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Floral Visitors of Different Crops as Recorded from an Agro-Ecosystem near Jhunjhunu, Rajasthan (India)

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Abstract: ***The relationship between pollinators and flowering plants is one of the mutually beneficial relationships in the natural world. The loss of a pollinator could cause the collapse of an ecosystem. During the present study an attempt has been made to record the floral visitors of different crops from an agro-ecosystem near Jhunjhunu, Rajasthan, India. The crop field comprised of different crops during the study period and included pearl millet, cotton, sorghum, cluster beans and mung bean during April to October, while, during November to March the major crops in the agricultural fields were mustard, rye, wheat, barley, gram and fenugreek. In all, 50 insect species belonging to 25 families and 7 orders were observed on flowers of various crops cultivated in the agro-ecosystem. Further, of these, based on number 9 were frequent and 41were rare visitors.***

Keywords: Floral visitors, agro-ecosystems, Crops, Rajasthan

1. Introduction

Insects are the most diverse and abundant of all terrestrial animals. They play a very important role in the ecosystem due to their vast diversity of form, function and life-style; their considerable biomass; and their interaction with plant life, other organisms and the environment. They aerate the soil, pollinate blossoms, and control insect and plant pests; they also decompose dead materials, thereby reintroducing nutrients into the soil. Insects have a direct impact on agricultural food production as on one side they act as pollinators while on the other act as pests. The relationship between pollinators and flowering plants is one of the mutually beneficial relationships in the natural world. The loss of a pollinator could cause the collapse of an ecosystem. Pollinators are also required for the successful proliferating communities and wildlife habitats. Estimates suggest that approximately 73 percent of the world's cultivated crops are pollinated by some varieties of bees, 19 percent by files, 6.5 percent by bats, 5 percent by wasps, 5 percent by beetles, 4 percent by birds and 4 percent by butterflies, indicating that most of the plant species rely on insects for pollination. Looking into the importance of insect pollinators, agricultural practices must be designed to incorporate the protection and sustainable management of pollinators.

Over the last few decades the perception has been growing among pollination biologists that pollinators have declined in numbers resulting in decreased seed and fruit set in the plants that they service. Threats to pollinators include habitat reduction, use of pesticides and other agrochemicals, invasive species, fungal, protozoan and bacterial diseases, modern agricultural practices etc. The present study was therefore planned to observe and document insect visitors on various crops cultivated in an agro-ecosystem near Jhunjhunu , Rajasthan (India).

2. The Study Area and Methodology

The state of Rajasthan is the largest state of Indian republic located between 23º3' to 20'13 N latitude and 69º30' to 78º17'C longitudes and the area under study falls in the Indian desert near Jhunjhunu situated in Rajasthan, India. The crop field comprised of different crops during the study period and included pearl millet, cotton, sorghum, cluster beans and mung bean during April to October, while, during November to March the major crops in the agricultural fields were mustard, rye, wheat, barley, gram and fenugreek.

As the study concentrated on insect visitors, therefore, the flowering period in different crops was also recorded. The flower status whether solitary or in the form of inflorescence and the colour and size of flowers were also documented. It was also noted that whether the flowers released scent or not (Table 2.). Visit of a particular insect species to a specific flower was documented and expressed as number of visits/man/h. The insect visitors to different flowering crops were surveyed and collected every week from November 2011 to October 2013. For the study, the field area was divided into five stations from where the insects on flowers were collected. Sweep net was used for insect collection. The insects collected by the above method were transferred to killing bottles, killed and preserved. Large winged insects were put to dry preservation by pinning them in insect boxes, while smaller insects were preserved in 70% alcohol. The fauna were sorted out group wise and help from the Section of Entomology, Department of Agriculture, Bikaner and Desert Regional Station of the Zoological Survey of India, Jodhpur was also taken for identification and for confirmation. Besides, the reference collection in the Department of Zoology, Dungar College was also consulted.

