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RESEARCH ARTICLE

A PRELIMINARY STUDY ON THE SUCCESSION OF INSECT VISITORS AND THEIR SYMBIOTIC INTERACTION FOR EFFECTIVE POLLINATION IN *BRASSICA JUNCEA* (L.) OF SOUTHERN WEST BENGAL.

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Abstract

A preliminary study was conducted for nine days in a commercial crop field at Haripal in Hooghly district of West Bengal during the flowering phase of *Brassica juncea* L. to observe the periodical occurrence of various insect visitors and their role in pollination. 29 insect species belonging to 16 families under 7 orders were recorded as visitors of *Brassica*. As a whole, Lepidoptera had maximum number of species occurrence followed by Coleoptera and Hymenoptera. It has also been observed that species were found to visit in different parts of plant but most of them had a common location with flowers. It is indicated that most of the insect species has specific intension of nectar collection which led the pollination efficiency. Symbiotic interaction of the visited insect species was also studied.

Introduction:-

Survey of insect pollinators in any cultivation field is a common field work practice to get an idea of abundance of pollinator species or visitors (Mitra, 2010; Mitra et al., 2005). The blooming phase of any plant is the most crucial period as the diversity of insects, both occasional and regular is higher than any other phase of that plant species (Bhalchandra et al., 2014; Rasheed et al. 2015; Ali et al., 2015; Nicholls and Altieri, 2012; Belavadi and Ganeshaiah, 2013). However, there are many species which perform their activities only as visitor of flowers or sometimes remain as local inhabitants only. So, overall survey and inventory of insect species at the blooming phase of nectar plants keep records of taxa, their availability and abundance.

However, the major aims of the present study was to record the insect diversity and their visitation pattern, visited plant parts, presence and absence during the flowering period, abundance, and moreover their biological role on *Brassica juncea* L. According to Atmowidi et al. (2007) and Kunjwal et al. (2014), the location of the collected specimens on plant individuals, like flower, leaf, stem etc. and also their pollination status like effective pollinators, visitors etc. can give an idea of plant-insect interaction of *Brassica* sp. There are earlier studies also which revealed

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the insect species abundance of *Brassica* sp. at the blooming phase (Atmowidi et al., 2007; Goswami and Khan, 2014).

The mutual occurrence of species-pairs is a co-species or con-generic interaction where more than two species assemblage for the same resources (Kulloli et al., 2011; Hu et al. 2005). The presence of a species or any particular taxon may affect the occurrence of another species or some taxon at the same time period (Alagumurugan et al. 2011; Navatha et al., 2012; Duara and Kalita, 2013). The symbiotic interactions between species-pairs among the insect species were also noticed in the present study. But the conclusion in details this type of symbiotic information could not be possible from the present study as the records of mutual occurrences were mostly based on limited observation.

The present study reports 29 insect species belonging to 16 families under 7 orders of insect visitors of *Brassica juncea* L. Of them, Lepidoptera shares maximum number of species (8 species), followed by Coleoptera (7 species) and Hymenoptera (5 species).

Methods:-

The study was conducted at Krishnapur, Haripal in Hooghly district of West Bengal ($22^0 49'$ N, $88^0 6'$ E). The insect species on *Brassica juncea* L. during its blooming phase was recorded from 22nd January to 19th February of 2016. The study site (almost 937.56m^2) was a cultivation land of *Brassica*. The samplings were planted keeping an average distance of 20cm x 2 cm. The flower visitors were observed for an interval of each 2 minutes within quadrate plots of 1 m^2 each. The study was carried out for 9 days of flowering session. The overall observation was recorded by four session, *viz*., 08:00-10:00 hours (Session 1), 10:00-12:00 hours (Session 2), 12-14 hours (Session 3) and 14-16 hours (Session 4) of each day (GMT+5:30).

Collection of insects was made by insect sweeping net and hand picking methods. The insect species were collected from the samplings of the study sites and from four different locations of the plant individual. The specimens were identified with the help of the experts of Zoological Survey of India, New Alipore, Kolkata.

