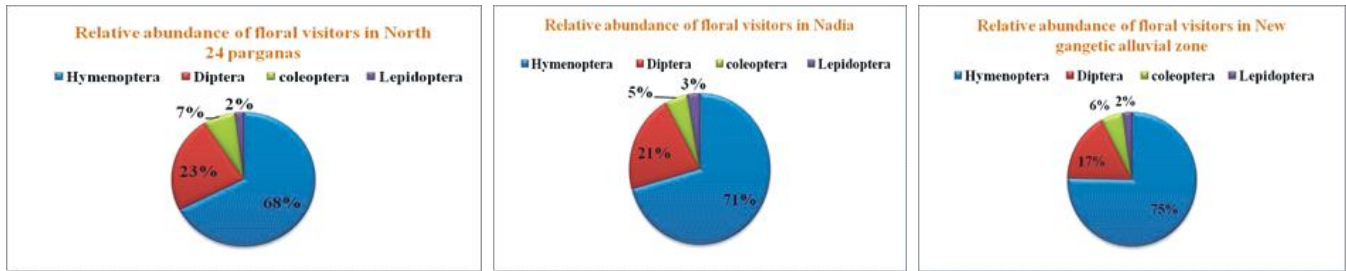
Location	Shanon Weaver Index	Species richness (Hmax=ln(s))	Species evenness (J=H/Hmax)	Dominance (1- J)
<b>Coriander</b>				
North 24 parganas	2.24	3.14	0.71	0.29
Nadia	2.21	3.22	0.69	0.31
Hoogly	1.99	2.71	0.73	0.27
Overall New Gangetic alluvial area	2.20	3.22	0.68	0.32
<b>Black cumin</b>				
Nadia	1.88	2.71	0.69	0.31
Hoogly	1.71	2.30	0.74	0.26
Overall New Gangetic alluvial area	1.81	2.71	0.67	0.33

higher in New gangetic alluvial area where coriander crop is grown. Similar observations have been made by Ranjitha *et al.* (2019). The family, Apidae constituted the major pollinators among the total pollinator guild. Within Apidae, Indian bee (*Apis cerana indica* F.). The pollinator diversity indices are in a given range of 0 to 4.6 (Mudri-Stojnic *et al.*, 2012). Results further revealed that overall diversity indices of insect visitors in New Gangetic alluvial areas was (2.20), evenness (0.68) and richness was about (3.22). Different ranges of Shannon Wiener diversity index have also been calculated by various workers. For example, Shannon Weiner diversity index ranged from 2.262 to 2.945 for hymenopterans pollinators of Himalayan foot hills (Hussain *et al.*, 2012) and from 1.478 to 2.653 for hymenoptera and diptera in semi- natural habitats (Mudri-Stojnic *et al.*, 2012).