3. Results and Discussion

During the present study, different insects visiting flowers were documented and have been presented in Table 1. In all, 50 insect species belonging to 25 families and 7 orders were

observed on flowers of various crops cultivated in the agro-ecosystem. Further, of these, based on number 9 were frequent and 41were rare visitors.

During April to October the inflorescence of pearl millet was noted to be visited by 20 insects (*P. nasutus, C. pictus, A. ferruginea, C. vestalis, C. fieldii, E. hecabe, D. chrysippus, M. separata, H. fasclies, S. exigua, E. zinckenella, Tephrina* sp. *Oncocephalus* sp., *A. cerana, A. melliferea, A. dorsata, A. florea, Delta* sp., *C. quinquefasciatus* and *Stichopogon* sp.); 2 on cotton (*C. fieldii* and *E. hecabe*); 8 on sorghum (*D. chrysippus, C. fieldii, E. hecabe, M. separata, H. recurvalis, Tephrina* sp., *A. dorsata* and *C. quinquefasciatus*); 12 on cluster beans (*C. vestalis, C. fieldii, H. recurvalis, N. viridula, D. cingulatus, X. violacea, A. cerana, A. mellifera, A. dorsata, E. farternus, C. quinquefasciatus* and *Euconocephalus* sp.); 14 on mung bean (*O. catta, O. bonasus, Adoretus* sp., *P. nasutus, Myllocerus* sp., *C. vestalis, C. fieldii, E. hecabe, L. boeticus, D. chrysippus, X. violacea, A. cerana, A. mellifera* and *C. quinquefasciatus*.).

During November to March the inflorescence of mustard was found to be visited by most number of insects (30) which included *C. septempunctata, M. sexmaculatus, Myllocerus* sp., *C. pomona, C. vestalis, C. fieldii, E. hecabe, A. aurota, D. chrysippus, L. boeticus, J. orithya, M. separata, A. ipsilon, S. exigua, H. recurvalis, C. medinalis, U. pulchella, Tephrin*a sp., *L. erysmi, X. fenestrata, X. violacea, A. cerana, A. mellifera, A. dorsata, A. florea, Polistes* sp., *C. megacephala, C. rufifacies, C. quinquefasciatus* and *C. carnea*; followed by 17 on rye *C. septempunctata, M. sexmaculatus, Myllocerus* sp., *C. vestalis, C. fieldii, E. hecabe, L. boeticus, D. chrysippus, E. insulana, M. separata, A. ipsilon, Tephrina* sp., *A. cerana, X. violacea, A. dorsata, A. florea*, and *C. quinquefasciatus*; 17 also on wheat (*C. septempunctata, M. sexmaculatus, Myllocerus* sp., *C. vestalis C. fieldii, E. hecabe, D. chrysippus, J. orithya, L. boeticus, Tephrina* sp., *X. violacea, A cerana, A. dorsata, A. florea, Enicospilus* sp., *C. quinquefasciatus and C. carnea*); 10 on barley (*C. septempunctata, M. sexmaculatus, C. vestalis, C. fieldii, C. chrysippus, Tephrina* sp., *A. cerana, X. violacea, C. quinquefasciatus and C. carnea*); 7 on gram (*C. fieldii, D. chrysippus, L. boeticus, A. cerana, A. dorsata, A. florae* and *S. brunneum*); 15 on fenugreek (*P. nasutus, H. truncatulus, C. septempunctata, C. fieldii, E hecabe, L. boeticus, D. chrysippus, J. orithya, E. insulana, T. orichalcea, X. violacea, A. cerana, Enicospilus* sp., *C. quinquefasciatus* and *C. carnea*).

4. Discussion

The number of flowers visited / minute by any bee species depends upon a number of factors including floral structure (Free 1970) instinctive foraging behavior, length of proboscis (Inouye, 1980), corolla depth (Gilbert, 1980), type and quantity of floral rewards (Rao & Suryanarayana, 1990; Rao, 1991), besides density of flowers and hour of the day.