Result:-

Of the collected insect species, *Delias eucharis* (Drury, 1773), *Pseudozizeeria maha* (Kollar 1848) and *Eurema hecabe* (Linnaeus, 1758) were found exclusively on flowers. It was also noticed that *Lipaphis erysimi* Kaltenbach, 1843 and *Modicogryllus* sp. were found to visit different parts of *Brassica* other than flowers. One species, *Modicogryllus* sp. was found to visit only close to root of the plant species. No species were found to visit only stems or leaves of any individual plant. Among the 29 species reported as visitors of *Brassica juncea* L., the maximum number of species were found from flower (27), followed by Leaf (22) and Stem (10) (Table 1).

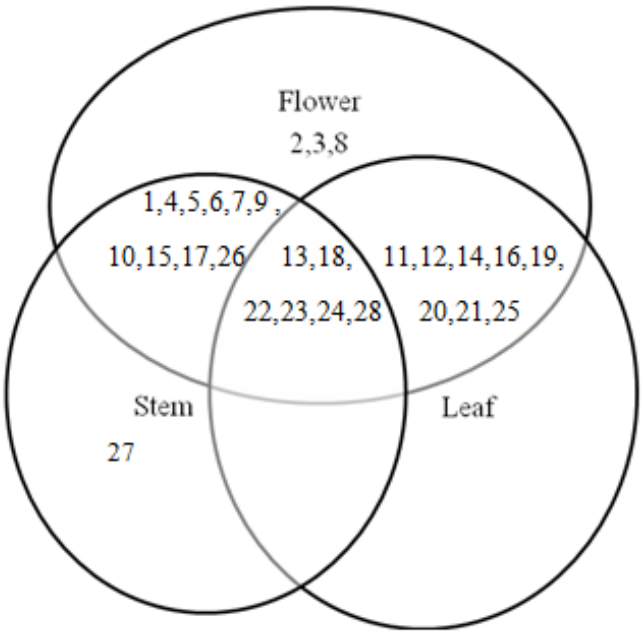
Table 1:- List of insect species and their locations when observed on *Brassica juncea* L.

No.	Species	Order	Family	Locations			
				Flower	Stem	Leaf	Near root
1	*Danaus genutia* (Cramer, 1779)	Lepidoptera	Nymphalidae	Y		Y	
2	*Delias eucharis* (Drury, 1773)	Lepidoptera	Pieridae	Y			
3	*Pseudozizeeria maha* (Kollar 1848)	Lepidoptera	Lycanidae	Y			
4	*Junonia almana* Linnaeus, 1758	Lepidoptera	Nymphalidae	Y		Y	
5	*Amata cyssea* Stoll, 1782	Lepidoptera	Erebidae	Y		Y	Y
6	*Amata passalis* (Fabricius, 1781)	Lepidoptera	Erebidae	Y		Y	Y
7	*Plutella* sp.	Lepidoptera	Plutellidae	Y		Y	
8	*Eurema hecabe* (Linnaeus, 1758)	Lepidoptera	Pieridae	Y			
9	*Apis (Apis) cerena indica* Fabricius, 1798	Hymenoptera	Apidae	Y		Y	Y
10	*Xylocopa fenestrate* (Fabricius, 1798)	Hymenoptera	Apidae	Y		Y	Y
11	*Camponotus* sp.	Hymenoptera	Formicidae	Y		Y	
12	*Solenopsis* sp.	Hymenoptera	Formicidae	Y		Y	
13	*Tetraponera* sp.	Hymenoptera	Formicidae	Y	Y	Y	