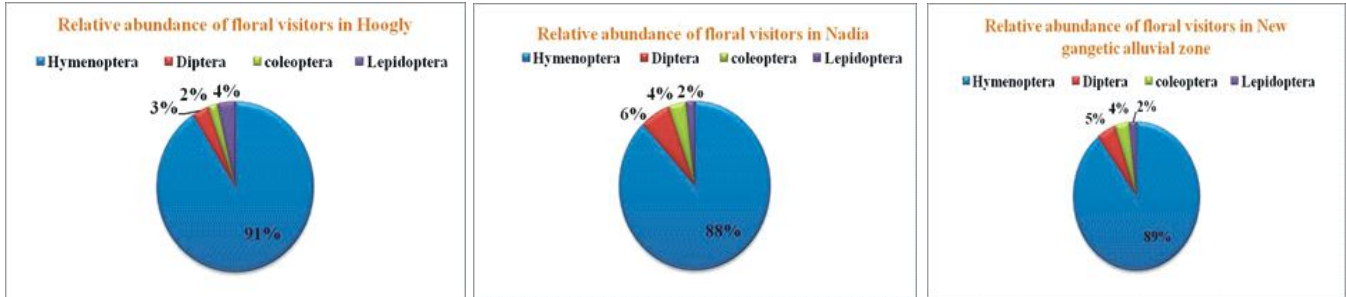
#### **Insect visitors in Black cumin**

Fifteen species of insect pollinators were recorded during blooming period on black cumin. Among them, six species of insect pollinators belonging to Lepidoptera, five species belong to order Hymenoptera, three species to Diptera and two species to coleoptera represented in Table 3. The relative abundance of insect pollinators was recorded in Nadia during the blooming period of the crop (percentage of insect fauna/sq.m/5 min) among flower visitors, Hymenoptera had the major proportion of the visiting (87.98%) followed by Diptera (6.43%). The next notable visitors were recorded in Coleoptera (3.73%) and least was with Lepidoptera (1.87%). The relative abundance of insect visitors was recorded in Hoogly district during the blooming period (Fig. 2) among flower visitors, Hymenoptera had the major proportion of the visiting (90.96%) followed by Diptera (3.41%). The next notable visitors were Coleopterans (1.95%) and least was recorded with order Lepidoptera (3.67%). Results further

revealed that overall diversity of insect visitors in New Gangetic alluvial zone of Black cumin growing areas furnished in Table 3. Among the 5 hymenopteran species, Indian hive bee *A. cerana* F. (25.97%) followed by European honeybee *A. mellifera* and rock bee *A. dorsata* F. (21.10 and 21.35%, respectively and little bee *A. florea* F. (20.33%) and among non apis species *Halictus sp.* contributed (0.90%). Among the syrphid fly, *Episyrphus balteatus* was the major floral visitor (2.31%) followed by *Eristalinus sp.* (1.40%) and *Musca sp.1* (1.04 %). Among the 6 lepidopteran species *Junonia sp.* (0.61 %) was major floral visitor followed by *Eurema hecaba* and *Polyommatus icarus* contributed (0.52 % each), *Ariadne ariadne* (0.11%) and *Danaus chrysippus* and *Amata phega* (0.08% each). On the other hand, among the 2 coleopteran species *Coccinella transversalis* contributed was (2.96%) and *Coccinella septumpunctata* (0.76%). Among the 3 coleopteran species *Coccinella transversalis* contributed (2.92%) followed by *Coccinella septumpunctata* (0.77%). The pollinator diversity index for all the areas nearly same and moderately dominant computed for the number of insects counted during black cumin blooming period furnished in Table 4. Under roving and transact survey total number of insects was counted in districts like Nadia (34.03%) and Hoogly (42.49%). About Seventy per cent of the total groups (*Apis dorsata*, *Apis cerana indica* F., *Apis mellifera* L. *Apis florea* were dominant in all the habitats. H max value (Table 4) showed that distribution of insect visitors was highest in Nadia (1.88) followed by Hoogly (1.71). Evenness of insect visitors was more in Hoogly comprised of (0.74) followed by Nadia (0.69) also indicating closeness among the relative abundance of insect groups. Species richness was more in Nadia (2.71), followed by and Hoogly (2.30).



**Fig. 1 :** Relative abundance of floral visitors in coriander growing areas of New gangetic alluvial areas of West Bengal.



**Fig. 2 :** Relative abundance of floral visitors in black cumin growing areas of New gangetic alluvium of West Bengal.

These findings were in conformity with results of Meena *et al.* (2018) studied Cumin flowers, which were visited by 20 species of insects belonging to 11 families from 6 orders. Apoidea (62.4%) and Diptera (27.5%) were the two major groups comprising 89.9% of the total visitors. Overall diversity indices of New gangetic alluvial zone was (1.81), which indicates insect visitors are moderately diversified and J value or evenness within the 4 orders of insect visitors being more in Hoogly district (0.74) as compared to Nadia. Similarly, Shannon Weiner diversity index ranged from 2.262 to 2.945 for hymenopterans pollinators of Himalayan foot hills (Hussain *et al.*, 2012) and from 1.478 to 2.653 for hymenoptera and diptera in semi-natural habitats (Mudri-Stojnic *et al.*, 2012).

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