Coriander flowers are scented and bees visiting flowers possessing strong odour was observed by Bogoyanlenseii & Akimenko (1966). Agarwal & Rastogi (2008) also noticed hymenopterans on the flowers of *L. cylindrica*. According to Hodges & Baxendale (2007) cucumber flowers are exclusively pollinated by honeybees and it takes at least 9 honeybee visits / flower to pollinate cucumber adequately. Carrillo et al. (2007) observed honeybees as pollinators of *C. melo*. Singh et al. (2006) reported that most of the insect pollinators of Brassica crops belong to *Apis* species. *A. mellifera, A. dorsata* and *A. cerana* as floral visitors of mustard were also observed by Povada et al. (2004). Honeybees are efficient pollinators of *B. campestris* were also observed by Langride & Goodmen (1975); Mohar & Jay (1988) and Perveen et al. (2000) and therefore, support the present findings.

Sekhar & Gowda (2006) noted bees on brinjal flowers from November to July. According to Tootland & Mathews (1998) flower density was much more important than temperature, humidity, time of day and season in explaining variation in bee numbers, total numbers of flowers visited, the number of flowers visited by individual bees and the total number of visits / flowers. Singh et al. (2006) suggested most of the insect pollinators of *Brassica* crops belong to *Apis* species. Heithans (1974) observed a positive relationship between bee and floral abundance. Change in major weather factors such as temperature and RH might be responsible for the difference in visitation rate of honeybee was suggested by Selva Kumar et al. (1996). Bee foraging activity is highly influenced by prevailing weather factors have also been reported by Szabo (1980), Sihag & Abrol (1986), Abrol (1987). This could be true for the present study also.

According to Cervencia & Bargonia (2000) the most common flower visitors of cucumber included *X. chorna* and *X. philippinensis*. Earlier *Xylocopa* bees as pollinator of cucurbit crop were also identified by Njorage et al. (2004) which corroborate the present findings. Thapa (2006) and Hannan (2007) also reported *Xylocopa* as insect pollinators of *Brassica*. *X. virginica* as floral visitors of *Delphinium* by Macior (1975), *Xylocopa basilis* and *X. fenestreta* as pollinators of Alfalfa were reported by Ahmed (1976); *X. virginica* as pollinator of milkweed by Kephart (1983), Ivey et al. (2003); X. aestuans as visitor of *Acacia* by Stone et al. (2003), X. aestuans as visitors of *Justicia* by Sheikh (2005), *X. aestuans* as visitors of Teak by Tangmitcharoen et al. (2006).

According to Martin (1993) *Xylocopa* spp. are common visitors of *Acacia* flowers, transport large pollen loads, move large distances between plants. Lane (1996) also considered *Xylocopa* as efficient pollinators and reported that *Xylocopa* have a tendency to collect pollen and nectar simultaneously. Amoako & Yeboah (2000) found *Xylocopa* to be an important pollinator of *S. melongena* and *Xylocopa darwini* was noted as visitor of *Lecocarpus pinnatifidus* (Asteraceae) by them. Two solitary bees including *Xylocopa caffra* were identified as effective pollinators of *Solanum melongena* in Kenya, by Herren & Ochieng (2008). Somanathan & Borges (2002) found that the number of carpenter bees visiting a tree per minute and number of flowers visited per visiting bout were positively related to the size of the floral display. Ahmed (1976) observed the visit of *Xylocopa bassiles* ranged between 4–10 (average 7 flowers / min).

Macior (1975) also reported butterfly as important pollinator of *Delphinium. Danaus* as pollinator of *Satyrium* was observed by Johnson (1997), as pollinator of Asteraceae and representing nearly 75% of all visitors by Mani & Sarvanan (1999), of milkweed by Ivey et al. (2003), of *Wedelia calendulacea* by Mitra et al. (2004), of *Justicia* by Seikh (2005), of *Woodfordia floribonda* by Soloman Raju (2005), of Teak flowers by Tangmitcharoen et al. (2006). *D. plexippus* as a floral visitor of brinjal has also been reported by Thapa (2006). *Danaus* as pollinator of *Strobilanthes consangoinea* was suggested by Anitha & Prasad (2007). *D. chrysippus* was recorded to transport some pollen of *Acacia*, by Martin (1993). Thapa (2006) reported *Lampides boeticus* to visit flowers of *L. siceraria, B. campestris and S. melongena*.