14	*Altica* sp.	Coleoptera	Chrysomelidae	Y		Y	
15	*Aulachophora* sp.	Coleoptera	Chrysomelidae	Y	Y		
16	*Coccinella septempunctata* (Linnaeus, 1758)	Coleoptera	Coccinellidae	Y		Y	
17	*Anisolemnia* sp.	Coleoptera	Coccinellidae	Y	Y		
18	*Genocethalum* sp.	Coleoptera	Tenebrionidae	Y	Y	Y	
19	*Tachys* sp.	Coleoptera	Carabidae	Y		Y	
20	*Phyllotreta striolata* Fabricius, 1801	Coleoptera	Carabidae	Y		Y	
21	*Episyrphus balteatus* (De Geer, 1776)	Diptera	Syrphidae	Y		Y	Y
22	*Atherigona* sp.	Diptera	Muscidae	Y	Y	Y	
23	*Ischiodon scutellaris* (Fabricius, 1805)	Diptera	Syrphidae	Y	Y	Y	
24	*Crocothemis servilia* (Drury, 1773)	Odonata	Libellulidae	Y	Y	Y	
25	*Rhyothemis variegate* (Linnaeus, 1763)	Odonata	Libellulidae	Y		Y	
26	*Chrysocoris stolli* (Wolff, 1801)	Hemiptera	Scutelleridae	Y	Y		Y
27	*Lipaphis erysimi* Kaltenbach, 1843	Hemiptera	Aphididae		Y	Y	Y
28	*Dysdercus* sp.	Hemiptera	Pyrrhocoridae	Y	Y	Y	
29	*Modicogryllus* sp.	Orthoptera	Gryllidae				Y

From the present investigation (Fig.1) it was also revealed that, the insect found to visit maximum in both the plant parts i.e., Flower and Leaf (15) followed by Flower and Stem (03), Stem and Leaf (01), whereas 06 species were only found to visit in commonly used location i.e., Flower, Stem and Leaf (Figure 1).

Figure 1:- species (number were used as identity according to the list of table 1) found from different locations (flower, leaf and stem), location-pairs and commonly used location.



The reported species of the present investigation was categorized as per the previous records and references (Table 2). Out of 29 species reported here, only 5 species, *Apis (Apis) cerena indica* Fabricius, 1798 (Hymenoptera), *Xylocopa fenestrata* (Fabricius, 1798) (Hymenoptera), *Episyrphus balteatus* (De Geer, 1776) (Diptera), *Atherigona* sp. (Diptera), *Ischiodon scutellaris* (Fabricius, 1805) (Diptera) were reported as effective pollinators. Apart from these, 10 species, namely, *Danaus genutia* (Cramer, 1779) (Lepidoptera), *Delias eucharis* (Drury, 1773) (Lepidoptera), *Pseudozizeeria maha* (Kollar 1848) (Lepidoptera), *Junonia almanac* Linnaeus, 1758 (Lepidoptra), *Plutella* sp. (Lepidoptera), *Eurema hecabe* (Linnaeus, 1758) (Lepidoptera), *Camponotus* sp. (Hymenoptera), *Solenopsis* sp. (Hymenoptera), *Tetraponera* sp. (Hymenoptera), *Anisolemnia* sp. (Coleoptera) were recorded as