Maner et al. (1999) observed milkweed flowers to attract *C. pipiens* and Anderson & Joenson (1986) who found *C. pipiens* to feed on nectar of *Tanacetum vulgare*. According to Jhumur et al. (2006) *C. pipiens* are effectively attracted by appropriate floral scent of flowers. The male members of Culicidae are floral visitors which feed on nectar and other plants. Dipterans as visitors to the flowers of chervil were reported by Knuth (1908) and Sievers (1948). Robertson (1928) also recorded dipterans on the flowers of Asteraceae, Apiacae, Fabaceae, Lamiaceae, Asclepiadaceae. Dipterans as pollinators of plants belonging to Asteraceae were noted by Noronha & Gottsberger (1980); Arroyo et al. (1982); Sazima & Machado (1983); Abbot & Irwin (1988), Herrera (1990) and Iwata (1990). Khemba & Mutinga (1982) suggested dipteran species as pollinator of sunflower especially when the number of bee visitors is too low to provide sufficient pollination. Dipteran as pollinator of an umbelliferous plant, carrot was reported by Ahmed & Aslam (2002), as pollinators of *T. erecta* have been noticed by Gange & Smith (2005), as floral visitors of mango were reported by Sung et al. (2006) and on the heads of Mikania were noted by Cerena (2004).

Thapa (2006) reported lady beetle *Coccinella* as pollinators of cucumber, pumpkin and brinjal which were true for the present study also. Goodman et al. (2001) observed *Coccinella* on flowers of buck wheat, Dunne (2001) on *Foenicolum vulgare*, Ahmed (1976) on Alfalfa flowers and Singh (1983) on mango flowers. *M. sexmaculatus* as flower visitors of mango has been reported by Sung et al. (2006), while, Patt (2000) and Ambrisomo et al. (2006) reported coccinellids as pests of *C. sativum*. Tybirk (1989) recorded beetles as floral visitors of *Acacia*. Gottsberger (1990) studied the relationship between flowers and beetles in the South American tropics. Sakai & Inone (1999) recorded beetles as pollinator of *Orchidantha inouei* and according to them beetles are effective pollinators to provide long distance pollen transfer. Kearns (2001) also noted beetles to be minor pollinators. Coleopterans as visitors to the flowers of chervil were reported by Knuth (1908) and Sievers (1948). Coleopterans as pollinators of plants belonging to Asteraceae were noticed by Noronha & Gottsberger (1980); Sazima & Machado (1983); Abbot & Irwin (1988) and Herrera & Iwata (1990). Coleopterans were noted as pollinators of an umbelliferous plant carrot by Ahmed & Aslam (2002). Samantha (2003) found pollen feeding beetle to be attracted towards the flowers of oil seed rape. Njorage et al. (2004) observed beetles as pollinators of *Citrullus lanatus*. Coleopterans were noted on the heads of *Mikania* by Cerena (2004). According to Beach (1981) beetle pollinated flowers, often provide the pollinators with a space to protect them from predators and/or produce relatively large amounts of pollen and sometimes special nutritive tissue to provide nutrition for the pollinators.

Pollen is primary attractant and is an important food and protein source for beetles as suggested by Faegri & Pijl (1979). They also reported that beetles directly eat it, while according to Gottsberger (1990) in most beetles, scent acts as the primary attractant. This statement was also supported by Harborne (1993). Picker & Midgley (1996) studied flower and colour preferences of beetles and observed beetles pollinated blue violet and white flowers.