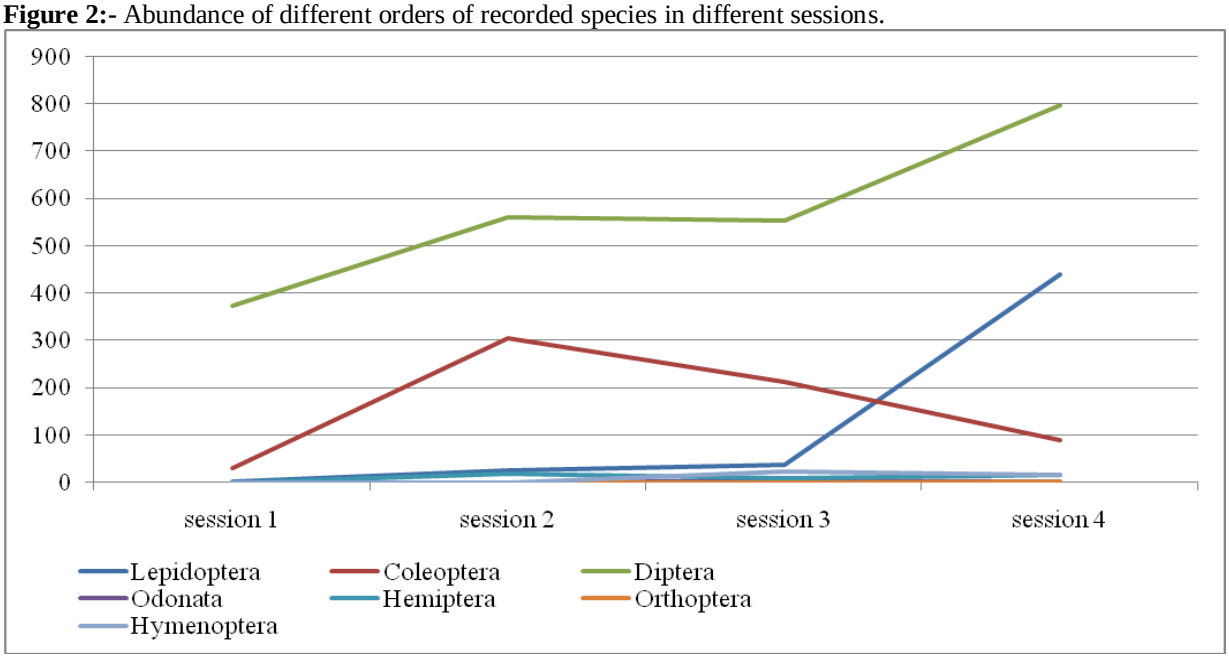
pollinators by several authors. Three species, i.e. *Amata cyssea* Stoll, 1782 (Lepidoptera), *Amata passalis* (Fabricius, 1781) (Lepidoptera), *Coccinella septempunctata* (Linnaeus, 1758) (Coleoptera) were recorded as flower visitors. As per the published literature, there is nothing known about the pollination efficiency or as flower visitors of the rest of the species reported during this present investigation.

Table 2:- List of insect species found on *Brassica juncea* L. in present survey and their role on plant (as per earlier records)

No.	Species	Effective Pollinator	Pollinator	Flower Visitor	Others
1	*Danaus genutia* (Cramer, 1779)		Y		
2	*Delias eucharis* (Drury, 1773)		Y		
3	*Pseudozizeeria maha* (Kollar 1848)		Y		
4	*Junonia almana* Linnaeus, 1758		Y		
5	*Amata cyssea* Stoll, 1782			Y	
6	*Amata passalis* (Fabricius, 1781)			Y	
7	*Plutella* sp.		Y		
8	*Eurema hecabe* (Linnaeus, 1758)		Y		
9	*Apis (Apis) cerena indica* Fabricius, 1798	Y			
10	*Xylocopa fenestrata* (Fabricius, 1798)	Y			
11	*Camponotus* sp.		Y		
12	*Solenopsis* sp.		Y		
13	*Tetraponera* sp.		Y		
14	*Altica* sp.				Y
15	*Aulachophora* sp.				Y
16	*Coccinella septempunctata* (Linnaeus, 1758)			Y	
17	*Anisolemnia* sp.		Y		
18	*Genocethalum* sp.				Y
19	*Tachys* sp.				Y
20	*Phyllotreta striolata* Fabricius, 1801				Y
21	*Episyrphus* sp.	Y			
22	*Atherigona* sp.	Y			
23	*Ischiodon scutellaris* (Fabricius, 1805)	Y			
24	*Crocothemis servilia* (Drury, 1773)				Y
25	*Rhyothemis variegata* (Linnaeus, 1763)				Y
26	*Chrysocoris stolli* (Wolff, 1801)				Y
27	*Lipaphis erysimi* Kaltenbach, 1843				Y
28	*Dysdercus* sp.				Y
29	*Modicogryllus* sp.				Y

Considering to the availability and abundance of the insect groups visited *Brassica*, the number of species of order Coleoptera was found to be higher from session 1 to session 2, and lesser in session 3 and session 4 accordingly, lepidopteran species were found in higher abundance from session 1 to session 4. The number of the recorded species of order Diptera was found to be increased gradually throughout the study period (Figure 2).

Figure 2:- Abundance of different orders of recorded species in different sessions.