The neuropteran *Chrysopa* sp. is commonly known as lace wing fly. It is a predacious insect which preys upon aphids, jaccids, psyllids, coccids, thrips etc. (Nayar, 1998). Bruce et al. (2002) also recorded lace wings on the flowers of *T. erecta* which support the present findings. Lace wings were observed to be attracted towards dill by Dunne (2001), while, according to Ivey et al. (2003) although *Chrysopa* sp. visited the flowers of milkweed they were not found to carry pollen.

The observations made during the present study therefore suggest that the frequent visitors would definitely act as pollinators, but, others cited as rare, could also by chance help in pollination.

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Table 1: Insect visitors on flowers on different crops at the agro – ecosystem during the period of study

Order:Coleoptera	*Mustard*	*Rye*	*Wheat*	*Barley*	*Gram*	*Fenugreek*	*Pearl millet*	*Cotton*	*Sorghum*	*Cluster beans*	*Mung bean*
Family: Scarabaeidae											
Onthophagus catta	-	-	-	-	-	-	-	-	-	-	2
Onthophagus bonasus	-	-	-	-	-	-	-	-	-	-	3
Adoretus sp.	-	-	-	-	-	-	-	-	-	-	3
Ochodius sp.	-	-	-	-	-	-	-	-	-	-	-
Peltonotus nasutus Arrow	-	-	-	-	-	4	10	-	-	-	1
Apogonia ferruginea	-	-	-	-	-	-	15	-	-	-	-
Family:Coccinellidae											
Coccinella septempunctata	35*	20*	20*	10	-	15	-	-	-	-	-
Menochilus sexmaculatus	10	12	10	8	-	-	-	-	-	-	-
Family:Curculionidae											
Myllocerus sp.	10	5	1	-	-	-	-	-	-	-	5
Hypolixus truncatulus Fab.	-	-	-	-	-	1	-	-	-	-	-
Family: Meloidae											
Cylindrothorax pictus Fast	-	-	-	-	-	-	25*	-	-	-	-
Order:Lepidoptera											
Family:Pieridae											
Catopsila pomona Cramer	1	-	-	-	-	-	-	-	-	-	
Colotis vestalis Butler	11	9	1	2	-	-	10	-	-	1	8
Colias fieldii Menetries	6	6	3	1	1	3	2	1	1	12	2
Eurema hecabe	7	10	4	-	-	3	6	1	1	-	10
Anaphaes aurota	1	-	-	-	-	-	-	-	-	-	-
Family:Lycaenidae											
Lampides boeticus Linn.	6	2	1	-	1	4	-	-	-	-	12