During this present study, it has been observed that, the number of occurrence of *Altica* sp. (Coleoptera) was found to be increased with the increase of the number of *Amata passalis* (Fabricius, 1781) and *Amata cyssea* Stoll, 1782 (Lepidoptera). Similarly the number of occurrence of *Lipaphis erysimi* Kaltenbach, 1843 (Hemiptera) was found to be increased with the increase of the number of *Plutella* sp. (Lepidoptera). Increased number of *Eurema hecabe* (Linnaeus, 1758) (Lepidoptera) was coupled with the increased number of occurrence of *Coccinella septempunctata* (Linnaeus, 1758) (Coleoptera). There was no data had been recorded to comment on the correlation of the occurrences of species-pairs. But the personal observation state that the abundance (by numbers) of *Plutella* sp. had been increased when the numbers of *Amata passalis* (Fabricius, 1781) and *Amata cyssea* Stoll, 1782 had decreased. Similarly, the number of *Altica* sp. had been higher when the number of *Plutella* sp. was less.

Discussion:-

Most of the species in the present study had been recorded within a pre-determined time schedule. There was no study of visitation frequency or duration of stay or amount of pollen carried by the insect individuals had been conducted. The species which were mentioned as pollinators or effective pollinators were stated purely on the basis of earlier references (Sung et al., 2006; Chen et al., 2015; Sajjad et al., 2015; Roy and Mitra, 2012).

The species which were observed in the different parts of plant individuals probably denoted their nature of interaction with the nectar plants (Thakur and Mattu, 2014; Hayter and Cresswell, 2006). Species which were mostly found on flowers most of them were pollinators, however, pollinator species might be found on other parts of plants like leaf, stem etc. In other words, pollinator species have specific intension for nectar and also target locations like flowers (Westphal et al., 2003; Rajkumar et al., 2015; Bhuyan et al. 2005). But some species which are casual visitors or occasional pollinators can be found different locations of nectar plants even excluding flowers as they don't have such intensions (Sima et al., 2014; Rajkumari et al., 2014**)**.

The efficiency of pollination of certain species can be affected by the presences of other species (Meena et al., 2015; Mahmoud and Shebl, 2014; Navatha and Sreedevi, 2012). During this study, it has been observed that the number and presence of specific insect species/group is responsible for presence or abundance of other insect species/group. For examples, in between *Altica* sp. (Coleoptera) and *Amata passalis* (Fabricius, 1781) and *Amata cyssea* Stoll, 1782 (Lepidoptera), *Lipaphis erysimi* Kaltenbach,1843 (Hemiptera) and *Plutella* sp. (Lepidoptera) and *Eurema hecabe* (Linnaeus, 1758) (Lepidoptera) and *Coccinella septempunctata* (Linnaeus, 1758) (Coleoptera).

The presence of more than one species depending on same resources sometime shows the symbiotic interaction between species or order pairs (Abid et al., 2010; Dharmendra et al., 2014). This symbiotic interaction might be

positive or negative, as the presence or absence of any order or species may allow or restrict some other order (Kapkoti et al., 2016; Revathi and Remadevi, 2011). In the present study, the session-wise abundance of order Diptera has negatively related with the order Coleoptera and positively related with the order Hemiptera.

The overall study showed the species abundance of different orders in the blooming stage of *Brassica juncea* L. Of them, Lepidoptera had maximum number of species occurrence followed by Coleoptera and Hymenoptera. The blooming period of *Brassica juncea* L. varies from 20 days to 22 days depending on many environmental factors (Roy et al., 2014). This study also revealed that, most of the insect species start to visit at its full grown time and reduces their occurrence gradually. Similarly, many species occur at the post blooming phase (after 8 to 9 days of blooming) and stay still they are dried up. There are also some species which were found irregularly throughout the blooming session and there was no specific interaction with other co-taxa.

In the present study, there was no species which was collected exclusively from stem or leave. The species which was collected from stem and leaves was mostly local inhabitants and frequently available. Many species were found in different plant parts but most of them had a common location with flowers. It clearly indicates that most of the insect species has specific intension of nectar collection which led the pollination efficiency. Present study also focused that presence of other non-specific insect groups may also act as indicator of specific pollinator groups and their symbiotic interaction may cause the effective pollination of that particular crops.

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