Order:Coleoptera	*Mustard*	*Rye*	*Wheat*	*Barley*	*Gram*	*Fenugreek*	*Pearl millet*	*Cotton*	*Sorghum*	*Cluster beans*	*Mung bean*
Family:Danaidae											
Danaus chryssipus	10	6	1	1	2	4	2	-	1	-	10
Family:Nymphalidae											
Junonia orithya Linn.	4	-	2	-	-	1	-	-	-	-	-
Family:Noctuidae											
Earias insulana Boisduival	-	5	-	-	-	1	-	-	-	-	-
ThysanoMythimna seprata Walker	2	1	-	-	-	-	10	-	20*	-	-
Agrotis Ipsilon Hufnagel	15	10	-	-	-	-	-	-	-	-	-
Mythimna seprata Walker	-	-	-	-	-	10	-	-	-	-	-
Spodoptera exigua Hubner	1	-	-	-	-	-	1	-	-	-	-
Family:Crambidae											
Hymenia fasciles Cramer	4	-	-	-	-	-	20*	-	10	1	-
Cryptographis indica Saunders	1	-	-	-	-	-	-	-	-	-	-
Family:Pyralidae											
Etiella zinckenella Treitschke	-	-	-	-	-	-	4	-	-	-	-
Family:Arctidae											
Utethesia pulchella Linn.	2	-	-	-	-	-	-	-	-	-	-
Family :Geometridae											
Tephrina disputara Guenee	10	5	21*	10	-	-	35*	-	5	-	-
Order:Hemiptera											
Family: Pentatomidae											
Nezara viridula	-	-	-	-	-	-	-	-	-	1	-
Oncocephalus Sp.	-	-	-	-	-	-	1	-	-	-	-
Family:Pyrrhocoridae											
Dysdercus cingulatus Fab.	-	-	-	-	-	-	-	-	-	2	-
Family:Aphididae											
Lipaphis erysimi	15	-	-	-	-	-	-	-	-	-	-
Order:Hymenoptera											
Family:Apidae											
Xylocopa fenestrate Fab.	3	-	-	-	-	-	-	-	-	-	-
Apis cerana Fab.	25*	18*	36*	10	-	10	15	4	-	7	2
Apis melifera Linn.	47*	45*	10	15	15	8	25*	1	-	5	4
Apis dorsata Fab.	13	-	1	2	-	-	15	4	-	6	1
Apis florae Fab.	40*	28*	25*	-	9	-	20*	3	10	4	-
Amegila cingulata	2	1	1	-	1	-	1	-	-	-	-
Family: Vespidae											
Polistes sp.	1	-	-	-	-	-	-	1	1	-	-
Delta sp.	-	-	-	-	-	-	1	-	-	-	-
Eumenus fenestrata	-	-	-	-	-	-	-	-	-	1	-
Family:Sphecidae											
Sceliphron brunneum	-	-	-	-	1	-	-	-	-	-	-
Family:Ichneumonidae											
Enicospilus sp.	-	-	2	-	-	1	-	-	-	-	-
Order:Diptera											
Family:Calliphoridae											
Chrysoma megacephala Fab.	2	-	-	-	-	-	-	-	-	-	-
Chrysoma saffrocnea	1	-	-	-	-	-	-	-	-	-	-
Family: Asilidae											
Stichopogon sp.	-	-	-	-	-	-	4	-	-	-	-
Family: Culicidae											
Culex quinquefasciatus	28*	25*	15	10	-	15	20*	-	15	25*	31*
Order:Orthoptera											
Family:Tettigoniidae											
Eucenocephalus sp.	-	-	-	-	-	-	-	-	-	10	-
Order:Neuroptera											
Family:Chrysopidae											
Chrysopa carnea	15	-	15	5	-	5	-	-	-	-	-

* Frequent visitors (number of visits/man hour ≥16)

Table 2: Botanical names and floral attributes of different crops cultivated in the agro-ecosystem during the period of study

Crop	*Botanical name*	*Family*	*Inflorescence*	*Scent*	*Colour*	*Self/Cross*	*Flowering period*
Pearl-millet	*Pennisetum typhoidea*	Poaceae	Cymose	Scented	Pale and brownish purple	Cross	Sept. to Oct.
Cotton	*Gossypium herbaceum*	Malvaceae	Solitary axillary	Scented	Yellow and blues	Cross	Sept. to Oct.
Sorghum	*Sorghum cernuum*	Poaceae	Solitary	Scented	Red	Self	Sept. to Oct.
Clusterbeans	*Cyamposis tetragonoloba*	Fabaceae	Spiked	Scented	Purple/blues	Self/cross	Sept. to Oct.
Mung beans	*Vigna radiata*	Fabaceae	Raceme	Scented	Light Yellow	Self/cross	Sept. to Oct.
Mustard	*Brassica campestris*	Brassicaceae	Corymbose/racem e	Aromati c	Yellow	Self/cross	Jan to Feb.
Rapeseed	*Brassica juncea*	Brassicaceae	Corymbose/racem e	Aromati c	Yellow	Self/cross	Jan to Feb.
Wheat	*Triticum aestivum*	Graminae	Spike	Scented	Green	Wind pollinated	Jan to Feb.
Barley	*Hordeum vulgare*	Graminae	Raceme	Scented	Green	Wind pollinated	Jan to Feb.
Gram	*Cicer arietinum*	Leguminosae	Solitary	Scented	Dark purple	Self/cross	Jan to Feb.
Fenugreek	*Trigonella foenum-graecum*	Leguminosae	Axillary	Scented	Purple	Self	Jan to Feb.